PHILIPS

Data handbook

PHILIPS Electronic components and materials

Electron tubes

Part 6 September 1972

Photomultiplier tubes

Channel electron multipliers

Scintillators

Photoscintillators

Radiation counter tubes

Semiconductor radiation detectors

Neutron generator tubes

Photo diodes

ELECTRON TUBES

Part 6 **September 1972**

DATA HANDBOOK SYSTEM

To provide you with a comprehensive source of information on electronic components, subassemblies and materials, our Data Handbook System is made up of three series of handbooks, each comprising several parts.

The three series, identified by the colours noted, are:

ELECTRON TUBES (9 parts)	**BLUE**
SEMICONDUCTORS AND INTEGRATED CIRCUITS (6 parts)	**RED**
COMPONENTS AND MATERIALS (7 parts)	**GREEN**

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically; the contents of each series are summarized on the following pages.

We have made every effort to ensure that each series is as accurate, comprehensive and up-to-date as possible, and we hope you will find it to be a valuable source of reference.

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You will understand that we can not guarantee that all products listed in any one edition of the handbook will remain available, or that their specifications will not be changed, before the next edition is published.

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Part 5 **Cathode-ray tubes; Photo tubes; Camera tubes** — **July 1972**

Part 6 **Devices for nuclear equipment** — **September 1972**

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Channel electron multipliers
Scintillators
Photoscintillators
Radiation counter tubes
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Neutron generator tubes
Photo diodes

Part 7 **Gas-filled tubes** — **July 1971**

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DTL/HNIL (FZ family)
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CML (GH family)
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CARACAS

Photomultiplier tubes

Some devices are labelled

Mainteneance type

or

Obsolescent type

Maintenance types	- still in production but to be avoided when designing new equipment.
Obsolescent types	- will be supplied until present stocks are exhausted.

SURVEY OF TYPES

Photo cathode diameter (mm)	Tube type	Spectral response								
		Super A	C (S1)	A (S4)	A (S11)	U (S13)	T (S20)	TU	D	DU
13	XP1220				X					
14	XP1110				X					
	XP1113				X					
	XP1114				X					
	XP1115				X					
	XP1116		X							
	XP1117						X			
	XP1118					X				
	XP1119								X	
20	XP1180				X					
32	150AVP	X								
	150CVP		X							
	150DVP									
	150UVP					X				
	XP1010	X								
	XP1011	X								
	XP1015				X					
	XP1016						X			
42	56AVP				X					
	56CVP		X							
	56DVP								X	
	56DVP/03								X	
	56DUVP									X
	56TVP						X			
	XP1020				X					
	XP1021				X					
	XP1023					X				
	XP1210				X					
	XP1230							X	X	
	XP2020								X	

Photo cathode diameter (mm)	Tube type	Spectral response								
		Super A	C (S1)	A (S4)	A (S11)	U (S13)	T (S20)	TU	D	DU
44	53AVP *	X								
	53DVP *								X	
	53UVP *					X				
	XP1000	X								
	XP1001	X								
	XP1002						X			
	XP1003							X		
	XP1004					X				
	XP1005		X							
	XP1006								X	
	XP2000	X								
63, 3	XP1030				X					
	XP1031				X					
	XP1032					X				
	XP1033					X				
	XP2030	X								
110	54AVP				X					
	54DVP								X	
	54UVP					X				
	58AVP				X					
	58DVP								X	
	58UVP					X				
	XP1040 **				X					
	XP1041 **								X	
200	57AVP				X					
	60AVP **				X					
	60 DVP								X	

* still in production but to be avoided for new equipment
** will be supplied until present stocks are exhausted

LIST OF SYMBOLS

Photocathode	k
Secondary emission electrode (dynode) No.n	S_n
Anode	a
Accelerating electrode	acc
Luminious cathode sensitivity	N_k
Radiant cathode sensitivity	N_{kr}
Luminious 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_{a_o}
Cathode current	I_k
Efficiency	η
Wavelength	λ
Internal connection. Do not use.	i.c.

GENERAL OPERATIONAL RECOMMENDATIONS PHOTOMULTIPLIER TUBES

1. GENERAL

1.1 A photomultiplier is a photosensitive vacuum device comprising a photoemissive cathode, a photo-electron collection system and one or more stages of current multiplication utilizing secondary emission electrodes (dynodes), plus an anode.

1.2 A photocathode consists of a light-sensitive film (the emission layer) and a supporting layer on which the emission layer is deposited.
Two types of cathode may be distinguished:

a. the opaque photocathode
b. the semi-transparent photocathode.

In the first type, the emission layer is deposited on a metal surface. In the second type the light quanta must pass through the wall of the tube and the transparent carrier layer before penetrating the photosensitive film. Although opaque photocathodes can be made more easily, semi-transparent photocathodes are most widely used, since they can be placed in the front of the tube, which has many advantages for the construction and use of the photomultipliers.

1.3 The photo-electron collection system (electron-optical input system) is that part of the photomultiplier which focuses the photo-electrons on to the first dynode, thus mainly determining the spread in the electron transit times. The quality of the input optics can be measured not only by the spread in the electron transit times, but also by the collection efficiency, i.e. the percentage of electrons emitted by the photocathode which land on the first dynode.
Because of the variation in magnitude and direction of the initial velocity of the electrons, each point on the cathode corresponds to a small image area on the dynode. In practice, it is sufficient to ensure that the first dynode is large enough to capture all electrons.
It is possible to improve the input optics by adding other electrodes, or by making an accelerating electrode separate from the first dynode, and one or more focusing electrodes separate from the cathode, but the improvement is only noticeable in very high-quality fast tubes such as the 56AVP, XP1020, etc.

1.4 The dynode system consists of a number of secondary-emission electrodes (dynodes). Several dynode constructions are possible. All tubes mentioned in this book have a dynode structure of the linear-focused type built up from dynodes of caesium-coated silver magnesium, excepted the windowless types which are equipped with copper-beryllium dynodes. Every electron which lands on a dynode does not produce the same number of secondary electrons: this number depends on the angle of incidence and velocity of the electron. Usually, however, it is sufficient to consider the mean secondary-emission factor δ_p of the p^{th} dynode, which is equal to the total number of secondary electrons emitted by that dynode divided by the number of electrons falling on it. As a rule it is also permissible to assume that all dynodes have the same value of this factor, δ, so that the amplification produced by the tube is given by

$$G = \delta^n$$

where n is the number of dynodes.

1.4.1. Damping resistor in the dynode circuit

A 50 ohm resistor is fitted in the base of the following types of fast photomultiplier tube

- 56AVP, 56CVP, 56DVP, etc. from serial number 31000 onwards
- 58AVP, 58DVP, 58UVP, XP1040, XP1041, from serial number 5677 onwards;
- 60AVP, from serial number 144 onwards.

This resistor is part of the circuit of the final dynode; since the tube works as a current generator the insertion of the resistor does not modify the amplitude of the signal.

The reason for including the resistor is the following:
At light pulses shorter than the tube's response time the anode current showed ringing. See Fig. 1.4.1.a. These oscillations were set up in the resonant circuit comprising the wiring inductance of the final dynode and the interelectrode capacitance. The resistor sufficiently damps the oscillations (Fig. 1.4.1.b).

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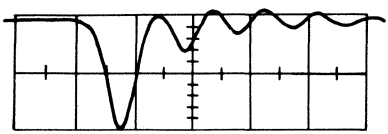


Fig. 1.4.1.a

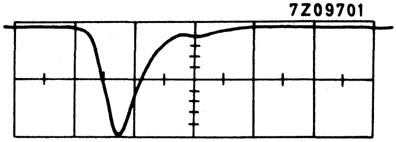


Fig. 1.4.1.b

1.5 The anode is usually made of wire mesh in order to ensure a low anode capacitance, and is placed directly in front of the last dynode. Although the secondary-emission factor of the anode material is very small, it cannot be ignored completely, since the number and velocity of the electrons landing on the anode is relatively large.
Such ions as are formed in the anode space, are mainly attracted to the last dynode. Since the distance between the anode and this dynode is relatively small, the ions do not acquire enough energy to give rise to any secondary electrons.

2. INTERPRETATION OF CHARACTERISTICS

The characteristics given in the Data section are typical values which indicate the performance of an average tube under certain operating conditions; individual tubes may have characteristics that deviate from the values given in the characteristic curves. All tubes are accompanied by a test-card indicating the test conditions.
The more important characteristics for photomultipliers are discussed below.

2.1 Spectral response

The materials employed to make the photocathode are of great importance to the response. Many substances show photo-emission, but often differ greatly in their spectral sensitivity and quantum yield.
Usually the spectral response of a photosensitive device is given as a function of wavelength in per cent of the maximum response.
As to the spectral response our range of photomultipliers can be subdivided into the following categories:

2.1.1 The A-types (S11) are equipped with a semi-transparent caesiumantimony photocathode precipitated on the inner side of a polished B40-glass window; these types are sensitive to light in the visible region, and have their maximum sensitivity in the blue region (see Fig. 1).

2.1.2 The U-types (S13) having the same photocathodes as the A-types but are provided with a polished optical quartz window, which gives them a sensitivity that extends into the ultraviolet region (see Fig. 2) and guarantees the absence of ^{40}K radiation.

2.1.3 The C-types (S1), which have a semi-transparent caesium-on-silver oxide photocathode on a polished B40-glass window. The sensitivity lies mainly in the red and near-infrared region, with a maximum at about 8000 Å (see Fig. 3).

2.1.4 The T-types (S20), which have a multi-alkaline semi-transparent photocathode on a polished B40-glass window. This photocathode is the most sensitive known for the region from the ultraviolet to the red end of the spectrum (see Fig. 4).

2.1.5 The TU-types, which have the same photocathode as the T-types but are provided with a polished optical quartz window, giving them a sensitivity that extends into the ultraviolet region (see Fig. 5).

2.1.6 The D-types, which have a bi-alkaline semi-transparent photocathode on a polished Pyrex 7740 window. The 7740 glass is a low activity glass with less than 0.05 % potassium 40 content. This photocathode has a high quantum efficiency in the blue region and a low parasitic emission (see Fig. 7).

2.1.7 the DU-types, which have the same photocathode as the D-types but are provided with a polished optical quartz window, giving them a sensitivity extending into the ultra-violet region and guaranteeing the absence of ^{40}K radiation.

2.1.8 The SBU (solar blind)-types, which are provided with a semi-transparent caesium-tellurium photocathode on a polished optical quartz window. These types have an ultraviolet response but are insensitive to light in the visible region (see Fig. 6).

2.2 Cathode luminous sensitivity

The cathode luminous sensitivity is defined as the photocurrent emitted per lumen of incident light flux, generally expressed in $\mu A/lm$. For the measurement the multiplier is connected as a diode. The cathode current (corrected for dark current) I_k is of the order of 100 nano amperes. The voltage must be chosen so high that the tube is surely operating in the saturation range. The sensitivity is given by

$$N_k = I_k/\Phi;$$

where Φ is the luminous flux in lumens of a tungsten ribbon lamp having a colour temperature of 2854 ^oK.

2.3 Cathode radiant sensitivity

The cathode radiant sensitivity is defined as the photocurrent emitted per watt of incident radiation, generally expressed in mA/W at the wavelength of maximum response. For the measurement the same procedure is used as for the luminous sensitivity. The value of incident radiation is measured by a thermopile.

2.4 Cathode quantum efficiency

The cathode quantum efficiency (η_q) is defined as the mean number of photoelectrons per incident photon, usually expressed in per cent at a certain wavelength.
At any given wavelength it can be easily calculated from the following formula:

$$\eta_q = N_{kr} \cdot \frac{1.24}{\lambda} \cdot 100\,\%$$

where N_{kr} = the cathode radiant sensitivity at wavelength λ in mA/W.

λ = 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 relative response curve.
Lines of constant quantum efficiency are shown on page 22 .

2.5 Current amplification (gain) and anode sensitivity

The current amplification (G) is the ratio of the anode signal current to the cathode signal current at stated electrode voltages and fully illuminated cathode. The anode sensitivity (N_a) is related to the gain (G) and the cathode sensitivity (N_k) by the formula

$$N_a = G \cdot N_k \cdot$$

Since the gain is usually very high ($> 10^6$) it is seldom possible to measure both the anode current and cathode current under the same conditions. With most photomultipliers the maximum permissible anode current is about 1 mA which, with a gain of 10^6, corresponds to a cathode current of 1 nA. Considering the high voltage involved, measurement of such small currents is apt to be considerable influenced by leakage currents between the base connections and in the measuring set-up. In practice it is, therefore, customary to measure the gain in two or more steps, advantage being taken of the following properties:

- a direct linear relationship exists between incident luminous flux and cathode current, anode current and dynode currents;

- gain is independent of the luminous flux and of the wavelength of the light.

The photomultiplier is connected as shown in Fig. 2.5.1. With the dynodes S(5) and S(6) connected to the negative terminal of the high voltage source via earth, the electron current flowing through the multiplier system will not reach the anode. Luminous flux can be increased until the cathode current (in the order of 0.1 μA) is high enough for leakage currents to be neglected.

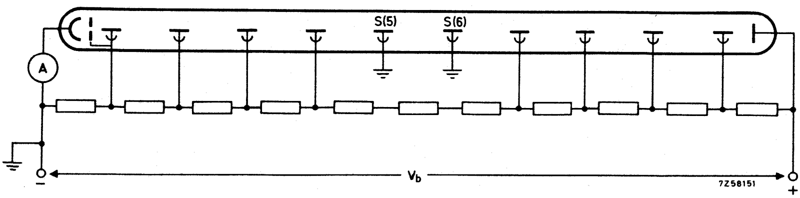


Fig. 2.5.1

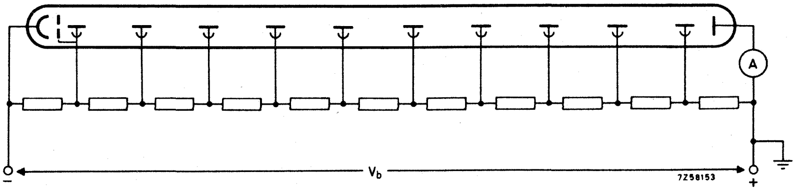


Fig. 2.5.2

To measure the anode current the photomultiplier is connected as shown in Fig. 2.5.2. The luminous flux is then reduced by neutral filters until the anode current corresponds to the value encountered in practice (< 100 μA).
The gain is now given by:

$$G = I_a A / I_k,$$

in which the factor A accounts for the attenuation by the neutral filter. If the gain of the photomultiplier is extremely high, it is advisable to measure it in steps, for example from the cathode to the n^{th} dynode and from the n^{th} dynode to the anode. In this way there is no need for such a dense neutral filter, which is difficult to calibrate.
Errors caused by the filter not being quite neutral are avoided by using monochromatic light, obtained by placing an interference filter between the light source and the photocathode.

2.6 Dark current

Even when the cathode is not illuminated, a certain current flows through the anode lead. This is known as the anode dark current (I_{a0}).
Anode dark current is measured at stated electrode voltages, or at electrode voltages required to provide a stated anode luminous sensitivity. Possible causes of anode dark current are electrical leakage, thermionic emission, field emission, residual gas ionization and tube fluorescence. At low operating voltages its major components are normally electrical leakage and thermionic emission. Thermionic emission can be recognized by its temperature dependence. At high values of applied voltage the other dark current components may become an appreciable part of the total dark current.

2.7 Linearity and saturation

The cathode and dynode currents should always be in the region of saturation so as to guarantee the proportionality between the current and the cathode illumination over the whole operating range. Fig. 2.7 shows the cathode current as a function of the voltage for a number of different luminous fluxes. The resistance of the photocathode plays an important role in the shape of these characteristics. When the tube is operated with a voltage V_{kS}, within the limiting values saturation of the cathode is assured.

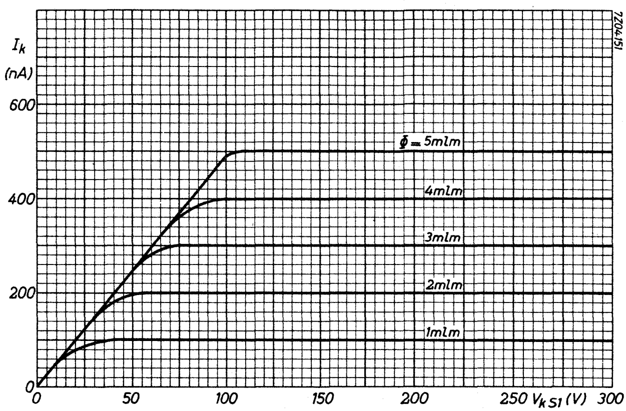


Fig. 2.7 Example of cathode current as a function of the voltage between the photocathode and the first dynode at various values of the luminous flux.

The saturation current of the dynodes, is always reached under normal operating conditions even at the highest permissible luminous flux.

The situation at the anode is once again different. The anode current causes a voltage drop across the resistance in series with the tube, so that the anode voltage decreases as the anode current increases. Moreover, care must be taken that the current is not limited by space-charge effects even at the largest permissible anode currents in order to ensure an undistorted output signal.

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

2.8.1 The transit time of a photomultiplier tube is defined as the time interval between the arrival of a delta-function light pulse (a pulse having finite light flux and infinitesimal width) at the entrance window of the tube and the moment the output pulse at the anode terminal reaches peak amplitude.

2.8.2 The anode pulse rise time indicates the time required for the amplitude to rise from 10 % to 90 % of the peak amplitude. For this measurement the delta function light pulse usually illuminates the entire photocathode.

2.8.3 The anode pulse width at half weight is an indication for the rise time at the anode if a step-function light pulse is applied.

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

3. OPERATING NOTES

3.1 The overall supply voltage should be well stabilized, since the gain of a photomultiplier is critically dependent on the voltage as expressed by the following relation

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

So 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 employ a high-current source of comparatively low voltage for the last three or four stages only, and a low-current high-voltage source for the remaining stages. If it is undesirable to maintain one power supply terminal at the sum fo the two voltages with respect to earth, the common terminal may be be earthed.

3.2 The voltage divider of a photomultiplier tube must be so designed that it does not give any troublesome shift in the dynode voltage caused by variations in incident radiation. The divider current I_{bl} (current flowing through the voltage divider) must therefore be large compared to the anode current. If this condition is not fulfilled a large dynode current, being linked up with a large anode current, will have a serious decreasing effect on the dynode voltages between the last stages.

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

$$\frac{\Delta G}{G} \approx \frac{I_k}{I_{bl}} \left[\delta^n - \frac{\delta^{n+1}}{(n+1)(\delta-1)} \right] \approx \frac{I_a}{I_{bl}} \left[1 - \frac{\delta}{(n+1)(\delta-1)} \right]$$

So the relative change in gain is approximately proportional to the ratio of the anode current to the divider current. For example, to maintain the gain stable within 1% when measuring continuous luminous flux, the divider current should be at least 100 times the anode current.

3.2.2 In pulsed operation, as in scintillation counting, the fluctuations in gain can be restricted without the need for a high divider current by shunting each resistor in the divider chain with a capacitor. Since the first few dynodes carry a very much lower current than following ones, it is sufficient in practice to bypass the last three or four stages only.

Calculations on capacitively stabilized voltage dividers are very complicated 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 if it is assumed that the charge Q_c that C_{n+1} should supply during the anode current pulse is much greater than the charge Q_a transported by the pulse.

$$Q_a = \int i_a \cdot dt \,.$$

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

$$C_{n+1} = \frac{Q_c}{V_{S(N)}} = \frac{100\,Q_a}{V_{S(N)}} = \frac{100}{V_{S(N)}} \int i_a \cdot dt \,.$$

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

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

Bypass capacitors reduce the required bleeder current quite considerably and greatly reduce voltage variations, but it should be borne in mind that they do make the time constant of the bleeder circuit very long. With high pulse rates, that is, when the intervals between successive pulses are short, the capacitors will not fully discharge and the pulse effects will add up until the amplitude of the voltage fluctuations has become quite appreciable. The error thus produced is a function of the pulse frequency, and for high pulse frequencies, where a short time constant is obligatory, a high bleeder current must be accepted.

3.3 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 the maximum useful life from the photocathode the tube should be protected from light as far as possible even when not in use.

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

The dark current may be further reduced by applying to the photocathode a jet of dry air cooled by being passed through, for example, a spiral immersed in liquid nitrogen. It is very important to ensure that no condensation occurs on the base or socket of the tube if air-cooling is adopted.

4. RUGGEDIZED PHOTOMULTIPLIERS

4.1 Tubes having a rugged construction, intended for application under severe operating conditions (e.g. geophysical and astronomical missile experiments), can be divided in two classes.

Class I : Conventional cylindrical tubes with a reinforced construction such as well fixed cathode connectors, rigid structure, flying leads, etc.

Class II: Specially designed extremely rugged tubes, potted or not potted (e.g. the rectangular XP1220).
The connections are made to the sides of the tubes to prevent long connections inside, thus preventing mechanical vibrations.

4.2 It is not possible to give exact, complete test conditions because these conditions can differ very much from one application to the other. Therefore it is necessary to state these conditions for each specific application for which the tubes are needed.

The following conditions are only given to indicate some tests done for both classes, without indicating the upper limits.

Class I : Shock 30 g, half wave sinusoidal, duration 11 ms, 3 shocks in each of 3 orthogonal axes.

Vibration 5 to 20 g, frequency 20 to 2000 Hz, duration 30 min. in each of 3 orthogonal axes.

Class II: Shock up to 100 g, duration 11 ms, 3 shocks in each of 3 orthogonal axes.

Vibration up to 30 g, frequency 20 to 2000 Hz duration 20 s, in each of 3 orthogonal axes.

Constant acceleration 45 g during 30 s in each of 3 orthogonal axes.

5. SPECIALLY SELECTED PHOTOMULTIPLIERS

For several applications it can be of importance to use specially selected tubes or a special version of a standard type photomultiplier.
The following selected tubes and versions exist:

Selection 01: Tubes specially selected to have a high gain.
Example: The XP1110/01, used in photoscintillator type PS1520 and selected for a gain of 10^7.

Selection 02: Tubes specially selected for X-ray spectrometry.

The selection is performed with the photomultiplier mounted in a scintillator probe with a thin NaI(Tl) scintillator with Be window.
The count rate as a function of high voltage is measured with an ^{55}Fe source (MnK_α line 5.9 keV) with a fixed discriminator bias and at a count rate in the middle of the plateau of about 2500 Hz. After the plateau curve has been determined the background noise of the tube is measured in the middle of the plateau. Selected tubes are guaranteed to have a minimum stated plateau length, a maximum stated plateau slope and a maximum stated background noise.
Available types: 53AVP/02 and XP1010 (02-selection of type 150 AVP).

Selection 03: Tubes specially selected to have a low background noise.

These tubes have a guaranteed maximum background at a stated V_b.
Available types: 56DVP/03 and 56DUVP/03.

Selection 04: Tubes specially selected to have a good stability as a function of time and count rate.

1. Measuring conditions:

The drift of the gain is given by the drift of the channel number for the ^{137}Cs photopeak.
Each tube remains in the measuring probe for 24 hours with HT applied:
- 23 hours 20 minutes for measurement at a count rate of 100 c/s. ($I_a \approx 10$ nA)
- 40 minutes for measurement at a count rate of 10.000 c/s. ($I_a \approx 100$ nA)

The change from 1000 c/s to 10.000 c/s is made within some seconds by moving the radioactive source towards the NaI (Tl) crystal.

To observe the shift caused by the change of count rate one measurement is made at the low count rate, just before the source is moved towards the probe and another measurement just after at the high count rate.
The measuring time is about 1.5 min.

Use is made of a 100-channel analyzer and a stabilized HT supply with the negative terminal grounded.
The HT at the voltage divider of the multiplier is about 900 to 1000 V.
The ^{137}Cs photopeak is positioned in the neighbourhood of channel 75 by means of the amplifier gain adjustment. The ambient temperature is stabilized within ± 0.5 °C. The dimensions of the NaI (Tl) scintillator are matched to the photomultiplier tube to be measured.

2. Selection requirements:

2.1 Stability as a function of time

After three hours with HT applied and at a count rate of 1000 c/s for the photopeak; the position of this peak is observed each hour.

The mean value of the drift during 24 hours is calculated as follows:

$$D = \frac{\sum_{i=1}^{n} |\overline{P} - P_i|}{n} \; \frac{100}{\overline{P}} \quad (\%)$$

In which: P_i = i^{th} measurement of the series of n peaks measured at 1000 c/s.

$\overline{P}$ = arithmetical average of the series.

2.2 Stability as a function of count rate

After the n^{th} measurement at a count rate of 1000 c/s the ^{137}Cs source is moved towards the scintillator of the probe to obtain a count rate of 10.000 c/s for the photopeak.

Four measurements are made during a period of 40 minutes. The mean value of the shift is given by:

$$SH = \frac{\sum_{i=n+1}^{n+4} |P_i - P_n|}{4} \; \frac{100}{P_n} \quad (\%)$$

in which P_n is the last measurement at 1000 c/s.

2.3 Requirements for approval

A tube is considered as being stable if both D and SH $\leq$ 1%.

Available type: XP1031/04.

Selection 05: Tubes with a special construction, e.g. type 56AVP/05 having a thin convex window instead of a thicker window with plane face as used with type 56AVP.

Selection 08: Tubes specially selected to have a good stability as a function of count rate.

1. Measuring conditions:

A ^{137}Cs source is placed in front of the photomultiplier with HT applied at such a distance that the count rate is 1000 c/s for the photopeak and with a mean current of 10 nA (adjusted by means of the HT).

- First measurement during 1 minute, the abscissa corresponding to a peak A_1.
- A 4-minute waiting period under these conditions.
- Second measurement during 1 minute, the abscissa corresponding to a peak A_2.
- Fast change from 1000 c/s to 10.000 c/s in the photopeak, corresponding to a mean current of 100 nA.
- A 10 minute waiting period under these conditions.
- Third measurement during 1 minute, the abscissa corresponding to A_3.
- A 4 minute waiting period under these conditions.
- Fourth measurement during 1 minute, the abscissa corresponding to A_4.

The anode is connected to a charge-sensitive pre-amplifier with a feed-back capacitor of 51 pF.
Under these conditions the given values of the mean current correspond with a photomultiplier gain of about 15.000 to 20.000 and a HT $\leq$ 1000 V.

2. Selection requirements:

2.1 Stability as a function of count rate

The mean value of the shift is given by:

$$S_{cr} = \frac{(A_3 + A_4) - (A_1 + A_2)}{A_1 + A_2} \times 100\%$$

2.2 Requirement for approval

$S_{cr} \leq 1\%$

Available types: XP1001/08, XP1031/08, 54AVP/08, 150AVP/08 and 153AVP/08.

Selection Sp: Tubes specially selected for γ-spectrometry, having a guaranteed resolution.
The energy is measured with an NaI(Tl) scintillator.
The resolution is stated for ^{137}Cs (0.661 MeV).

Available types: XP1001 (Sp selection of type XP1000)
XP1031 (Sp selection of type XP1030)
54AVP/Sp, 56AVP/Sp, 150AVP/Sp and 153AVP (Sp-selection of type 53AVP).

Selections of other types than mentioned above can be made available on request.

Selection A

For use in coincidence circuits, selected pairs of photomultiplier tubes can be delivered under type number ...../A.

Selection requirements

Tolerance of V_b of a tube pair having the same efficiency for single photons: $\Delta V_b \leq \pm 15$ V.
Product of background wise of a tube pair: sufficiently low to keep the effect of spurious coincidences negligible.

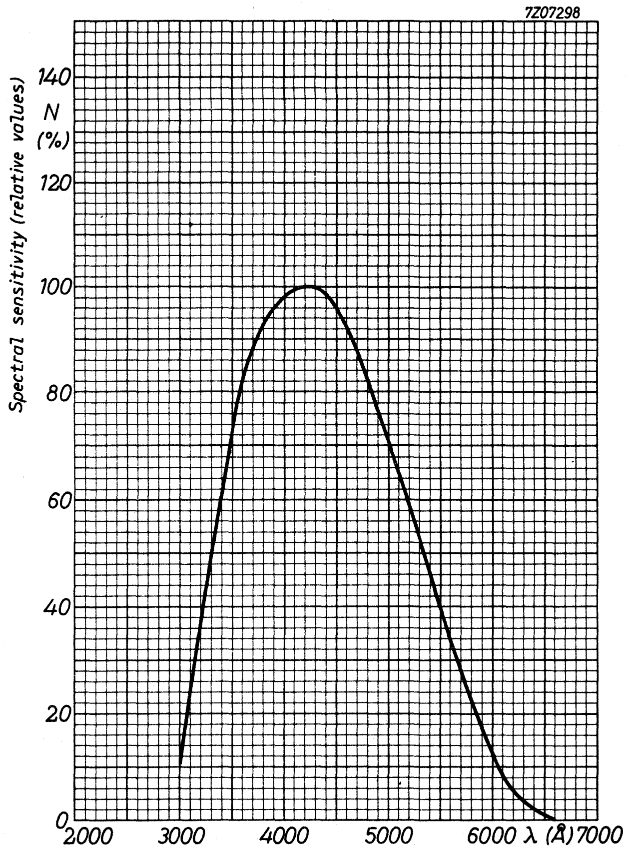
For XP1230/A see below

Available pairs

56DUVP/A, 56DUVP/03/A, 56DVP/A, 56DVP/03/A.

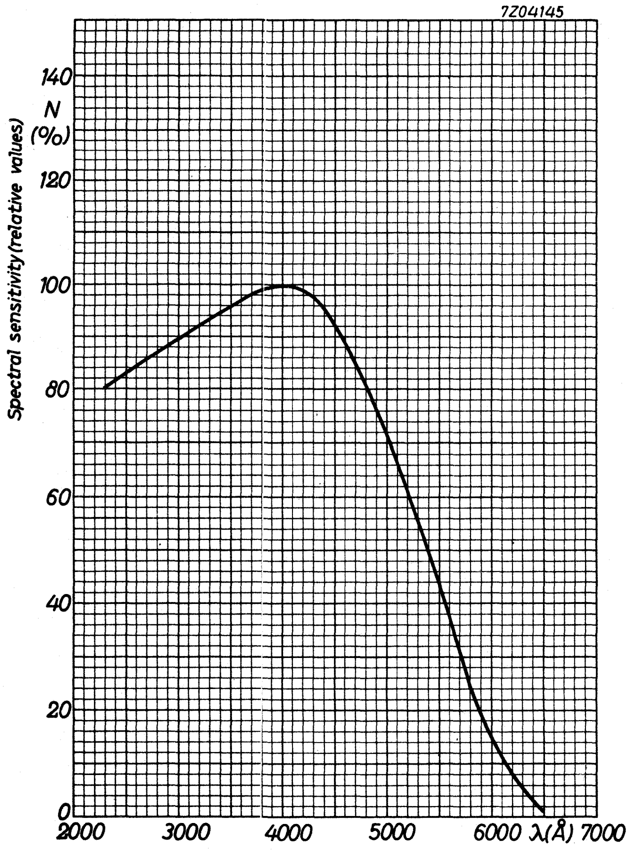
XP1230A

Efficiency for Tritium	η	av.	60	%
	η	min.	55	%
Background wise at V_b = 2100 V in coincidence circuit	B	av.	30	c/s
	B	max.	35	c/s
Tolerance of V_b of a tube pair having the same gain	ΔV_b	max.	10	%



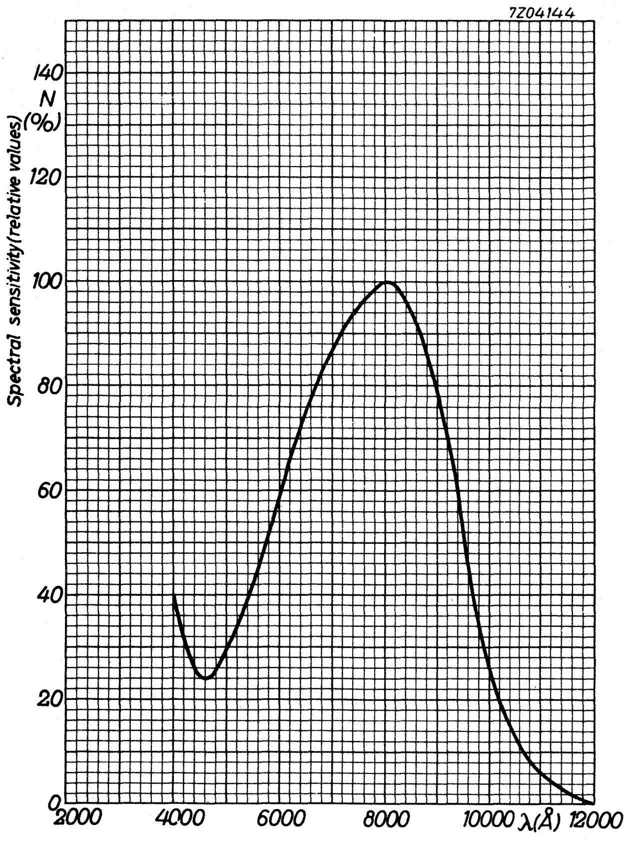
Spectral response curve type A (S11)

Fig. 1



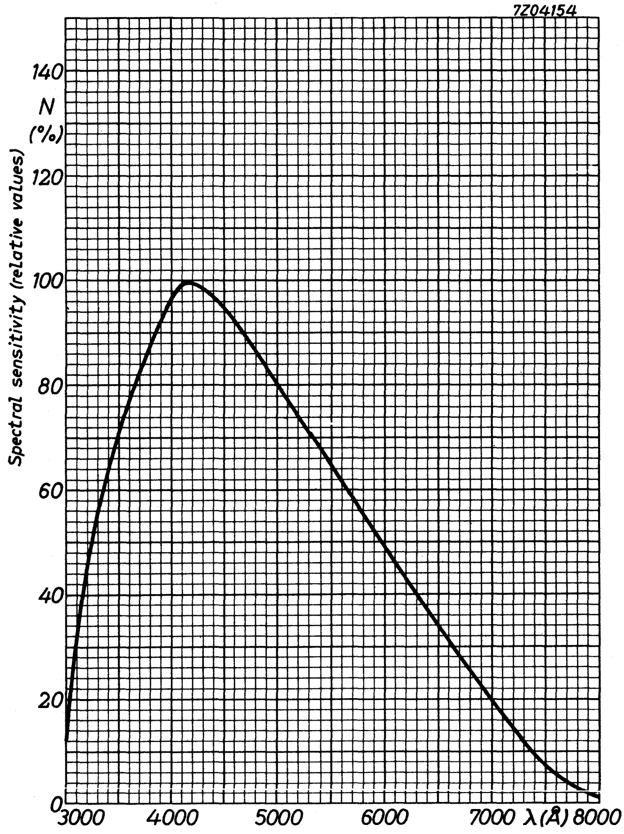
Spectral response curve type U (S13)

Fig. 2



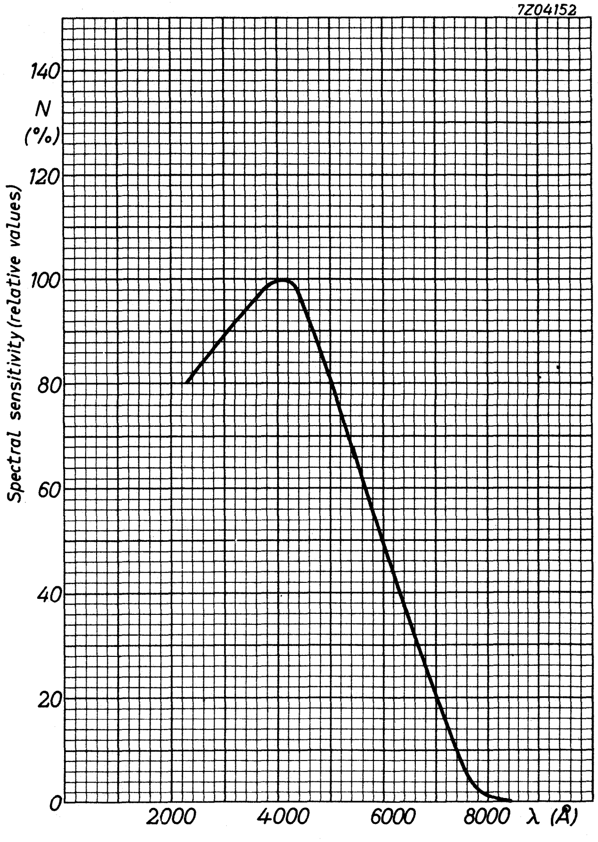
Spectral response curve type C (S1)

Fig.3



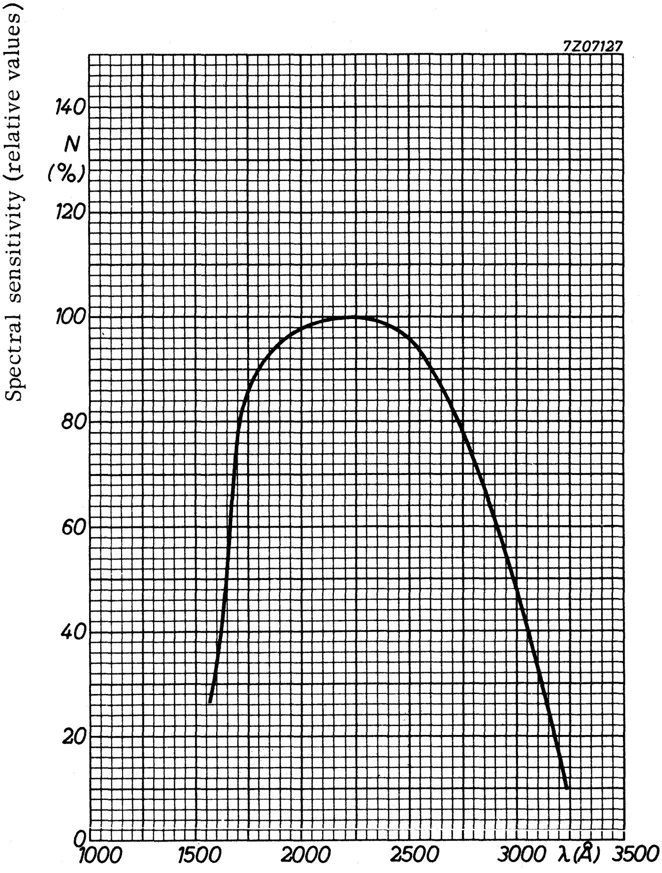
Spectral response curve type T (S20)

Fig.4



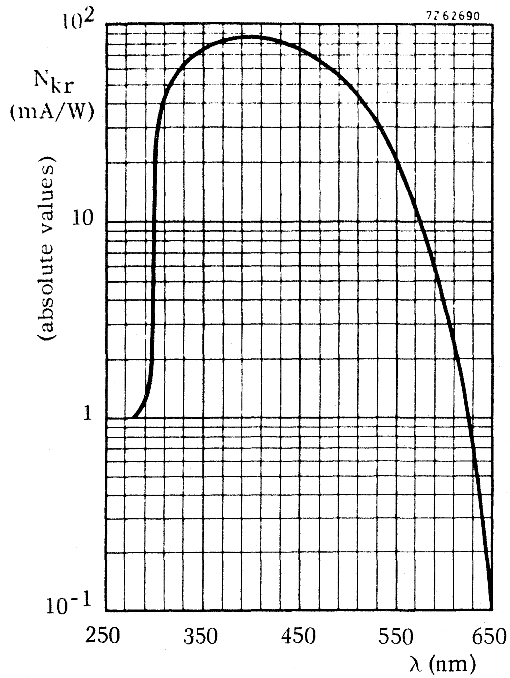
Spectral response curve type TU

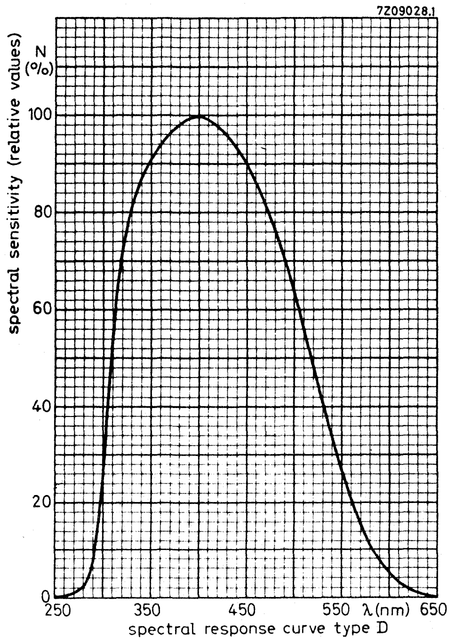
Fig. 5



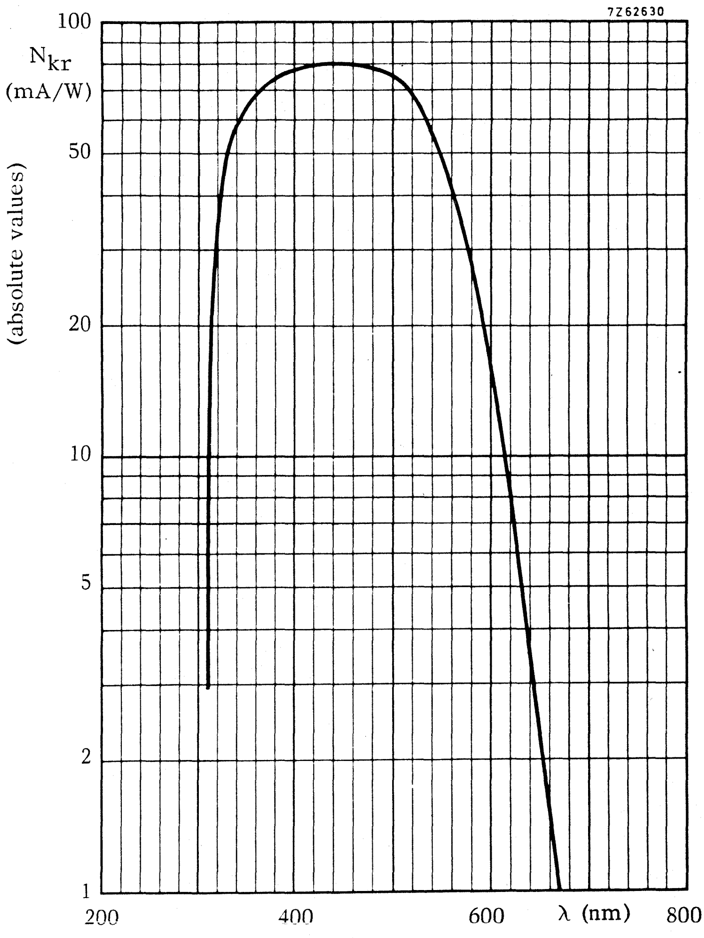
Spectral response curve type SBU

Fig.6



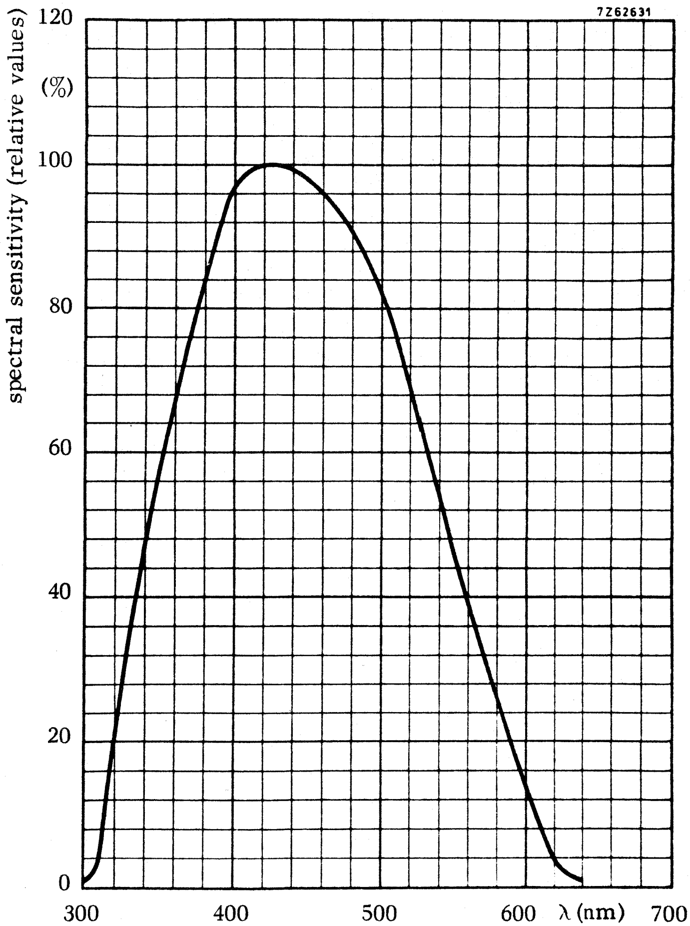


Spectral response curve type D
Fig. 7



Spectral response curve type Super A

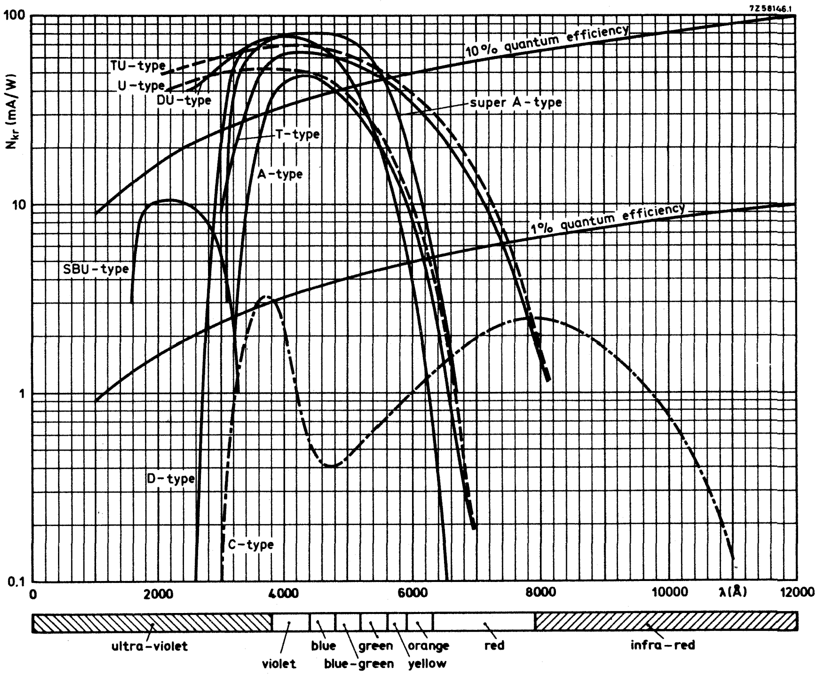
Fig. 8



Spectral response curve type Super A

Fig. 9

Comparison of the various spectral response curves



Absolute spectral sensitivity of different types of cathode.

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.

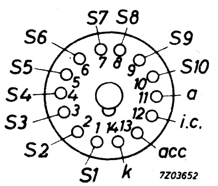
10 STAGE PHOTOMULTIPLIER TUBE

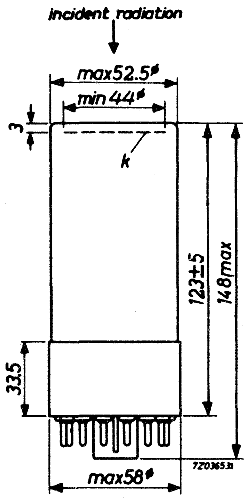
The tube is intended for use in applications such as scintillation counting of alpha, beta, gamma, neutron radiation and X-rays and different kinds of optical instruments.

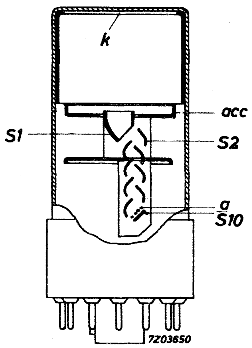
QUICK REFERENCE DATA		
Spectral response	type Super A	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			44	mm
→ Spectral response curve [1]			type Super A	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
→ Radiant sensitivity at 437 nm			80	mA/W

Multiplier system

Number of stages	10	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{10}	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	250	A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_o}	av.	0.015	μA
		max.	0.050	μA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

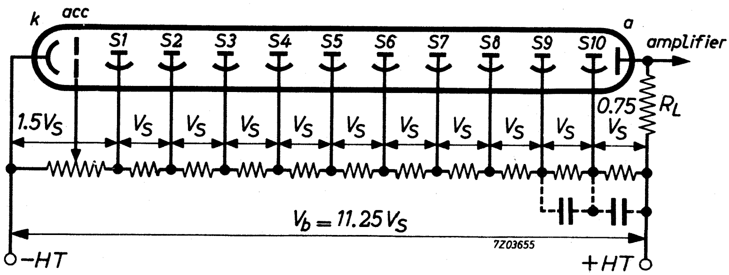
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max. min.	300 80	V V

RECOMMENDED CIRCUITS

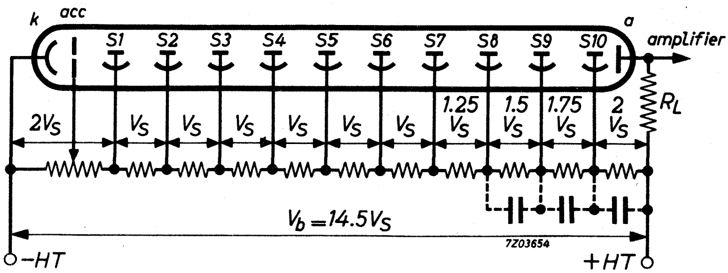


Voltage divider type A

1) For an infinitely short light pulse, fully illuminating the photocathode.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

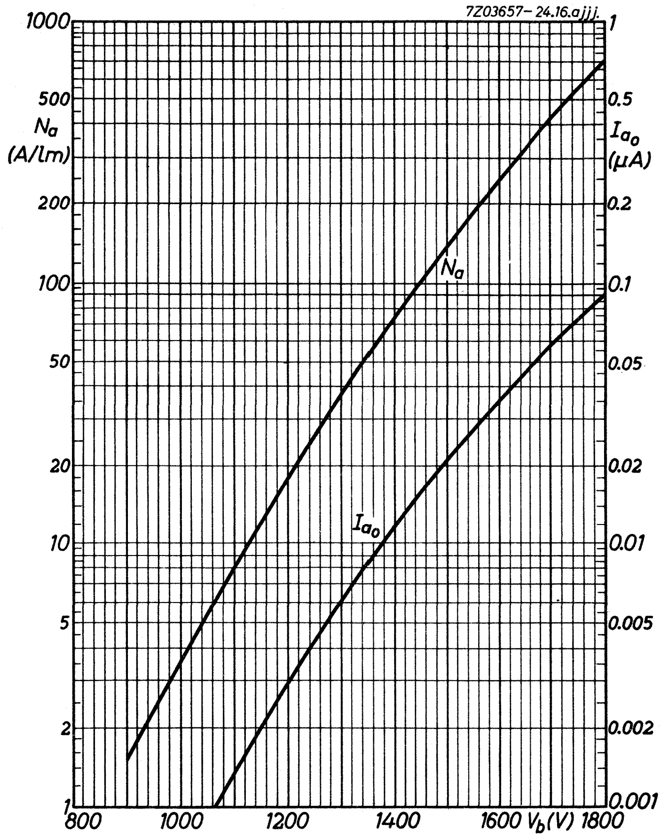
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.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1000
500
200
100
50
20
10
5
2
1
N_a (A/lm)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
I_{a_0} (μA)
N_a
I_{a_0}
800
1000
1200
1400
1600
V_b(V)
1800

10 STAGE PHOTOMULTIPLIER TUBE

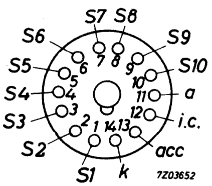
The tube is intended for use in applications such as gamma-ray spectrometry.

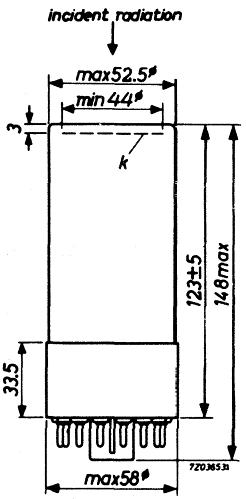
QUICK REFERENCE DATA		
Spectral response	type Super A	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm
Energy resolution for ^{137}Cs (0.661 MeV) [4])	8.5	%

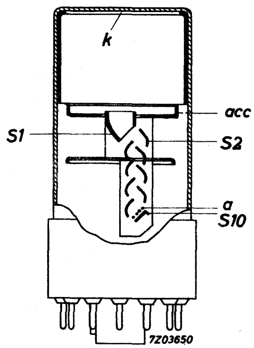
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			44	mm
→ Spectral response curve [1]			type Super A	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	80	μA/lm
		min.	70	μA/lm
→ Radiant sensitivity at 437 nm			80	mA/W

Multiplier system

Number of stages	10	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	400	A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_o}	av.	0.015	μA
		max.	0.050	μA
Energy resolution for ^{137}Cs (0.661 MeV) [4]		av.	8.5	%
		max.	9.0	%
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

[4]) Measured with a 1.5" x 1" NaI(Tl) crystal

TYPICAL CHARACTERISTICS (continued)

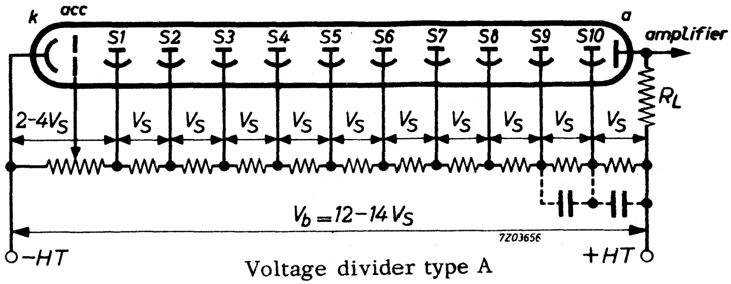
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



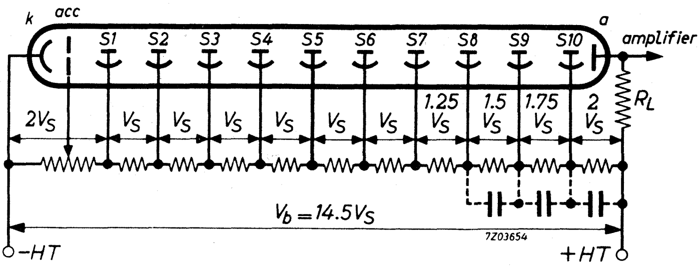
Voltage divider type A

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

[1] For an infinitely short light pulse, fully illuminating the photocathode.

[2] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

k = cathode
acc = accelerating electrode

Sn = dynode No.n
a = anode

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be a practical value.

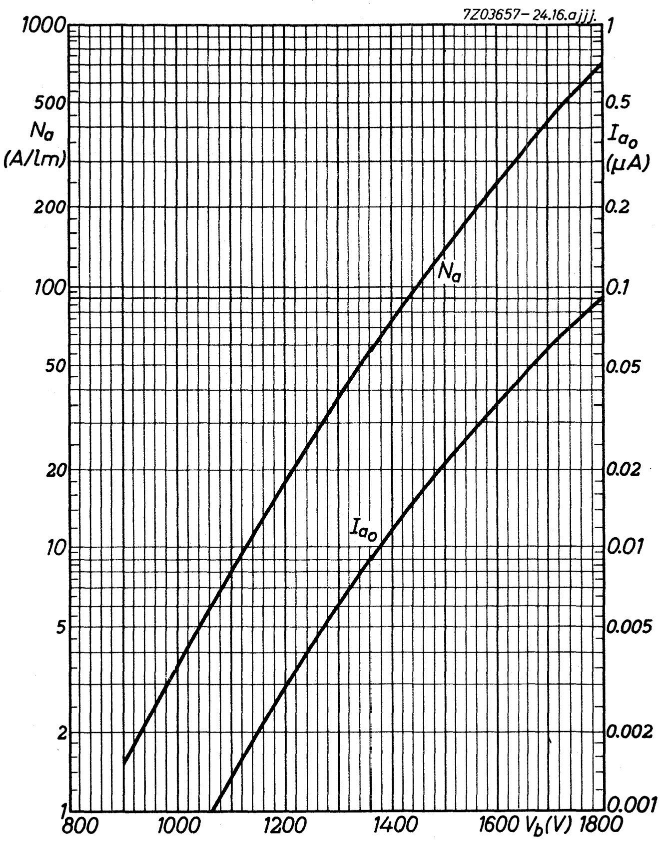
The best results in γ-ray spectrometry will be achieved with a voltage of 4-times "V_S" between the cathode and the first dynode; however, the limiting values must not be exceeded. At a high tension of about 1100 V the tube will work most favourably.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

At high pulse amplitudes it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03657-24.16.ajjj.
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
1
0.5
I_{a_o}
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
800
1000
1200
1400
1600 V_b(V) 1800
N_a
I_{a_o}

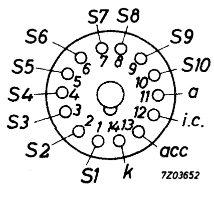
10 STAGE PHOTOMULTIPLIER TUBE

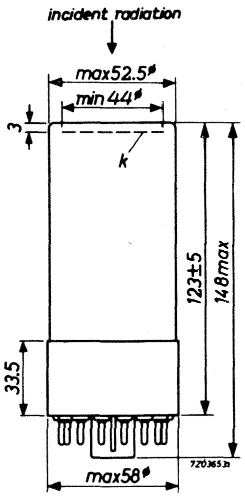
The tube is intended for use in laser technics, working in the orange and green range and for photometry where a high sensitivity in the whole visible region is required.

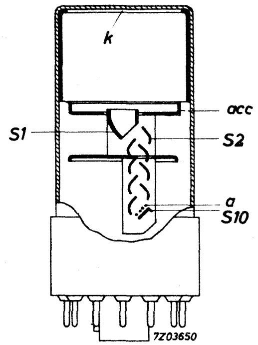
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec 14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface	
Cathode material		Sb-K-Na-Cs	
Minimum useful diameter		44	mm
Spectral response curve [1]		type T (S20)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	av. 150 min. 110	μA/lm μA/lm
Radiant sensitivity at 4200 Å		70	mA/W
at 7000 Å		12	mA/W

Multiplier system

Number of stages		10	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 400 min. 100	A/lm A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av. 0.015 max. 0.050	μA μA
Linearity between anode pulse amplitude and input light pulse		up to 30	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

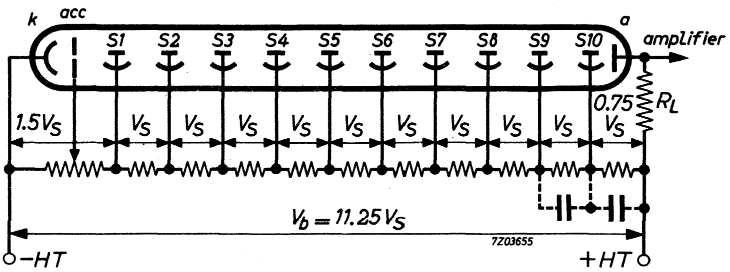
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	180	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

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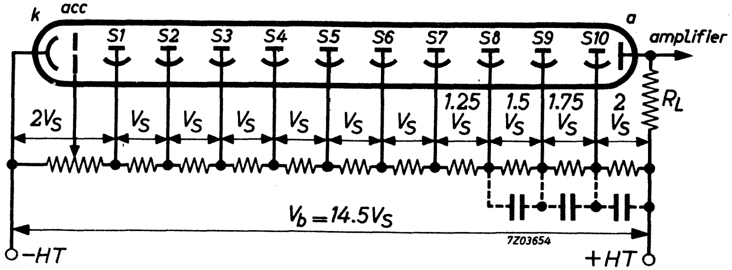
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

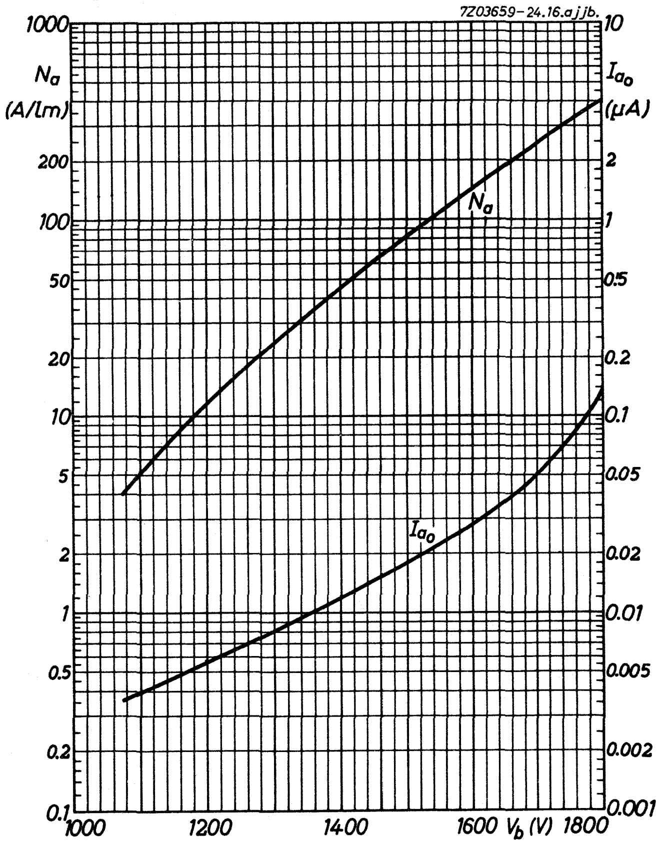
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to de-couple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.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1000
N_a
(A/lm)
200
100
50
20
10
5
2
1
0.5
0.2
0.1
10
I_{a_0}
(µA)
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
N_a
I_{a_0}
1000
1200
1400
1600 V_b (V) 1800

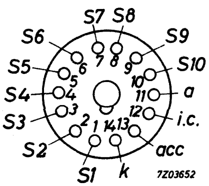
10 STAGE PHOTOMULTIPLIER TUBE

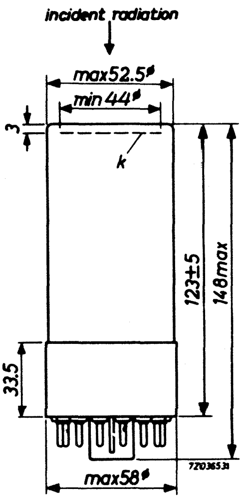
The tube is intended for use in laser technics, and photometry where a high sensitivity in the whole visible and ultraviolet region is required.

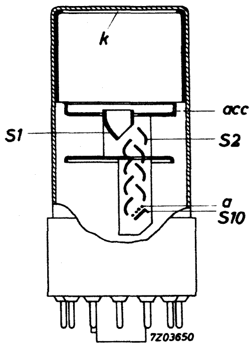
QUICK REFERENCE DATA			
Spectral response	type	TU (extended S20)	
Window material	quartz		
Useful diameter of the photocathode		44	mm
Anode sensitivity (at 1800 V)		400	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface	
Cathode material		Sb-K-Na-Cs	
Minimum useful diameter		44	mm
Spectral response curve [1]		type T (S20)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	av. 150	μA/lm
		min. 110	μA/lm
Radiant sensitivity at 4200 Å		70	mA/W
at 7000 Å		12	mA/W

Multiplier system

Number of stages		10	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 400	A/lm
		min. 100	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av. 0.015	μA
		max. 0.050	μA
Linearity between anode pulse amplitude and input light pulse		up to 30	mA

---

[1] See spectral response curve in front of this section

[2] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3] At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

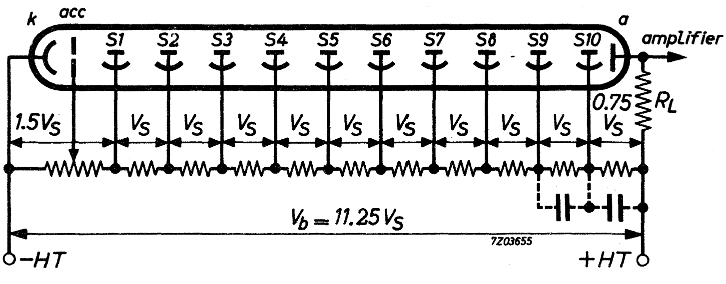
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	180	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS

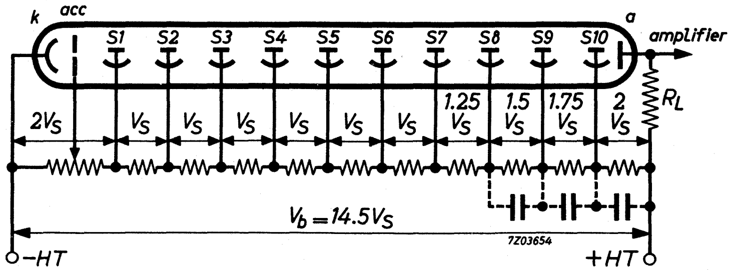


Voltage divider type A

[1] For an infinitely short light pulse, fully illuminating the photocathode.

[2] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

k = cathode

acc = accelerating electrode

S_n = dynode No. n

a = anode

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

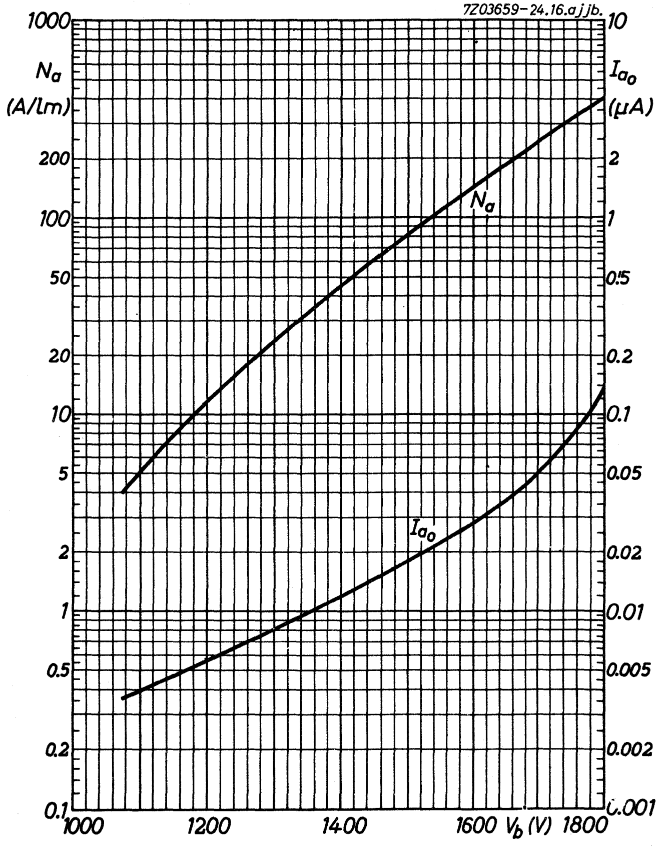
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.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1000
N_a
(A/lm)
200
100
50
20
10
5
2
1
0.5
0.2
0.1
10
I_{a_0}
(μA)
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1000
1200
1400
1600 V_b (V) 1800
N_a
I_{a_0}

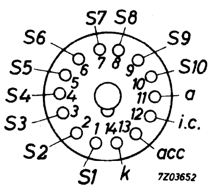
10 STAGE PHOTOMULTIPLIER TUBE

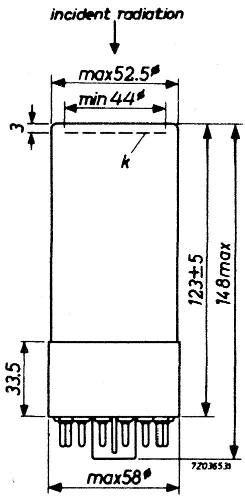
The tube is intended for use in optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

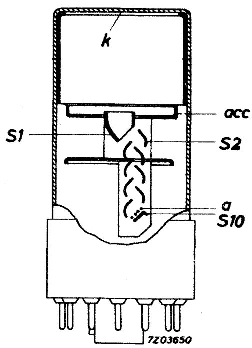
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm

DIMENSIONS AND CONNECTIONS — Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			44	mm
Spectral response curve [1]			type U (S13)	
Wavelength at maximum response			4000 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4000 Å			60	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

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

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	250	A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_o}	av.	0.015	μA
		max.	0.050	μA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

---

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

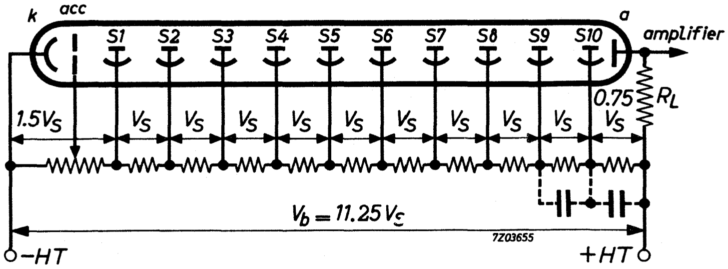
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

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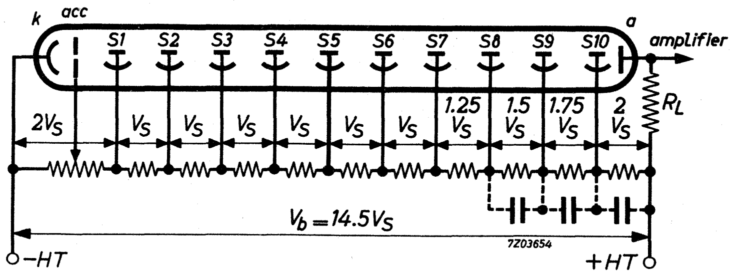
[1] For an infinitely short light pulse, fully illuminating the photo cathode.

[2] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

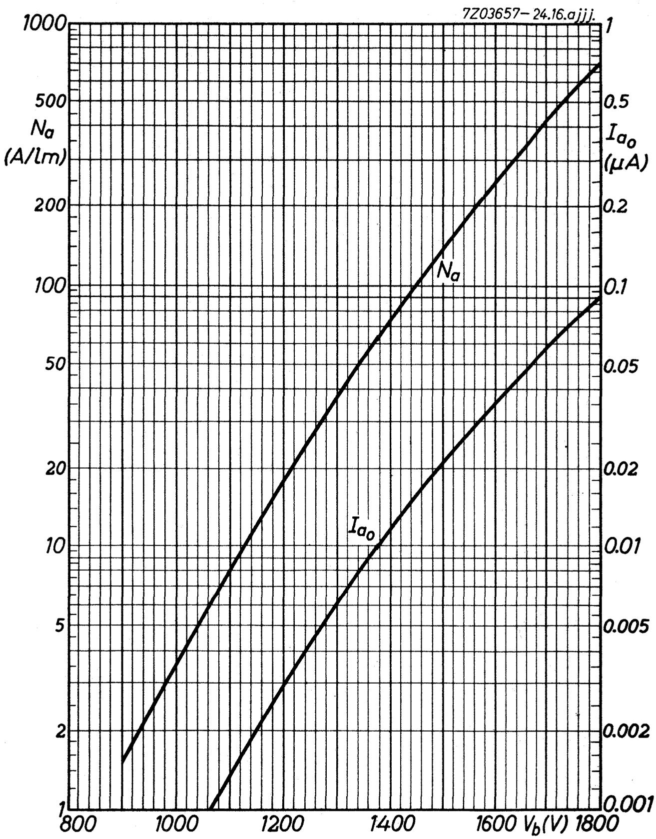
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.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1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
800
1000
1200
1400
1600
V_b(V)
1800
1
0.5
I_{a_0}
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
N_a
I_{a_0}

10 STAGE PHOTOMULTIPLIER TUBE

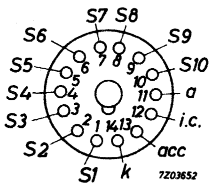
The tube is intended for use in applications such as infra-red telecommunication and ranging and in optical instruments operating in the far red and near infra-red region.

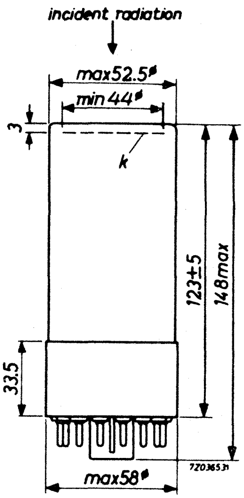
QUICK REFERENCE DATA		
Spectral response	type C (S1)	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	100	A/lm

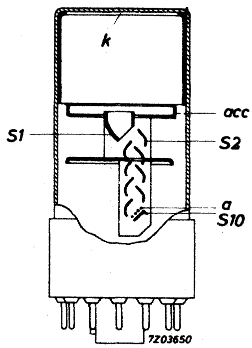
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Ag-O-Cs		
Minimum useful diameter			44	mm
Spectral response curve [1]		type C (S1)		
Wavelength at maximum response			8000 ± 1000	Å
Luminous sensitivity [2]	N_k	av.	20	μA/lm
		min.	15	μA/lm
Infra-red luminous sensitivity [3]	N_k	av.	3	μA/lm
		min.	1.4	μA/lm
Radiant sensitivity at 8000 Å			2	mA/W

Multiplier system

Number of stages			10	
Dynode material		Ag-Mg-O-Cs		

Capacitances

Anode to final dynode	$C_{a/S_{10}}$		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	100	A/lm
		min.	20	A/lm
Anode dark current at N_a = 20 A/lm [4]	I_{a_o}	max.	10	μA
Linearity between anode pulse amplitude and input light pulse		up to	5	mA

---

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

3) The infra-red lumen is the flux resulting from one lumen yielded by a tungsten ribbon lamp (colour temperature 2854 °K) going through an infra-red filter Corning CS94 No. 2540, fusion 1613 thickness 2.61

4) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

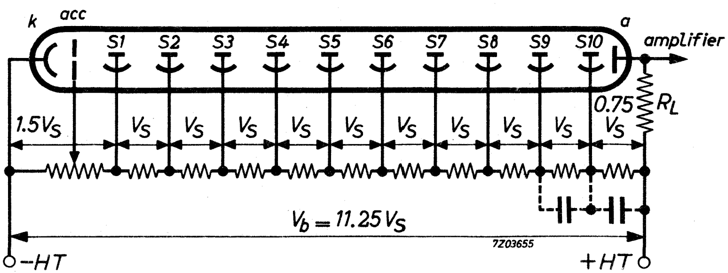
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	10	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	30	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS

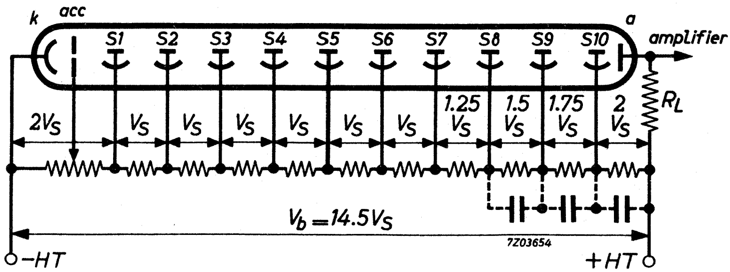


Voltage divider type A

[1]) For an infintely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

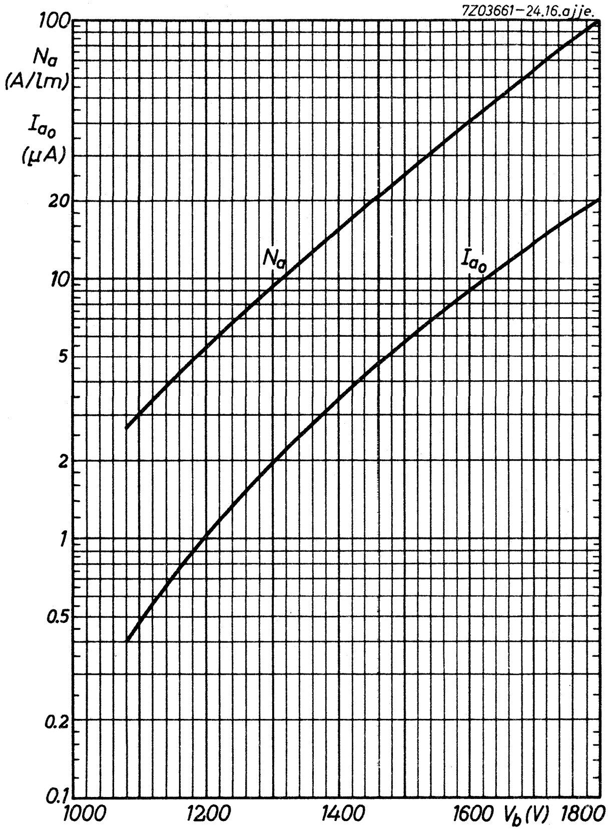
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03661−24.16.ajje.
100
N_a
(A/lm)
I_{a_0}
(μA)
20
10
5
2
1
0.5
0.2
0.1
N_a
I_{a_0}
1000
1200
1400
1600
V_b (V)
1800

10 STAGE PHOTOMULTIPLIER TUBE

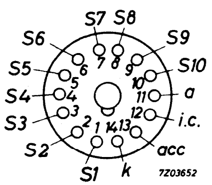
The tube is intended for use in applications such as scintillation counting and measurement of low luminous fluxes.

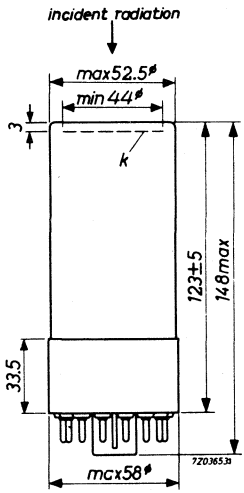
QUICK REFERENCE DATA		
Spectral response	bialkali type D	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	250	A/lm
Energy resolution for ^{137}Cs (0.661 MeV)	max. 9	%

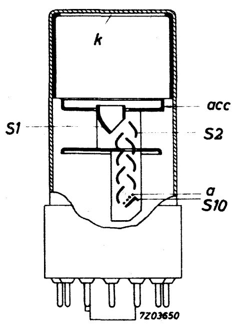
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56128

Data based on pre-production tubes

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			K-Cs-Sb	
Minimum useful diameter			44	mm
Spectral response curve (see page 5)			type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity [1]	N_k	av.	50	μA/lm
		min.	30	μA/lm
Radiant sensitivity at 437 nm		av.	75	mA/W
		min.	50	mA/W

Multiplier system

Number of stages		10	
Dynode material		Ag-Mg-O-Cs	

Capacitances

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

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	250	A/lm
		min.	100	A/lm
Anode dark current at N_a = 60 A/lm [2]	I_{ao}	av.	20	nA
		max.	50	nA
Energy resolution for ^{137}Cs (0.661 MeV) [3]		max.	9	%
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

[1]) Measured with a tungsten ribbon lamp with a colour temperature of 2854 °K. Because of the resistivity of D-type photocathodes the value of the cathode sensitivity is only an approximation. (See also the "operational considerations")
[2]) At an ambient temperature of 25 °C.
[3]) Measured with a 1.5 in x 1 in NaI (Tℓ) crystal.

TYPICAL CHARACTERISTICS (continued)

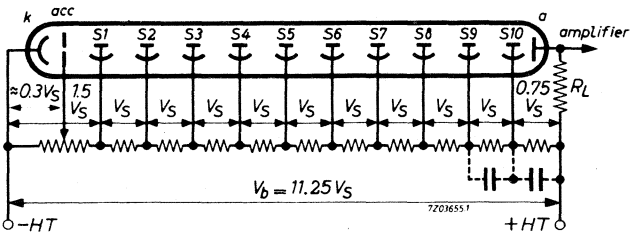
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4	ns
Anode pulse width at half height at V_b = 1500 V [1]		12	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		40	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage [2]	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



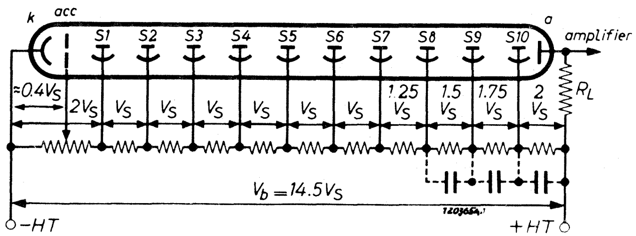
Voltage divider type A

1) For an infinitely short light pulse, fully illuminating the photocathode.

2) Or the voltage at which the tube circuited in the voltage divider A has an anode sensitivity of 500 A/lm whichever is lowest.

3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

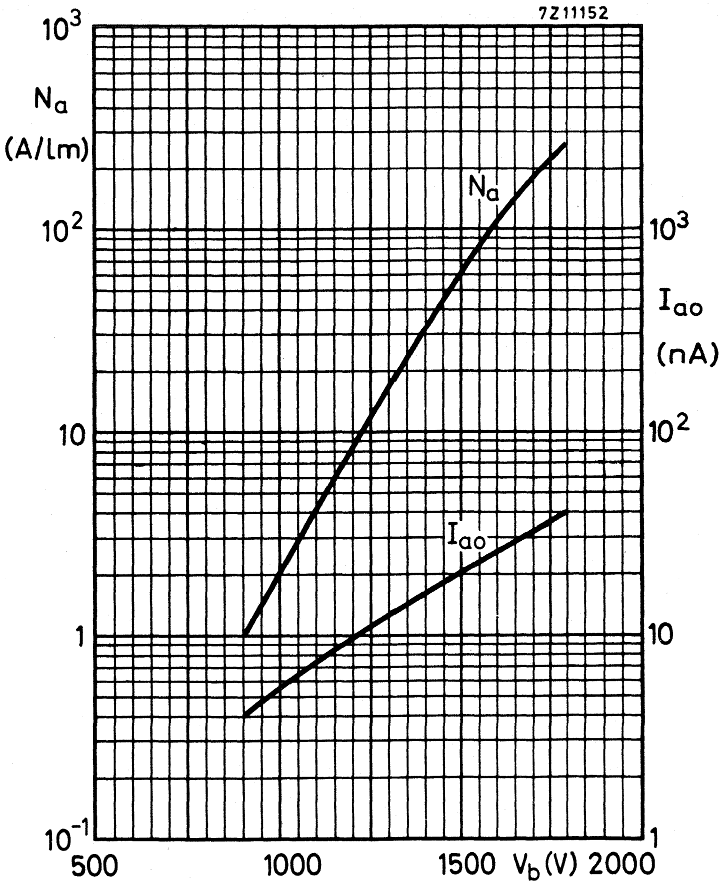
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z11152
10^3
N_a
(A/lm)
10^2
10
1
10^{-1}
10^3
I_{ao}
(nA)
10^2
10
1
500
1000
1500
V_b (V)
2000
N_a
I_{ao}

10 STAGE PHOTOMULTIPLIER TUBE

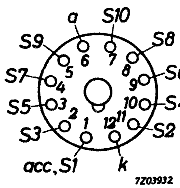
This low noise tube is intended for use in applications such as X- and γ-ray spectrometry.

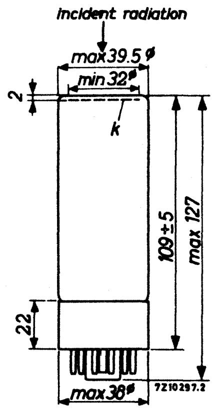
QUICK REFERENCE DATA			
Spectral response		type Super A	
Useful diameter of the photocathode		32	mm
Anode sensitivity (at 1800 V)		700	A/lm
Plateau length (Mn, K_α line 5.9 keV)	min.	70	V
Plateau slope	max.	0.08	%/V
Background in middle of plateau		10	c/s

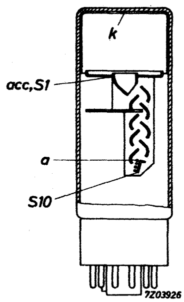
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			32	mm
→ Spectral response curve [1]			type Super A	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	80	μA/lm
		min.	70	μA/lm
→ Radiant sensitivity at 437 nm			80	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{10}		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	400	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	0.010	μA
		max.	0.050	μA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

3) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

Plateau length (Mn, K α line 5.9 KeV) [1]	min.	70	V
Plateau slope [1]	max.	0.08	%/V
Background in middle of plateau [1]	av.	10	c/s
	max.	50	c/s
Total voltage in middle of plateau		1100	V
Energy resolution for Cu, K α (8 KeV)		50	%

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [2]		4	ns
Anode pulse width at half height at V_b = 1500 V [2]		8	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		3	ns
Total transit time at V_b = 1500 V [2]		36	ns

LIMITING VALUES (Absolute max. rating system)

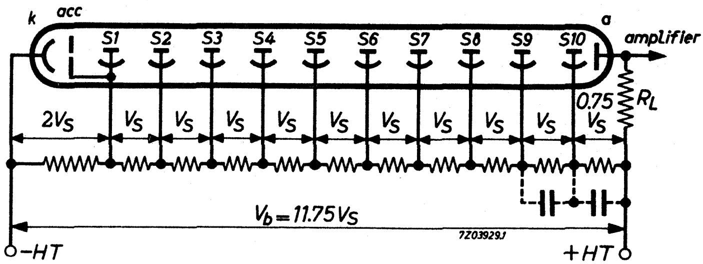
Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

[1]) Measured with a 32 mm x 1 mm NaI(Tl) crystal, at a counting rate of about 2500 c/s in the middle of the plateau, and with the discriminator bias set at 0.7 V. Preamplifier gain 250 x (source 100 μCi ^{55}Fe).

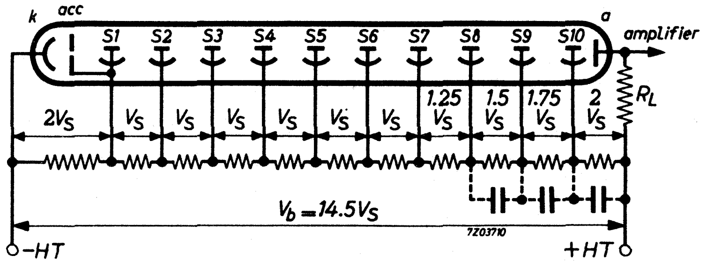
[2]) For an infinitely short light pulse, fully illuminating the photocathode.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

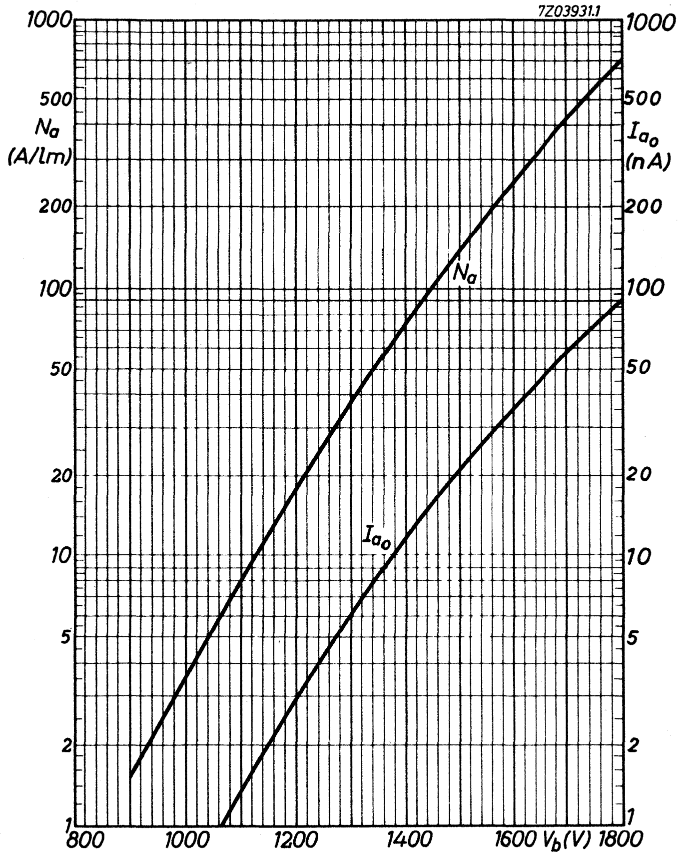
To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisible to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03931.1
1000
500
200
100
50
20
10
5
2
1
N_a
(A/lm)
I_{a_o}
(nA)
800
1000
1200
1400
1600
V_b (V)
1800

10 STAGE PHOTOMULTIPLIER TUBE

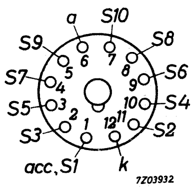
The tube is intended for scintillation counting and optical measurements under severe operating conditions. Its rugged construction makes it particularly suitable for application under severe operating conditions.

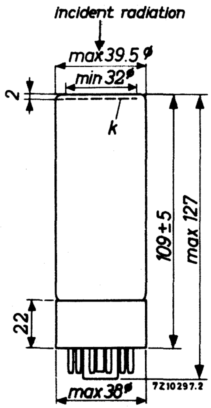
QUICK REFERENCE DATA		
Spectral response	type Super A	
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

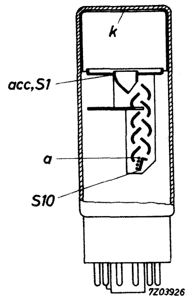
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface	
Cathode material		Cs-Sb	
Minimum useful diameter		32	mm
→ Spectral response curve [1]		type Super A	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	av. 70 min. 40	µA/lm µA/lm
→ Radiant sensitivity at 437 nm		80	mA/W

Multiplier system

Number of stages	10	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3	pF
Anode to all other electrodes	C_a	5	pF

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. min.	700 100	A/lm A/lm
Anode dark current at N_a = 60 A/lm [1]	I_{a_o}	av. max.	10 50	nA nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Anode pulse rise time at V_b = 1500 V [2]			4	ns
Anode pulse width at half height at V_b = 1500 V [2]			8	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V			3	ns
Total transit time at V_b = 1500 V [2]			36	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max. min.	300 80	V V

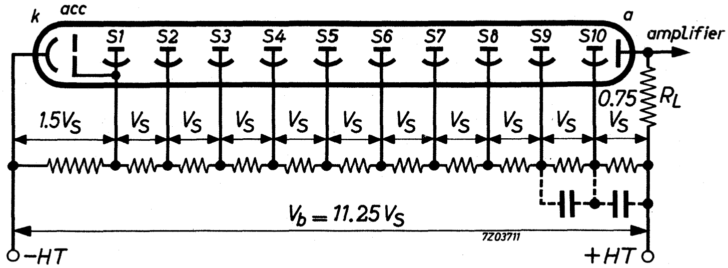
---

1) At an ambient temperature of 25 °C.

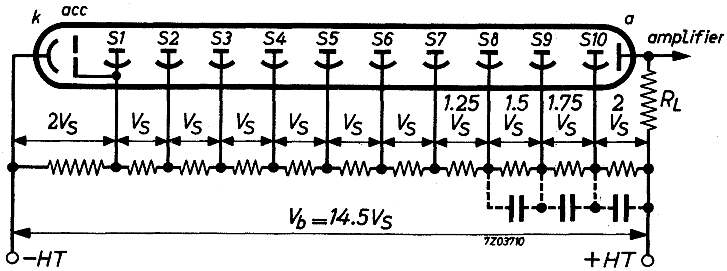
2) For an infinitely short light pulse, fully illuminating the photocathode.

3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

k = cathode

acc = accelerating electrode

S_n = dynode No.n

a = anode

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

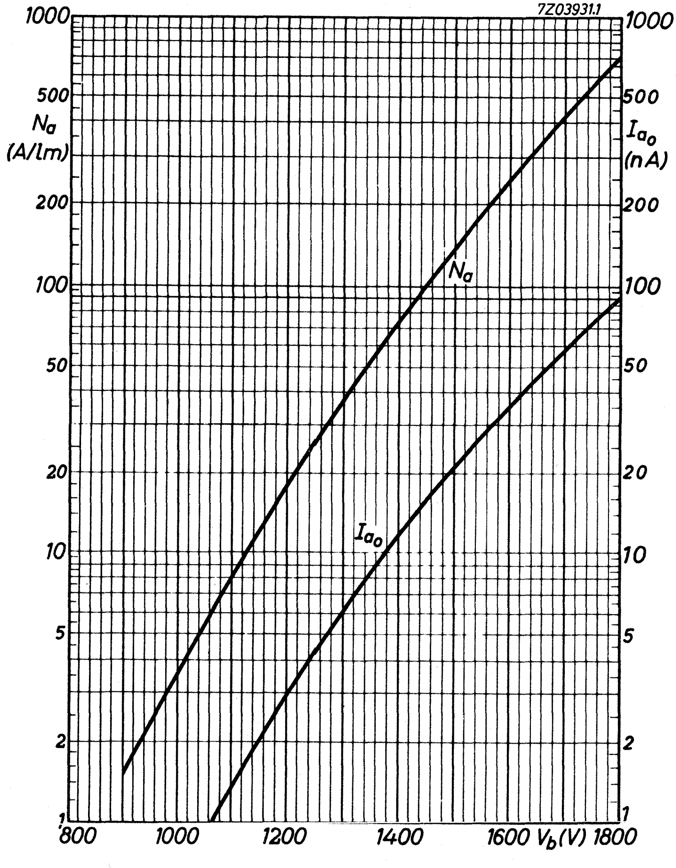
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03931.1
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
1000
500
I_{a_0}
(nA)
200
100
50
20
10
5
2
1
N_a
I_{a_0}
800
1000
1200
1400
1600 V_b(V) 1800

10 STAGE PHOTOMULTIPLIER TUBE

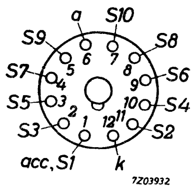
The tube is intended for scintillation counting and optical measurements under severe operating conditions. Its rugged construction makes it particularly suitable for application under severe operating conditions

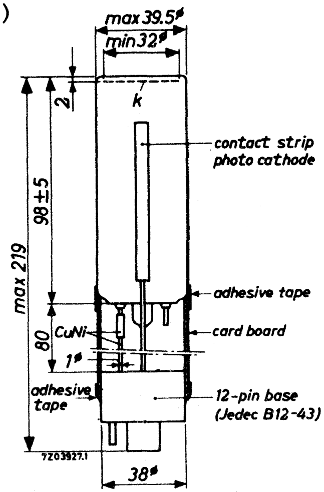
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

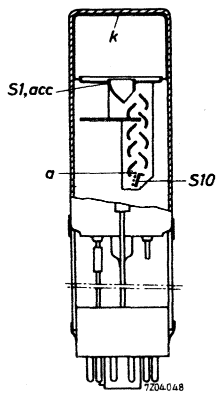
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface	
Cathode material		Cs-Sb	
Minimum useful diamter		32	mm
Spectral response curve [1]		type A (S11)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	av. 60	μA/lm
		min. 40	μA/lm
Radiant sensitivity at 4200 Å		60	mA/W

Multiplier system

Number of stages		10	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{10}	3	pF
Anode to all other electrodes	C_a	5	pF

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. min.	700 100	A/lm A/lm
Anode dark current at N_a = 60 A/lm [1])	I_{a_o}	av. max.	10 50	nA nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Anode pulse rise time at V_b = 1500 V [2])			4	ns
Anode pulse width at half height at V_b = 1500 V [2])			8	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V			3	ns
Total transit time at V_b = 1500 V [2])			36	ns

LIMITING VALUES (Absolute max. rating system)

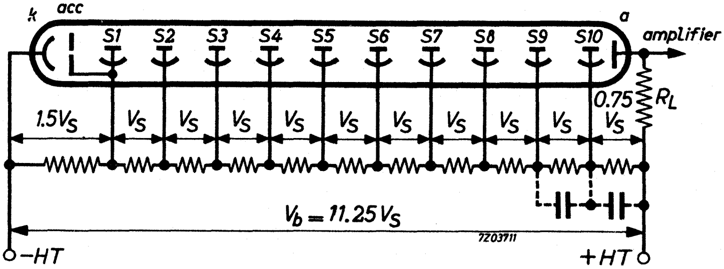
Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [3])	$V_{a/S_{10}}$	max. min.	300 80	V V

[1]) At an ambient temperature of 25 °C.

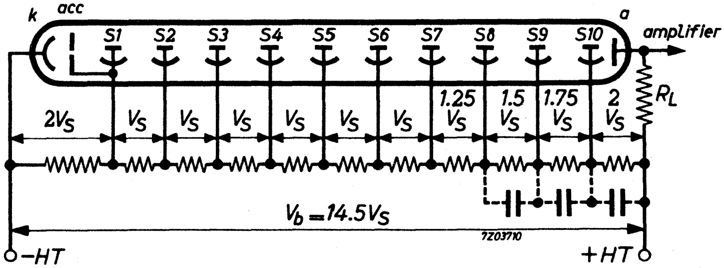
[2]) For an infinitely short light pulse, fully illumunating the photocathode.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

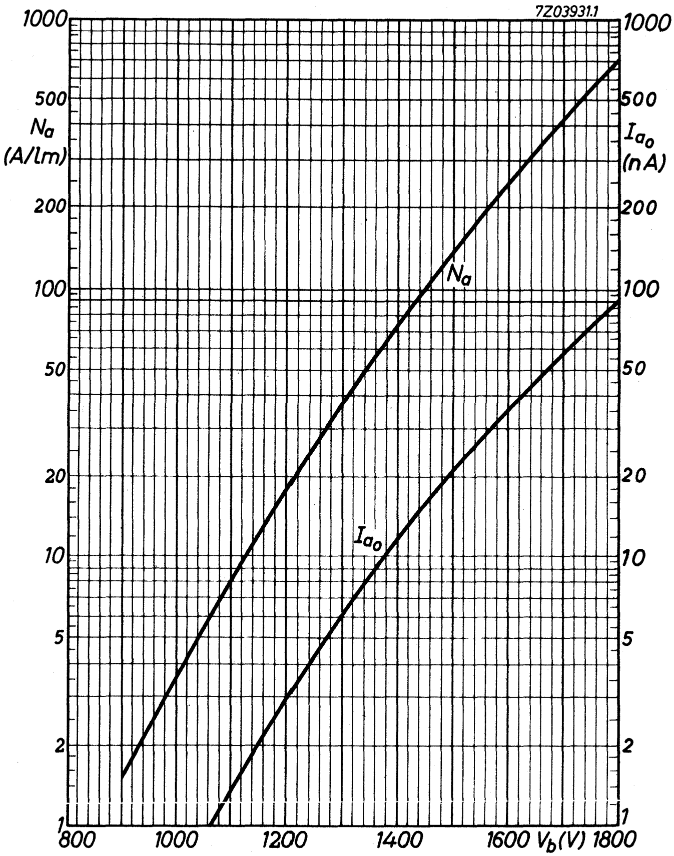
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to de-couple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

The semiflexible leads of the tube may be soldered into the circuit; care must be taken to conduct the heat away from the glass seals. Excessive bending of the leads is to be avoided. The tube is provided with a 12-pin base to facilitate testing. After testing, the attached base should be removed prior to installing the tube in a given system.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03931.1
1000
500
200
100
50
20
10
5
2
1
N_a
(A/lm)
I_{a_0}
(nA)
N_a
I_{a_0}
800
1000
1200
1400
1600
V_b(V)
1800

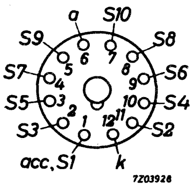
10 STAGE PHOTOMULTIPLIER TUBE

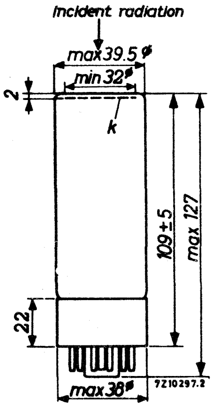
The tube is intended for use in laser technics working in the orange, yellow and green range and in photometric applications. Its rugged construction makes it particularly suitable for application under severe operating conditions.

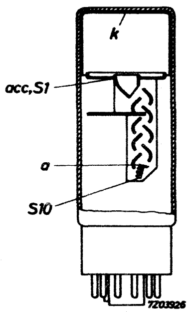
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	400	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

Data based on pre-production tubes

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Sb-K-Na-Cs		
Minimum useful diameter			32	mm
Spectral response curve [1]		type T (S20)		
Wavelength at maximum response			420 ± 30	nm
Luminous sensitivity [2]	Nk	av.	140	μA/lm
		min.	100	μA/lm
Radiant sensitivity at 698 nm		min.	7	mA/W

Multiplier system

Number of stages			10	
Dynode material		Ag-Mg-O-Cs		

Capacitances

Anode to final dynode	Ca/S10		3	pF
Anode to all other electrodes	Ca		5	pF

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	Na	av.	400	A/lm
		min.	100	A/lm
Anode dark current at Na = 60 A/lm [1]	Ia_o	av.	10	nA
		max.	50	nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Anode pulse rise time at V_b = 1500 V [2]			4	ns
Anode pulse width at half height at V_b = 1500 V [2]			8	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V			3	ns
Total transit time at V_b = 1500 V [2]			36	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage [3]	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	Vk/S_1	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [4]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

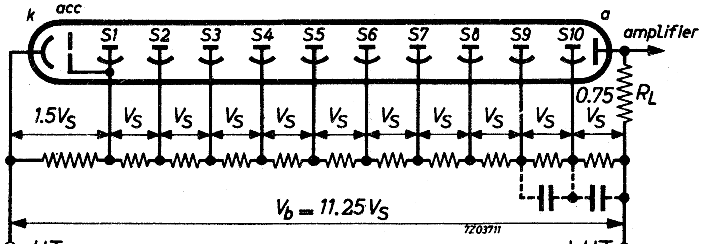
[1]) At an ambient temperature of 25 °C.

[2]) For an infinitely short light pulse, fully illuminating the photocathode.

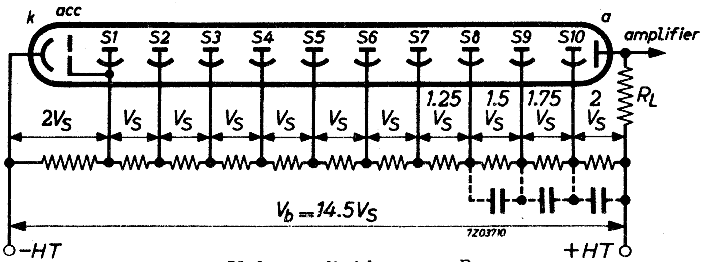
[3]) Or the voltage at which the tube circuited in the voltage divider A has an anode sensitivity of 600 A/lm whichever is lowest.

[4]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

k = cathode
acc = accelerating electrode

S_n = dynode No.n
a = anode

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current throuhg the voltagedivider bridge to that throuhg the heaviest loaded stage of the tube should be approx. 100.

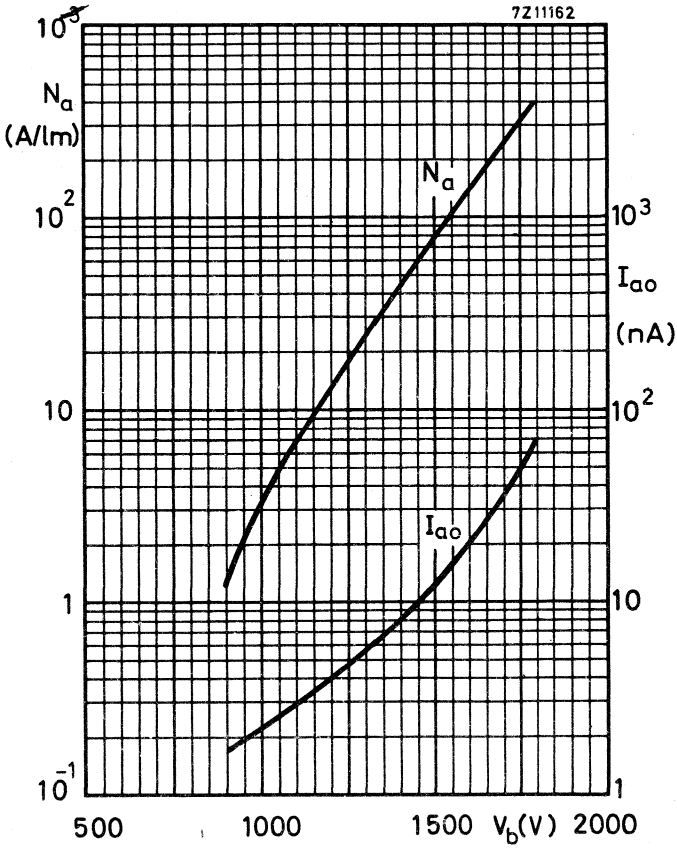
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type Bgives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z11162
10^3
N_a
(A/lm)
N_a
10^2
10
1
10^{-1}
10^3
I_{ao}
(nA)
10^2
10
1
I_{ao}
500
1000
1500
V_b(V)
2000

12 STAGE PHOTOMULTIPLIER TUBE

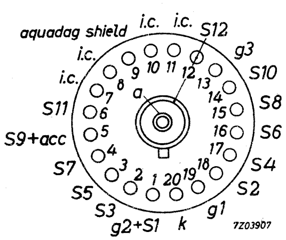
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, "time-of-flight" measurements, Cerenkov counters).

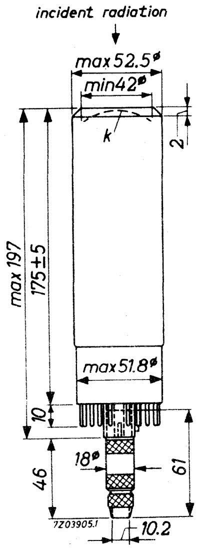
QUICK REFERENCE DATA			
Spectral response		type A (S11)	
Useful diameter of the photocathode		42	mm
Gain (at 2500 V)		10^8	
Anode pulse rise time	<	1.8	ns
Coaxial outlet		100	Ω
Linearity		up to 300	mA

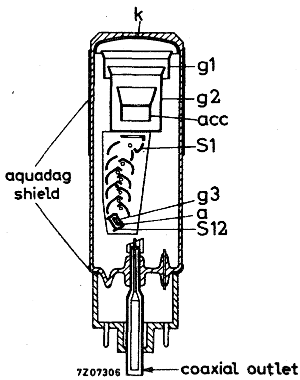
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 20-pin (Jedec B20-102) with coaxial outlet [1])







[1]) The tube is delivered with a coaxial cable connector LEMO 3.C 100.

ACCESSORIES

Socket [1]	type FE1003
Mu-metal shield [2]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface
Cathode material		Cs-Sb
Minimum useful diameter		42 mm
Spectral response curve [3]		type A (S11)
Wavelength at maximum response		4200 ± 300 Å
Luminous sensitivity [4]	N_k	av. 65 μA/lm min. 45 μA/lm
Radiant sensitivity at 4200 Å		55 mA/W

Multiplier system

Number of stages	12
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to cathode	C_{k/g_1}	25 pF
Grid No.1 to all other electrodes	C_{g_1}	30 pF
Grid No.1 to grid No.2	C_{g_1/g_2}	17 pF
Anode to final dynode	$C_{a/S_{12}}$	8 pF
Anode to all other electrodes	C_a	9 pF

---

[1] The tube is delivered with a coaxial cable connector LEMO 3.C.100

[2] To avoid field distortion in the electron optical input system it is advised to connect the aquadag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen

[3] See spectral response curve in front of this section

[4] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. max.	2500 3000	V V
Anode dark current at $G = 10^8$ [1]	I_{a_o}	max.	5	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	300	mA
Anode pulse rise time at $V_b = 2500$ V [2]	<	1.8	ns
Anode pulse width at half height at $V_b = 2500$ V [2]		3.2	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V		0.2	ns
Total transit time at 2500 V [2]		28	ns
Maximum peak current		0.5 to 1	A

With voltage divider B'

Anode pulse rise time at $V_b = 2500$ V [2]	<	1.8	ns
Anode pulse width at half height at $V_b = 2500$ V [2]		2.7	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V		0.2	ns
Total transit time at $V_b = 2500$ V [2]		28	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage [3]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	600 300	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode [4]	$V_{a/S_{12}}$	max. min.	500 80	V V

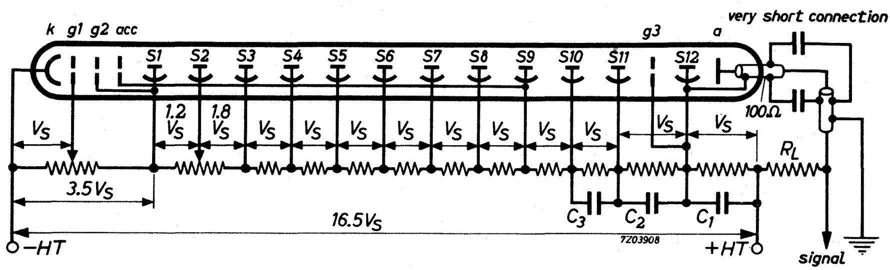
1) At an ambient temperature of 25 °C.

2) For an infinitely short light pulse, fully illuminating the photocathode.

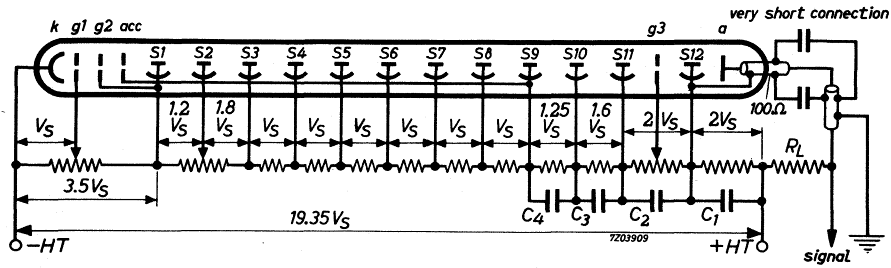
3) Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.

4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

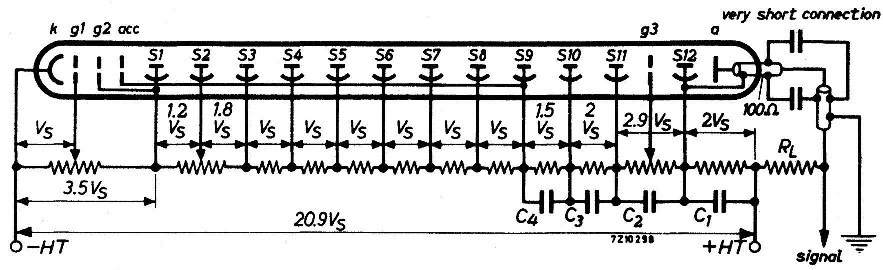
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode No.1
g_2 = focusing electrode No.2
acc = accelerating electrode
g_3 = shadow grid
S_n = dynode No.n
a = anode

Voltage between k and g_1 to be adjusted at about 1 Vs
Voltage between S_1 and S_2 to be adjusted at about 1.2 Vs
Voltage between g_3 and S_{12} to be adjusted for optimum time characteristics.

1) To avoid field distortion in the electron optical input system it is advised to connect the aqaudag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of five elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc;
the deflector.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the ninth dynode) voltage of 1750 V ensures a field strength of about 200 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum of the potential is about 1 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Because the first dynode cannot be placed parallel to the photocathode, the beam of primary electrons is deflected by the deflector to make it impinge at right angles to the first dynode surface. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

OPERATIONAL CONSIDERATIONS (continued)

B. The multiplier system consists of 12 stages, providing a total current amplification of 10^8 at about 2500 V (see figures 3 and 4).
The tube is capable of producing very strong peak currents (up to 1 A). Actually the time constant at the output of the multiplier must be very small. Therefore it is necessary to use a low load resistance, well matched to the associated electronic circuitry. For this reason the tube is provided with an coaxial outlet, having a characteristic impedance of 100 Ω. With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous, without attenuation or distortion.

To avoid the effects, which are responsible for rounding of the leading edge and the "jagged" trailing edges, a shadow grid (g_3) is placed parallel to the anode with its wires aligned with those of the anode.
Thus electrons going from the next-to-last dynode (S11) to the last dynode (S12) are prevented to impinge directly upon the anode.
At the same time induction and oscillations in the anode grid are minimized. The potential of this electrode is to be adjusted at an optimum close to that of the last dynode. Figure 1 shows anode pulses produced by a 50 Ω version of the tube.

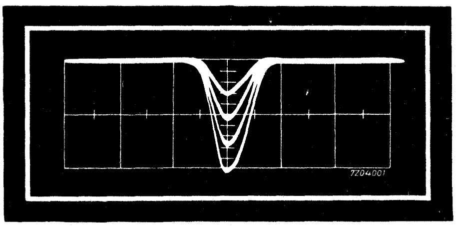


Fig. 1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

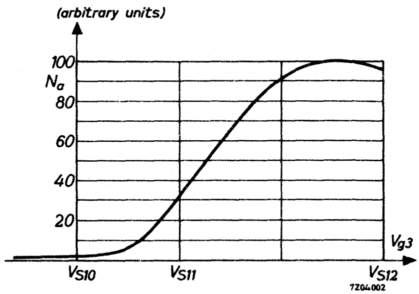
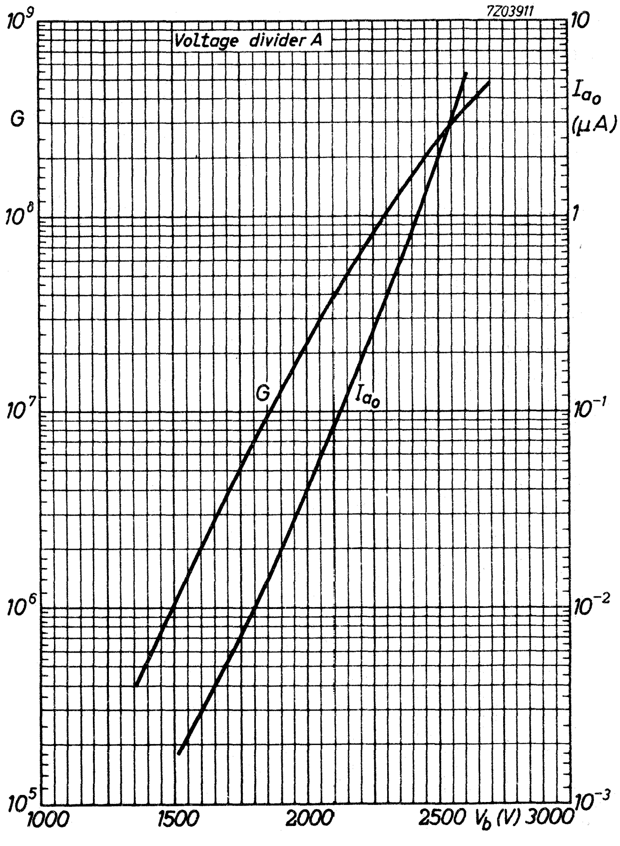


Fig. 2 Anode sensitivity as a function of shadow grid potential

A further characteristic of g_3 is that it can be used as a control electrode determining the amplitude of anode pulses without the necessity of adjusting the incident light or the gain of the tube, and hence the H.V. supply. Figure 2 illustrates the control characteristics of g_3.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. (See figures 3 and 4.)

It is advisable to screen the tube with a mu-metal cylinder against magnetic field influences.



7Z03911
Voltage divider A
10^9
10^8
10^7
10^6
10^5
G
10
1
10^{-1}
10^{-2}
10^{-3}
I_{a_0}
(μA)
G
I_{a_0}
1000
1500
2000
2500
V_b (V)
3000

Fig. 3

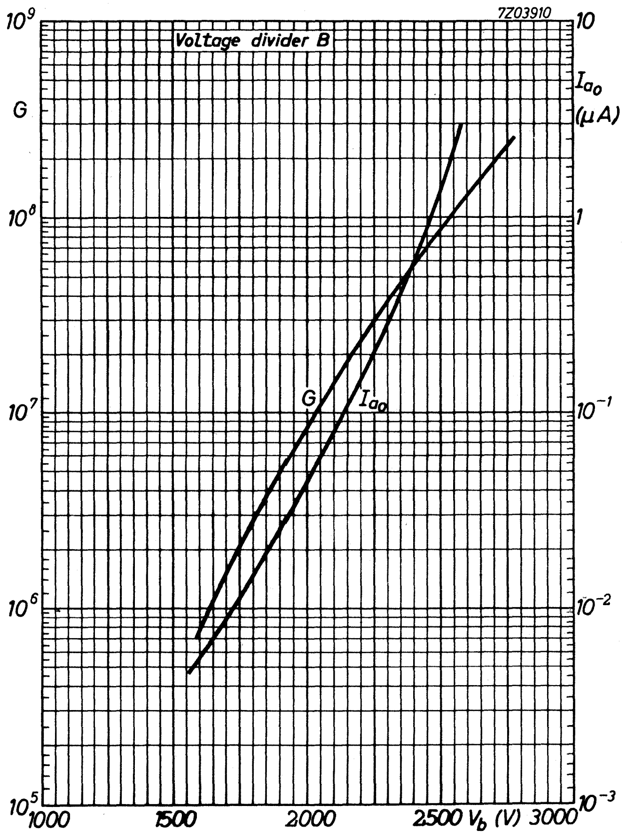

7Z03910
Voltage divider B
G
I_{a_0} (μA)
10^9
10^8
10^7
10^6
10^5
10
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
1000
1500
2000
2500 V_b (V) 3000

Fig.4

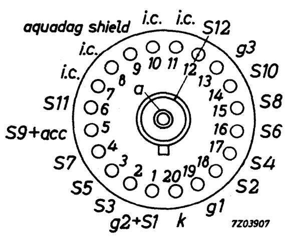
12 STAGE PHOTOMULTIPLIER TUBE

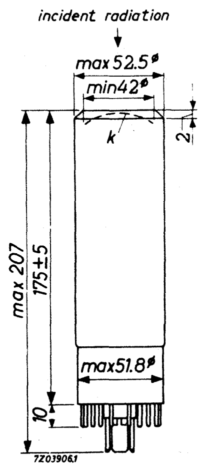
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, "time-of-flight" measurements, Cerenkov counters).

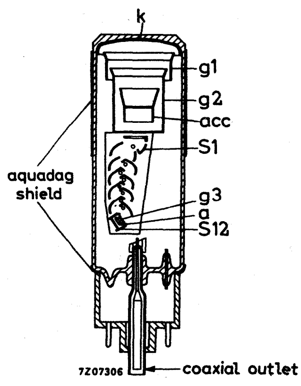
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	< 1.8	ns
Coaxial outlet	50	Ω
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)
with coaxial outlet







ACCESSORIES

Socket		type	FE1003
Coaxial cable connector	"General Radio"	type	874/C8A
Mu-metal shield [1]		type	56130
		type	56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		Cs-Sb	
Minimum useful diameter		42	mm
Spectral response curve [2]		type A (S11)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [3]	N_k	av. 65	µA/lm
		min. 45	µA/lm
Radiant sensitivity at 4200 Å		55	mA/W

Multiplier system

Number of stages	12	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Grid No.1 to cathode	C_{k/g_1}	25	pF
Grid No.2 to all other electrodes	C_{g_1}	30	pF
Grid No.1 to grid No.2	C_{g_1/g_2}	17	pF
Anode to final dynode	$C_{a/S_{12}}$	8	pF
Anode to all other electrodes	C_a	9	pF

---

1) To avoid field distortion in the electron optical input system it is advised to connect the aquadag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen.

2) See spectral response curve in front of this section

3) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. max.	2500 3000	V V
Anode dark current at $G = 10^8$ 1)	I_{a_o}	max.	5	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at $V_b = 2500$ V 2)		<	1.8	ns
Anode pulse width at half height at $V_b = 2500$ V 2)			3.2	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V			0.2	ns
Total transit time at $V_b = 2500$ V 2)			28	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

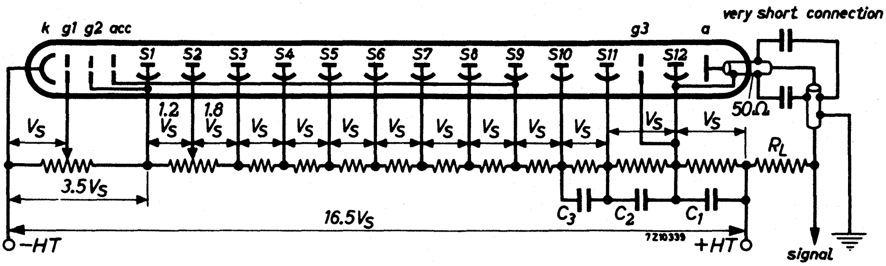
Anode pulse rise time at $V_b = 2500$ V 2)		<	1.8	ns
Anode pulse width at half height at $V_b = 2500$ V 2)			2.7	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V			0.2	ns
Total transit time at $V_b = 2500$ V 2)			28	ns

LIMITING VALUES (Absolute max. rating system)

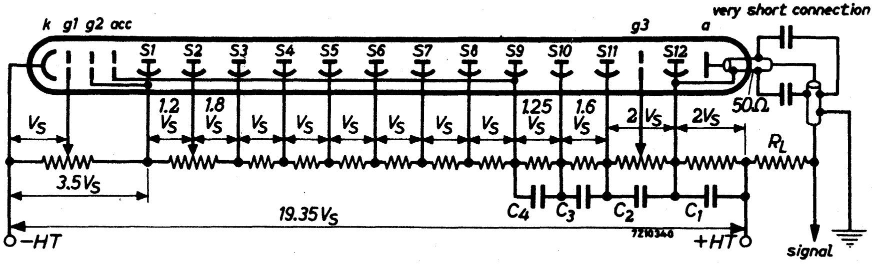
Supply voltage 3)	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	600 300	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode 4)	$V_{a/S_{12}}$	max. min.	500 80	V V

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

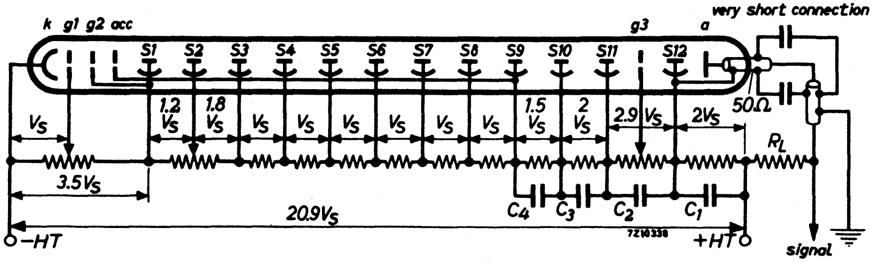
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode No.1
g_2 = focusing electrode No.2
acc = accelerating electrode
g_3 = shadow grid
S_n = dynode No.n
a = anode

Voltage between k and g_1 to be adjusted at about 1 V_s
Voltage between S_1 and S_2 to be adjusted at about 1.2 V_s
Voltage between g_3 and S_{12} to be adjusted for optimum time characteristics.

[1]) To avoid field distortion in the electron optical input system it is advised to connect the aquadag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of five elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc;
the deflector.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the ninth dynode) voltage of 1750 V ensures a field strength of about 200 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about 1 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Because the first dynode cannot be placed parallel to the photocathode, the beam of primary electrons is deflected by the deflector to make it impinge at right angles to the first dynode surface. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

OPERATIONAL CONSIDERATIONS (continued)

B. The multiplier system consists of 12 stages, providing a total current amplification of 10^8 at about 2500 V (see figures 3 and 4).
The tube is capable of producing very strong peak currents (up to 1 A). Actually the time constant at the output of the multiplier must be very small. Therefore it is necessary to use a low load resistance, well matched to the associated electronic circuitry. For this reason the tube is provided with an coaxial outlet, having a characteristic impedance of 50 Ω. With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous, without attenuation or distortion.

To avoid the effects, which are responsible for rounding of the leading edge and the "jagged" trailing edges, a shadow grid (g_3) is placed parallel to the anode with its wires aligned with those of the anode.
Thus electrons going from the next-to-last dynode (S11) to the last dynode (S12) are prevented to impinge directly upon the anode.
At the same time induction and oscillations in the anode grid are minimized. The potential of this electrode is to be adjusted at an optimum close to that of the last dynode. Figure 1 shows anode pulses of the tube.

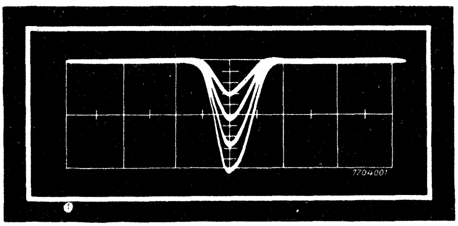


Fig.1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

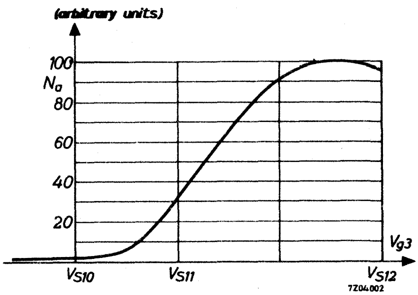


Fig.2 Anode sensitivity as a function of shadow grid potential

A further characteristic of g_3 is that it can be used as a control electrode determining the amplitude of anode pulses without the necessity of adjusting the incident light or the gain of the tube, and hence the H.V. supply. Figure 2 illustrates the control characteristics of g_3.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. (See figures 3 and 4.)

It is advisable to screen the tube with a mu-metal cylinder against magnetic field influences.

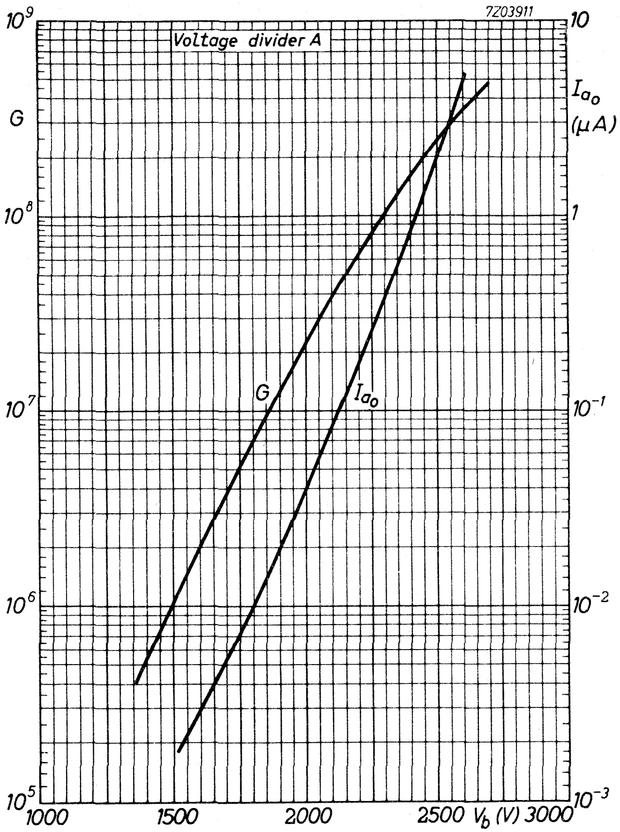

7Z03911
Voltage divider A
G
10^9
10^8
10^7
10^6
10^5
10
1
10^{-1}
10^{-2}
10^{-3}
I_{a_o} (μA)
1000
1500
2000
2500
V_b (V)
3000

Fig. 3

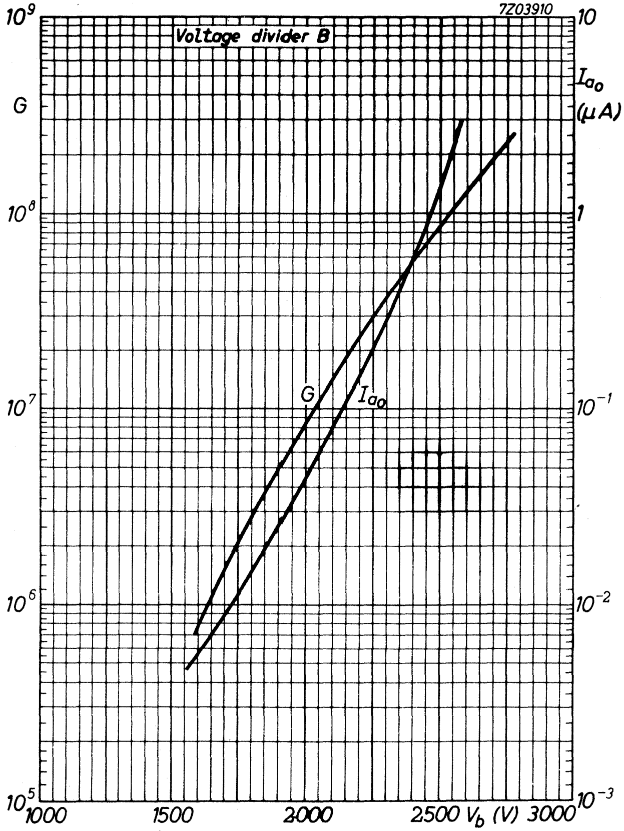

7Z03910
Voltage divider B
10^9
G
10^8
10^7
10^6
10^5
10
I_{ao}
(μA)
1
10^{-1}
10^{-2}
10^{-3}
G
I_{ao}
1000
1500
2000
2500 V_b (V) 3000

Fig. 4

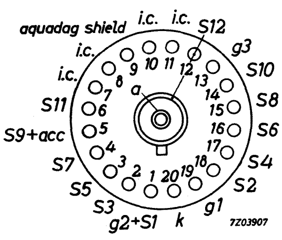
12 STAGE PHOTOMULTIPLIER TUBE

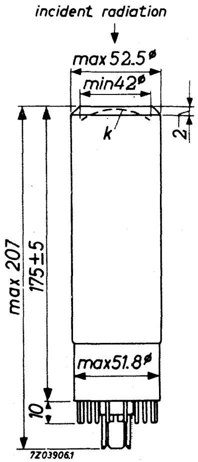
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the ultraviolet region.

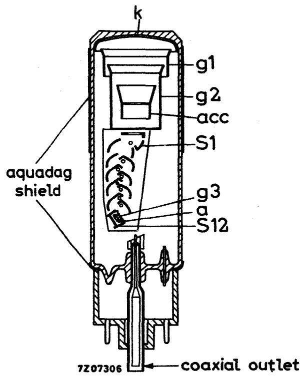
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	< 1.8	ns
Coaxial outlet	50	Ω
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)
with coaxial outlet







ACCESSORIES

Socket		type FE1003
Coaxial cable connector	"General Radio"	type 874/C8A
Mu-metal shields [1]		type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		Cs-Sb	
Minimum useful diameter		42	mm
Spectral response curve [2]		type U (S13)	
Wavelength at maximum response		4000 ± 300	Å
Luminous sensitivity [3]	N_k	av. 65 min. 45	µA/lm µA/lm
Radiant sensitivity at 4000 Å		55	mA/W

Multiplier system

Number of stages	12	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Grid No.1 to cathode	C_{k/g_1}	25	pF
Grid No.1 to all other electrodes	C_{g_1}	30	pF
Grid No.1 to grid No.2	C_{g_1/g_2}	17	pF
Anode to final dynode	$C_{a/S_{12}}$	8	pF
Anode to all other electrodes	C_a	9	pF

[1]) To avoid field distortion in the electron optical input system it is advised to connect the aquadag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen.

[2]) See spectral response curve in front of this section

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. max.	2500 3000	V V
Anode dark current at $G = 10^8$ [1]	I_{a_0}	max.	5	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V [2]		<	1.8	ns
Anode pulse width at half height at V_b = 2500 V [2]			3.2	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V			0.2	ns
Total transit time at V_b = 2500 V [2]			28	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

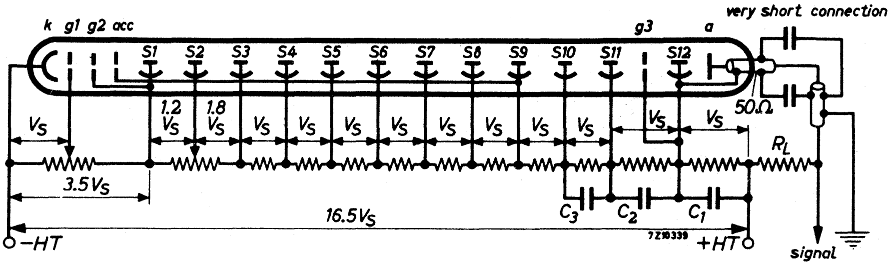
Anode pulse rise time at V_b = 2500 V [2]		<	1.8	ns
Anode pulse width at half height at V_b = 2500 V [2]			2.7	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V			0.2	ns
Total transit time at V_b = 2500 V [2]			28	ns

LIMITING VALUES (Absolute max. rating system)

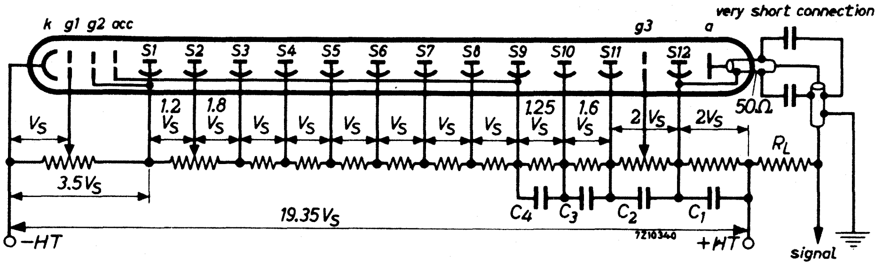
Supply voltage [3]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	600 300	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode [4]	$V_{a/S_{12}}$	max. min.	500 80	V V

1) At an ambient temperature of 25 °C
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

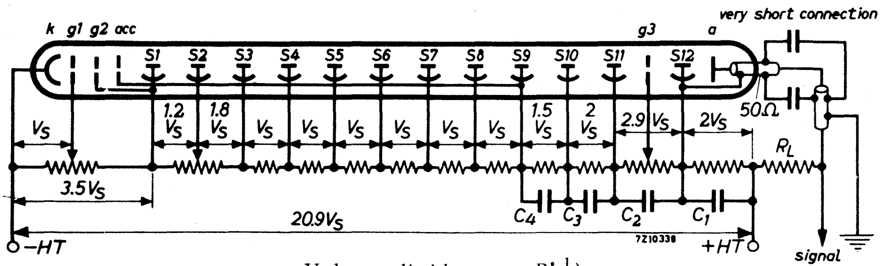
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode No.1
g_2 = focusing electrode No.2
acc = accelerating electrode
g_3 = shadow grid
S_n = dynode No.n
a = anode

Voltage between k and g_1 to be adjusted at about 1 V_S
Voltage between S_1 and S_2 to be adjusted at about 1.2 V_S
Voltage between g_3 and S_{12} to be adjusted for optimum time characteristics.

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1) To avoid field distortion in the electron optical input system it is advised to connect the aquadag shield (pin No.9) to the cathode. If the cathode is circuited to a negative high tension care should be taken to ensure a high tension insulation between the aquadag-shield and the mu-metal screen.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of five elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc;
the deflector.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the ninth dynode) voltage of 1750 V ensures a field strength of about 200 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum of the potential is about 1 V_s;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Because the first dynode cannot be placed parallel to the photocathode, the beam of primary electrons is deflected by the deflector to make it impinge at right angles to the first dynode surface. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

OPERATIONAL CONSIDERATIONS (continued

B. The multiplier system consists of 12 stages, providing a total current amplification of 10^8 at about 2500 V (see figures 3 and 4).
The tube is capable of producing very strong peak currents (up to 1 A). Actually the time constant at the output of the multiplier must be very small. Therefore it is necessary to use a low load resistance, well matched to the associated electronic circuitry. For this reason the tube is provided with an coaxial outlet, having a characteristic impedance of 50 Ω. With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous, without attenuation or distortion.

To avoid the effects, which are responsible for rounding of the leading edge and the "jagged" trailing edges, a shadow grid (g_3) is placed parallel to the anode with its wires aligned with those of the anode.
Thus electrons going from the next-to-last dynode (S11) to the last dynode (S12) are prevented to impinge directly upon the anode.
At the same time induction and oscillations in the anode grid are minimized. The potential of this electrode is to be adjusted at an optimum close to that of the last dynode. Figure 1 shows anode pulses of the tube.

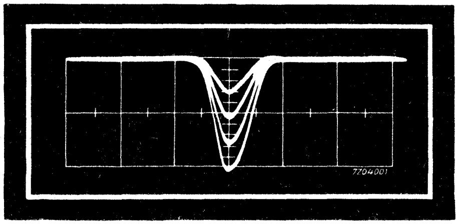


Fig. 1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

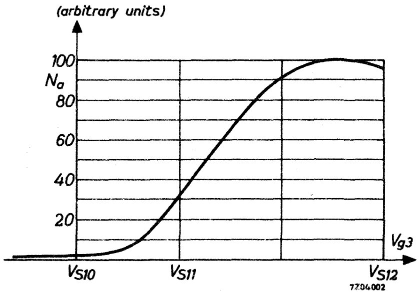


Fig. 2 Anode sensitivity as a function of shadow grid potential

A further characteristic of g_3 is that it can be used as a control electrode determining the amplitude of anode pulses without the necessity of adjusting the incident light or the gain of the tube, and hence the H.V. supply. Figure 2 illustrates the control characteristics of g_3.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. (See figures 3 and 4.)

It is advisable to screen the tube with a mu-metal cylinder against magnetic field influences.

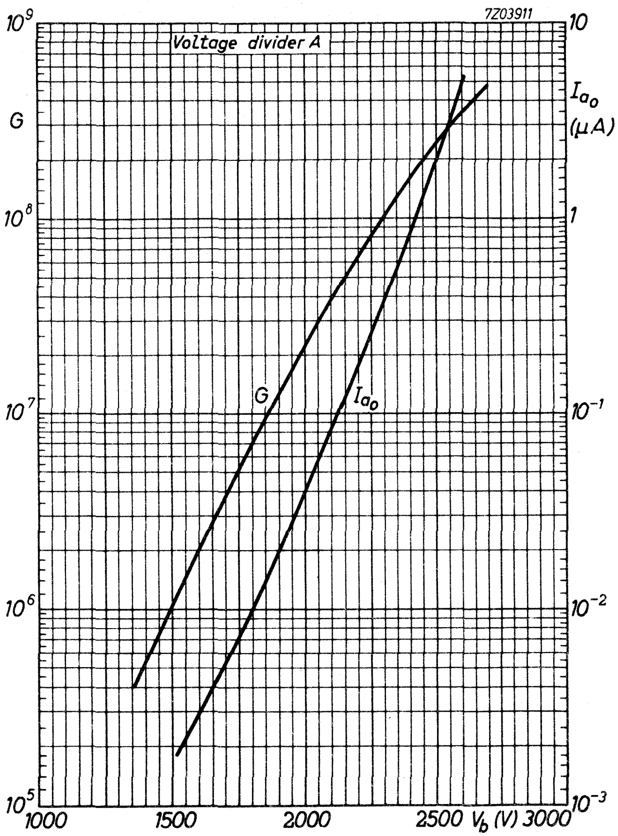
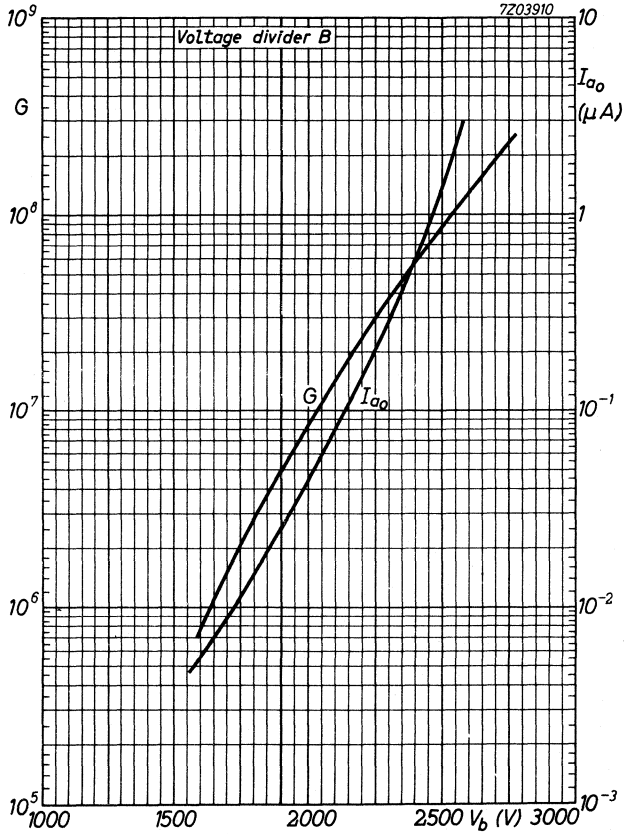

7Z03911
Voltage divider A
G
10^9
10^8
10^7
10^6
10^5
10
1
10^{-1}
10^{-2}
10^{-3}
I_{a_0} (µA)
I_{a_0}
1000
1500
2000
2500
V_b (V)
3000

Fig.3



7Z03910
Voltage divider B
G
I_{a_0} (μA)
10^9
10^8
10^7
10^6
10^5
10
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
1000
1500
2000
2500
V_b (V)
3000

Fig. 4

Recommended replacement type XP2030

10 STAGE PHOTOMULTIPLIER TUBE

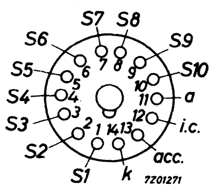
The tube is intended for use in applications such as scintillation counting in nuclear research together with large size crystals, plastic or liquid scintillators and in optical equipment in which a photomultiplier with a photosensitive area larger than usual is required.

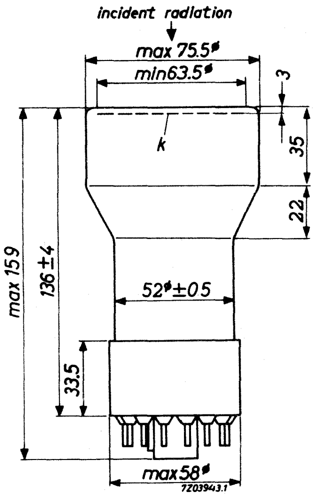
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm

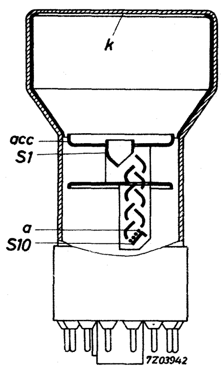
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56135

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface
Cathode material		Cs-Sb
Minimum useful diameter		63.5 mm
Spectral response curve [1]		type A (S11)
Wavelength at maximum response		4200 ± 300 Å
Luminous sensitivity [2]	N_k	av. 70 µA/lm min. 40 µA/lm
Radiant sensitivity at 4200 Å		60 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3 pF
Anode to all other electrodes	C_a	5 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 A/lm min. 100 A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_o}	max. 0.2 µA
Linearity between anode pulse amplitude and input light pulse		up to 50 mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1400 V [1]		7	ns
Anode pulse width at half height at V_b = 1400 V [1]		15	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V		7	ns
Total transit time at V_b = 1400 V [1]		60	ns

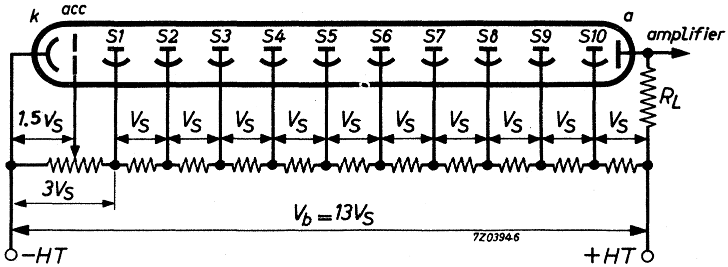
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	100	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

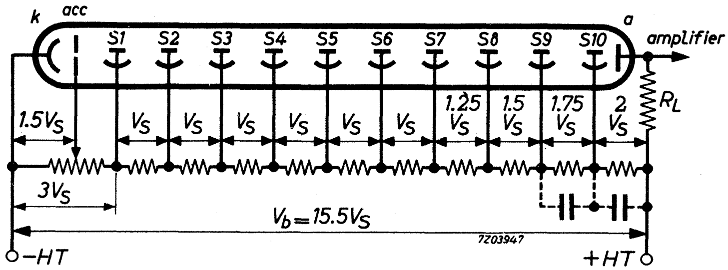
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

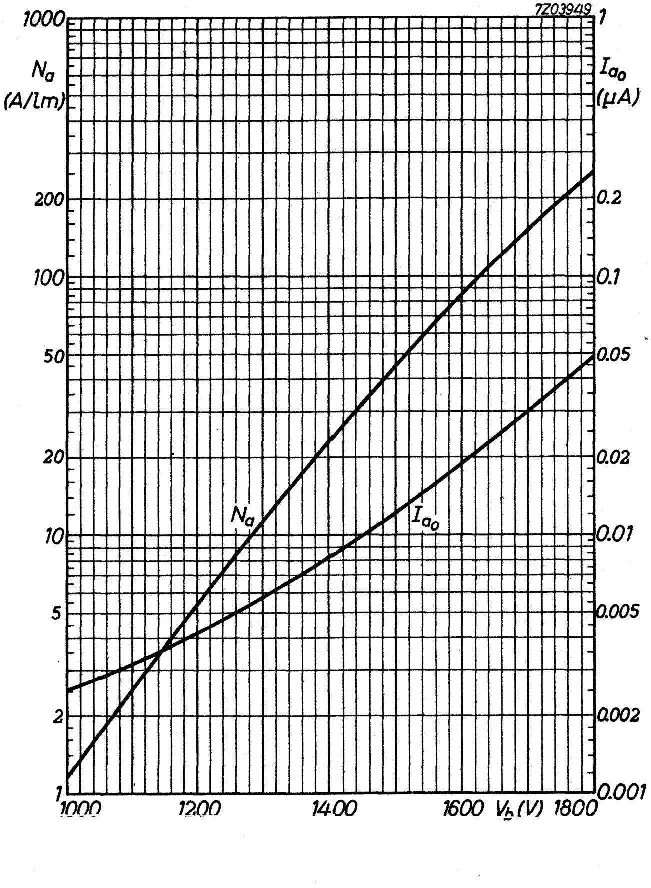
A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a seperate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

With high amplitude pulses, it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03949
1000
N_a
(A/lm)
200
100
50
20
10
5
2
1
1
I_{a_0}
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
N_a
I_{a_0}
1000
1200
1400
1600
V_b (V)
1800

Recommended replacement type XP2030

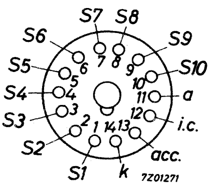
10 STAGE PHOTOMULTIPLIER TUBE

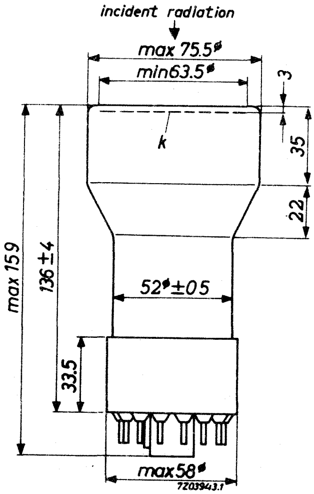
The tube is intended for use in applications such as gamma-ray spectrometry and gamma scintillation cameras.

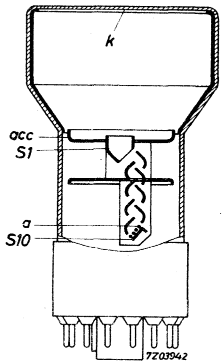
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm
Energy resolution for ^{137}Cs(0.661 MeV)	8.5	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56135

GENERAL

Photocathode

Description		semi-transparent, head-on, flut surface		
Cathode material		Cs-Sb		
Minimum useful diameter			63.5	mm
Spectral response curve 1)		type A (S11)		
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity 2)	N_k	av.	80	µA/lm
		min.	70	µA/lm
Radiant sensitivity at 4200 Å			65	mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	250	A/lm
		min.	100	A/lm
Anode dark current at N_a = 100 A/lm 3)	I_{a_o}	max.	0.2	µA
Energy resolution for ^{137}Cs (0.661 MeV) 5)		av.	8.5	%
		max.	9.0	%
Linearity between anode pulse amplitude and input light pulse		up to	50	mA

With voltage divider B

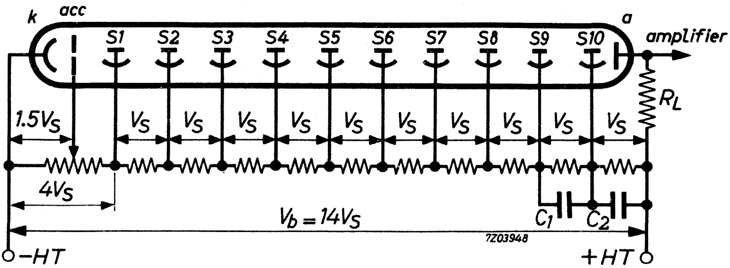
Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1400 V 4)		7	ns
Anode pulse width at halfheight at V_b = 1400 V 4)		15	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V		7	ns
Total transit time at V_b = 1400 V 4)		60	ns

1)2)3)4)5) See page 3.

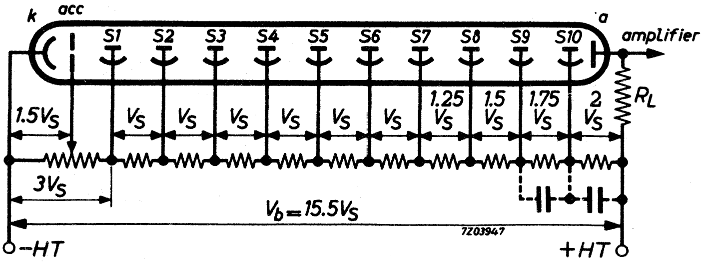
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	$V_{k/S1}$	max. min.	500 100	V V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [6]	$V_{a/S10}$	max. min.	300 80	V V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

k = cathode	S_n	= dynode No.n	C_1	= 470	pF
acc = accelerating electrode	a	= anode	C_2	= 1000	pF

1) See spectral response curve in front of this section.
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K.
3) At an ambient temperature of 25 °C.
4) For an infinitely short light pulse, fully illuminating the photocathode.
5) Measured with a 2" x 2" NaI (Tl) crystal.
6) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

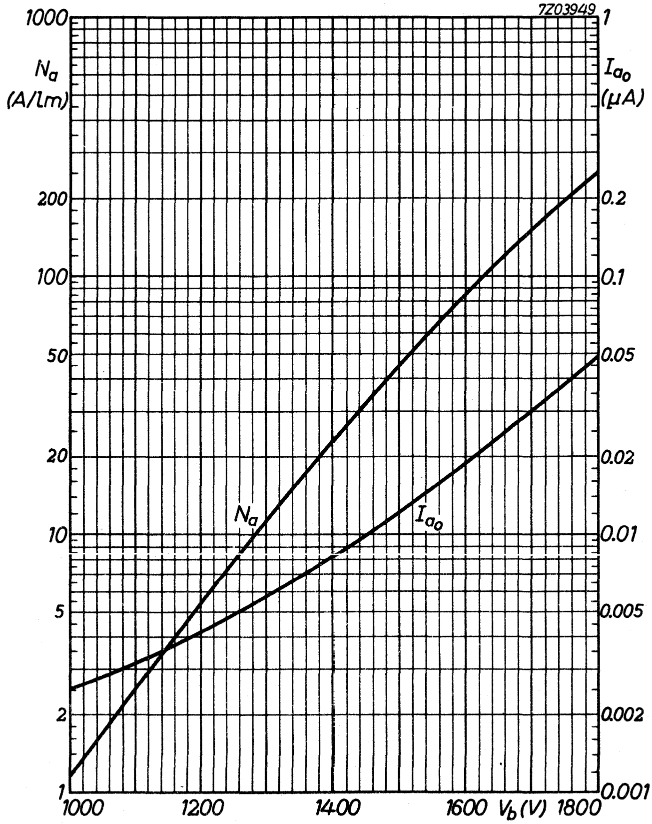
To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be a practical value.

Each tube is accompanied by a sheet with characteristics, on which is indicated the voltage to be applied between the cathode and the first dynode. The best results in gamma-ray spectrometry will be achieved with this voltage, when the recommended voltage-divider bridge is used.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.



10 STAGE PHOTOMULTIPLIER TUBE

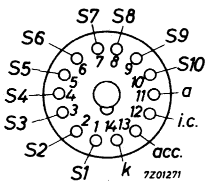
The tube is intended for use in applications which require a good sensitivity in the ultraviolet region, combined with a photosensitive area larger than usual.

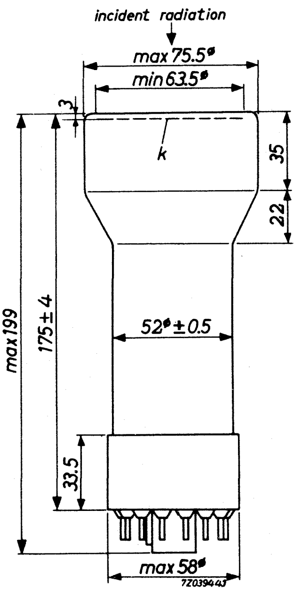
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm

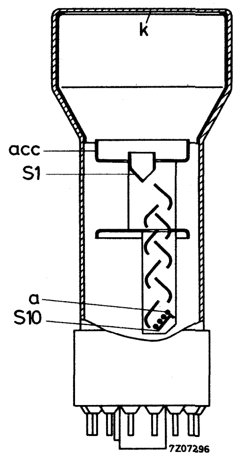
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56135

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface
Cathode material		Cs-Sb
Minimum useful diameter		63.5 mm
Spectral response curve [1]		type U (S13)
Wavelength at maximum response		4000 ± 300 Å
Luminous sensitivity [2]	N_k	av. 70 μA/lm min. 40 μA/lm
Radiant sensitivity at 4000 Å		60 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

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

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 A/lm min. 100 A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_o}	max. 0.2 μA
Linearity between anode pulse amplitude and input light pulse		up to 50 mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

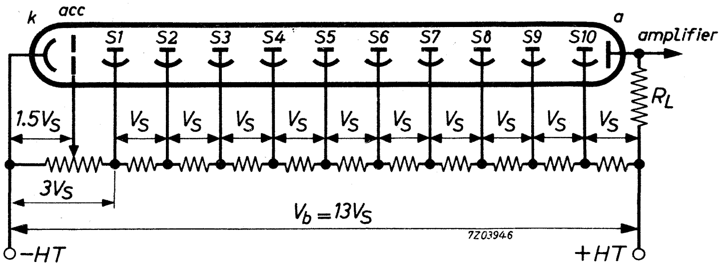
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1400 V [1]		7	ns
Anode pulse width at half height at V_b = 1400 V [1]		15	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V		7	ns
Total transit time at V_b = 1400 V [1]		60	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	100	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

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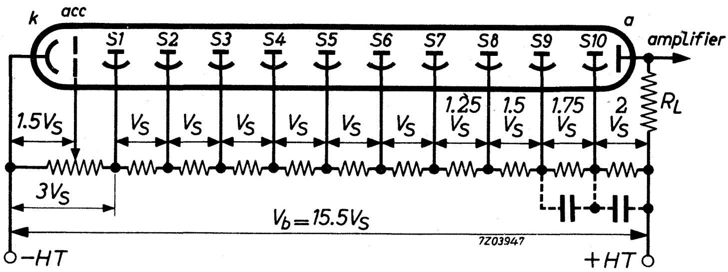
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

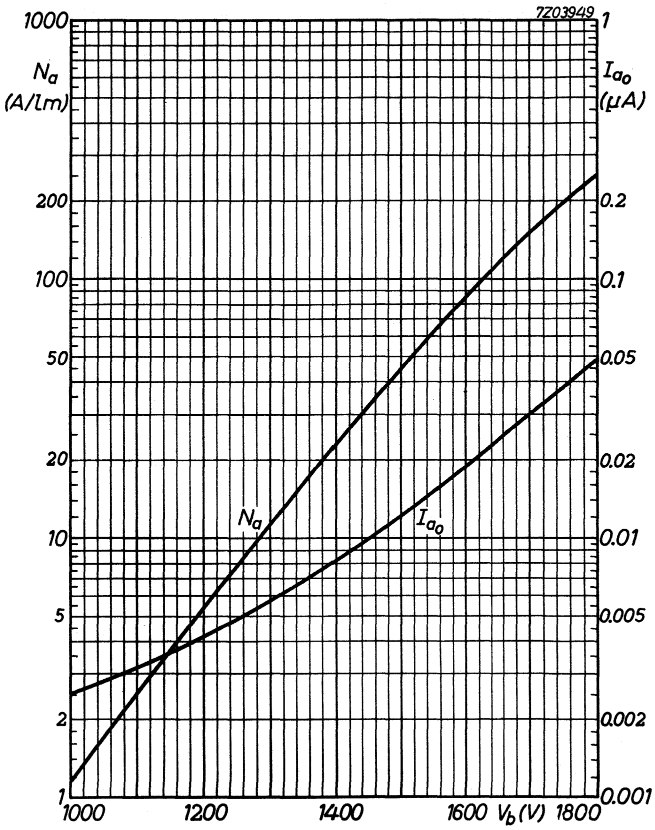
A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

With high amplitude pulses, it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03949
1000
N_a
(A/lm)
200
100
50
20
10
5
2
1
1
I_{ao}
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
N_a
I_{ao}
1000
1200
1400
1600
V_b(V)
1800

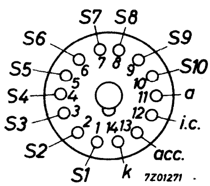
10 STAGE PHOTOMULTIPLIER TUBE

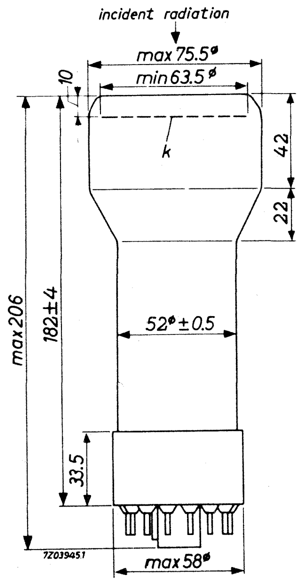
The tube is intended for geophysical measurements in which the thick quartz window serves as a medium for Cerenkov radiation caused by cosmic-rays.

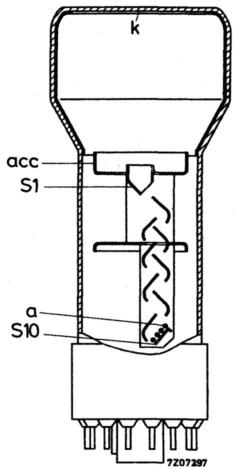
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	63.5	mm
Window thickness (quartz)	10	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56135

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface
Cathode material		Cs-Sb
Minimum useful diameter		63.5 mm
Spectral response curve [1]		type U (S13)
Wavelength at maximum response		4000 ± 300 Å
Luminous sensitivity [2]	N_k	av. 60 μA/lm min. 35 μA/lm
Radiant sensitivity at 4000 Å		50 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	3 pF
Anode to all other electrodes	C_a	5 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 A/lm min. 100 A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_0}	max. 0.2 μA
Linearity between anode pulse amplitude and input light pulse		up to 50 mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

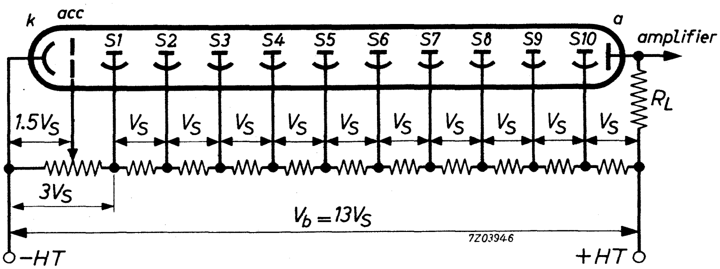
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1400 V [1]		7	ns
Anode pulse width at half height at V_b = 1400 V [1]		15	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V		7	ns
Total transit time at V_b = 1400 V [1]		60	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	100	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



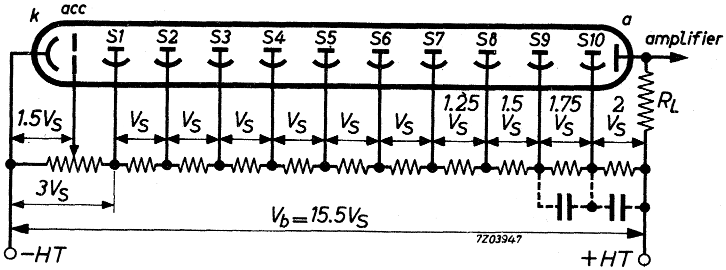
Voltage divider type A

---

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When caculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

With high amplitude pulses, it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

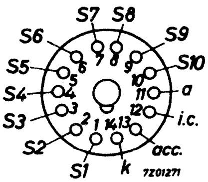
10 STAGE PHOTOMULTIPLIER TUBE

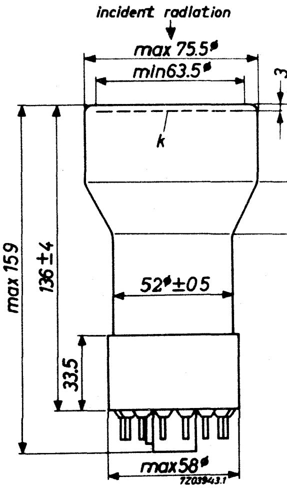
The tube is intended for use in applications such as scintillation counting and measurement of low luminous fluxes.

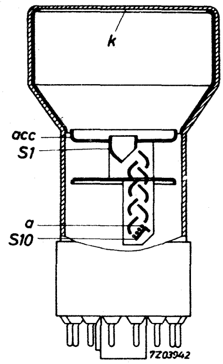
QUICK REFERENCE DATA			
Spectral response	bialkali	type	D
Useful diameter of the photocathode		63.5	mm
Anode sensitivity (at 1800 V)		250	A/lm
Energy resolution for ^{137}Cs (0.661 MeV)	max.	9	%

DIMENSIONS AND CONNECTIONS — Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56135

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		K-Cs-Sb		
Minimum useful diameter			63.5	mm
Spectral response curve (See page 6)		type	D	
Wavelength at maximum response		400 ±	30	nm
Luminous sensitivity [1]	N_k	av.	50	µA/lm
		min.	30	µA/lm
Radiant sensitivity at 437 nm		av.	75	mA/W
		min.	50	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{10}		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	250	A/lm
		min.	100	A/lm
Anode dark current at N_a = 60 A/lm [2]	I_{a_o}	av.	20	nA
		max.	50	nA
Energy resolution for ^{137}Cs (0.661 MeV) [3]		max.	9	%
Linearity between anode pulse amplitude and input light pulse		up to	50	mA

---

[1]) Measured with a tungsten ribbon lamp with a colour temperature of 2854 °K. Because of the resistivity of D-type photocathodes the value of the cathode sensitivity is only an approximation. (See also the "Operational Considerations")

[2]) At an ambient temperature of 25 °C.

[3]) Measured with a 2 in x 2 in NaI(Tl)crystal.

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Anode pulse rise time at V_b = 1400 V [1]			7	ns
Anode pulse width at half height at V_b = 1400 V [1]			15	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V			7	ns
Total transit time at V_b = 1400 V [1]			60	ns

LIMITING VALUES (Absolute max. rating system)

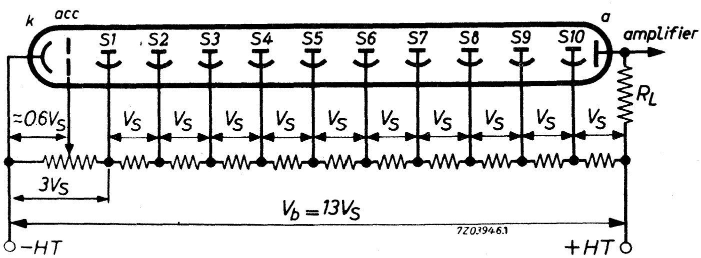
Supply voltage [2]	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	100	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

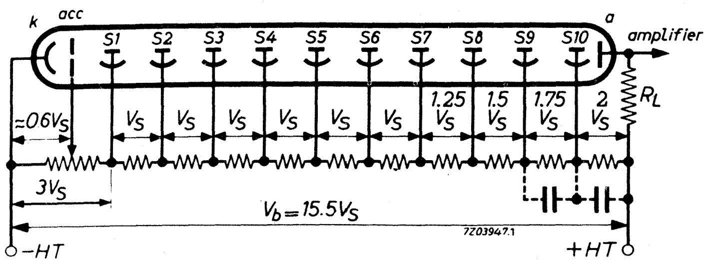
[2]) Or the voltage at which the tube circuited in the voltage divider A has an anode sensitivity of 500 A/lm whichever is lowest.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation.

It is advisable to limit the cathode peakcurrent to a value of 10 nA at room temperature and 0.1 nA at - 100 °C.

The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

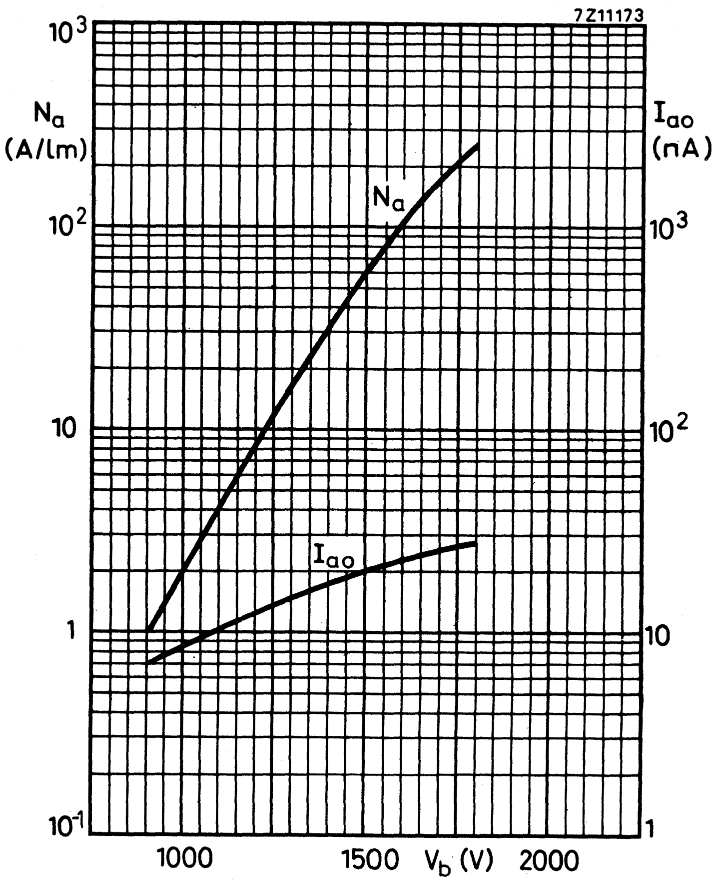
A circuit of type A results in the highest gain of the tube at a given total voltage.
A circuit of type B gives a higher current output with better time characteristics,but the total gain is less at the same total voltage.

The accelerating electrode has a seperate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

With high amplitude pulses, it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z11173
10^3
N_a
(A/lm)
10^2
10
1
10^{-1}
I_{ao}
(nA)
10^3
10^2
10
1
N_a
I_{ao}
1000
1500
V_b (V)
2000

Recommended replacement type 58AVP

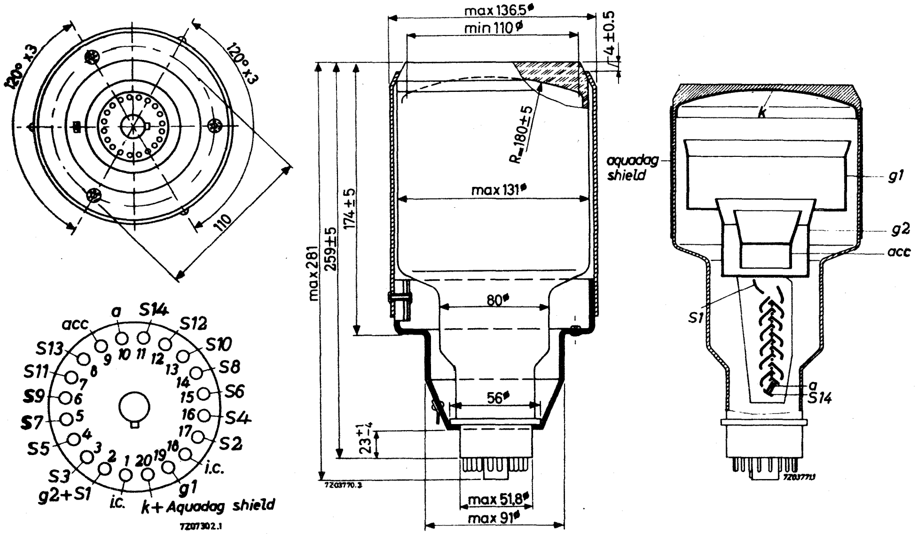
14 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in nuclear-physics applications where a high degree of time definition is required (fast coincidences, Cerenkov counters).

QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	110	mm
Gain (at 2400 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)



ACCESSORIES

Socket		type FE1003
Mu-metal shield	(for tube with metal container)	type 56133
	(for tube without metal container)	type 56129

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface [1]
Cathode material		Cs-Sb
Minimum useful diameter		110 mm
Radius of curvature		180 ± 5 mm
Spectral response curve [2]		type A (S11)
Wavelength at maximum response		4200 ± 300 Å
Luminous sensitivity [3]	N_k	av. 70 μA/lm min. 45 μA/lm
Radiant sensitivity at 4200 Å		60 mA/W

Multiplier system

Number of stages		14
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	C_a/S_{14}	5 pF
Anode to all other electrodes	C_a	7 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. 2400 V max. 3000 V
Anode dark current at $G = 10^8$ [4]	I_{a_o}	av. 2 μA max. 12 μA
Linearity between anode pulse amplitude and input light pulse		up to 100 mA

---

[1]) The tube has a plane-concave window and is delivered with a metal envelope.

[2]) See spectral response curve in front of this section

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[4]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	300	mA
Anode pulse rise time at V_b = 2800 V [1]		2	ns
Anode pulse width at half height at V_b = 2800 V [1]		3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V		1	ns
Total transit time at V_b = 2800 V [1]		46	ns
Maximum peak currents		0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2800 V [1]	2	ns
Anode pulse width at half height at V_b = 2800 V [1]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Transit time spread	1	ns
Total transit time at V_b = 2800 V [1]	43	ns

LIMITING VALUES (Absolute max. rating system)

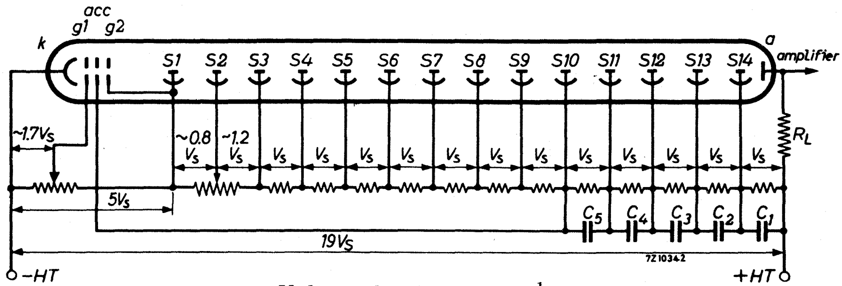
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	1400 to	1800	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

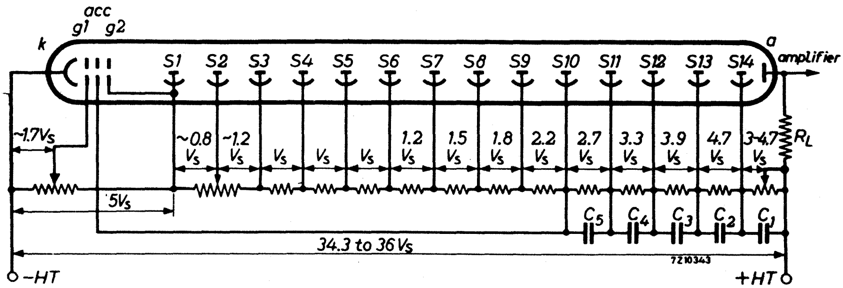
[2]) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

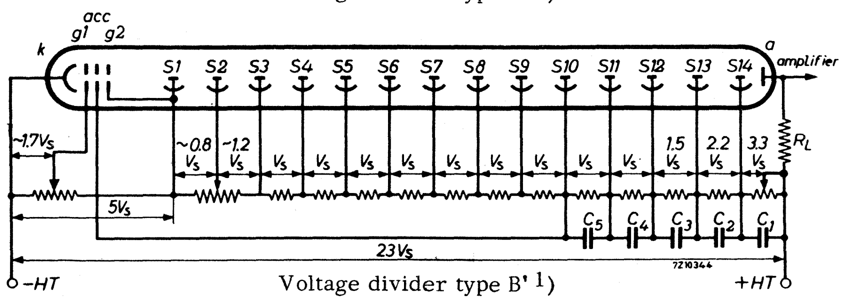
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 1.7 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances $C_1 = 100q/V_s$, $C_2 = 100q/3V_s$, $C_3 = 100q/9V_s$, $C_4 = 100q/27V_s$ etc. with q = quantity of electricity transported by the anode.

---

[1]) If the cathode is connected to negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the metal envelope or mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value of C_1 will be 2.10^{-9} F.

In the case of high counting rates and large peak power outputs, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc.

To reduce transit-time fluctuations and geometrical time spread, this system has the following advantages.

1. The photocathode is curved, with a curvature radius of 180 mm. To facilitate optical coupling to scintillators the tube is provided with a plane-concave window.
2. A high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator voltage of about 1500 V (to be connected to the tenth or a eleventh dynode) ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of the electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   (a) the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about 1.7 V_s;
   (b) the slightest transit-time fluctuations (the most homogeneous extraction field);
   (c) the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

4. Collection on the first dynode is controlled by the potential of the second dynode (See recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2400 V (see fig. 1) The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$) It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.3 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.2 the anode current variation is plotted against anode-to-final dynode voltage.

It should be noted that for equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.
In practice, therefore, it will be preferable to use the A type distribution, or a distribution between A and B, (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} etc., maintaining the same progression).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influence.

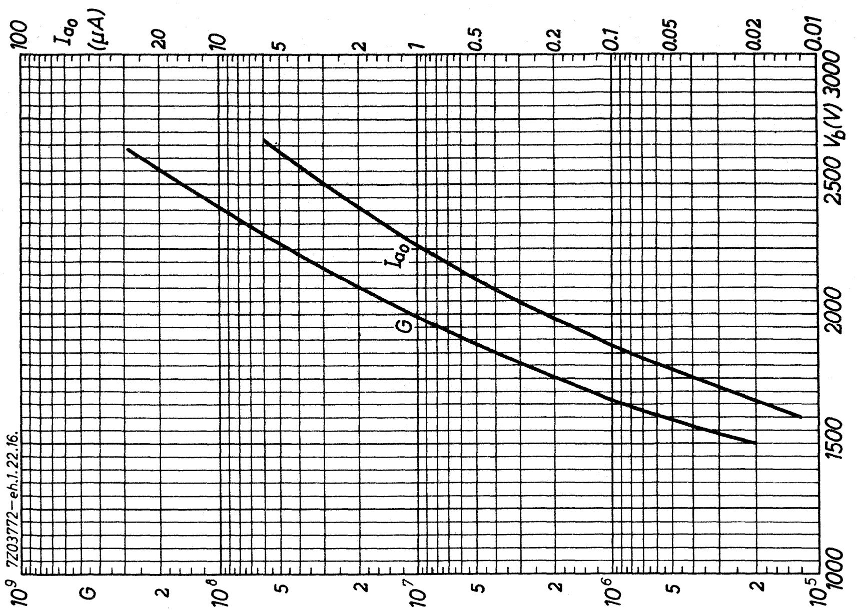

I_{ao} (μA)
100
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
G
10^9
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
I_{ao}
G
1000
1500
2000
2500
3000
V_b(V)
7Z03772–eh.1.22.16.

Fig. 1

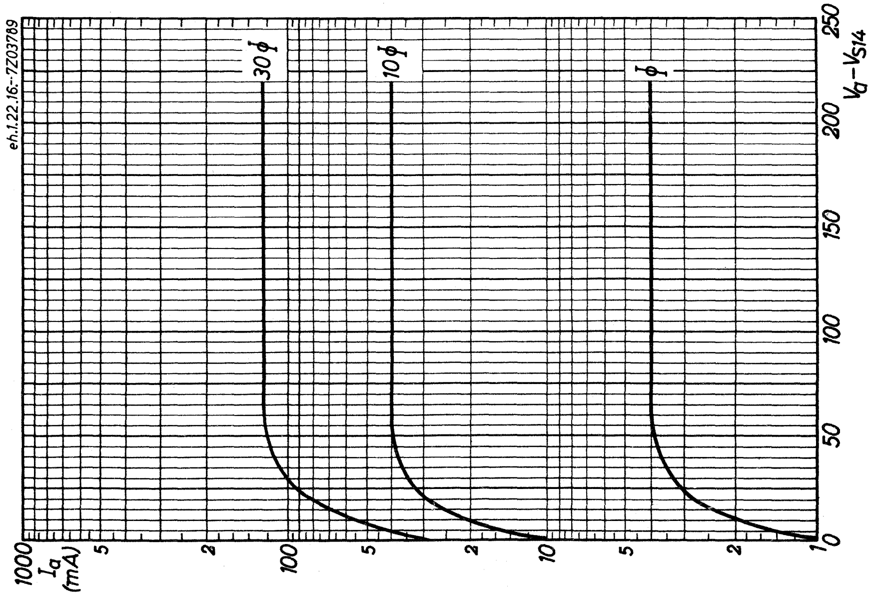

I_a (mA)
1000
5
2
100
5
2
10
5
2
1
30 Φ
10 Φ
Φ
0
50
100
150
200
250
$V_a - V_{S14}$
eh.1.22.16.–7Z03789

Fig. 2

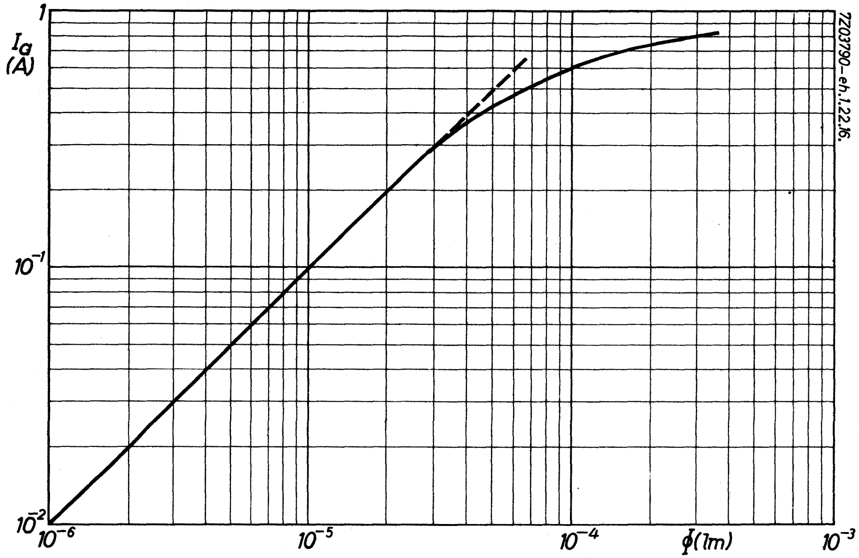


Fig. 3

Recommended replacement type 58DVP

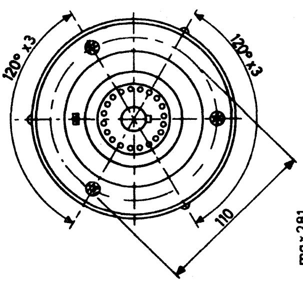
14 STAGE PHOTOMULTIPLIER TUBE

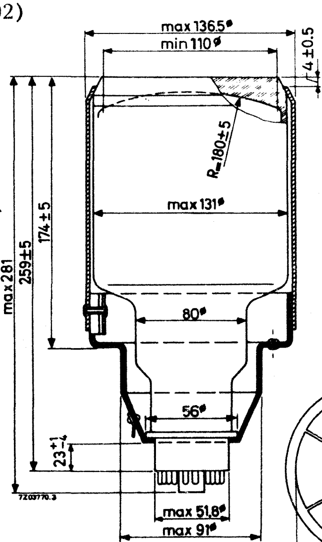
The tube is intended for use in nuclear-physics applications where very low luminous fluxes are to be measured and where a high degree of time definition is required.

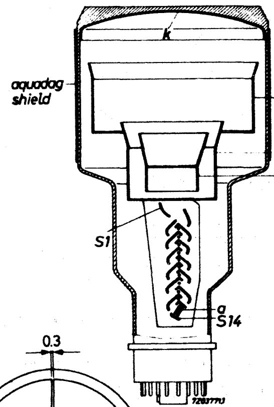
QUICK REFERENCE DATA		
Spectral response	bi-alkali type D	
Useful diameter of the photocathode	110	mm
Gain (at 2250 V)	10^8	
Anode pulse rise time	2	ns
Quantum efficiency (at 400 nm)	25	%

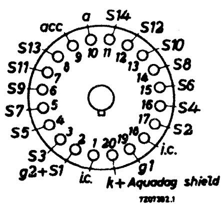
DIMENSIONS AND CONNECTIONS Dimensions in mm

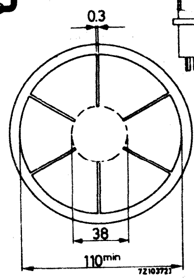
Base: 20-pin (Jedec B20-102)











top view

ACCESSORIES

Socket	type FE1003
Mu-metal shield (for tube with metal container)	type 56133
(for tube without metal container)	type 56129

Data based on pre-production tubes.

GENERAL

Photocathode

Description	semi-transparent, head-on, curved surface 1)			
Cathode material			K-Cs-Sb	
Minimum useful diameter			110	mm
Radius of curvature			183 ± 5	mm
Spectral response curve			See page 10 type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity 2)	N_k	min.	45	μA/lm
Radiant sensitivity at 437 nm			75	mA/W
Quantum efficiency at 400 nm	η_q	av	25	%

Multiplier system

Number of stages	14	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{14}}$	5	pF
Anode to all other electrodes	C_a	7	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2250	V
		max.	3000	V
Anode dark current at $G = 10^8$ 3)	I_{a_o}	max.	2	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

1) The tube has a plane-concave window and is supplied with a metal envelope.

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K. Because of the resistivity of D-type photocathodes the value of the cathode sensitivity is only an approximation. (See also the "Operational Considerations")

3) At an ambient temperature of 25 °C.

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode-pulse amplitude and input light pulse	up to	300	mA
Anode rise time at V_b = 2800 V [1]		2	ns
Anode pulse width at half height at V_b = 2800 V [1]		3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V		1	ns
Total transit time at V_b = 2800 V [1]		46	ns
Maximum peak currents		0.5 to 1	A

With voltage divider B'

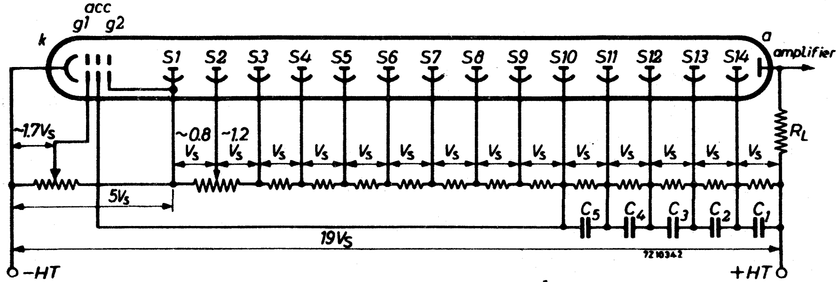
Anode pulse rise time at V_b = 2800 V [1]	2	ns
Anode pulse width at half height at V_b = 2800 V [1]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Transit time spread	1	ns
Total transit time at V_b = 2800 V [1]	43	ns

LIMITING VALUES (Absolute max. rating system)

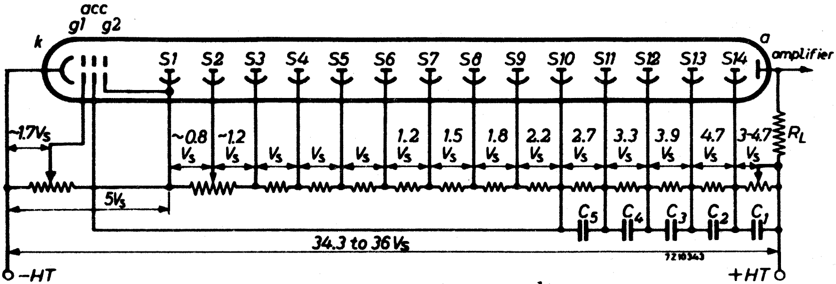
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max. min.	800 250	V V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	14 V_s to	18	V_s
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode [3]	$V_{a/S_{14}}$	max. min.	500 80	V V

1) For an infinitely short light pulse, fully illuminating the photocathode.
2) Or the voltage at which the tube circuited in the voltage divider A has a gain of about $5x10^8$, whichever is lowest.
3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

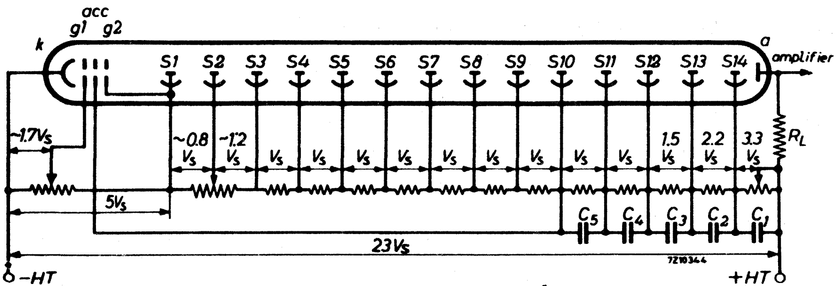
RECOMMENDED CIRCUITS



Voltage divider type A 1)



Voltage divider type B 1)



Voltage divider type B' 1)

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 1.7 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances $C_1 = 100q/V_s$, $C_2 = 100q/3V_s$, $C_3 = 100q/9V_s$, $C_4 = 100q/27V_s$ etc. with q = quantity of electricity transported by the anode.

1) If the cathode is connected to negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the metal envelope or mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value of C_1 will be 2.10^{-9} F.

In the case of high counting rates and large peak power outputs, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc.

To reduce transit-time fluctuations and geometrical time spread, this system has the following advantages.

1. The photocathode is curved, with a curvature radius of 180 mm. To facilitate optical coupling to scintillators the tube is delivered with a acrylate plane-concave adaptor.
2. A high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator voltage of about 1500 V (to be connected to the tenth or eleventh dynode) ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of the electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:

   (a) the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about 1.7 V_s;

   (b) the slightest transit-time fluctuations (the most homogeneous extraction field);

   (c) the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

4. Collection on the first dynode is controlled by the potential of the second dynode. (See recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2250 V (see fig.1). The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.3 the anode current variation is plotted against anode-to-final dynode voltage.

It should be noted that for equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.
In practice, therefore, it will be preferable to use the A type distribution, or a distribution between A and B, (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} etc., maintaining the same progression).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influence.

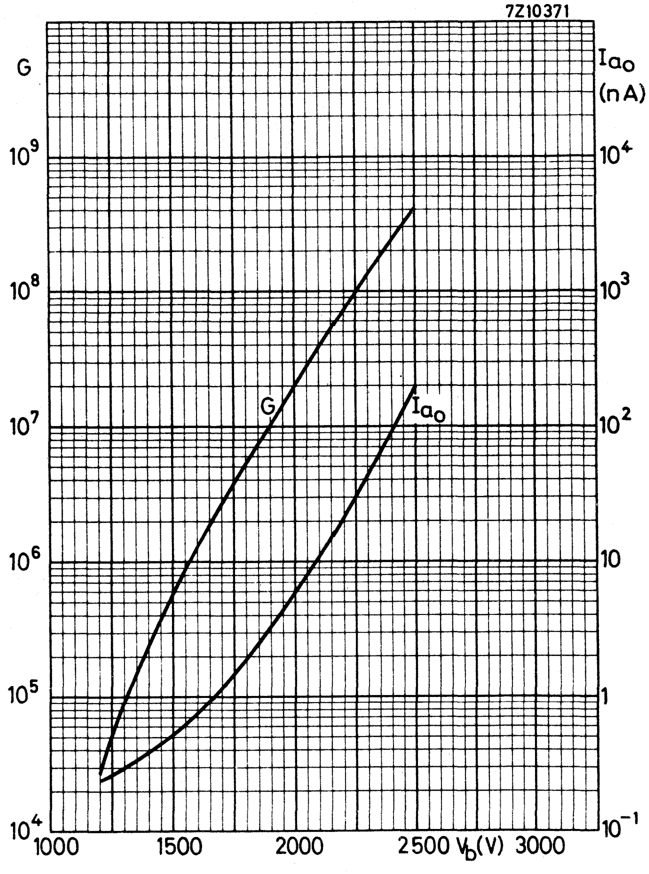

7Z10371
G
I_{ao} (nA)
10^9
10^8
10^7
10^6
10^5
10^4
10^4
10^3
10^2
10
1
10^{-1}
G
I_{ao}
1000
1500
2000
2500
V_b(V)
3000

Fig. 1

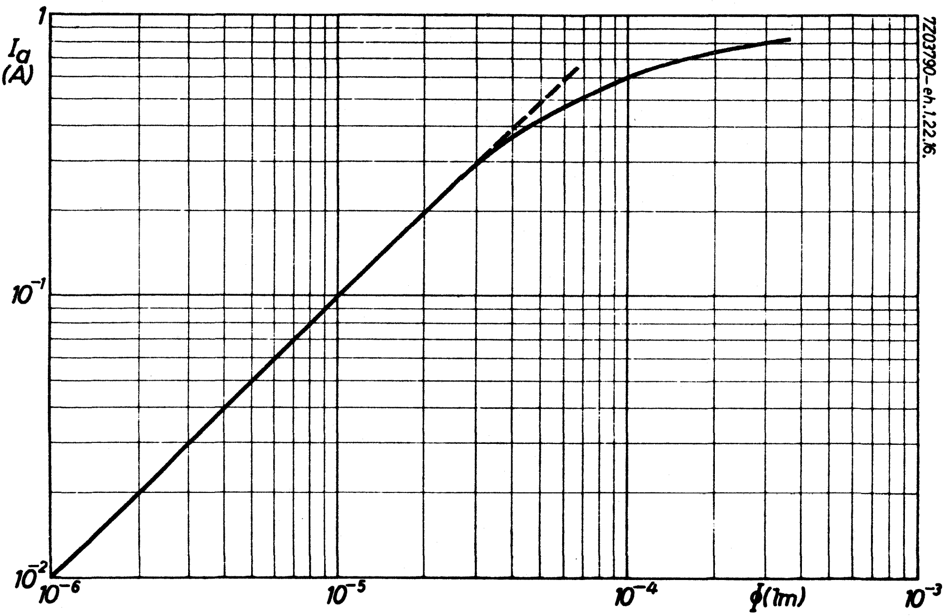


Fig. 2

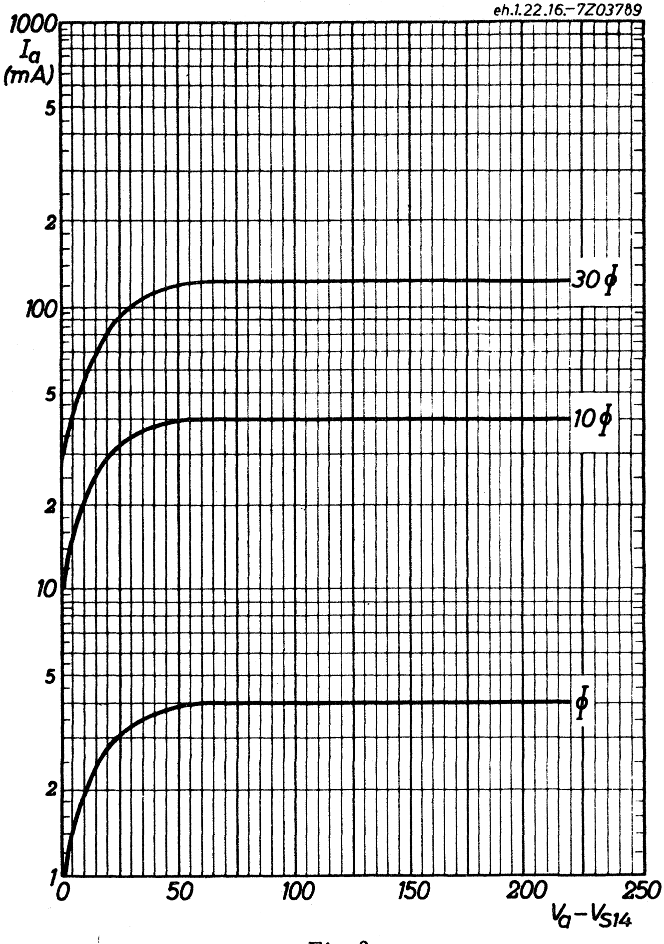

eh.1.22.16.-7Z03789
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 ϕ
10 ϕ
ϕ

Fig. 3

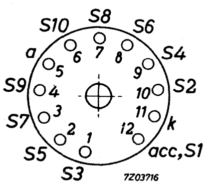
10 STAGE PHOTOMULTIPLIER TUBE

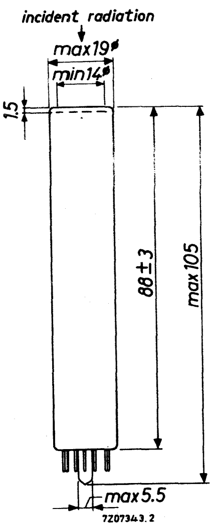
The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements with narrow light beams, etc. Its rugged construction makes it particularly suitable for geophysical and astronomical missile experiments as well as for industrial equipment.

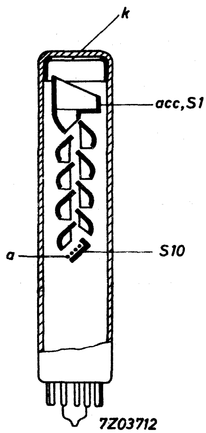
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56134

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface
Cathode material		Cs-Sb
Minimum useful diameter		14 mm
Spectral response curve [1]		type A (S11)
Wavelength at maximum response		420 ± 30 nm
Luminous sensitivity [2]	N_k	av. 60 μA/lm min. 30 μA/lm
Radiant sensitivity at 4200 Å		60 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	1.9 pF
Anode to all other electrodes	C_a	3.0 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 A/lm min. 30 A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av. 0.02 μA max. 0.10 μA
Linearity between anode pulse amplitude and input light pulse		up to 10 mA

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

3) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS

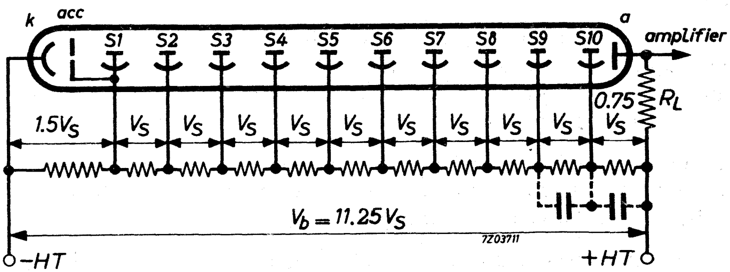
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 1800 V 1)		3	ns
Anode pulse width at half height at V_b = 1800 V 1)		4	ns
Total transit time at V_b = 1800 V 1)		25	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage 2)	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	300	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode 3)	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



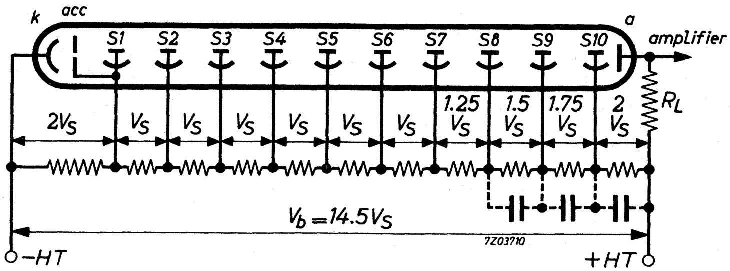
Voltage divider type A

1) For an infinitely short light pulse, fully illuminating the photocathode.

2) Or the voltage at which the tube circuited in the voltage divider A has a gain of 10^7, whichever is lowest.

3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

k = cathode

acc = accelerating electrode

S_n = dynode No.n

a = anode

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

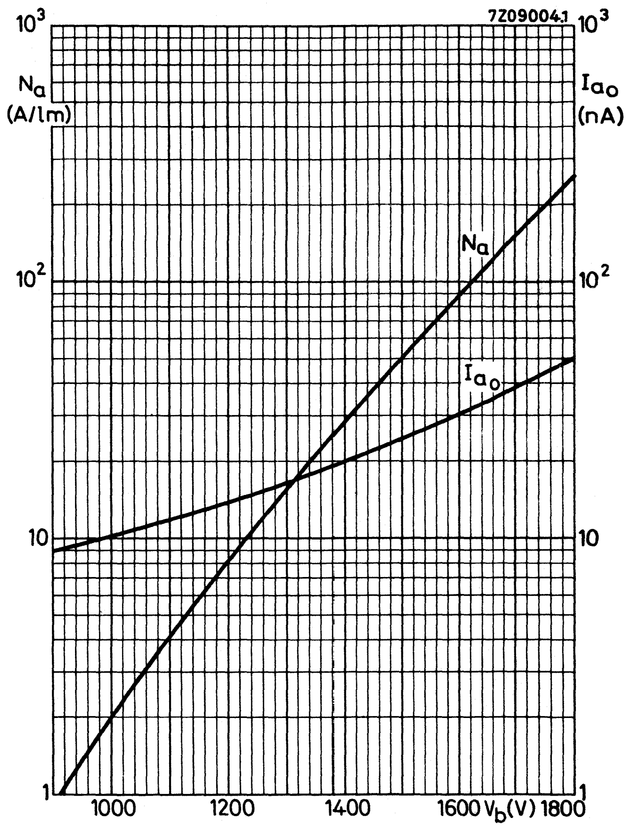
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.



7Z09004.1
10^3
N_a
(A/lm)
10^3
I_{a_0}
(nA)
N_a
10^2
10^2
I_{a_0}
10
10
1
1
1000
1200
1400
1600 V_b(V) 1800

6 STAGE PHOTOMULTIPLIER TUBE

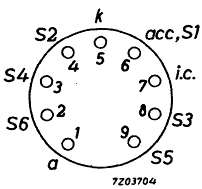
The tube is intended for use in optical applications, where space is very restricted and relatively high light fluxes are to be measured (10^{-5} to 10^{-3} lm).

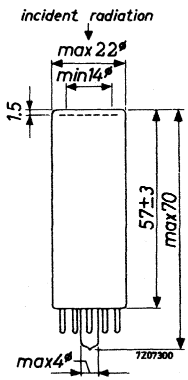
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1200 V)	0.9	A/lm

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 9-pin miniature with pumping stem (Jedec E9-37)





ACCESSORIES

Socket type 2422 502 90003

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Cs-Sb		
Minimum useful diameter			14	mm
Spectral response curve [1]		type A (S11)		
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	30	μA/lm
Radiant sensitivity at 4200 Å			60	mA/W

Multiplier system

Number of stages			6	
Dynode material		Ag-Mg-O-Cs		

Capacitances

Anode to final dynode	C_{a/S_6}		1.6	pF
Anode to all other electrode	C_a		1.3	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1200 V	N_a	av.	0.9	A/lm
		min.	0.2	A/lm
Anode dark current at N_a = 0.3 A/lm [3]	I_{a_o}	max.	10	nA
Linearity between anode pulse amplitude and input light pulse		up to	15	mA

With voltage divider B

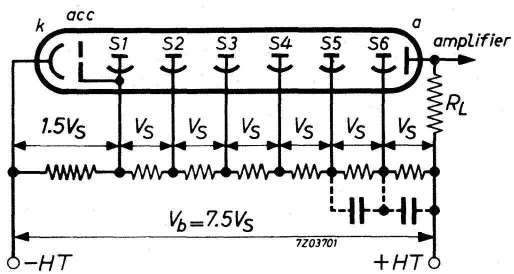
Linearity between anode pulse amplitude and input light pulse		up to	30	mA
Anode pulse rise time at V_b = 1000 V [4]			3	ns
Anode pulse width at half height at V_b = 1000 V [4]			5	ns
Total transit time at V_b = 1000 V [4]			17	ns

[1]) See spectral response curve in front of this section
[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K
[3]) At an ambient temperature of 25 °C
[4]) For a infinitely short light pulse, fully illuminating the photo cathode.

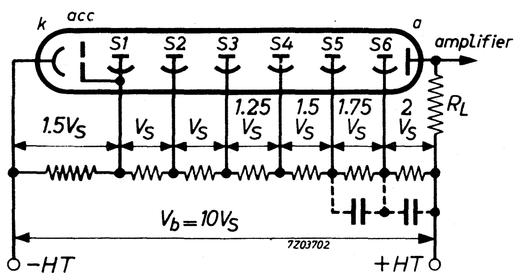
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1200	V
Continuous anode current	I_a	max.	0.5	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	200	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode [1]	V_{a/S_6}	max.	200	V
		min.	50	V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

---

[1]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

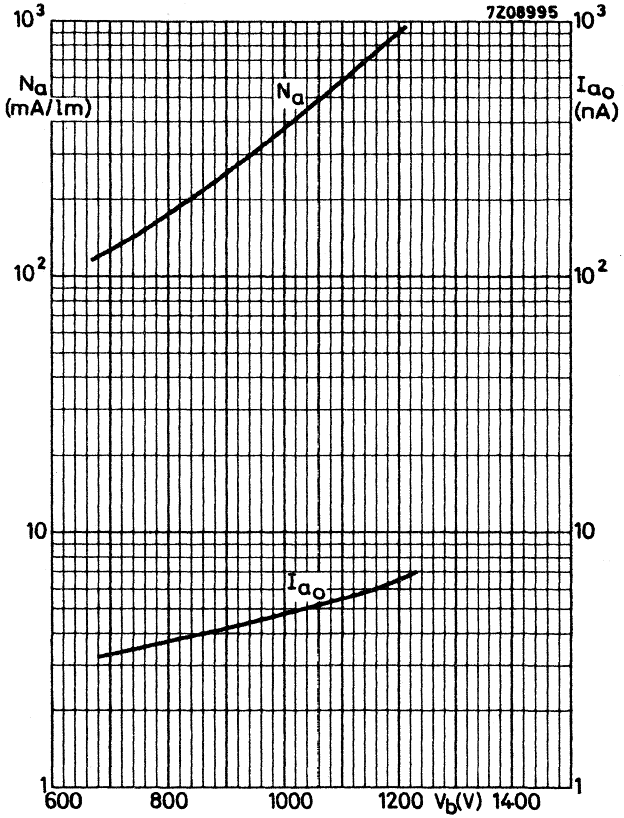
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage, a circuit of type B gives higher currents in the last stages, but the total gain is less at the same total voltage.

At high pulse amplitudes it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube against the influence of magnetic fields by means of a mu-metal cylinder.


7Z08995
10^3
N_a
(mA/lm)
N_a
I_{ao}
(nA)
10^2
10
I_{ao}
1
600
800
1000
1200
V_b(V)
1400

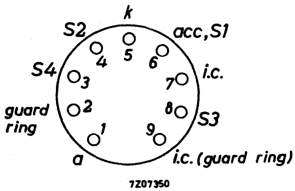
4 STAGE PHOTOMULTIPLIER TUBE

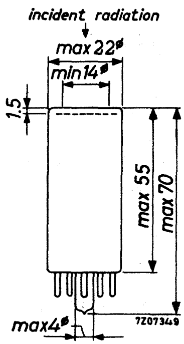
The tube is intended for use in optical applications, where space is very restricted and relatively high light fluxes are to be measured (10^{-4} to 10^{-1} lm).

QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 900 V)	20	mA/lm
Dark current (at 4 mA/lm)	max. 0.1	nA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 9-pin miniature with pumping stem (Jedec E9-37)





ACCESSORIES

Socket type 2422 502 90003

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			14	mm
Spectral response curve [1]			type A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	30	μA/lm
Radiant sensitivity at 4200 Å			60	mA/W

Multiplier system

Number of stages		4	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_{a/S_4}	1.9	pF
Anode to all other electrodes	C_a	2.7	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 900 V	N_a	av.	20	mA/lm
		min.	4	mA/lm
Anode dark current at N_a = 4 mA/lm [3]	I_{a_o}	max.	0.1	nA

With voltage divider B

Anode pulse rise time at V_b = 850 V [4]	2	ns
Anode pulse width at half height at V_b = 850 V [4]	3	ns
Total transit time at V_b = 850 V [4]	11	ns

---

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

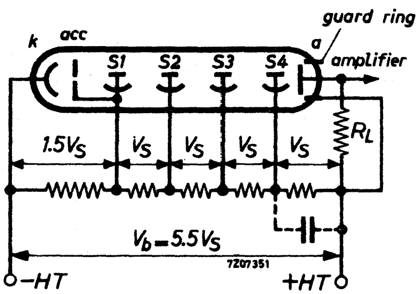
3) At an ambient temperature of 25 °C

4) For an infinitely short light pulse, fully illuminating the photocathode.

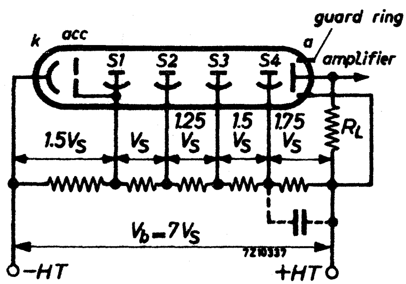
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 900	V
Continuous anode current	I_a	max. 0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. 200	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. 200	V
		min. 80	V
Voltage between anode and final dynode [1]	V_{a/S_4}	max. 200	V
		min. 50	V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

---

[1]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

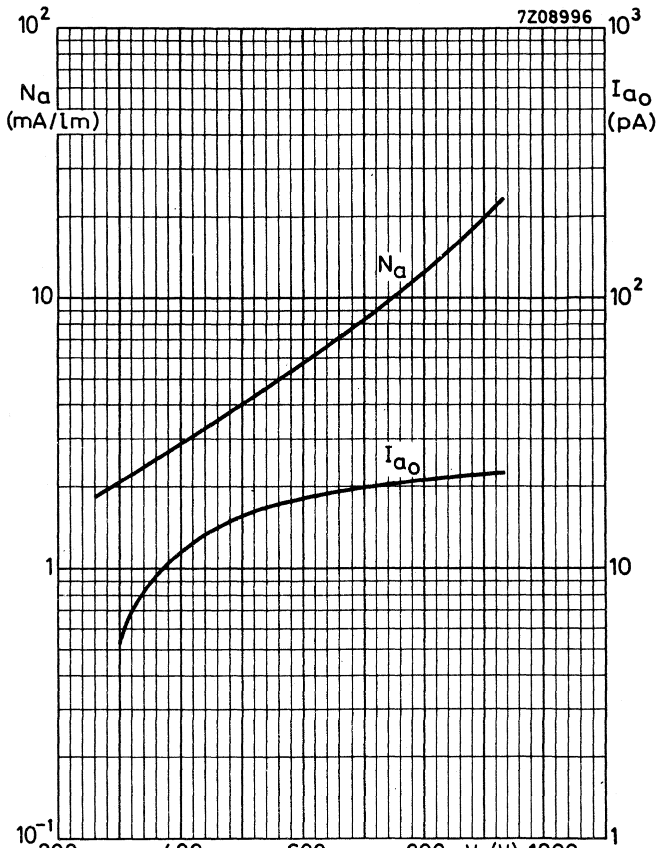
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage, a circuit of type B gives higher currents in the last stages, but the total gain is less at the same total voltage.

At high pulse amplitudes it is useful to decouple the last stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube against the influence of magnetic fields by means of a mu-metal cylinder.


7Z08996
10^2
N_a
(mA/lm)
10
1
10^{-1}
10^3
I_{a_0}
(pA)
10^2
10
1
200
400
600
800
V_b(V)
1000
N_a
I_{a_0}

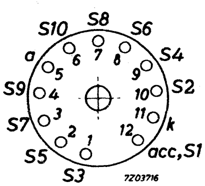
10 STAGE PHOTOMULTIPLIER TUBE

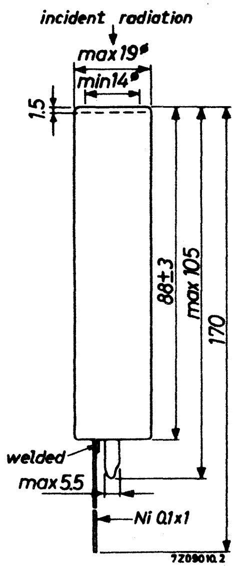
The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements with narrow light beams, etc. Its rugged construction makes it particularly suitable for geophysical and astronomical missile experiments as well as for industrial equipment.

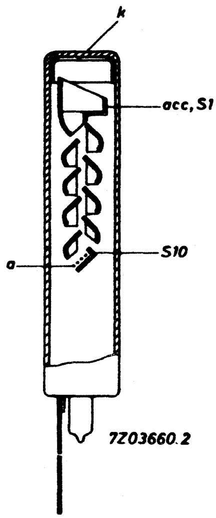
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12 semi-flexible leads







GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Cs-Sb		
Minimum useful diameter			14	mm
Spectral response curve [1]		type A (S11)		
Wavelength at maximum response		420 ±	30	nm
Luminous sensitivity [2]	N_k	av.	60	μA/lm
		min.	30	μA/lm
Radiant sensitivity at 4200 Å			60	mA/W

Multiplier system

Number of stages			10	
Dynode material		Ag-Mg-O-Cs		

Capacitances

Anode to final dynode	C_a/S_{10}		1.9	pF
Anode to all other electrodes	C_a		3.0	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	250	A/lm
		min.	30	A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av.	20	nA
		max.	100	nA
Linearity between anode pulse amplitude and input light pulse		up to	10	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS

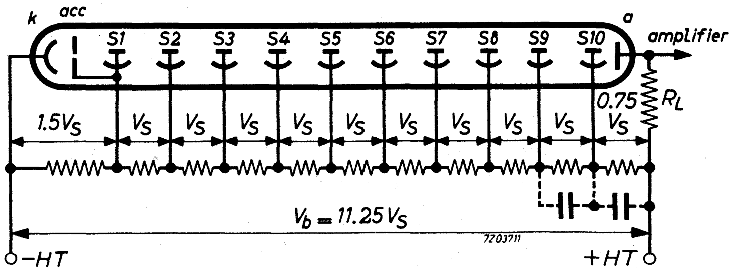
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse width at half height at V_b = 1800 V [1]		4	ns
Anode pulse rise time at V_b = 1800 V [1]		3	ns
Total transit time at V_b = 1800 V [1]		25	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage [2]	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	$V_{k/S1}$	max.	300	V
		min.	120	V
Voltage between consecutive dynodes	$V_{Sn/Sn+1}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S10}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



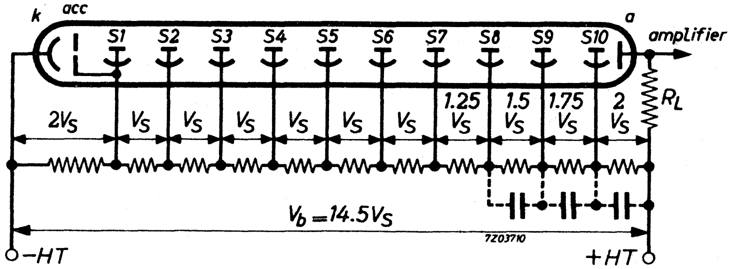
Voltage divider type A

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) Or the voltage at which the tube circuited in the voltage divider A has a gain of 10^7, whichever is lowest.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

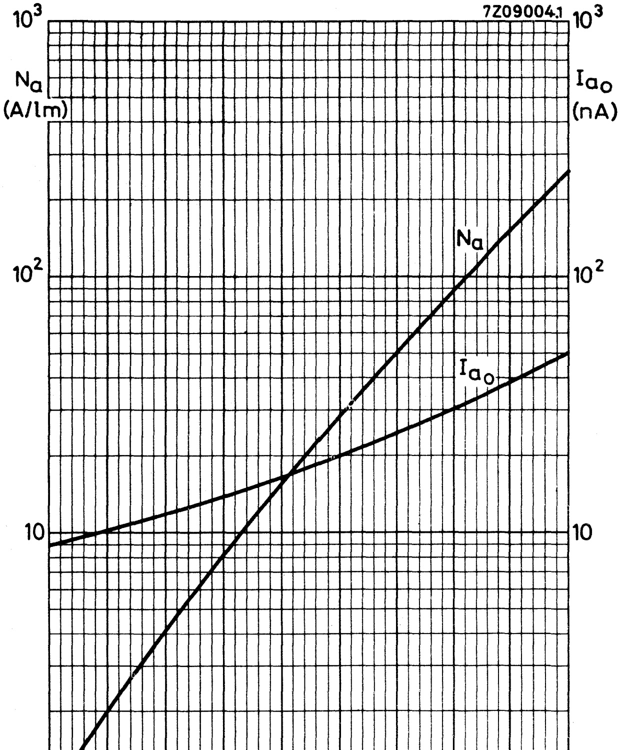
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

The semi-flexible leads of the tube may be soldered into the circuit; care must be taken to conduct the heat away from the glass seals. Excessive bending of the leads is to be avoided.



7Z09004.1
10^3
N_a
(A/lm)
10^2
10
1
10^3
I_{a_0}
(nA)
10^2
10
1
N_a
I_{a_0}
1000
1200
1400
1600
V_b(V)
1800

10 STAGE PHOTOMULTIPLIER TUBE

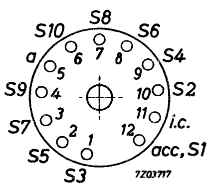
The tube is intended for use in applications such as infra-red telecommunication and ranging, under limited dimensional conditions. Its rugged construction makes it particularly suitable for industrial equipment.

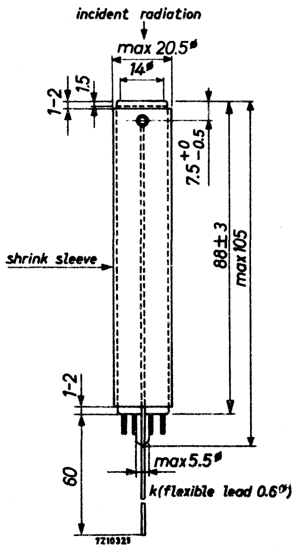
QUICK REFERENCE DATA		
Spectral response	type	C (S1)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	20	A/lm

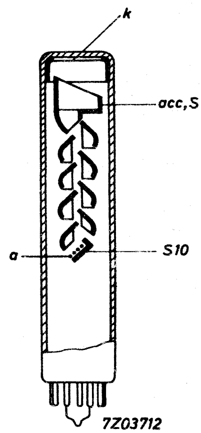
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type	FE1004
Mu-metal shield	type	56134

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Ag-O-Cs		
Minimum useful diameter			14	mm
Spectral response curve 1)		type C (S1)		
Wavelength at maximum response			8000 ± 1000	Å
Luminous sensitivity 2)	N_k	av.	20	μA/lm
		min.	15	μA/lm
Radiant sensitivity at 8000 Å			2	mA/W

Multiplier system

Number of stages	10	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S10}$	1.5	pF
Anode to all other electrodes	C_a	2.5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	20	A/lm
		min.	10	A/lm
Anode dark current at N_a = 20 A/lm 3)	I_{a_o}	max.	10	μA
Linearity between anode pulse amplitude and input light pulse		up to	10	mA

With voltage divider B

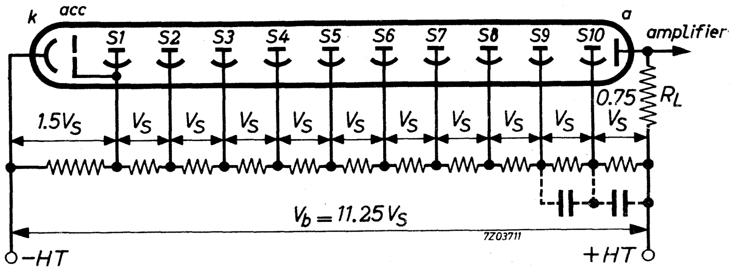
Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 1800 V 4)		3	ns
Anode pulse width at half height at V_b = 1800 V 4)		4	ns
Total transit time at V_b = 1800 V 4)		25	ns

1) See spectral response curve in front of this section
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K
3) At an ambient temperature of 25 °C
4) For an infinitely short light pulse, fully illuminating the photocathode

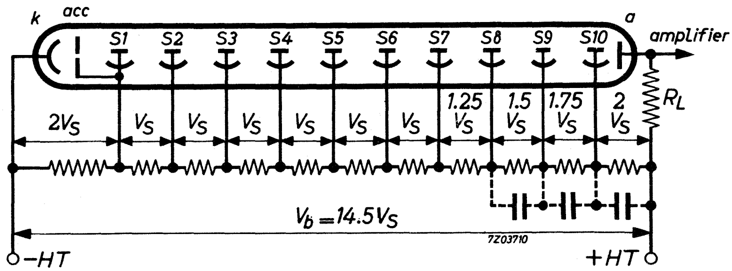
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	1800	V
Continuous anode current	I_a	max.	30	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	300	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

1) Or the voltage at which the tube circuited in the voltage divider A has an anode sensitivity of 50 A/lm, whichever is lowest.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

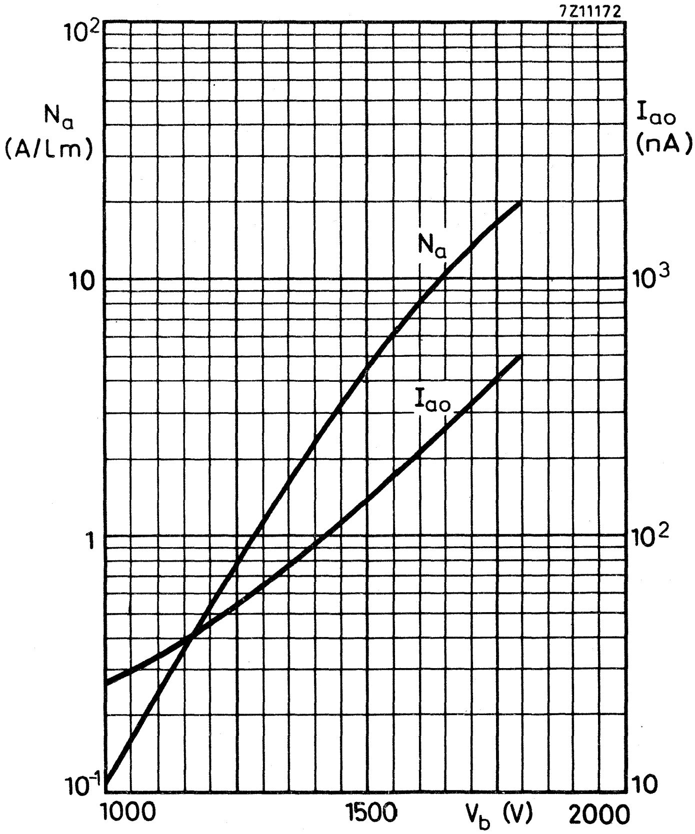
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to de-couple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z11172
N_a (A/Lm)
I_{ao} (nA)
N_a
I_{ao}
10^2
10
1
10^{-1}
10^3
10^2
10
1000
1500
V_b (V)
2000

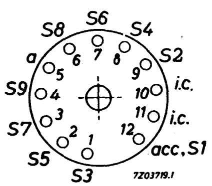
9 STAGE PHOTOMULTIPLIER TUBE

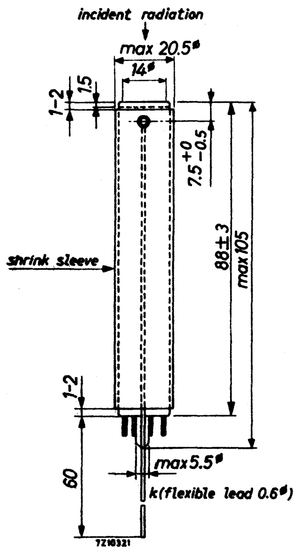
The tube is intended for use in laser-technics working in the orange, yellow and green range, under limited dimensional conditions. Its rugged construction makes it particularly suitable for industrial equipment.

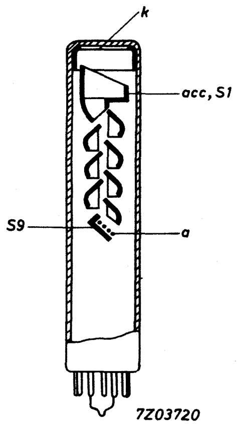
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	100	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type	FE1004
Mu-metal shield	type	56134

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface	
Cathode material		Sb-K-Na-Cs	
Minimum useful diameter		14	mm
Spectral response curve [1]		type T (S20)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	100	μA/lm
Radiant sensitivity at 4200 Å		60	mA/W

Multiplier system

Number of stages		9
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	C_{a/S_9}	1.5	pF
Anode to all other electrodes	C_a	2.5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	100	A/lm
		min.	30	A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av.	10	nA
		max.	100	nA
linearity between anode pulse amplitude and input light pulse		up to	10	mA

With voltage divider B

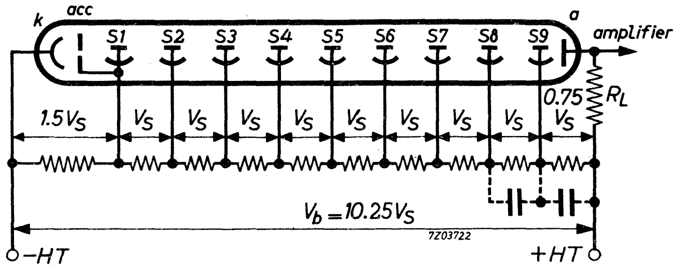
linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 1800 V [4]		3	ns
Anode pulse width at half height at V_b = 1800 V [4]		4	ns
Total transit time at V_b = 1800 V [4]		20	ns

[1] See spectral response curve in front of this section
[2] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K
[3] At an ambient temperature of 25 °C
[4] For an infinitely short light pulse, fully illuminating the photocathode.

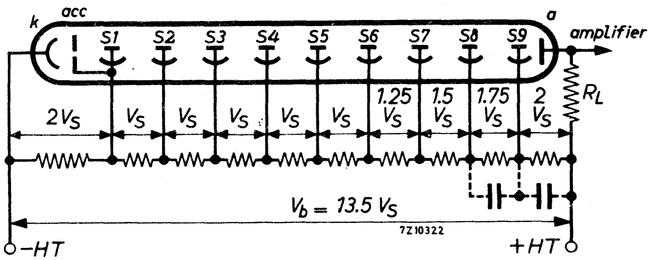
LIMITING VALUES (Absolute max. rating system)

Supply voltage 1)	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	300	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode 2)	V_{a/S_9}	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

1) Or the voltage at which the tube circuited in the voltage divider A has a gain of 3.10^6, whichever is lowest.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

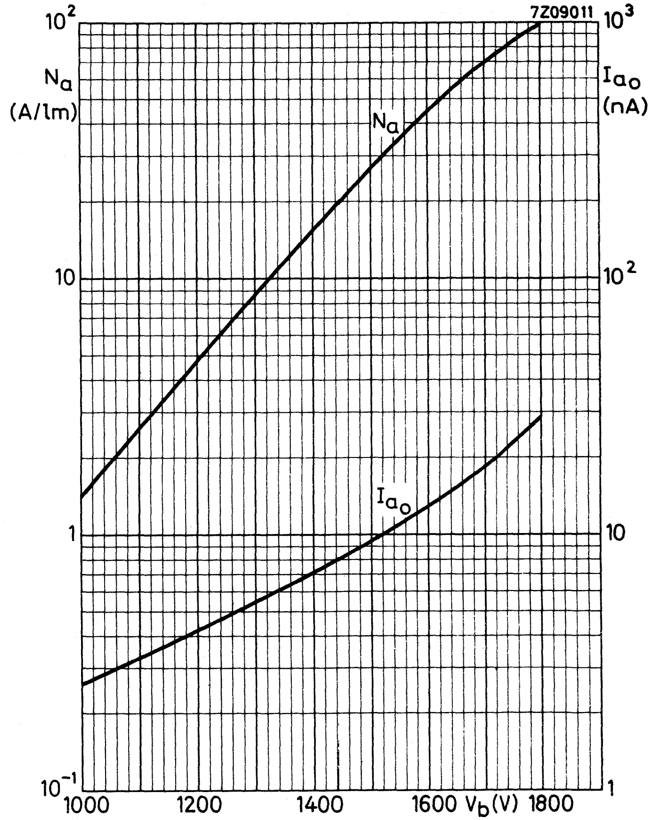
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z09011
10^2
N_a
(A/lm)
N_a
10
1
10^{-1}
10^3
I_{a_0}
(nA)
10^2
10
1
I_{a_0}
1000
1200
1400
1600 V_b(V) 1800

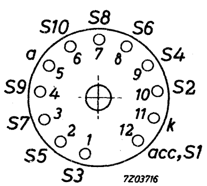
10 STAGE PHOTOMULTIPLIER TUBE

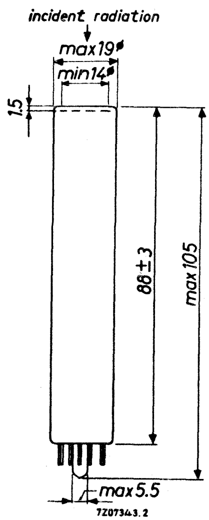
The tube is intended for use in optical applications which require a good sensitivity in the ultraviolet region, under limited dimensional conditions.

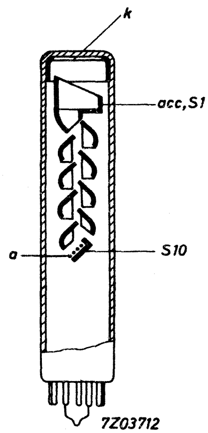
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS — Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type	FE1004
Mu-metal shield	type	56134

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface
Cathode material		Cs-Sb
Minimum useful diameter		14 mm
Spectral response curve [1]		type U (S13)
Wavelength at maximum response		4000 ± 300 Å
Luminous sensitivity [2]	N_k	av. 70 μA/lm min. 30 μA/lm
Radiant sensitivity at 4000 Å		60 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{10}}$	1.5 pF
Anode to all other electrodes	C_a	2.5 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 A/lm min. 30 A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av. 20 nA max. 100 nA
Linearity between anode pulse amplitude and input light pulse		up to 10 mA

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

3) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

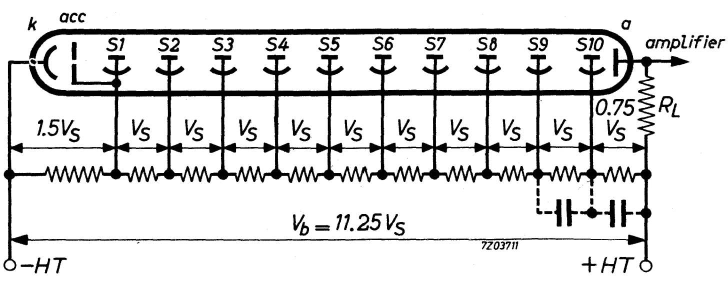
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 1800 V [1]		3	ns
Anode pulse width at half height at V_b = 1800 V [1]		4	ns
Total transit time at V_b = 1800 V [1]		25	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage [2]	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	300	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



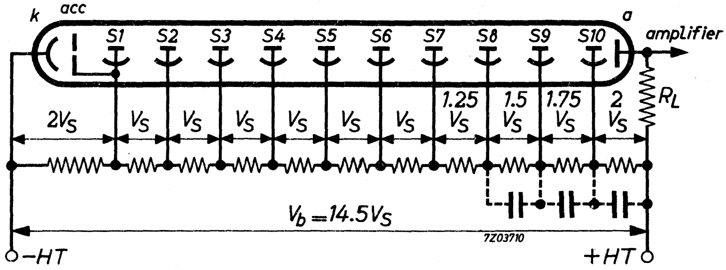
Voltage divider type A

1) For an infinitely short light pulse, fully illuminating the photocathode.

2) Or the voltage at which the tube circuited in the voltage divider A has a gain of 10^7, whichever is lowest.

3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

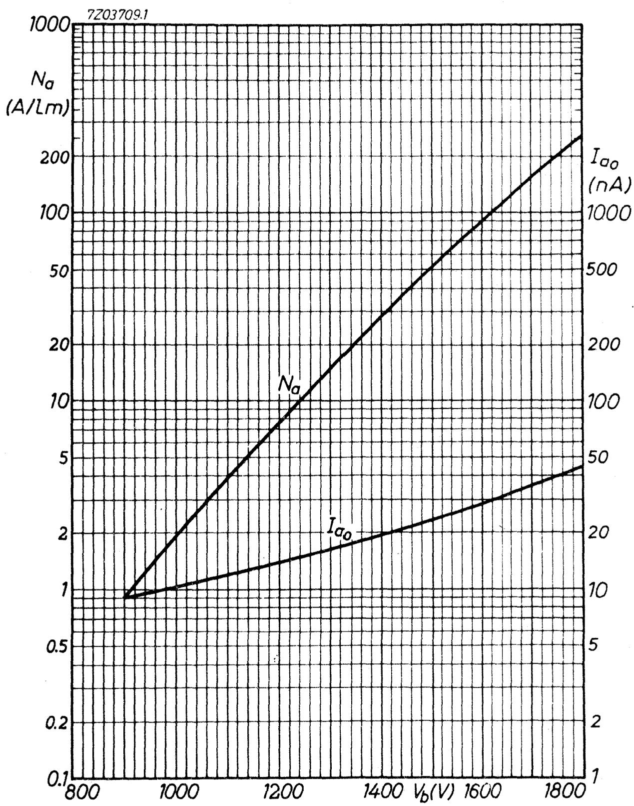
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03709.1
1000
N_a
(A/Lm)
200
100
50
20
10
5
2
1
0.5
0.2
0.1
I_{ao}
(nA)
1000
500
200
100
50
20
10
5
2
1
N_a
I_{ao}
800
1000
1200
1400
V_b(V)
1600
1800

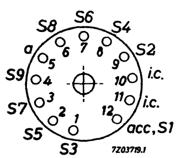
9 STAGE PHOTOMULTIPLIER TUBE

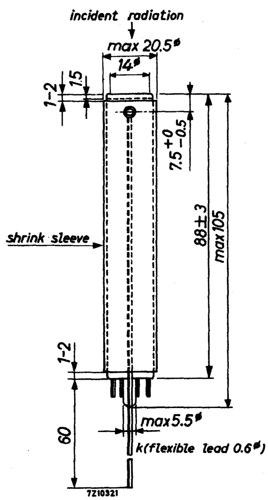
The tude is intended for use in spectrometry where low luminous fluxes are to be measured, e.g. radiation detection in which it is to be used in conjunction with scintillators.

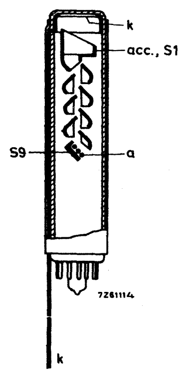
QUICK REFERENCE DATA		
Spectral response	type D	
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	100	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56134

Data based on pre-production tubes.

GENERAL

Photocathode

Description	semi-transparent, head-on, flat surface			
Cathode material			Sb-K-Cs	
Minimum useful diameter			14	mm
Spectral response curve (See Application directions)			type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity, measured with a tungsten ribbon lamp having a colour temperature of 2850 K	N_k	av.	70	µA/lm
Radiant sensitivity at 437 ± 5 nm			60	mA/W

Multiplier system

Number of stages	9
Dynode material	Ag-Mg-O-Cs

CAPACITANCES

Anode to final dynode	C_{aS9}	1.5	pF
Anode to all other electrodes	C_a	2.5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	100	A/lm
Anode dark current at N_a = 30 A/lm (t_{amb} = 25 °C)	I_{a_o}	max.	100	nA
Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V	up to I_{a_p} =		10	mA

TYPICAL CHARACTERISTICS (continued)

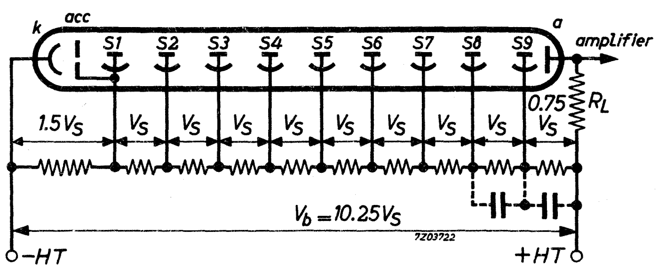
With voltage divider B

Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V	up to I_{ap} = 30	mA
Anode pulse rise time at V_b = 1500 V for an infinitely short light pulse	3	ns [2]
Total transit time at V_b = 1500 V	20	ns [2]
Anode pulse width at half height (V_b = 1500 V)	4	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	200	µA
Voltage between cathode and first dynode	$V_{k/S1}$	max. min.	300 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	200 80	V V
Voltage between anode and final dynode [1]	$V_{a/S9}$	max. min.	200 80	V V
Ambient temperature	t_{amb}	max.	+65	°C

RECOMMENDED CIRCUITS



Voltage divider A

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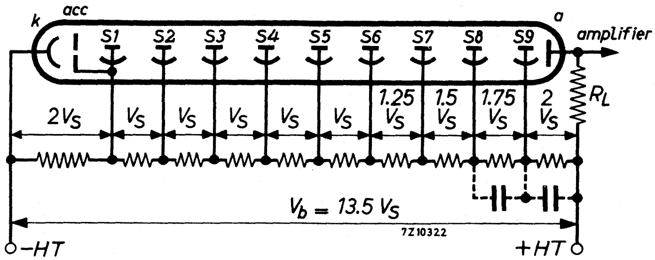
[1]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

[2]) For an infinitely short light pulse, fully illuminating the cathode.

RECOMMENDED CIRCUITS (continued)



Voltage divider B

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region ($\lambda < 1500$ Å) and soft X-ray counting ($\lambda > 2$ Å).

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 800 Å)	10	%
Useful area of the Ni photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation	10^{-5} to 10^{-6}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Ni	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	800 ± 100	Å
Quantum efficiency for UV-photons at 800 Å	10	%

Multiplier system

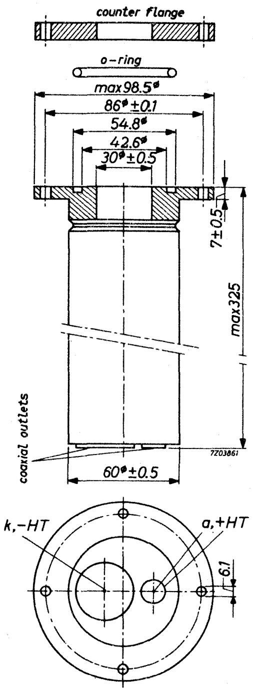
Number of stages	17
Dynode material	Cu-Be-O

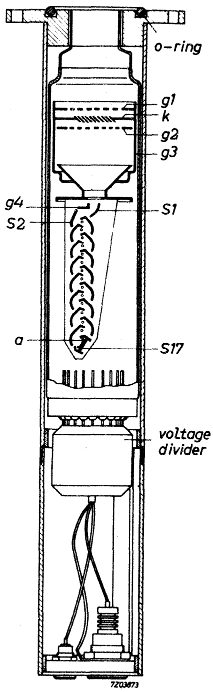
Capacitances

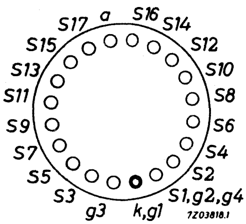
Anode to final dynode	$C_{a/S_{17}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Base connections

High voltage connector	"LEMO" type III C40 H.T.10
Signal connector	"LEMO" type OC50

TYPICAL CHARACTERISTICS

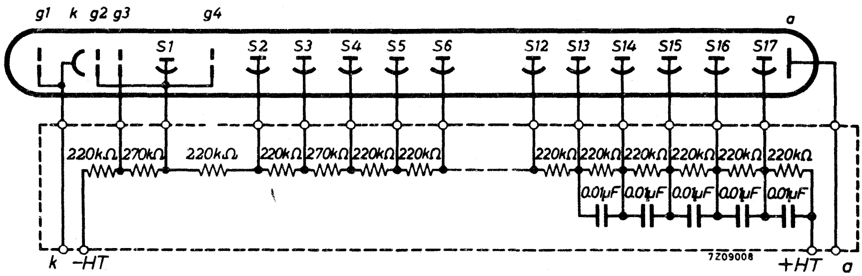
<u>With potted voltage divider</u>

Gain at V_b = 4000 V	G	av.	5.10^7
Anode dark current at V_b = 4000 V	I_{a_o}	av.	10^{-1} nA

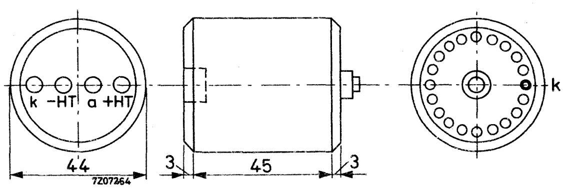
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max.	300	V
		min.	80	V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT



potted resistor chain type 56120



[1] When the tube is to be used at 5000 V preferably the cathode should be grounded.

[2] The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a glass envelope which is sealed to a metal flange to facilitate mounting to a vacuum system (vacuum seal with O-ring). The glass envelope is protected by a nickel plated iron mantle, which contains a complete potted voltage divider. The external connections are made via two coaxial connectors. Because of the O-ring the tube may not be heated for outgassing.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum.

A counter-flange with cock is delivered with the tube.

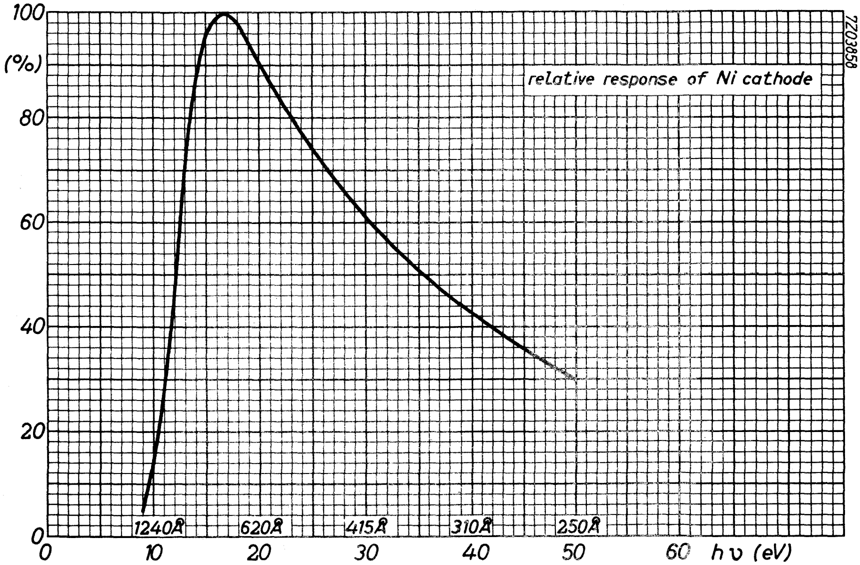
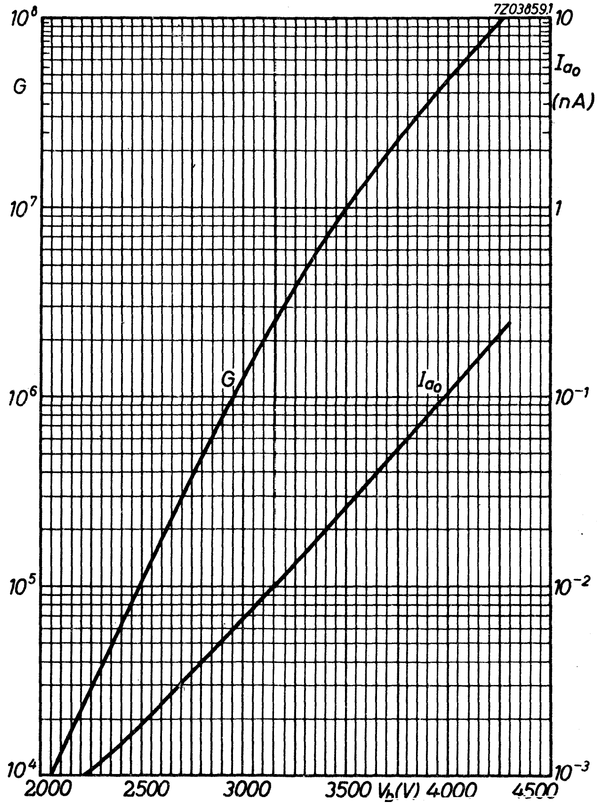

100
(%)
80
60
40
20
0
relative response of Ni cathode
7Z03858
1240Å
620Å
415Å
310Å
250Å
0
10
20
30
40
50
60
hν (eV)

Fig. 1


7Z03859.1
10^8
G
10^7
10^6
10^5
10^4
10
I_{a_0}
(nA)
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
2000
2500
3000
3500 V_b(V) 4000
4500

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region (λ < 1400 Å) detection of ions (> 10 keV) and electrons (0.1 to 10 keV).

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 680 Å)	20	%
Useful area of the Cu Be O photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation	10^{-5} to 10^{-6}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Cu-Be-O	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	680 ± 100	Å
Quantum efficiency for UV-photons at 680 Å	20	%

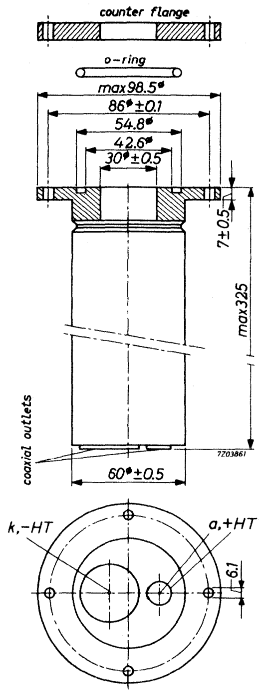
Multiplier system

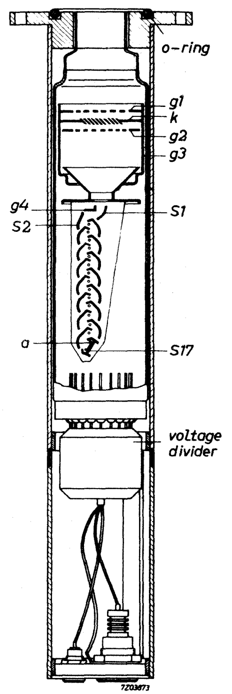
Number of stages	17
Dynode material	Cu-Be-O

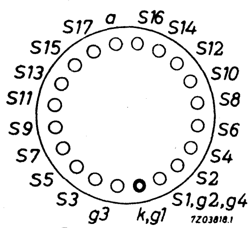
Capacitances

Anode to final dynode	C_a/S_{17}	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS Dimensions in mm







Base connections

High voltage connector "LEMO" type III C40 H.T.10

Signal connector "LEMO" type OC50

TYPICAL CHARACTERISTICS

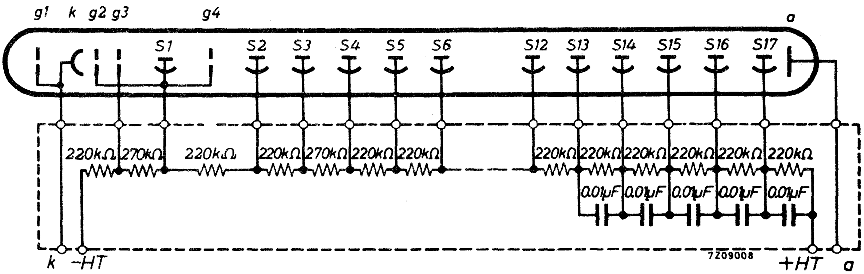
With potted voltage divider

Gain at V_b = 4000 V	G	av.	5.10^7
Anode dark current at V_b = 4000 V	I_{a_o}	av.	10^{-4} µA

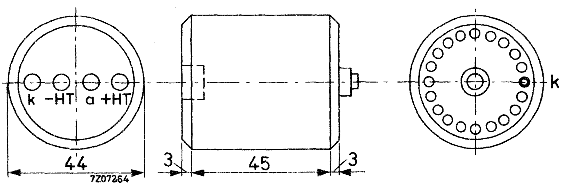
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max. min.	300 80	V V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT



potted resistor chain type 56120



1) When the tube is to be used at 5000 V preferably the cathode should be grounded.

2) The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a glass envelope which is sealed to a metal flange to facilitate mounting to a vacuum system (vacuum seal with O-ring). The glass envelope is protected by a nickel plated iron mantle, which contains a complete potted voltage divider. The external connections are made via two coaxial connectors. Because of the O-ring the tube may not be heated for outgassing.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum.

A counter-flange with cock is delivered with the tube.

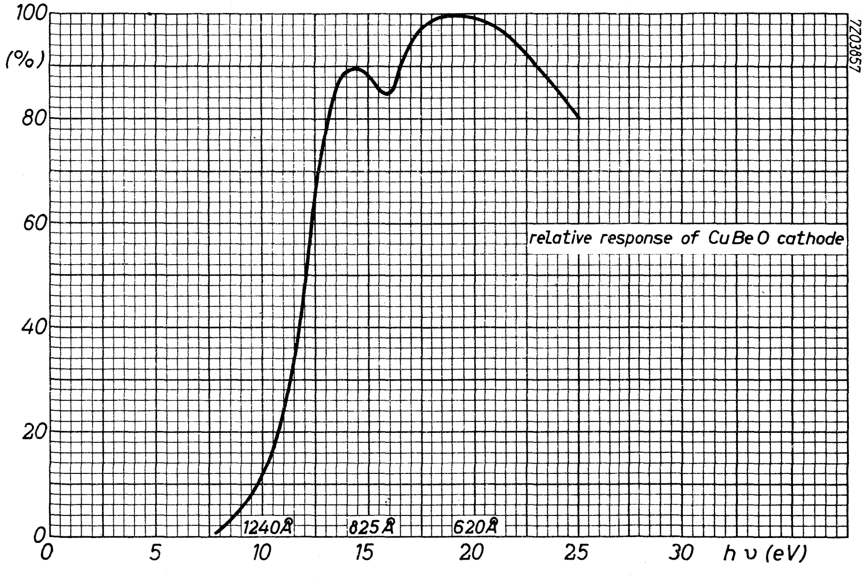
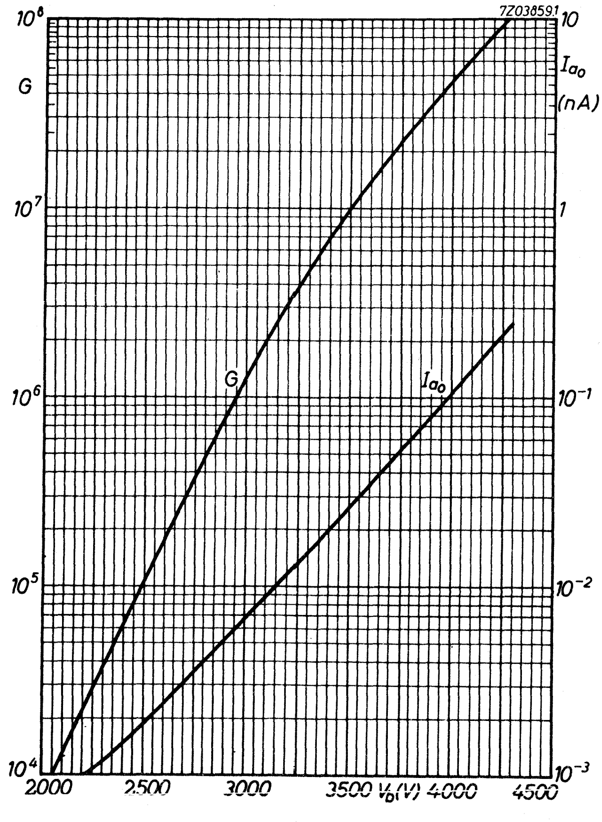

100
(%)
80
60
40
20
0
0
5
10
15
20
25
30
h υ (eV)
1240Å
825Å
620Å
relative response of CuBeO cathode
7Z03857

Fig. 1


7Z03859.1
10^8
G
10^7
10^6
10^5
10^4
10
I_{a_0}
(nA)
1
10^-1
10^-2
10^-3
G
I_{a_0}
2000
2500
3000
3500
V_b(V)
4000
4500

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region ($\lambda < 1500$ Å) and detection of soft X-rays ($\lambda > 2$ Å).

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 800 Å)	10	%
Useful area of the Ni photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation	10^{-5} - 10^{-6}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Ni	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	800 ± 100	Å
Quantum efficiency for UV-photons at 800 Å	10	%

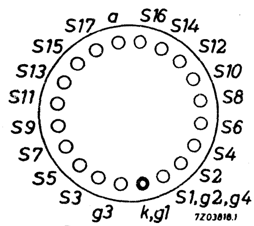
Multiplier system

Number of stages	17
Dynode material	Cu-Be-O

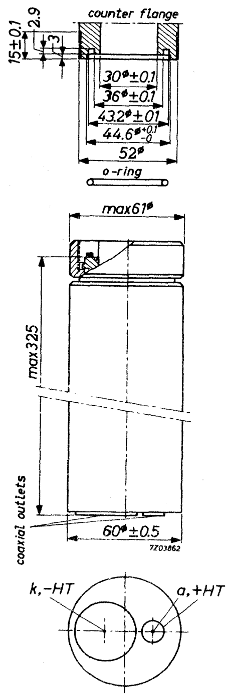
Capacitances

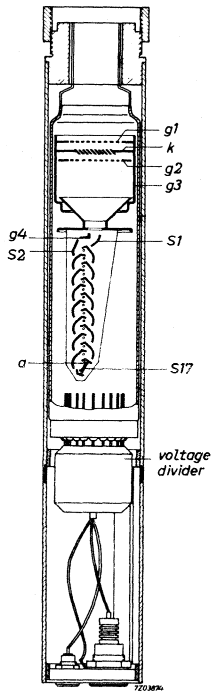
Anode to final dynode	$C_{a/S_{17}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS Dimensions in mm



Base connections





High voltage connector "LEMO" type III C40 H.T.10

Signal connector "LEMO" type OC50

TYPICAL CHARACTERISTICS

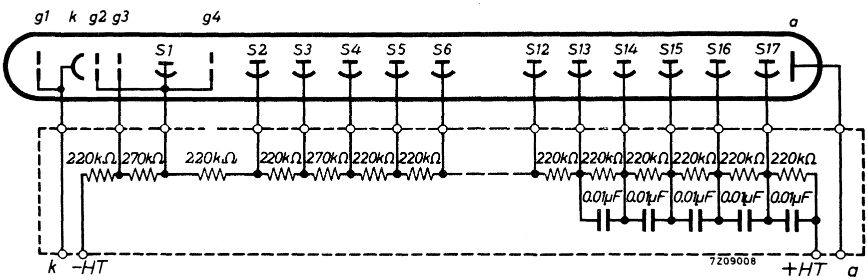
With potted voltage divider

Gain at V_b = 4000 V	G	av.	5.10^7	
Anode dark current at V_b = 4000 V	I_{a_o}	av.	10^{-4}	μA

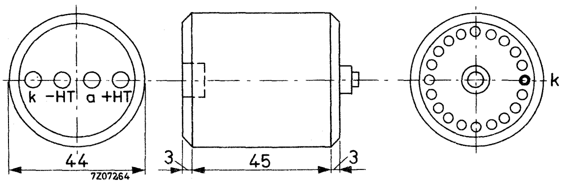
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max.	300	V
		min.	80	V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT



potted resistor chain type 56120



[1]) When the tube is to be used at 5000 V preferably the cathode should be grounded.

[2]) The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

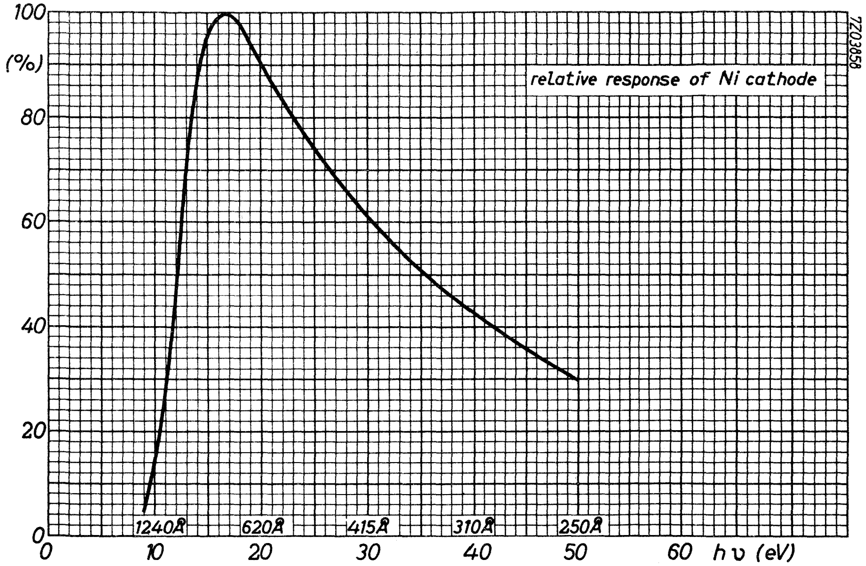
The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a glass envelope which is sealed to a metal flange to facilitate mounting to a vacuum system (vacuum seal with O-ring). The glass envelope is protected by a nickel plated iron mantle, which contains a complete potted voltage divider. The external connections are made via two coaxial connectors. Because of the O-ring the tube may not be heated for outgassing.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

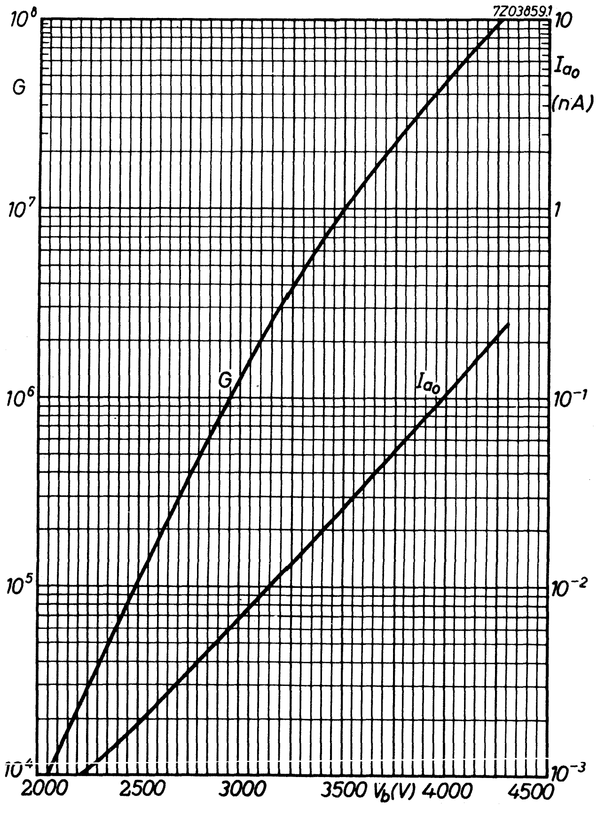
In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum.

A counter-flange with cock is delivered with the tube.



100
(%)
80
60
40
20
0
relative response of Ni cathode
7Z03858
1240Å
620Å
415Å
310Å
250Å
0
10
20
30
40
50
60
hυ (eV)

Fig.1


7Z03859.1
G
10^8
10^7
10^6
10^5
10^4
10
I_{ao}
(nA)
1
10^{-1}
10^{-2}
10^{-3}
G
I_{ao}
2000
2500
3000
3500
V_b(V)
4000
4500

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region (λ < 1400 Å) detection of ions (> 10 keV) and electrons (0.1 to 10 keV).

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 680 Å)	20	%
Useful area of the Cu Be O photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation.	10^{-5} to 10^{-6}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Cu-Be-O	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	680 ± 100	Å
Quantum efficiency for UV-photons at 680 Å	20	%

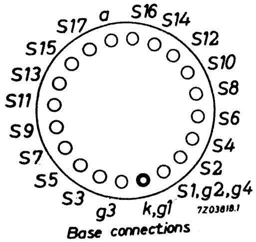
Multiplier system

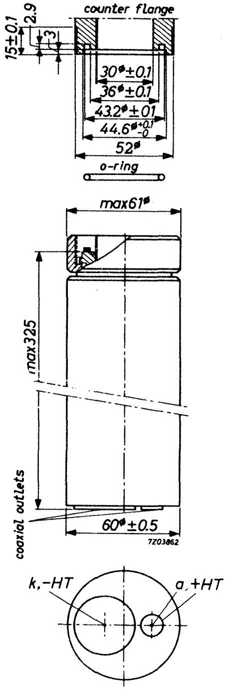
Number of stages	17
Dynode material	Cu-Be-O

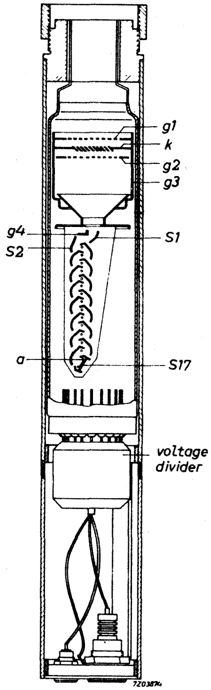
Capacitances

Anode to final dynode	C_a/S_{17}	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS Dimensions in mm







High voltage connector	"LEMO" type III C40 H.T.10
Signal connector	"LEMO" type OC50

TYPICAL CHARACTERISTICS

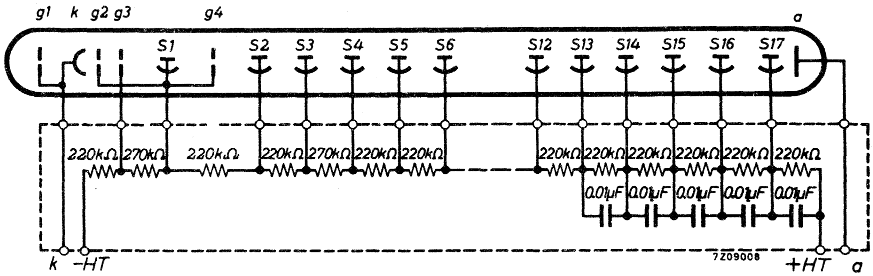
With potted voltage divider

Gain at V_b = 4000 V	G	av.	5.10^7	
Anode dark current at V_b = 4000 V	I_{a_o}	av.	10^{-4}	μA

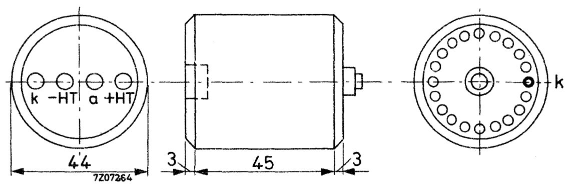
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max.	300	V
		min.	80	V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT



potted resistor chain type 56120



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[1]) When the tube is to be used at 5000 V preferable the cathode should be grounded.

[2]) The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a glass envelope which is sealed to a metal flange to facilitate mounting to a vacuum system (vacuum seal with O-ring). The glass envelope is protected by a nickel plated iron mantle, which contains a complete potted voltage divider. The external connections are made via two coaxial connectors. Because of the O-ring the tube may not be heated for outgassing.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum.

A counter-flange with cock is delivered with the tube.

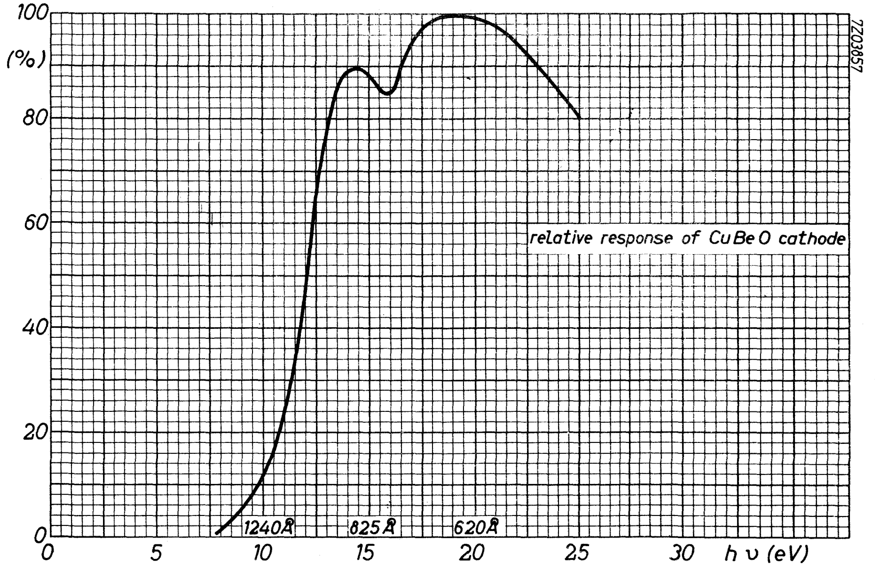
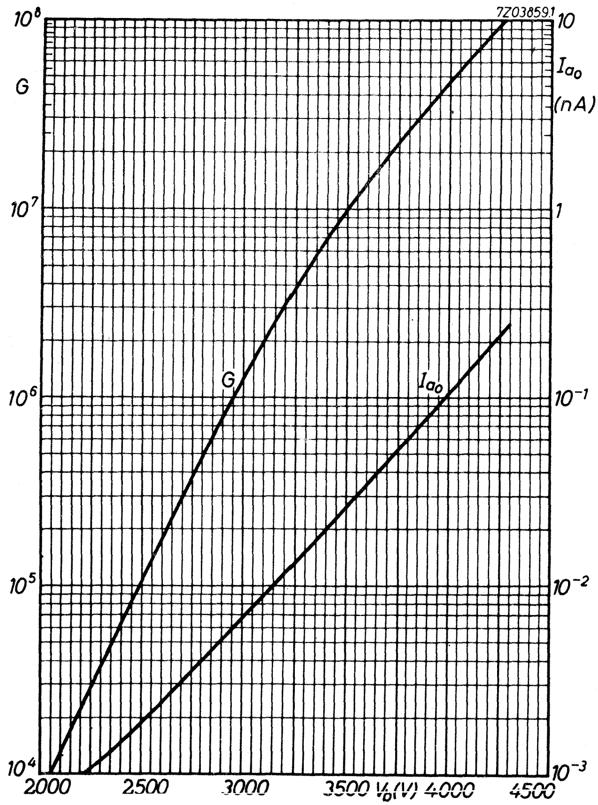

100
(%)
80
60
40
20
0
0
5
10
15
20
25
30
h υ (eV)
1240Å
825Å
620Å
relative response of CuBeO cathode
7203857

Fig.1


7Z03859.1
10^8
G
10^7
10^6
10^5
10^4
10
I_{a_0}
(nA)
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
2000
2500
3000
3500 V_b(V) 4000
4500

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region ($\lambda < 1500$ Å) and soft X-ray detection ($\lambda > 2$ Å) under ultra high vacuum conditions.

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 800 Å)	10	%
Useful area of the Ni photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation	10^{-5} to 10^{-10}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Ni	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	800 ± 100	Å
Quantum efficiency for UV-photons at 800 Å	10	%

Multiplier system

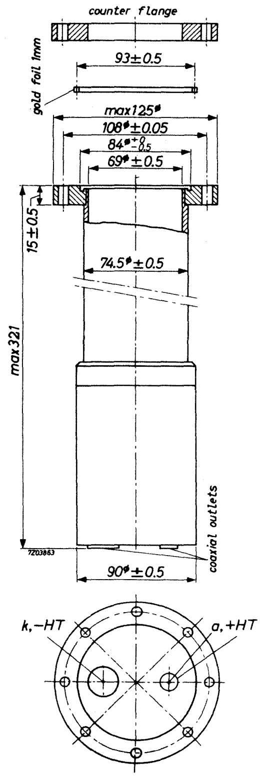
Number of stages	17
Dynode material	Cu-Be-O

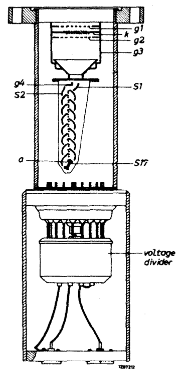
Capacitances

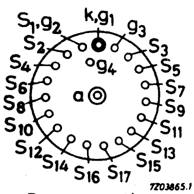
Anode to final dynode	7	pF
Anode to all other electrodes	9.5	pF

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Base connections

High voltage connector	"LEMO" type III C40 H.T.10
Signal connector	"LEMO" type OC50

TYPICAL CHARACTERISTICS

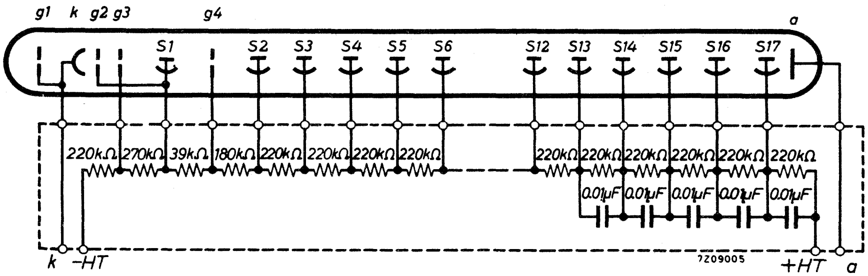
With potted voltage divider

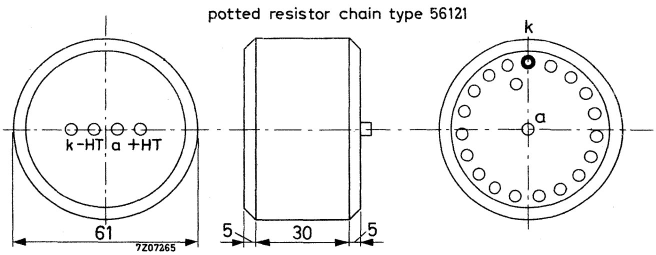
Gain at V_b = 4000 V	G	av.	5.10^7	
Anode dark current at V_b = 4000 V	I_{ao}	av.	10^{-4}	μA

LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max.	300	V
		min.	80	V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT





[1]) When the tube is to be used at about 5000 V preferable the cathode should be grounded, to avoid gas emission from the focusing electrodes of the input.

[2]) The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a stainless steel envelope and a heavy flange to facilitate mounting to a vacuum system (gold foil vacuum seal). The envelope contains also a complete potted voltage divider. The external connections are made via two coaxial connectors.

The tube may be heated to 300 ^oC for several hours to obtain an ultra high vacuum (10^{-10} mmHg), but this must be done with care. The temperature of the glass bottom with the pins must be kept always at about the same level as the one of the stainless steel flange by which it is carried. The potted resistor chain must be taken apart.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum. A counter flange with cock is delivered with the tube.

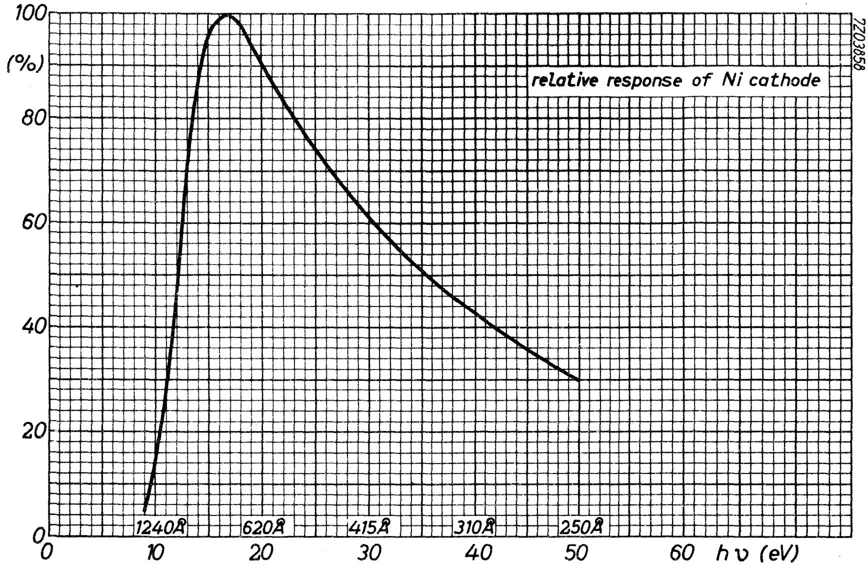
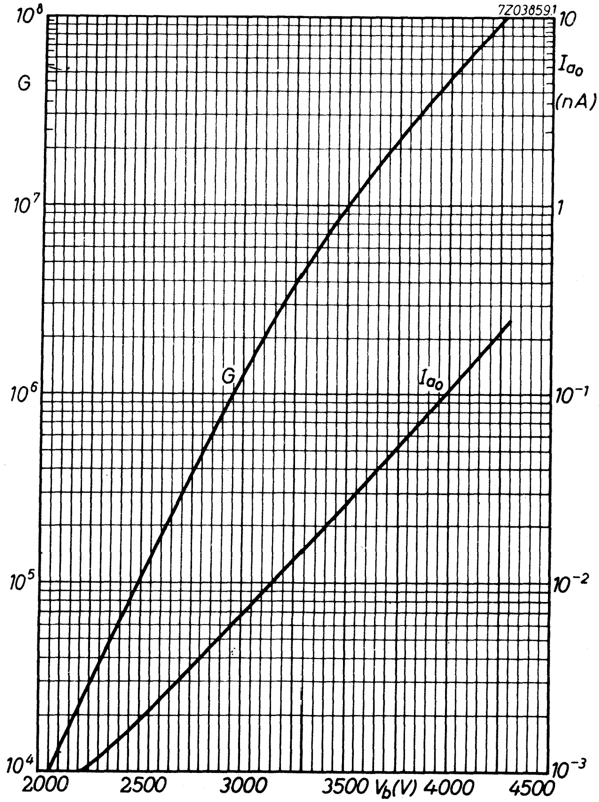

100
(%)
80
60
40
20
0
0
10
20
30
40
50
60
hν (eV)
1240Å
620Å
415Å
310Å
250Å
relative response of Ni cathode
7Z03858

Fig.1


7Z03859.1
10^8
G
10^7
10^6
10^5
10^4
10
I_ao
(nA)
1
10^-1
10^-2
10^-3
G
I_ao
2000
2500
3000
3500
V_b(V)
4000
4500

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region (λ < 1400 Å), detection of ions (> 10 keV) and electrons (0.1 to 10 keV), under ultra high vacuum conditions.

QUICK REFERENCE DATA		
Quantum efficiency for UV-photons (at 680 Å)	20	%
Useful area of the Cu Be O photocathode	22 x 22	mm^2
Gain (at 4000 V)	5.10^7	
Dark current (at 4000 V)	10^{-1}	nA
Pressure during operation	10^{-5} - 10^{-10}	mmHg
Potted voltage divider		

GENERAL

Photocathode

Description	opaque, head-on, venetian blind structure	
Cathode material	Cu-Be-O	
Minimum useful area	22 x 22	mm^2
Wavelength at maximum response (see fig.1)	680 ± 100	Å
Quantum efficiency for UV-photons at 680 Å	20	%

Multiplier system

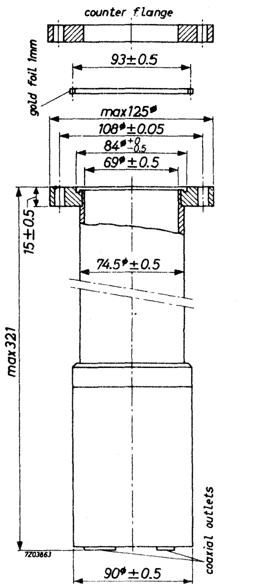
Number of stages	17
Dynode material	Cu-Be-O

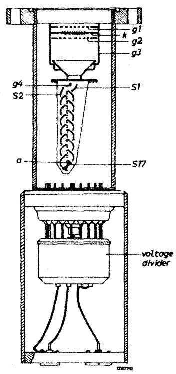
Capacitances

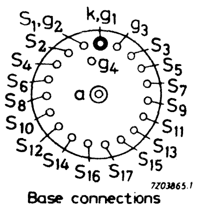
Anode to final dynode	C_a/S_{17}	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS

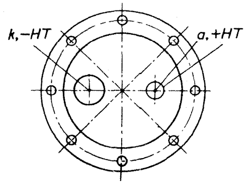
Dimensions in mm







Base connections



High voltage connector	"LEMO" type III C40 H.T.10
Signal connector	"LEMO" type OC50

TYPICAL CHARACTERISTICS

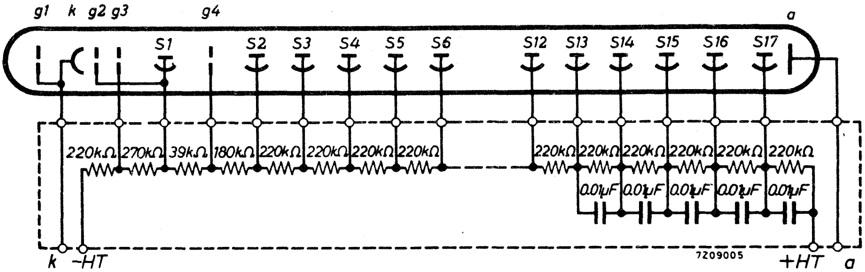
With potted voltage divider

Gain at V_b = 4000 V	G	av.	5.10^7
Anode dark current at V_b = 4000 V	I_{a_o}	av.	10^{-4} μA

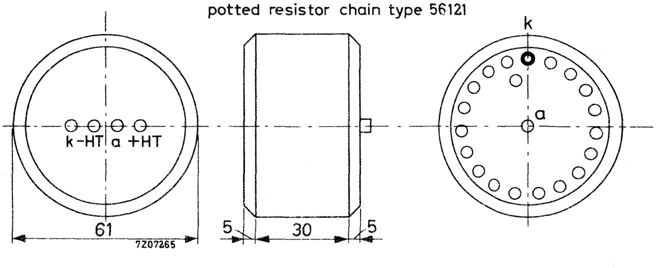
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	5000	V
Continuous anode current	I_a	max.	1	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max.	300	V
		min.	80	V
Pressure during operation [2]		max.	10^{-5}	mmHg

RECOMMENDED CIRCUIT



potted resistor chain type 56121



[1]) When the tube is to be used at about 5000 V preferable the cathode should be grounded, to avoid gas emission from the focusing electrodes of the input.

[2]) The HT shall never be applied to the tube when the inner pressure exceeds 10^{-5} mmHg.

OPERATIONAL CONSIDERATIONS

A good collection on the first dynode of the electrons originating from the cathode is obtained with the aid of an electrostatic focusing system equivalent to that in the 56AVP-family.

The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically necessary to operate the tube in a pulse circuit.

The tube has a stainless steel envelope and a heavy flange to facilitate mounting to a vacuum system (gold foil vacuum seal). The envelope contains also a complete potted voltage divider. The external connections are made via two coaxial connectors.

The tube may be heated to 300 ^{o}C for several hours to obtain an ultra high vacuum (10^{-10} mmHg), but this must be done with care. The temperature of the glass bottom with the pins must be kept always at about the same level as the one of the stainless steel flange by which it is carried. The potted resistor chain must be taken apart.

The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

In principle the electrodes are resistant to exposure to dry air but for longer periods in stock it is advised to keep the tube under primary vacuum. A counter flange with cock is delivered with the tube.

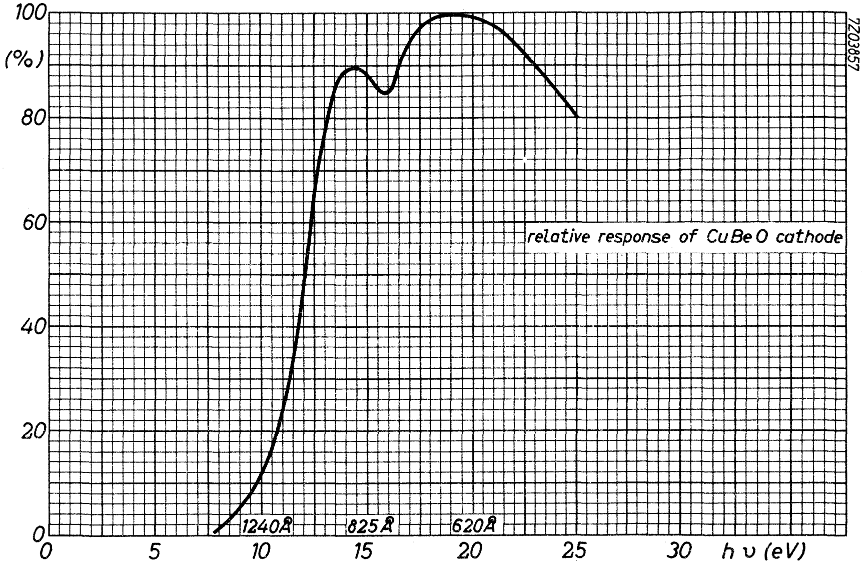
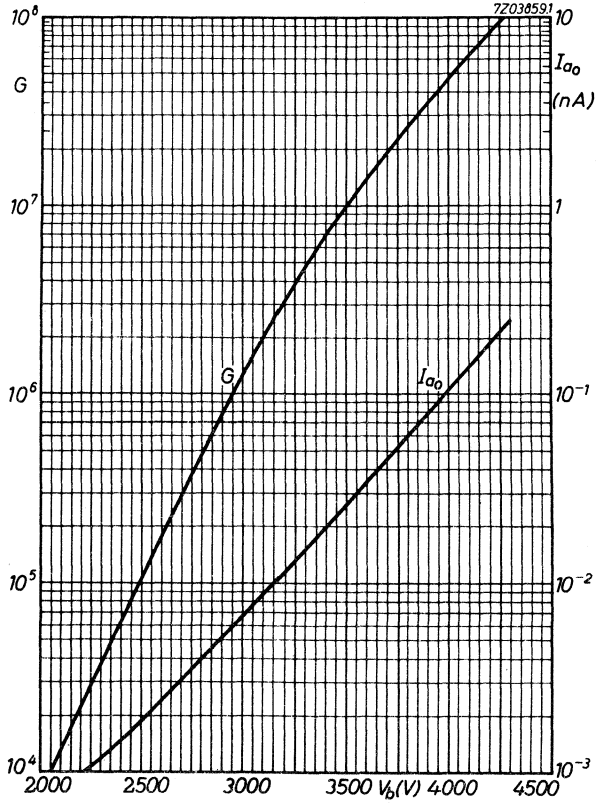

100
(%)
80
60
40
20
0
0
5
10
15
20
25
30
hυ (eV)
1240Å
825Å
620Å
relative response of CuBeO cathode
7Z03857

Fig.1


7Z03859.1
G
10^8
10^7
10^6
10^5
10^4
I_{a0}
(nA)
10
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a0}
2000
2500
3000
3500
V_b(V)
4000
4500

6 STAGE PHOTOMULTIPLIER TUBE

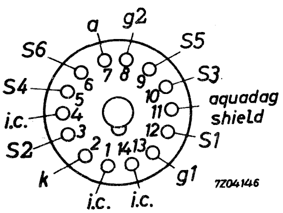
The tube is intended for use in plasma physics where high light flashes must be measured and other applications where a high degree of time definition and linearity is required.

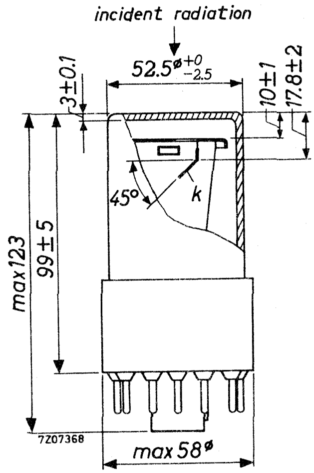
QUICK REFERENCE DATA		
Spectral response	type S4	
Useful window area	150	mm^2
Gain (at 3750 V)	10^4	
Anode pulse rise time	1.7	ns
Linearity	up to 2	A
Peak current	4	A

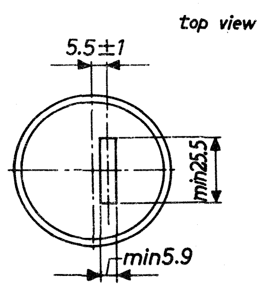
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56128

GENERAL

Photocathode

Description		opaque, head-on, flat window
Cathode material		Cs-Sb
Minimum useful window area		25.5 x 5.9 mm^2
Spectral response curve See page 4		type S4
Wavelength at maximum response		4000 ± 500 Å
Luminous sensitivity [1])	N_k	av. 45 μA/lm min. 25 μA/lm
Radiant sensitivity at 4200 Å		35 mA/W

Multiplier system

Number of stages	6
Dynode material	Ag-Mg-O-Cs

TYPICAL CHARACTERISTICS

With recommended voltage divider

Supply voltage for G = 10^4	V_b	av. 3750 V max. 5000 V
Anode dark current at G = 10^4 [2])	I_{a_o}	av. 0.03 μA max. 1 μA
Linearity (within 5%) between anode pulse amplitude and input light pulse		up to 2 A
Supply voltage for a linearity of 2 A	V_b	av. 6000 V max. 6500 V

[1]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[2]) At an ambient temperature of 25 °C

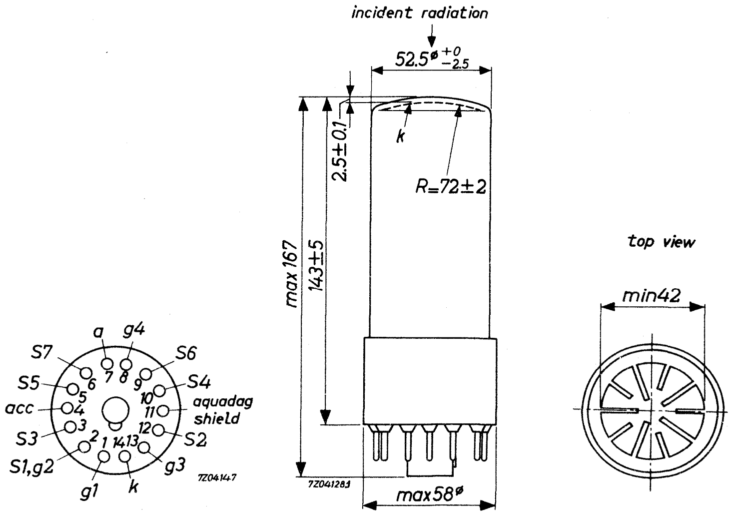
7 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in plasma physics where high light flashes must be measured and other applications where a high degree of time definition and linearity is required.

QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	42	mm
Gain (at 3500 V)	10^4	
Anode pulse rise time	1.9	ns
Linearity	up to 1	A
Peak current	3	A

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)



ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56130

GENERAL

Photocathode

Description		semi-transparent, low resistivity, head-on, curved surface		
Cathode material			Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature			72 ± 2	mm
Spectral response curve			type A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity 2)	N_k	av.	55	µA/lm
		min.	25	µA/lm
Radiant sensitivity at 4200 Å			50	mA/W

Multiplier system

Number of stages	7
Dynode material	Ag-Mg-O-Cs

TYPICAL CHARACTERISTICS

With recommended voltage divider

Supply voltage for G = 10^4	V_b	av.	3500	V
		max.	6500	V
Anode dark current at G = 10^4 3)	I_{a_o}	av.	0.1	µA
		max.	20	µA
Linearity (within 5%) between anode pulse amplitude and input light pulse		up to	1	A
Supply voltage for a linearity of 1 A	V_b	av.	6000	V
		max.	6500	V

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

3) At an ambient temperature of 25 °C

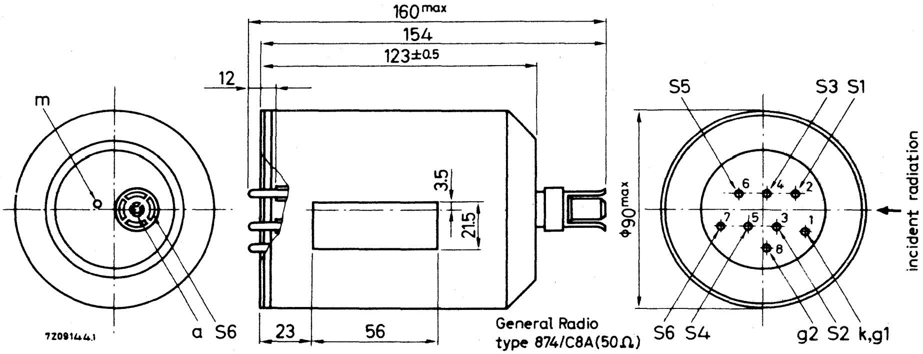
6 STAGE PHOTOMULTIPLIER TUBE

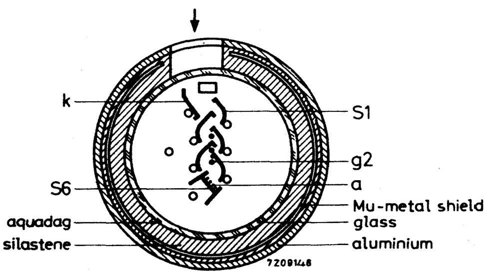
Photomultiplier tube intended for measuring very short light pulses having a very high luminous flux.

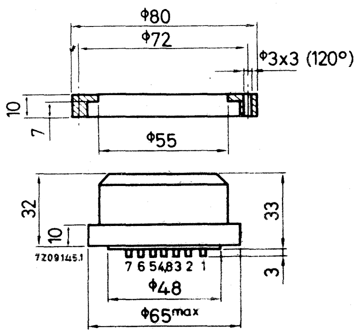
QUICK REFERENCE DATA		
Spectral response	type S4	
Useful area of the photocathode	280	mm^2
Gain (at 3500 V)	10^4	
Anode pulse rise time	1	ns
Coaxial outlet	50	Ω
Linearity	up to 5	A

DIMENSIONS AND CONNECTIONS

Dimensions in mm







socket

ACCESSORIES

Coaxial cable connector — "General Radio" type 874/C8A

Socket (see drawing above) — delivered with the tube

GENERAL

Photocathode

Description		opaque; lateral	
Cathode material		Cs-Sb	
Minimum useful area		280	mm^2
Spectral response curve		type S4	
Wavelength at maximum response		4000 ± 500	Å
Luminous sensitivity measured with a tungsten ribbon lamp	av.	40	μA/lm
having a colour temperature of 2854 °K	min.	25	μA/lm
Radiant sensitivity at 4000 Å		40	mA/W

Multiplier system

Number of stages	6	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_6	without coaxial connector	10	pF
		with coaxial connector	12	pF
Anode to all other electrodes	C_a		11	pF

TYPICAL CHARACTERISTICS

With recommended voltage divider

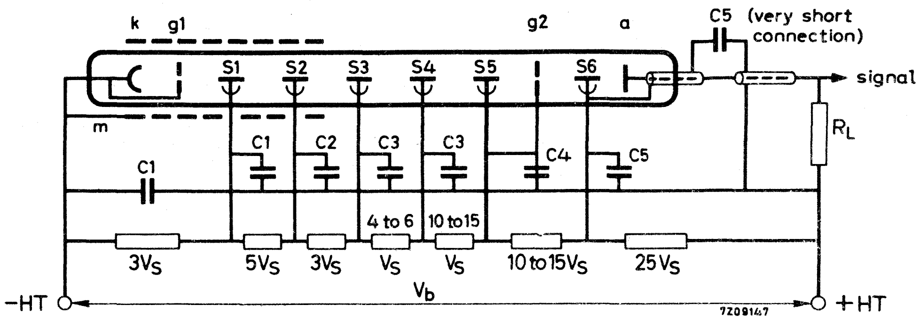
Supply voltage for G = 10^4 (See note 2, page 3)	V_b	av.	3500	V
		max.	7000	V
Anode dark current at G = 10^4 (ambient temperature 25 °C)	I_{a_o}	av.	1	μA
		max.	6	μA
Linearity (within 5%) between anode pulse amplitude and input light pulse		up to	5	A
Supply voltage for a linearity of 5 A	V_b	av.	6500	V
		max.	7000	V
Anode pulse rise time		<	1	ns [1]
Anode pulse width at half height		<	2	ns [1]
Total transit time			10	ns [1]

[1]) These time characteristics bear relation to an infinitely short light pulse, fully illuminating the photocathode and at V_b = 6500 V.

LIMITING VALUES (Absolute max. rating system)

Supply voltage 1) 2)	V_b	max.	7500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	1000	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	2000	V
Voltage between anode and final dynode 3)	V_{a/S_6}	max.	2750	V

RECOMMENDED CIRCUIT



Voltage divider 4)

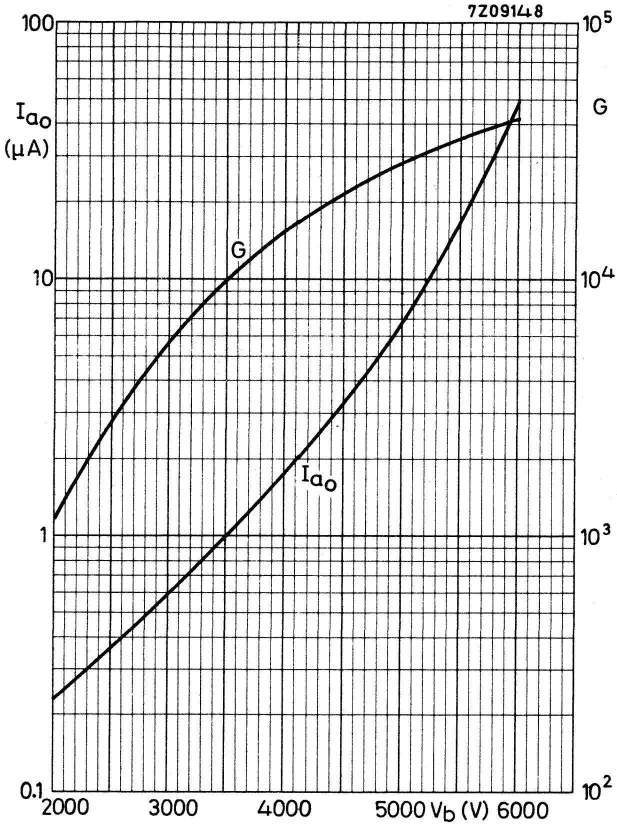
C_1 = 2.2 nF, 7.5 kV		Ceramic capacitors (low inductance)
C_2 = 2.2 nF, 7 kV		
C_3 = 2.2 nF, 6 kV		
C_4 = 30 nF, 4 kV		
C_5 = 50 nF, 3 kV		
R_L = 50 Ω		

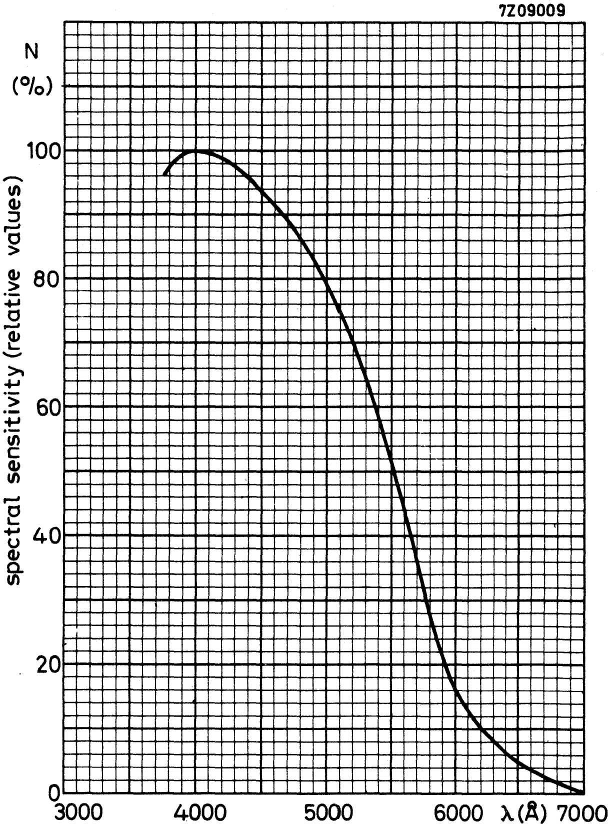
1) Or the voltage at which the tube circuited in above given voltage divider has a gain of 5.10^4, whichever is lowest.

2) If the tube has been out of use for some time it has to be reconditioned during 3 h for each week it has been inoperative. This is done by increasing the h.t. step by step from 2000 V up to the desired value during this reconditioning period. The tube must be placed in complete darkness.

3) When calculating the anode voltage the voltage drop in the load resistance should be overlooked.

4) Each tube is supplied with a certificate, indicating the exact voltage divider to obtain optimal performance.


7Z09148
100
10
1
0.1
I_{a_o}
(μA)
10^5
10^4
10^3
10^2
G
G
I_{a_o}
2000
3000
4000
5000 V_b (V) 6000



Spectral response curve type S4

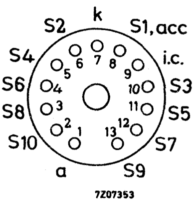
10 STAGE PHOTOMULTIPLIER TUBE

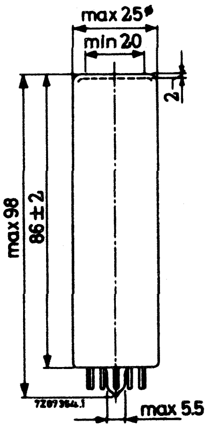
The tube is intended for use in applications such as X-ray spectrometry and scintillation counting, in small medical probes or in portable equipment or any optical or nuclear application in which a small diameter is required.

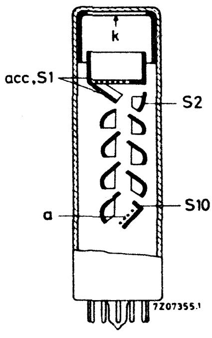
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	20	mm
Anode sensitivity (at 1800 V)	200	A/lm
Energy resolution for ^{137}Cs (0.661 MeV)	11	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 13-pin (glass)







ACCESSORIES

Socket	type B8 700 67
Mu-metal shield	type 56136
	type 56138

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			20	mm
Spectral response curve [1]			type A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	65	µA/lm
		min.	35	µA/lm
Radiant sensitivity at 4200 Å			50	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S10}$		1.3	pF
Anode to all other electrodes	C_a		3	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	200	A/lm
		min.	30	A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av.	5	nA
		max.	100	nA
Linearity between anode pulse amplitude and input light pulse		up to	5	mA
Energy resolution for ^{137}Cs (0.661 MeV)			11	%

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	10	mA
Anode pulse rise time at V_b = 1500 V [4]			5	ns
Anode pulse width at half height at V_b = 1500 V [4]			8.5	ns
Total transit time at V_b = 1500 V [4]			29	ns

---

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

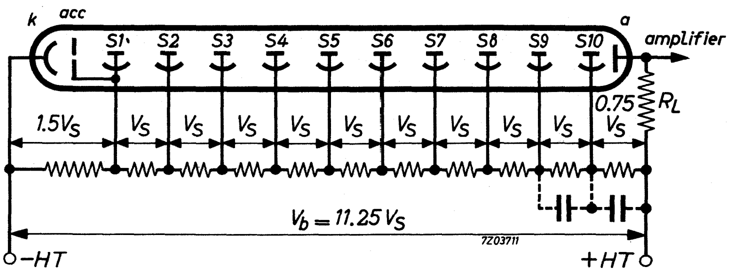
[3]) At an ambient temperature of 25 °C

[4]) For an infinitely short light pulse, fully illuminating the photocathode.

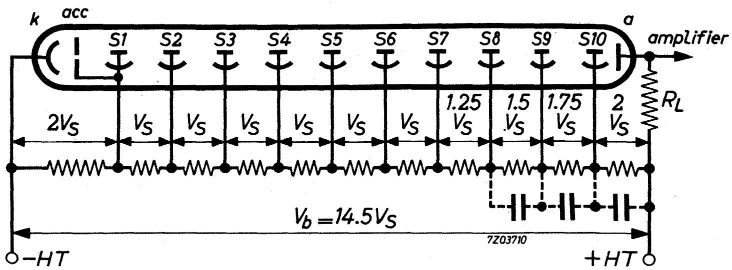
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.5	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	400	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	200	V
		min.	80	V
Voltage between anode and final dynode [1]	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

[1]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

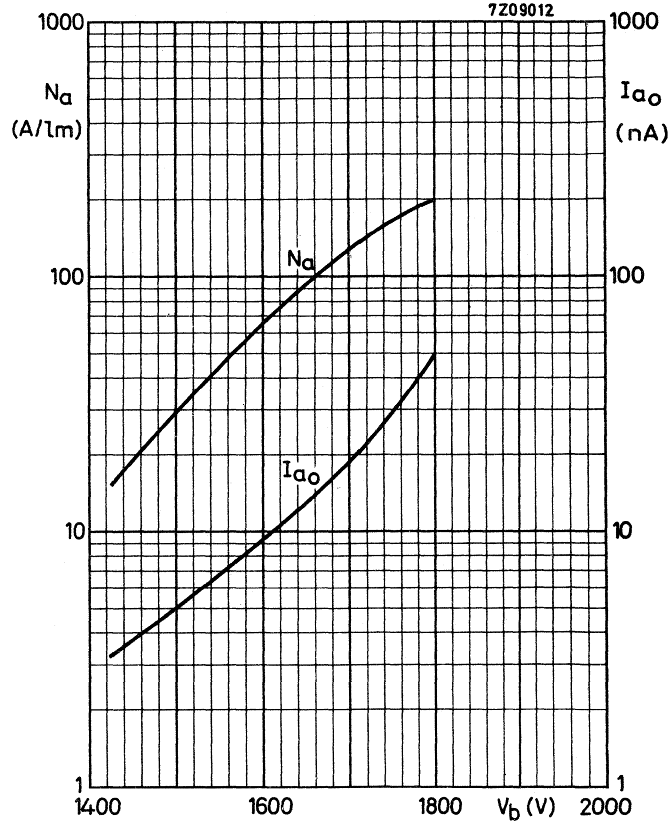
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

In pulse techniques, such as scintillation counting, it is advisable to decouple the last two or three stages by means of capacitors of approx. 100 pF, to avoid a serious voltage drop between these stages during a pulse.

With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver higher anode currents at the cost of the total gain.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against magnetic field influence.

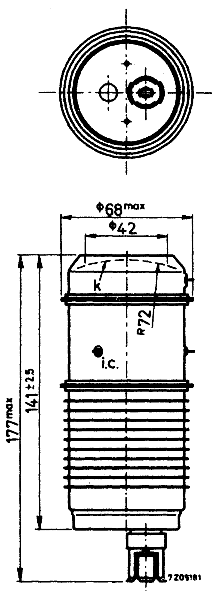

7Z09012
1000
100
10
1
N_a
(A/lm)
I_{ao}
(nA)
N_a
I_{ao}
1400
1600
1800
V_b (V)
2000

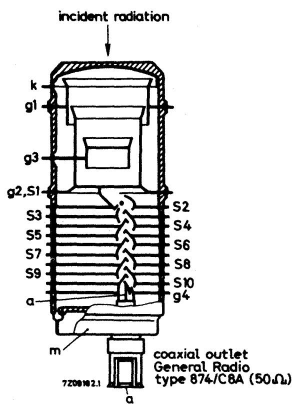
10 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in very fast light-pulse detection, life time of excited states, fast coincidence measurements, Cerenkov measurements etc.

QUICK REFERENCE DATA		
Spectral response		type A (S11)
Useful diameter of the photocathode	42	mm
Gain (at 4000 V)	10^7	
Anode pulse rise time	< 1	ns
Coaxial outlet	50	Ω
Linearity	min. up to 75	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

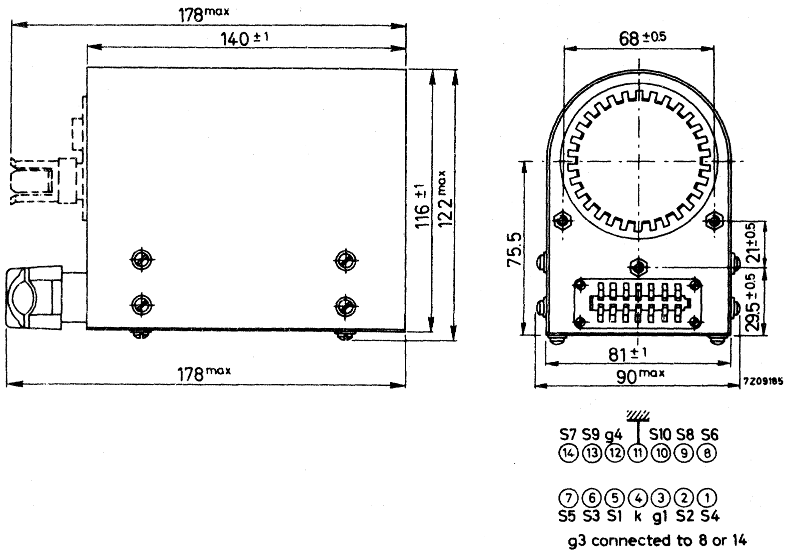




Data based on pre-production tubes.

ACCESSORIES

Socket type 56040



Coaxial cable connector General Radio type 874/C8A

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface
Cathode material		Cs-Sb
Minimum useful diameter		42 mm
Radius of curvature		72 mm
Spectral response curve [1]		type A (S11)
Wave length at maximum response		4200 ± 300 Å
Luminous sensitivity [2]	N_k	av. 45 μA/lm min. 25 μA/lm
Radiant sensitivity at 4200 Å		45 mA/W

Multiplier system

Number of stages		10
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to grid No.4	C_{ag_4}	4 pF
Anode to all other electrodes	C_a	6 pF
Decoupling capacitor between grid No.4 and outside of coaxial connector	C	400 pF

TYPICAL CHARACTERISTICS

With recommended voltage divider

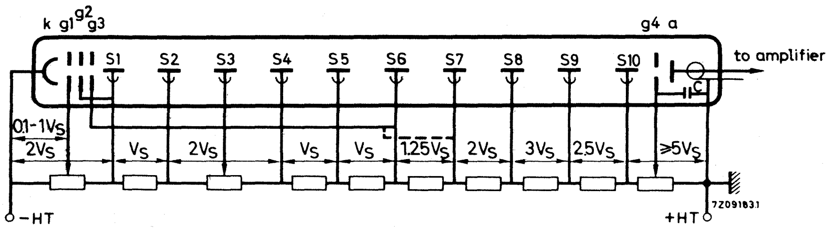
Supply voltage for G = 10^7	V_b	av. max.	4000 V 5000 V
Anode dark current at G = 10^7 [3]	I_{a_o}	max.	1 μA
Linearity within 5% between anode pulse amplitude and input light pulse		min.	up to 75 mA
Anode pulse rise time at V_b = 5000 V [4]		<	1 ns
Anode pulse width at half height at V_b = 5000 V [4]			1.5 ns
Transit time difference between the centre of the photocathode and the edge at V_b = 5000 V [4]		max.	0.2 ns
Total transit time at V_b = 5000 V [4]			20 ns

1) See spectral response curve in front of this section.
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K.
3) At an ambient temperature of 25 °C.
4) For an infinitely short light pulse, fully illuminating the photocathode.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 5000	V
Voltage between cathode and first dynode	V_k/S_1	max. 900	V
Voltage between grid No.2 and grid No.3	V_{g_2}/g_3	max. 1750	V
Voltage between consecutive dynodes	V_{S_n}/S_{n+1}	max. 900	V
Voltage between anode and grid No.4	V_a/g_4	max. 1500	V

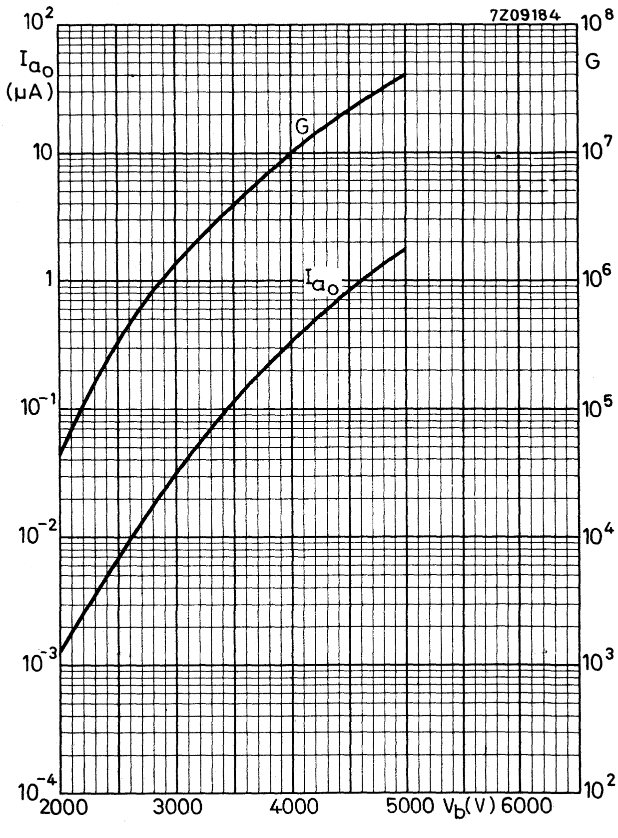
RECOMMENDED CIRCUIT



Voltage divider

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.
The voltage divider is designed to give optimum linearity, time characteristics and dark current at a gain of 10^7.
Each tube is accompanied by a certificate stating the divider to be used.
The disc shape of the dynode connections decreases their inductance and makes proper decoupling of the stages possible. This system results in a very rigid construction of the tube and considerably decreases the ion and light feed-back.
The accelerator electrode g_3 is connected to S6 or S7 inside the socket.
The decoupling capacitor C between g_4 and the anode outlet is mounted inside the tube.

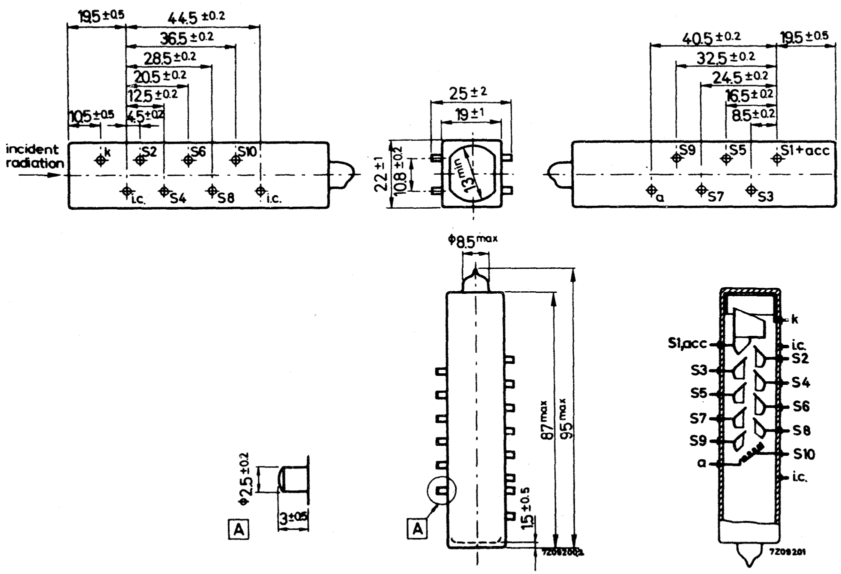

7Z09184
I_{a_0} (μA)
G
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^8
10^7
10^6
10^5
10^4
10^3
10^2
G
I_{a_0}
2000
3000
4000
5000
V_b(V)
6000

10 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use under severe shock and vibration conditions. Its very rugged construction makes it particularly suitable for geophysical and astronomical missile experiments.

QUICK REFERENCE DATA			
Spectral response	type A (S11)		
Useful diameter of the photocathode	min.	13	mm
Gain (at approx. 2100 V)		10^7	

DIMENSIONS AND CONNECTIONS Dimensions in mm



Data based on pre-production tubes.

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			13	mm
Spectral response curve [1]			type A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	µA/lm
		min.	35	µA/lm
Radiant sensitivity at 4200 Å			50	mA/W

Multiplier system

Number of stages	10	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S10}$	1.5	pF
Anode to all other electrodes	C_a	3.7	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for G = 10^7	V_b	av.	2100	V
		max.	3000	V
Anode dark current at G = 10^7 [3]	I_{ao}	max.	1	µA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 2400 V [4]		2.5	ns
Anode pulse width at half height at V_b = 2400 V [4]		4	ns
Total transit time at V_b = 2400 V [4]		19	ns

[1]) See spectral response curve in front of this section.

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K.

[3]) At an ambient temperature of 25 °C.

[4]) For an infinitely short light pulse, fully illuminating the photocathode.

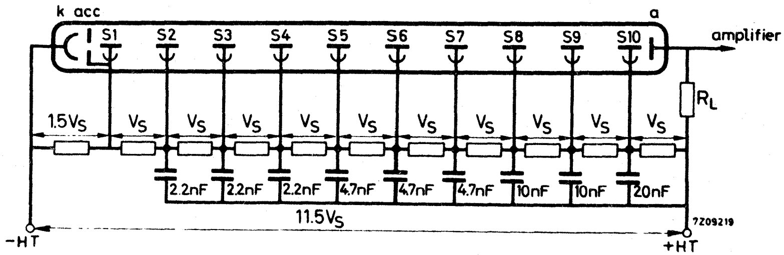
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	$V_{k/S1}$	max.	400	V
		min.	120	V
Voltage between consecutive dynodes	$V_{Sn/Sn+1}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S10}$	max.	300	V
		min.	80	V

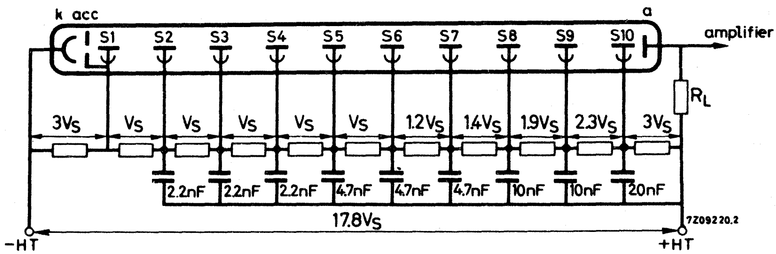
[1]) Or the voltage at which the tube circuited in the voltage divider A has a gain of 3.10^7, whichever is lowest.

[2]) When calculating the anode voltage the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider A



Voltage divider B

OPERATIONAL CONSIDERATIONS

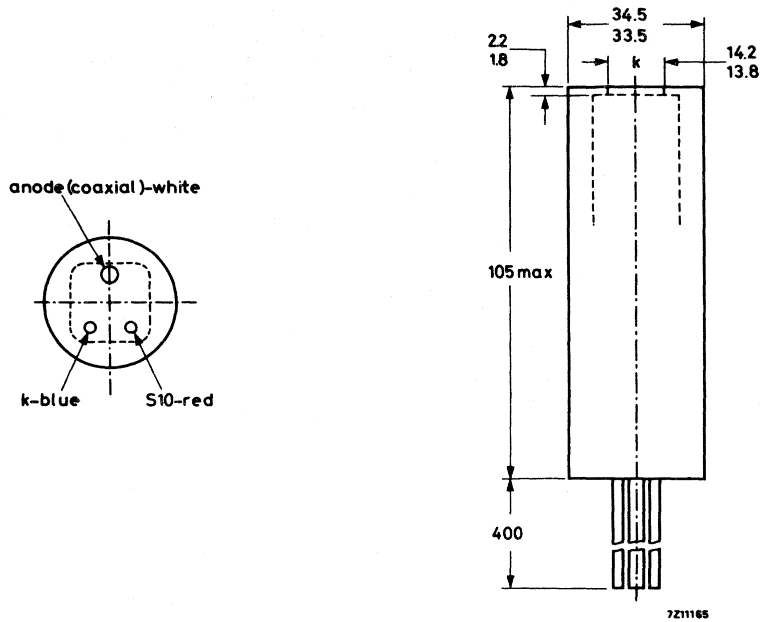
To prevent damage to the glass envelope and heating of the electrodes the connections should not be soldered to the contacts. The use of conductive epoxy cement is recommended.

XP1220/P

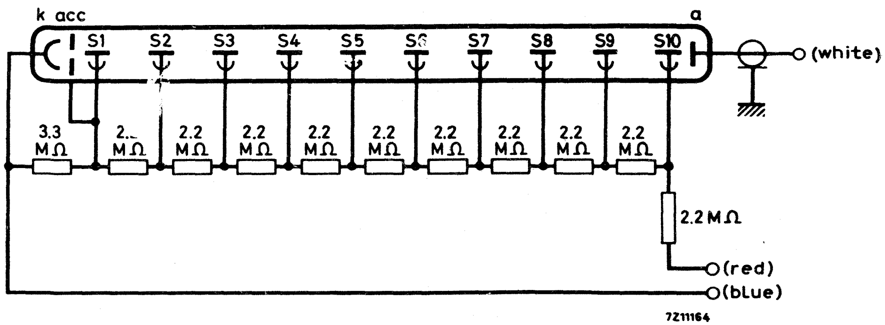
The tube XP1220 is also available with a voltage divider, mounted in a cylindrical envelope, with type number XP1220/P.

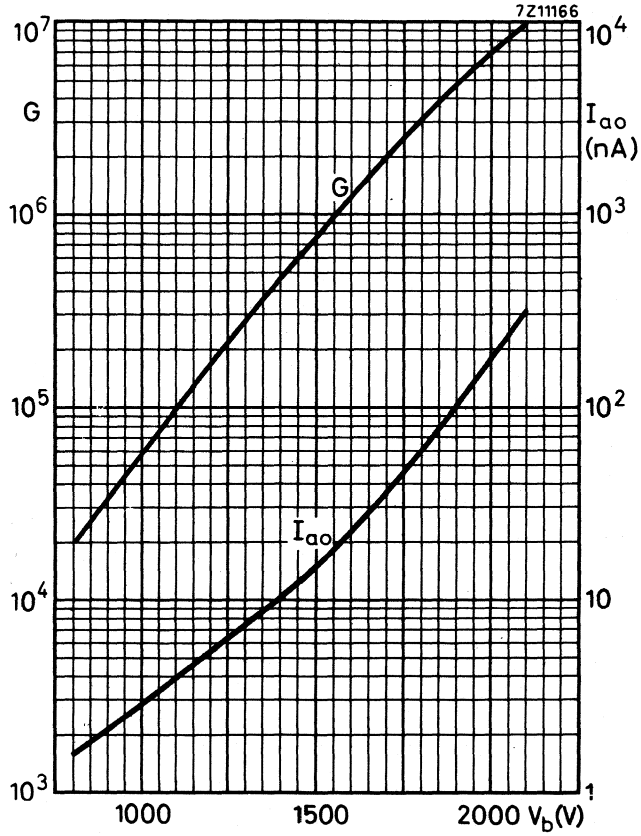
DIMENSIONS AND CONNECTIONS

Dimensions in mm



Voltage Divider.




7Z11166
10^7
G
10^6
10^5
10^4
10^3
10^4
I_{ao}
(nA)
10^3
10^2
10
1
G
I_{ao}
1000
1500
2000 V_b(V)

12 STAGE PHOTOMULTIPLIER TUBE

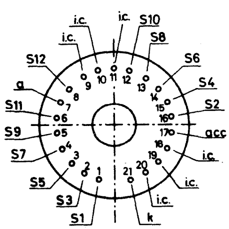
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. It features a high quantum efficiency, a high single photon efficiency and a very good collection efficiency.
The thin convex window is made of special low activity glass to obtain a low background.

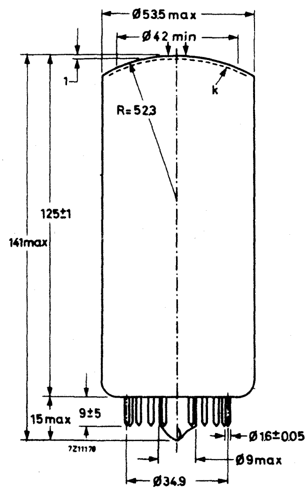
QUICK REFERENCE DATA		
Spectral response	bialkali type D	
Useful diameter of the photocathode	42	mm
Gain (at 2100 V)	10^8	
Anode pulse rise time	2.5	ns
Quantum efficiency (at 437 nm)	25	%
Efficiency for single photons (at 2100 V)	20	%
Collection efficiency	85	%

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 21-pin





Envelope

Material: Glass with low activity.

Data based on pre-production tubes.

ACCESSORIES

Socket	type FE2003
Mu-metal shield	type 56130

GENERAL

Photocathode

Description			semi-transparent, head-on curved surface	
Cathode material			K-Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature			52.3	mm
Spectral response curve (see page 5)			type D	
Wavelength at max. response			400 ± 30	nm
Radiant sensitivity at 437 mm			80	mA/W
Quantum efficiency	η_q	av.	25	%

Multiplier system

Number of stages	12
Dynode material	Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S12}$	6.5	pF
Anode to all other electrodes	C_a	7.7	pF

TYPICAL CHARACTERISTICS

With voltage divider A

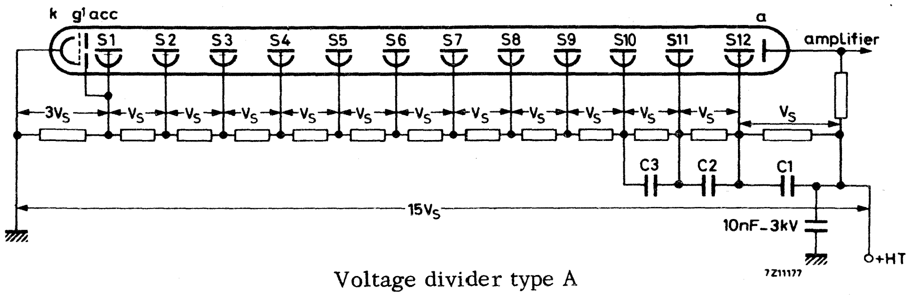
Supply voltage for G = 10^8	V_b	av.	2100	V
		max.	2500	V
Anode dark current at G = 10^8 1)	I_{ao}	max.	200	nA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Efficiency for single photons 2)	$\eta_{s.p.}$	av.	20	%
Supply voltage for $\eta_{s.p.}$ = 20% 2)	V_b	av.	2100	V
Background noise at V_b = 2100 V 1) 2)	B	av.	1500	counts/s
Anode pulse rise time at V_b = 2000 V 3)			2.5	ns
Anode pulse width at half height at V_b = 2000 V 3)			5	ns
Total transit time at V_b = 2000 V 3)			30	ns

Notes see page 3

LIMITING VALUES (Absolute max.rating system)

Supply voltage 4)	V_b	max.	2600	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	$V_{k/S1}$	max.	600	V
		min.	300	V
Voltage between consecutive dynodes	$V_{Sn/Sn+1}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode 5)	$V_{a/S12}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUIT



Voltage divider type A

k = cathode
g1 = focusing electrode
acc = accelerating electrode
Sn = Dynode No.n
a = anode

Decoupling capacitances:
C_1 = 100 q/V_S
C_2 = 100 q/3V_S
C_3 = 100 q/9V_S
with q = quantity of electricity transported by the anode

1) At an ambient temperature of 25 ^{o}C.

2) Measured with a threshold at the anode of the photomultiplier of 4.25×10^{-13} C.

3) For an infinitely short light pulse, fully illuminating the photocathode.

4) Or the voltage at which the tube circuited in the voltage divider A has a gain of 5.10^8 whichever is lowest.

5) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

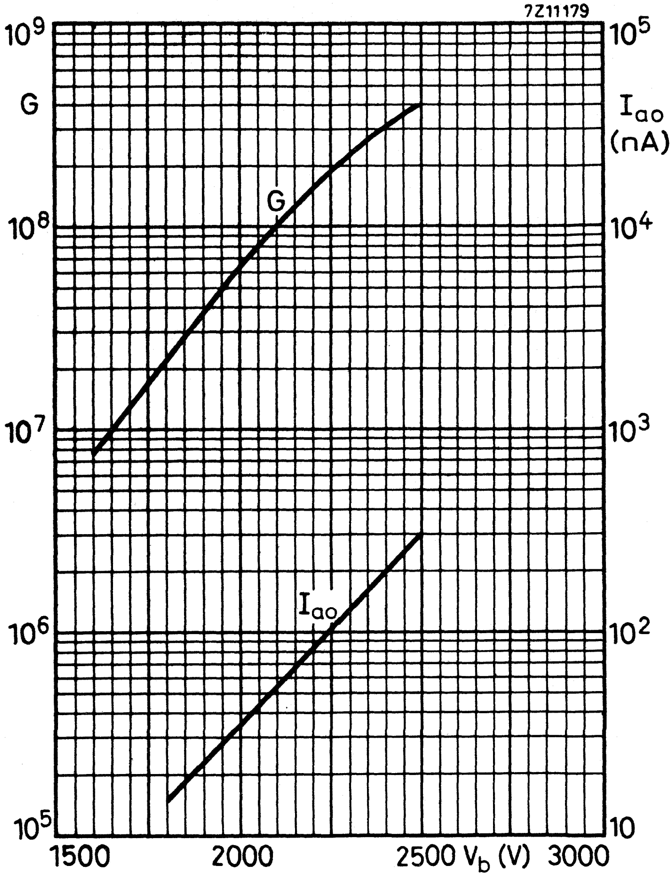
OPERATIONAL CONSIDERATIONS

Because of the resitivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at $-100\,^{o}C$.
The resistivity of the photocathode increases with decreasing temperature.
To achieve a stability of about 1% the ratio of the current through the voltage divider to that through the heaviest loaded stage of the tube should be approx.100.
The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

a. The electron optical input system consists of three elements:
   the photocathode k;
   the focusing electrode g_1, internally, connected to the cathode;
   the accelerating electrode acc, to be connected to the first dynode S_1
b. It is advisable to screen the tube with a mu-metal cylinder against magnetic field influences.
c. The single photon efficiency is measured with the tube circuited in voltage divider A and with a monochromatic light flux (λ = 424 nm) small enough to ensure that the interactions of the photons with the photocathode result in single photoelectron pulses. The supply voltage adjusted to obtain a gain of abt.10^8.
   The threshold at the anode of the tube is 4.25×10^{-13} C.

XP1230/A

The effect of the background noise of the photomultiplier can be minimized by making use of two tubes operating in coincidence. For this purpose particularly well matched pairs of tubes are available with type number XP1230/A.
The high voltages for these two tubes are equal within 10% at identical values of the gain.
Moreover they have a low value of $B_1 \times B_2$ (B_1 and B_2 being the values of the background noise of each tube).
Efficiency for ^3H detection measured with purified unquenched sample: min. 55%.


7Z11179
10^9
G
10^8
10^7
10^6
10^5
10^5
I_{ao} (nA)
10^4
10^3
10^2
10
G
I_{ao}
1500
2000
2500 V_b (V)
3000

12 STAGE PHOTOMULTIPLIER TUBE

The XP2020 is a 12-stage photomultiplier tube with a bialkali type D photocathode. It is intended for applications requiring good time resolution, and measurement of low-intensity light fluxes. The input optics provides an excellent time resolution and a typical collection efficiency of 88%.
With a high quantum efficiency and low background along with a high gain, it provides good detection of single photons and it is especially suited for use with fast scintillators and applications in coincidence measurements.

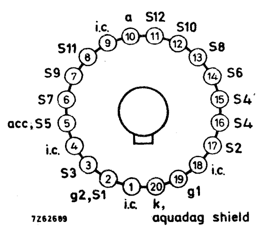
QUICK REFERENCE DATA		
Spectral response	bialkali type D	
Useful diameter of the photocathode	42	mm
Gain (at 3000 V)	10^8	
Quantum efficiency (at 400 nm)	25	%
Radiant sensitivity of the photocathode (at 437 nm)	85	mA/W
Collection efficiency	88	%.
Anode pulse rise time (at 2500 V)	1, 8	ns
Transit time fluctuation	0, 3	ns
Background noise	900	c/s

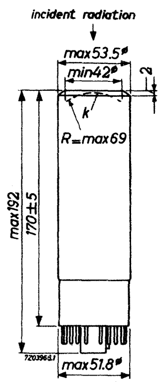
To be read in conjunction with "General Operational Recommendations Photomultiplier tubes"

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 20-pins (Jedec B20-102)





aquadag shield

Data based on pre-production tubes.

WEIGHT

Net weight		approx. 240	g

ACCESSORIES

Socket		type FE1003
Mu-metal shield		type 56130
		56131

GENERAL

Photocathode

Description	1)	semi-transparent, head-on	
Cathode material		K - Cs - Sb	
Useful diameter		> 42	mm
Spectral response curve		type D	
Wavelength at maximum response		400 ± 30	nm
Radiant sensitivity (at 437 nm)	2)	85	mA/W
Quantum efficiency (at 400 nm)	3)	25	%
Collection efficiency		88	%
Window material	4)	Borosilicate	
Window shape		plano-concave	
Radius of curvature		69	mm

Multiplier system

Dynode structure	in line, electrostatic focused	
Number of stages	12	
Dynode material	Ag - Mg	

Capacitances

Grid No. 1 to $(k + g_2 + acc + S1 + S5)$	$C_{g1/k, g2, acc, S1, S5}$	30	pF
Anode to final dynode	$C_{a/S12}$	< 7	pF
Anode to all other electrodes	C_a	< 9,5	pF

Notes see page 5.

TYPICAL CHARACTERISTICS

With voltage divider A

Gain at V_b = 2500 V		G		6×10^7	
Anode dark current at G = 10^8	5)	I_{a_o}	typ.	27	nA
			<	500	nA
Background noise at G = 10^7	6)		typ.	900	c/s
			<	2500	c/s

With voltage divider B

Gain at V_b = 2500 V		G		2×10^7	
Linearity (within 5%) between anode pulse amplitude and input light pulse			up to	250	mA
Maximum peak currents				0,5 to 1,0	A

With voltage divider B' and V_b = 2500 V

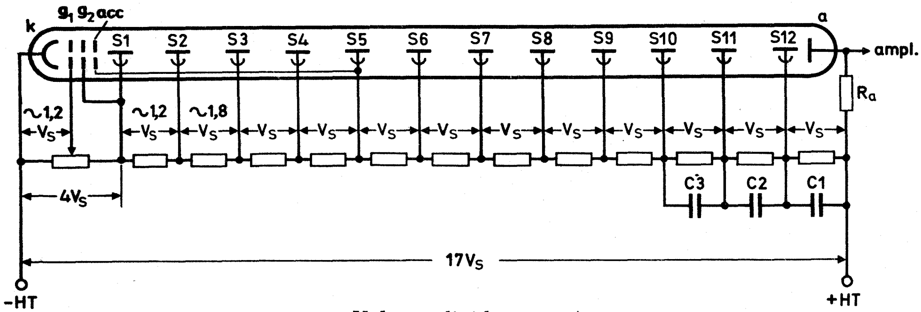
Gain		G		2×10^7	
Anode pulse rise time	7)			1,8	ns
Anode pulse width at half height				3	ns
Transit time difference between the centre of the photocathode and the edge				0,25	ns
			<	0,5	ns
Transit time fluctuation	7)			0,3	ns
Total transit time				30	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage		V_b	max.	3000	V 8)
Continuous anode current		I_a	max.	0,2	mA
Voltage between first dynode and cathode		$V_{k/S1}$	max.	800	V
			min.	210	V
Voltage between grid No. 1 (focusing electrode) and cathode		$V_{g1/k}$	max.	300	V
Voltage between consecutive dynodes		$V_{Sn/Sn-1}$	max.	400	V
Voltage between anode and final dynode	9)	$V_{a/S12}$	max.	600	V
			min.	80	V
Ambient temperature, operating	10)	t_{amb}	max.	70	°C
			min.	−30	°C

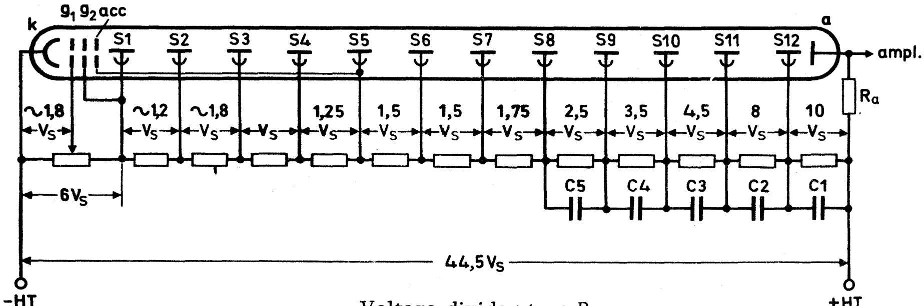
Notes see page 5 and 6.

RECOMMENDED CIRCUITS



Voltage divider type A

7Z62686

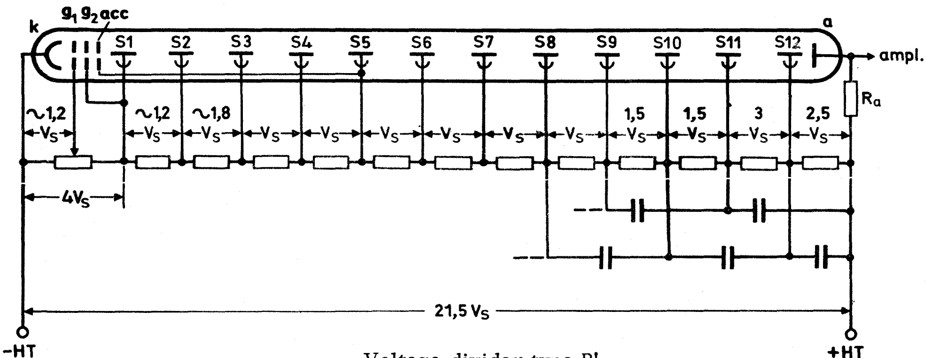


Voltage divider type B

7Z62687

$C_1 = 100\ Q/V_S$
$C_2 = 100\ Q/3V_S$
$C_3 = 100\ Q/9V_S$
$C_4 = 100\ Q/27V_S$

Q = charge transported to the anode during the anode current pulse



Voltage divider type B'

7Z62685

k = cathode
g_1, g_2 = focusing electrodes

S_n = dynode no. n
a = anode

NOTES

1) Because of the D-type photocathode, it is recommended not to expose the tube to too high radiation insentities. It is advisable to limit the cathode peak current to 10 nA at room temperature and to 0, 1 nA at -100 °C. The resistivity of the photocathode increases as the temperature decreases.

2) The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 437 ± 5 nm.

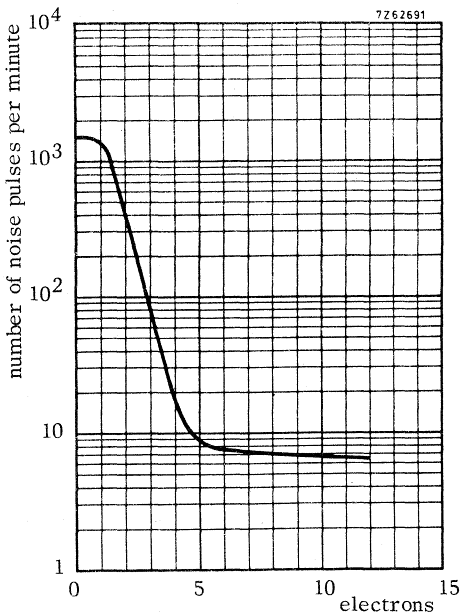
3) The quantum efficiency and radiant sensitivity have the following relation:

$$\text{Quantum efficiency } \eta_Q = N_{kr} \times \frac{1,24}{\lambda} \times 100\ \%$$

N_{kr} = the cathode radiant sensitivity at a wavelength λ and is expressed in mA/W.

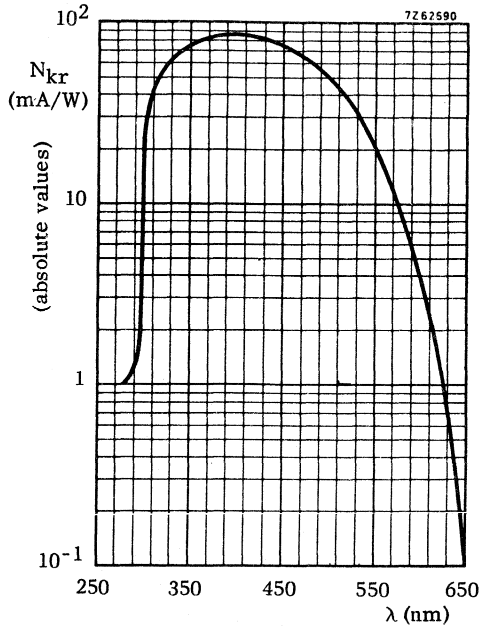
4) The window is made of special low activity glass to obtain a low background.

5) During normal operation it is recommendable to connect the photocathode to earth potential and the anode to positive high voltage.
As it is sometimes necessary to have the photocathode at positive high potential and the anode at earth potential, precautions should be taken to ensure a high voltage insulation between between the aquadag shield and the mu-metal shield greater than 10^{15} Ω. In this case the background and dark current may be higher than normal and somewhat unstable.

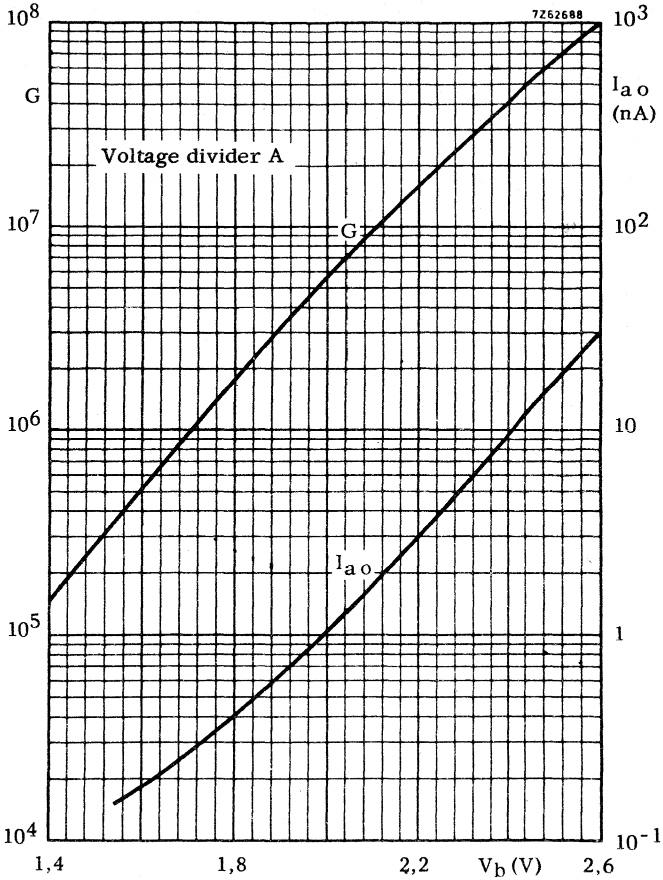


typical background spectrum from 1/10 to 10 equivalent photoelectrons at a gain of 3×10^7 with voltage divider A 6)

6) The background noise is the summation between 1/10 equivalent photoelectron and infinity. The measurement is made at a detection threshold of 4, 24 x 10^{-13} C.
7) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.
8) Or the voltage at which the tube circuited in voltage divider A has a gain of 5 x 10^{8}, whichever is lowest.
9) When calculating the anode voltage, the voltage across the load-resistance should be taken into account.
10) The temperature range is limited by mainly mechanical stresses which may arise in the base. For temperatures below −30 °C type XP2020/UB (= XP2020 without base) is recommended.
11) It is strongly recommended to screen the tube with a mu-metal shield against the influence of magnetic fields.
Under conditions of fully illuminated photocathode, the anode current will decrease by a factor of 2 when a magnetic field is applied :
a) perpendicular to the dynodes with a field intensity of 0, 13 mT.
b) parallel to the dynodes with a field intensity of 0, 07 mT.



Spectral response curve Type D


7Z62688
10^8
G
10^7
10^6
10^5
10^4
10^3
$I_{a\,o}$
(nA)
10^2
10
1
10^{-1}
Voltage divider A
G
$I_{a\,o}$
1,4
1,8
2,2
V_b (V)
2,6

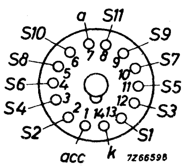
11 STAGE PHOTOMULTIPLIER TUBE

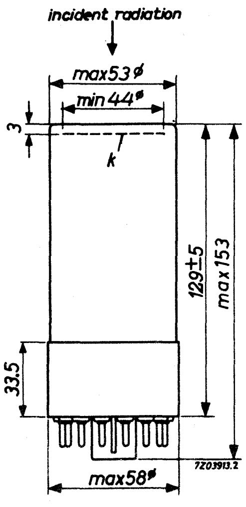
The tube is intended for use in applications such as scintillation counting of α, β, γ, n radiation and X-rays, in flying-spot apparatus and different kinds of optical instruments.

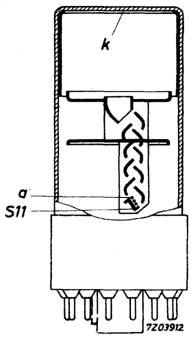
QUICK REFERENCE DATA		
Spectral response	type	Super A
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minium useful diameter			44	mm
→ Spectral response curve [1]		type	SuperA	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4200 Å			60	mA/W

Multiplier system

Number of stages			11	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{11}}$		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	400	A/lm
		min.	250	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	15	nA
		max.	50	nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

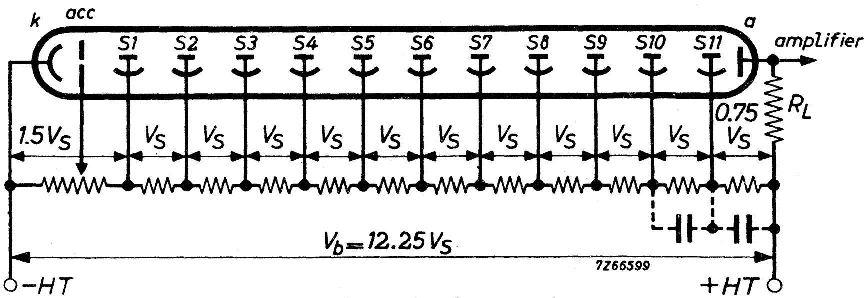
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		5	ns
Anode pulse width at half height at V_b = 1500 V [1]		14	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		45	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

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

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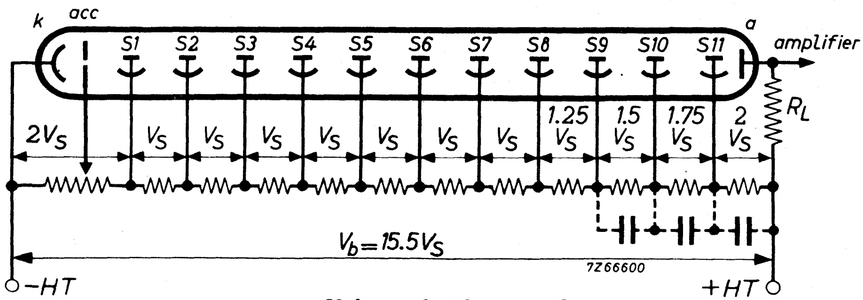
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

11 STAGE PHOTOMULTIPLIER TUBE

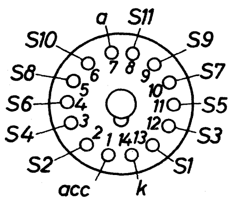
The tube is intended for use in spectrometry where low luminous fluxes are to be measured, e.g. radiation detection in which it is to be used in conjunction with scintillators.

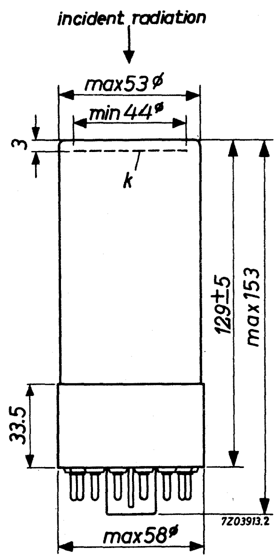
QUICK REFERENCE DATA		
Spectral response	type D	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

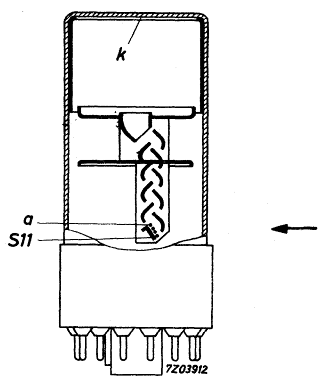
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56128

Data based on pre-production tubes.

GENERAL

Photocathode

Description		semi-transparent, head-on, flat-surface	
Cathode material		Sb-K-Cs (bi-alkali)	
Minimum useful diameter		44	mm
Spectral response curve (See Application directions)		type D	
Wavelength at maximum response		400 ± 30	nm
Luminous sensitivity, measured with a tungsten ribbon lamp having a colour temperature of 2854 K	N_k	av. 70	μA/lm
		min. 30	μA/lm
Radiant sensitivity at 437 ± 5 nm		75	mA/W

Multiplier system

Number of stages	11	
Dynode material	Ag-Mg-O-Cs	

CAPACITANCES

Anode to final dynode	$C_{aS_{11}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	400	A/lm
		min.	100	A/lm
Anode dark current at N_a = 60 A/lm (T_{amb} = 25 ^oC)	I_{a_o}	max.	50	nA
Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V		up to I_{a_p}	30	mA

TYPICAL CHARACTERISTICS (continued)

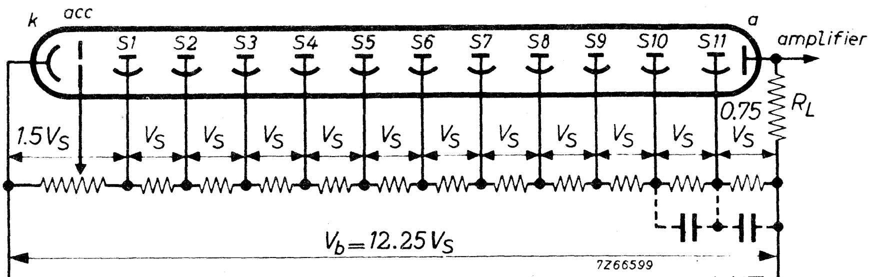
With voltage divider B

Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V	up to I_{ap} =	100	mA	
Anode pulse rise time at V_b = 1500 V for an infinitely short light pulse	max.	5	ns	2)
Transit time difference between the centre of the photocathode and the edge; V_b = 1500 V		4	ns	
Total transit time at V_b = 1500 V		45	ns	2)
Anode pulse width at halfheight at V_b = 1500 V		13	ns	2)

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	200	µA
Voltage between cathode and first dynode	$V_{k/S1}$	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{Sn/Sn+1}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [1]	$V_{a/S11}$	max.	300	V
		min.	80	V
Ambient temperature	t_{amb}	max.	+65	°C

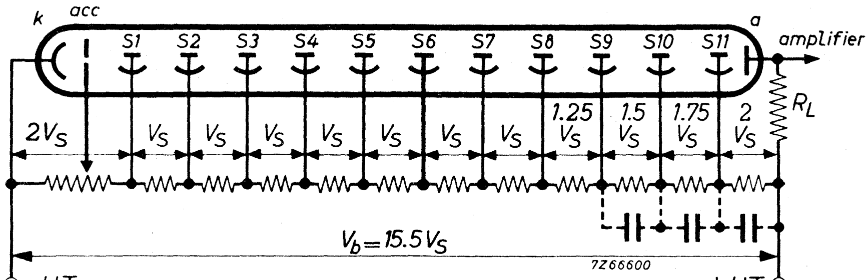
RECOMMENDED CIRCUITS



Voltage divider A

[1] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.
[2] For an infinitely short light pulse, fully illuminating the cathode.

RECOMMENDED CIRCUITS (continued)



Voltage divider B

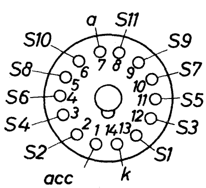
11 STAGE PHOTOMULTIPLIER TUBE

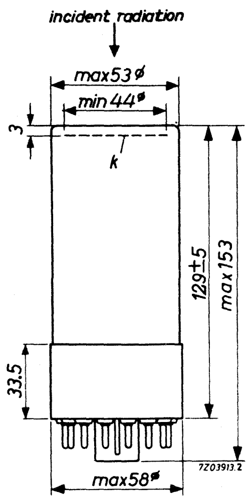
The tube is intended for optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

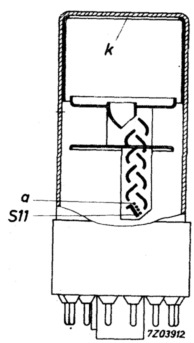
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			44	mm
Spectral response curve [1]			type U (S13)	
Wavelength at maximum response			4000 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4000 Å			60	mA/W

Multiplier system

Number of stages		11
Dynode material		Ag-Mg-O-Cs

Capacitances

Anode to final dynode	C_a/S_{11}	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	400	A/lm
		min.	250	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	15	nA
		max.	50	nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

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[1] See spectral response curve in front of this section

[2] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3] At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

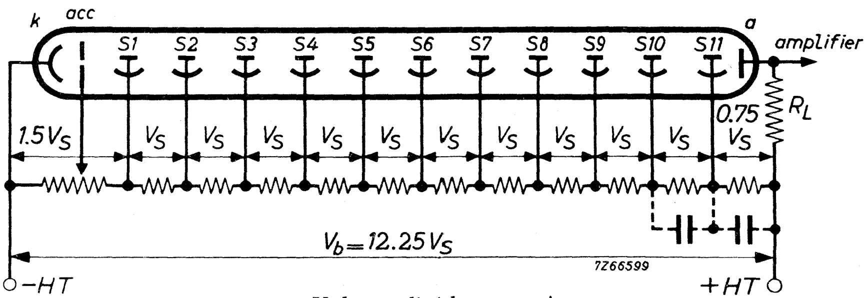
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		5	ns
Anode pulse width at half height at V_b = 1500 V [1]		14	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		45	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



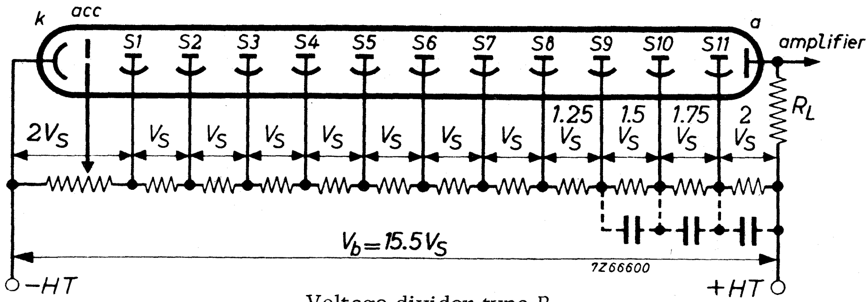
Voltage divider type A

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

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA to 1 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of mangetic fields.

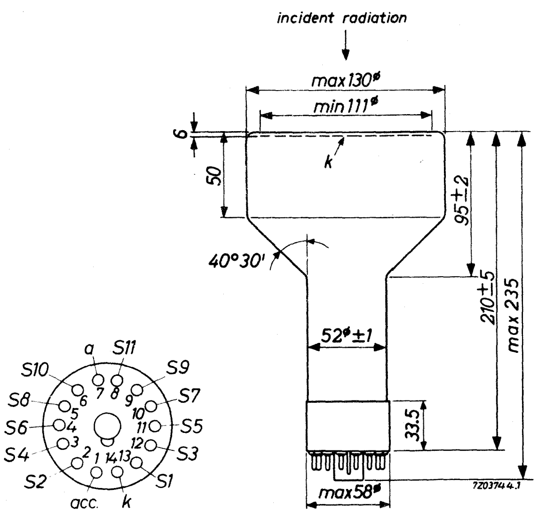
11 STAGE PHOTOMULTIPLIER TUBE

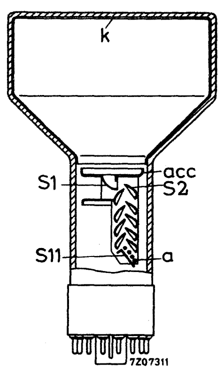
The tube is intended for use in applications such as scintillation counting with large crystals, or applications in which light must be gathered from a diffusely reflecting surface (e.g. flying-spot techniques in colour printing) or from a distant source.

QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	111	mm
Anode sensitivity (at 1800 V)	500	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56129

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			111	mm
Spectral response curve 1)			type A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity 2)	N_k	av.	60	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4200 Å			50	mA/W

Multiplier system

Number of stages	11
Dynode material	Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S_{11}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	500	A/lm
		min.	100	A/lm
Anode dark current at N_a = 250 A/lm 3)	I_{a_o}	av.	0.2	μA
		max.	0.5	μA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

1) See spectral response curve in front of this section
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K
3) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

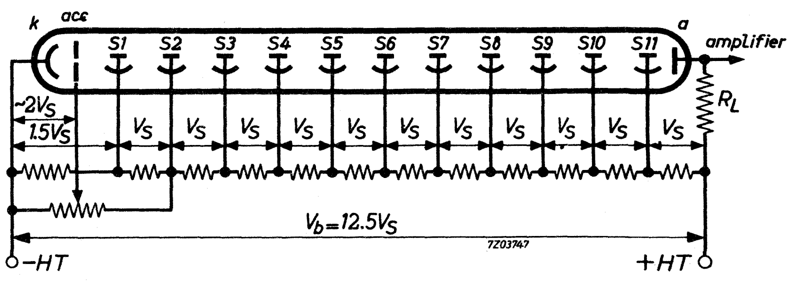
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1800 V 1)		15	ns
Anode pulse width at half height at V_b = 1800 V 1)		35	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		15	ns
Total transit time at V_b = 1800 V 1)		120	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode 2)	$V_{a/S_{11}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS

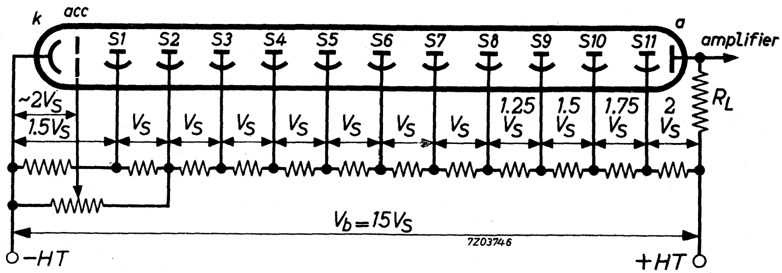


Voltage divider type A

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

1) For an infinitely short light pulse, fully illuminating the photocathode.
2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 1 mA will be sufficient.

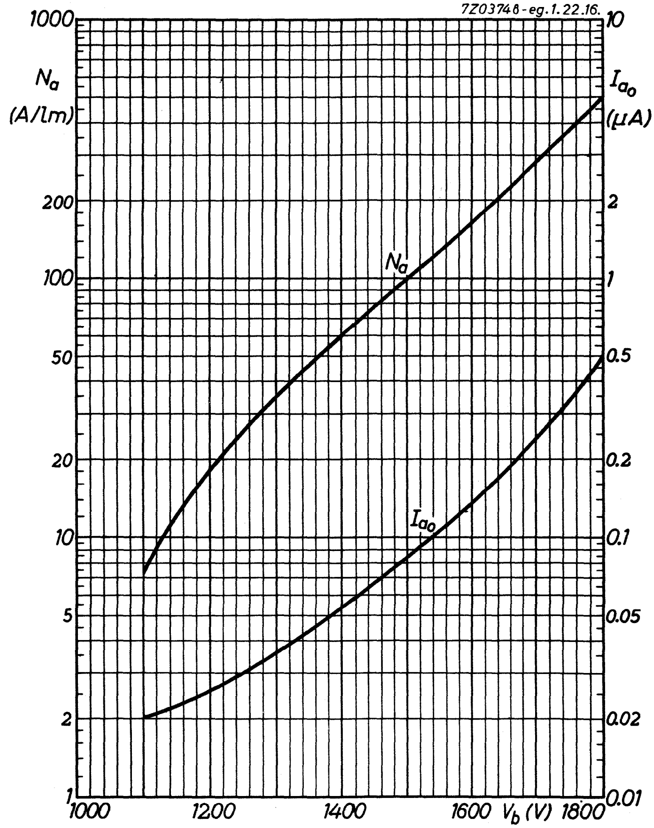
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

In pulse techniques, such as scintillation counting, it is advisable to decouple the last two or three stages by means of capacitors of 100 pF and 200 pF (the highest value at the last stage).

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.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N_a
(A/lm)
I_{a_0}
(µA)
1000
200
100
50
20
10
5
2
1
10
2
1
0.5
0.2
0.1
0.05
0.02
0.01
N_a
I_{a_0}
1000
1200
1400
1600
V_b (V)
1800

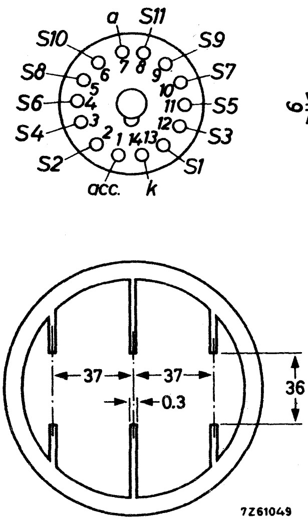
11 STAGE PHOTOMULTIPLIER TUBE

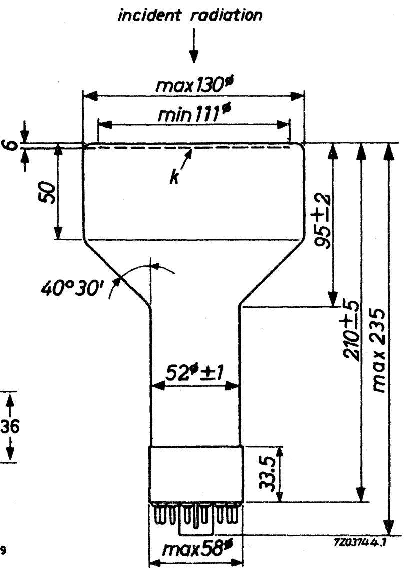
The tube is intended for use in, for instance, scintillation counting with large crystals.

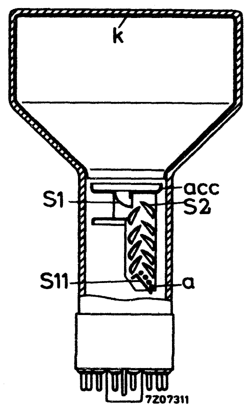
QUICK REFERENCE DATA		
Spectral response	type D	
Useful diameter of the photocathode	111	mm
Anode sensitivity (at 1800 V)	500	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56129

Data based on pre-production tubes.

GENERAL

Photocathode

Description			semi-transparent, head-on, flat surface	
Cathode material			Sb-K-Cs	
Minimum useful diameter			111	mm
Spectral response curve (See Application directions)			type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity, measured with a tungsten ribbon lamp having a colour temperature of 2850 K	N_k	av.	60	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 400 nm			50	mA/W

Multiplier system

Number of stages			11	
Dynode material			Ag-Mg-O-Cs	

CAPACITANCES

Anode to final dynode	$C_{aS_{11}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	500	A/lm
		min.	100	A/lm
Anode dark current at N_a = 250 A/lm (t_{amb} = 25 °C)	I_{a_o}	max.	500	nA
Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V		up to I_{a_p} =	30	mA

TYPICAL CHARACTERISTICS (continued)

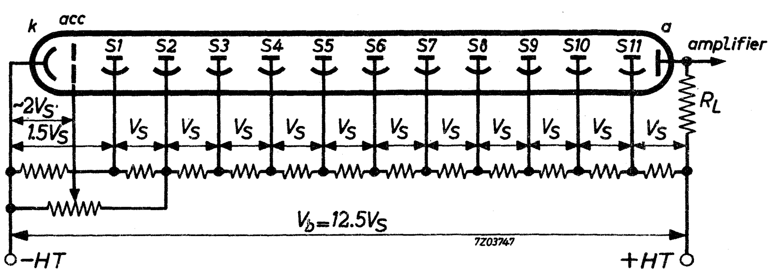
With voltage divider B

Linearity between anode pulse amplitude and input light pulse at V_b = 1800 V	up to	100	mA	
Anode pulse rise time at V_b = 1800 V for an infinitely short light pulse		15	ns	2)
Transit time difference between the centre of the photocathode and the edge; V_b = 1800 V		15	ns	
Total transit time at V_b = 1800 V		120	ns	2)
Anode pulse width at half height (V_b = 1800 V)		35	ns	2)

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	100	µA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode 1)	$V_{a/S_{11}}$	max.	300	V
		min.	80	V
Ambient temperature	t_{amb}	max.	+65	°C

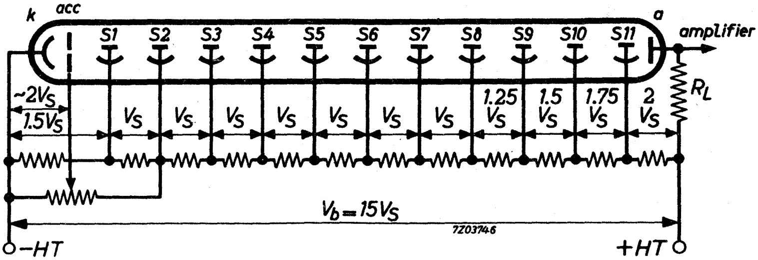
RECOMMENDED CIRCUITS



Voltage divider A

1) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.
2) For an infinitely short light pulse, fully illuminating the cathode.

RECOMMENDED CIRCUITS (continued)



Voltage divider B

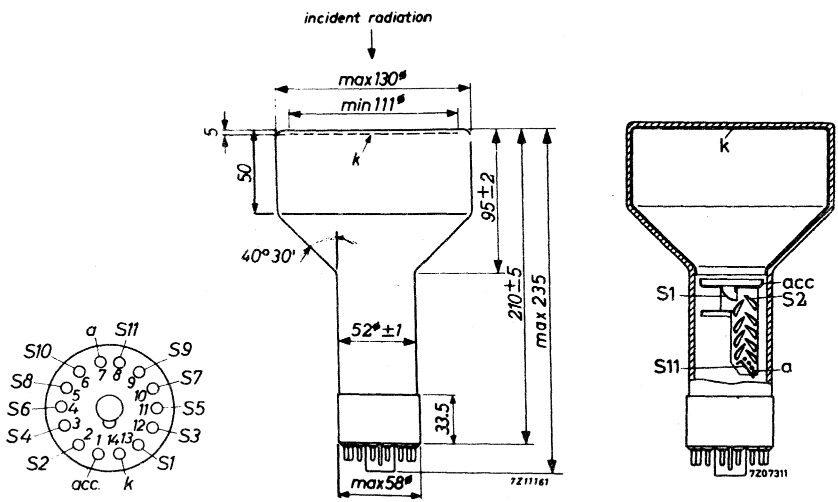
11 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in applications which require a good sensitivity in the ultra-violet region, combined with a photosensitive area larger than usual.

QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	111	mm
Anode sensitivity (at 1800 V)	500	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (B14-38)



ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56129

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			111	mm
Spectral response curve [1]			type U (S13)	
Wave length at maximum response			4000 ± 300	Å
Luminous sensitivity [2]	N_k	av.	60	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4000 Å			50	mA/W

Multiplier system

Number of stages			11	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{11}}$		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	500	A/lm
		min.	100	A/lm
Anode dark current at N_a = 250 A/lm [3]	I_{a_o}	av.	0.2	μA
		max.	0.5	μA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

[1] See spectral response curve in front of this section
[2] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K
[3] At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

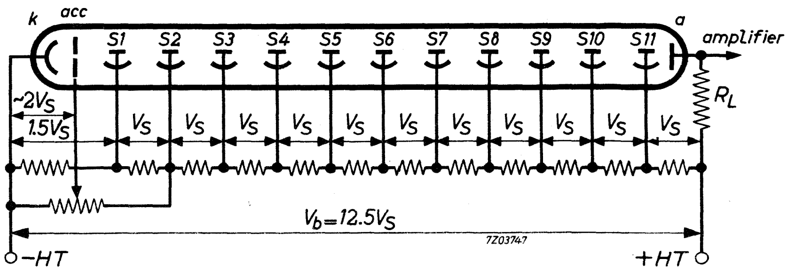
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1800 V [1]		15	ns
Anode pulse width at half height at V_b = 1800 V [1]		35	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		15	ns
Total transit time at V_b = 1800 V [1]		120	ns

LIMITING VALUES

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



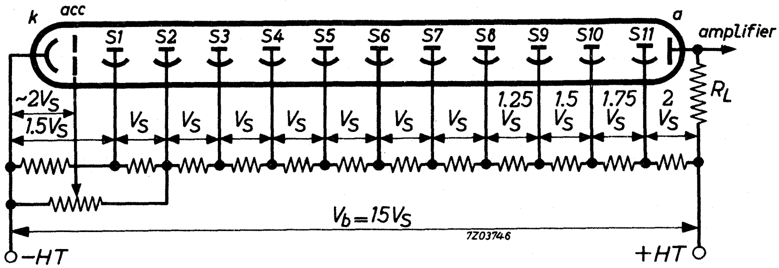
Voltage divider type A

k = cathode
acc = accelerating electrode

S_n = dynode No.n
a = anode

1) For an infinitely short light pulse, fully illuminating the photocathode.
2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 1 mA will be sufficient.

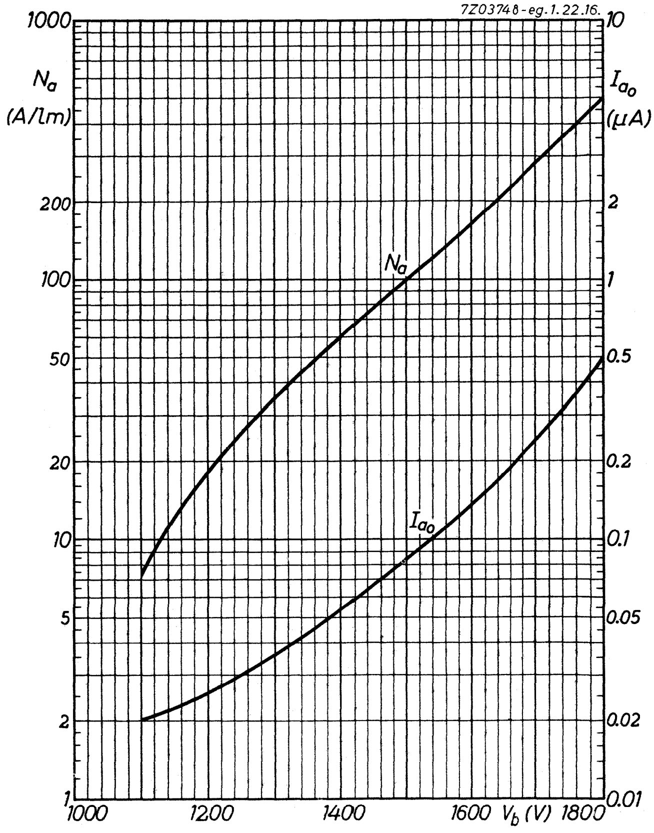
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

In pulse techniques, such as scintillation counting, it is advisable to decouple the last two or three stages by means of capacitors of 100 pF and 200 pF (the highest value at the last stage).

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03748-eg.1.22.16.
1000
N_a
(A/lm)
200
100
50
20
10
5
2
1
10
I_{a_0}
(µA)
2
1
0.5
0.2
0.1
0.05
0.02
0.01
N_a
I_{a_0}
1000
1200
1400
1600
V_b (V)
1800

14 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, life of unstable particles, Cerenkov counters).

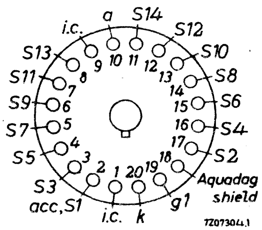
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	42	mm
Gain (at 2200 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

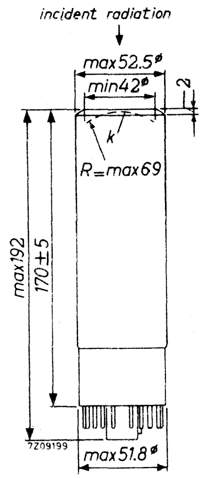
DIMENSIONS AND CONNECTIONS

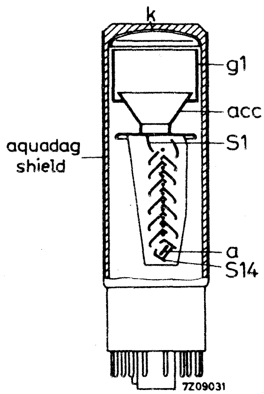
Dimensions in mm

Base: 20-pin (Jedec B20-102)

These connections are valid for serial number 24310 and higher.







ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material			Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature		max.	69	mm
Spectral response curve [2]		type	A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [3]	N_k	av. min.	65 45	μA/lm μA/lm
Radiant sensitivity at 4200 Å			55	mA/W

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc, S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

[2]) See spectral response curve in front of this section

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2200	V
		max.	2500	V
Anode dark current at $G = 10^8$ 1)	I_{a_o}	av.	0.5	µA
		max.	5.0	µA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	0.8	ns
Total transit time at V_b = 2500 V 2)			43	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

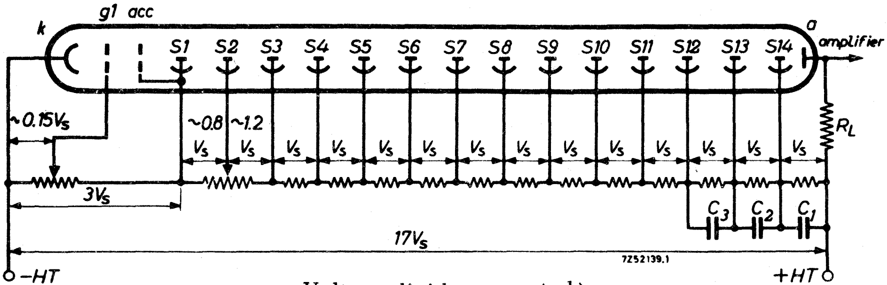
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3	ns
Total transit time at V_b = 2500 V 2)			39	ns

LIMITING VALUES (Absolute max. rating system)

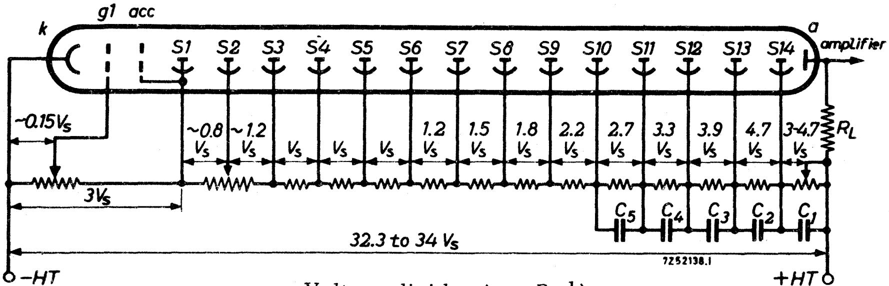
Supply voltage 3)	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

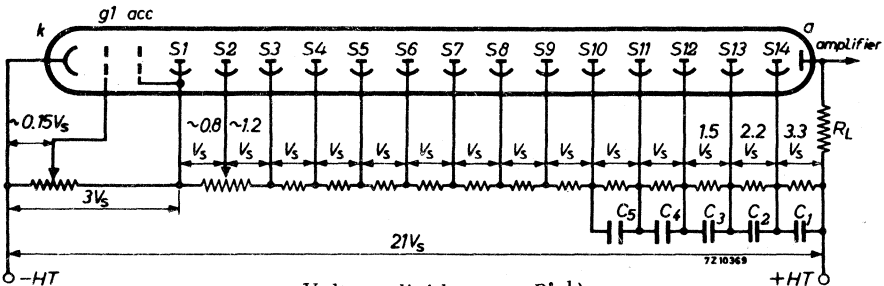
RECOMMENDED CIRCUITS



Voltage divider type A 1)



Voltage divider type B 1)



Voltage divider type B' 1)

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s (see fig.1); voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitance C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high countingrates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling to a scintillator.
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.1 the optimum value of the potential is about 0.15 V_s;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

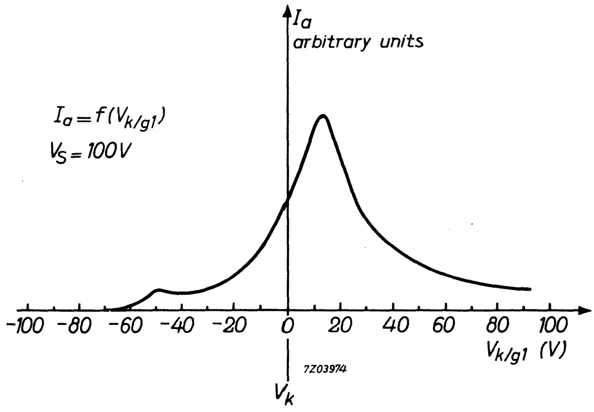


Fig. 1 Anode current variation with the adjustment of g_1

4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2200 V (see Fig. 2).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

OPERATIONAL CONSIDERATIONS (continued)

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact such short pulses are needed for time measurements only, so not for spectrography purposes. If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.3 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.4 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that for equal high tension the gain of the tube is smaller for voltage divider type B than for one according to type A. In practice, therefore, it will be preferable to use the type A distribution, or a distribution between A and B (e.g. starting with 1.2 V_s between S_8 and S_9 1.5 V_s between S_9 and S_{10} and so on, maintaining the same progression.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

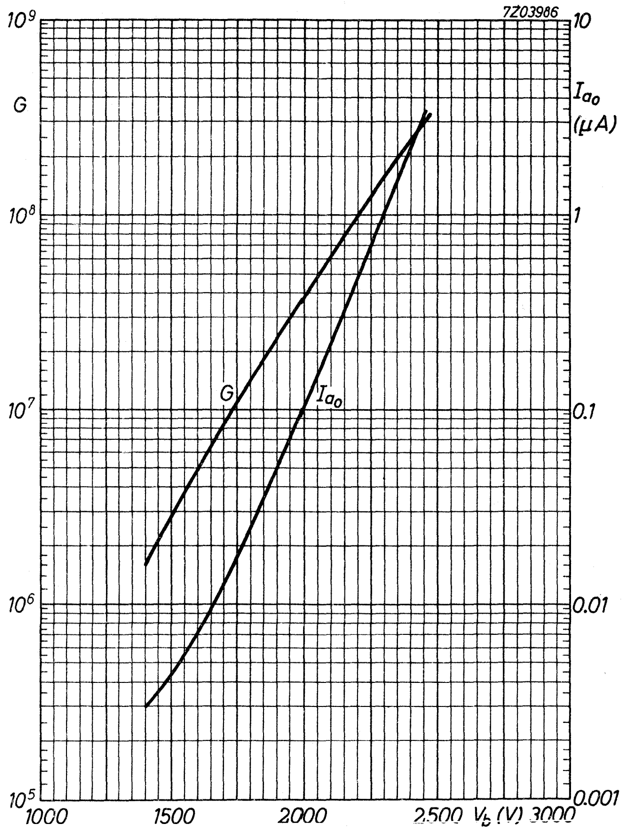

7Z03986
10^9
G
10^8
10^7
10^6
10^5
10
I_{a_0}
(μA)
1
0.1
0.01
0.001
G
I_{a_0}
1000
1500
2000
2500 V_b (V) 3000

Fig.2

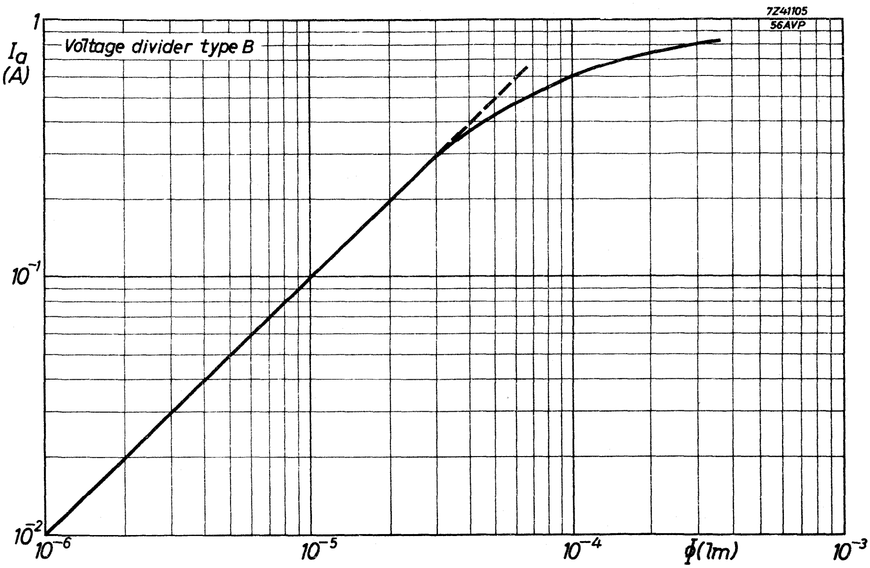
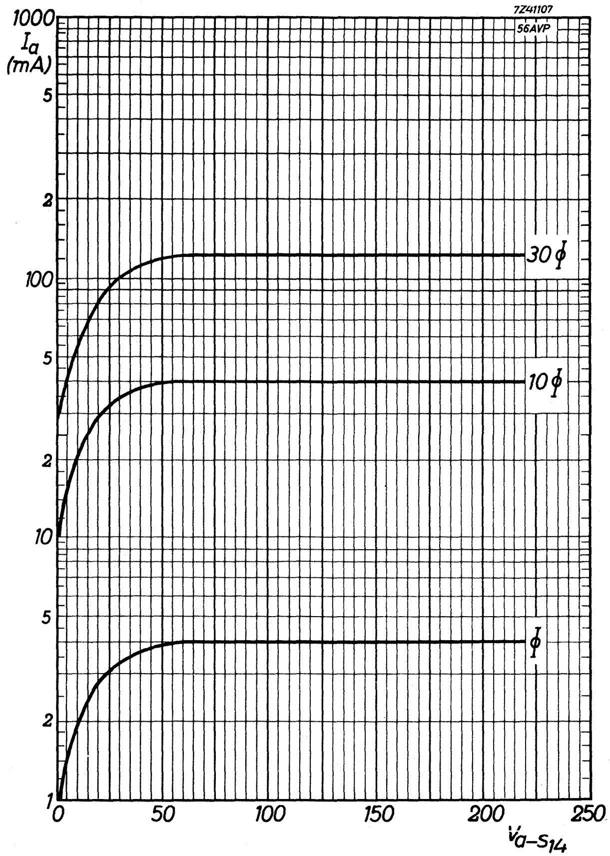

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
Φ(lm)

Fig.3



7Z41107
56AVP
1000
I_a
(mA)
100
10
1
0
50
100
150
200
250
V_{a-s14}
30 ϕ
10 ϕ
ϕ

Fig.4

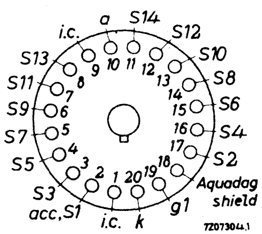
14 STAGE PHOTOMULTIPLIER TUBE

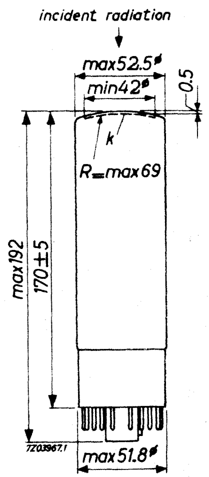
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the near-ultraviolet region.

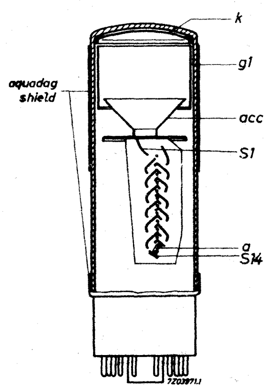
QUICK REFERENCE DATA		
Spectral response	type A/05 (extended S11)	
Useful diameter of the photocathode	42	mm
Window thickness	0.5	mm
Gain (at 2200 V)	10^8	
Anode rise time	2	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		Cs-Sb	
Minimum useful diameter		42	mm
Radius of curvature		max. 69	mm
Spectral response curve [2]		type A/05 (extended S11)	
Wavelength at maximum response		4400 ± 300	Å
Luminous sensitivity [3]	N_k	av. 65 min. 45	μA/lm μA/lm
Radiant sensitivity at 4400 Å		55	mA/W

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc,S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

2) See spectral response curve Fig.5.

3) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2200	V
		max.	2500	V
Anode dark current at $G = 10^8$ 1)	I_{a_o}	av.	0.5	μA
		max.	5.0	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	0.8	ns
Total transit time at V_b = 2500 V 2)			43	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3	ns
Total transit time at V_b = 2500 V 2)			39	ns

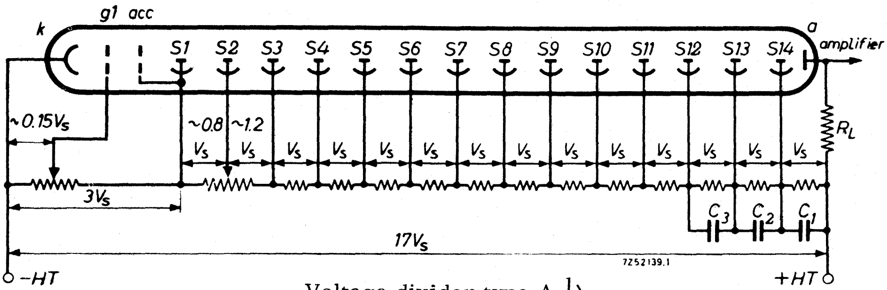
LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

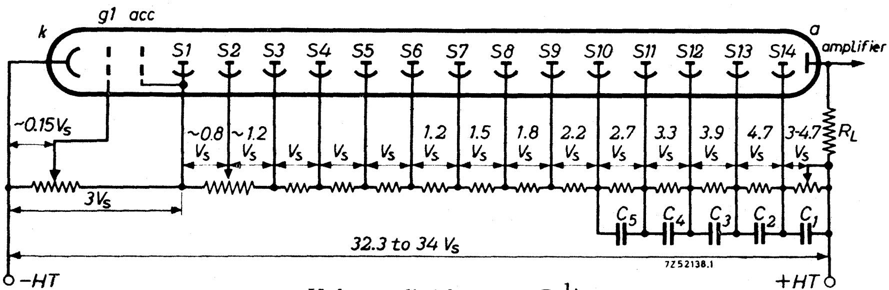
---

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

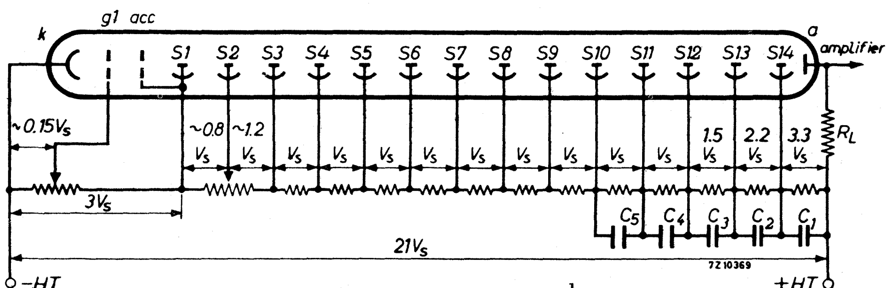
RECOMMENDED CIRCUITS



Voltage divider type A 1)



Voltage divider type B 1)



Voltage divider type B' 1)

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s (see fig.1); voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s; C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

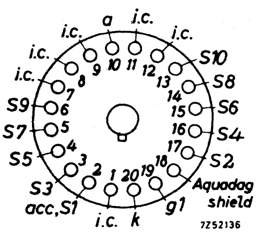
10 STAGE PHOTOMULTIPLIER TUBE

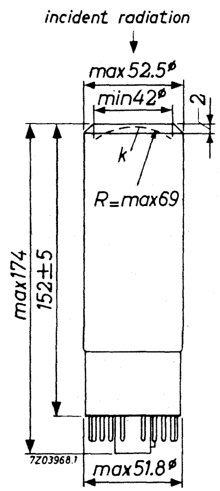
The tube is intended for use in such applications as infra-red telecommunication and ranging, and in optical experiments in which a fast response is required.

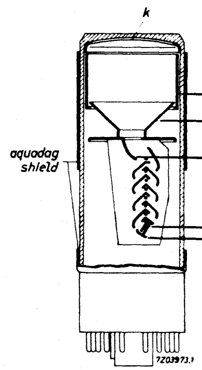
QUICK REFERENCE DATA		
Spectral response	type	C (S1)
Useful diameter of the photocathode	42	mm
Anode sensitivity (at 2750 V)	100	A/lm
Anode pulse rise time	2	ns

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material			Ag-O-Cs	
Minimum useful diameter			42	mm
Radius of curvature		max.	69	mm
Spectral response curve [2]		type	C (S1)	
Wavelength at maximum response			8000 ± 1000	Å
Luminous sensitivity [3]	N_k	av. min.	25 15	μA/lm μA/lm
Radiant sensitivity at 8000 Å			2	mA/W

Multiplier system

Number of stages	10
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc,S_1}$	25	pF
Anode to final dynode	$C_{a/S_{10}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

[2]) See spectral response curve in front of this section.

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 2750 V	av.	100	A/lm
	min.	20	A/lm
Anode dark current at N_a = 20 A/lm [1]	max.	10	μA

With voltage divider B

Anode pulse rise time at V_b = 2500 V [2]		2	ns
Anode pulse width at half height at V_b = 2500 V [2]		3	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	0.8	ns
Total transit time at V_b = 2500 V [2]		30	ns

With voltage divider B

Anode pulse rise time at V_b = 2500 V [2]		2	ns
Anode pulse width at half heigth at V_b = 2500 V [2]		2.5	ns
Total transit time at V_b = 2500 V [2]		28	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	3000	V
Continuous anode current	I_a	max.	30	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	500	V
		min.	80	V

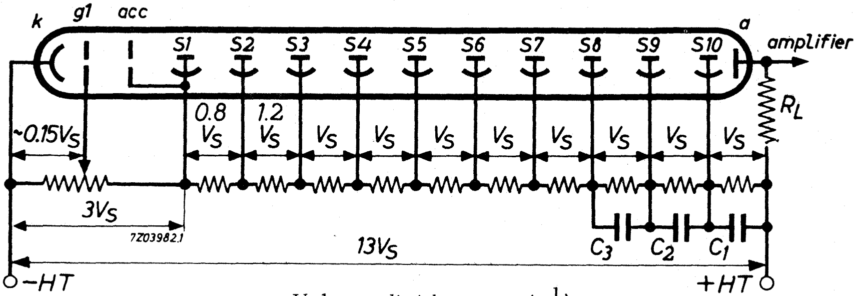
---

[1]) At an ambient temperature of 25 °C.

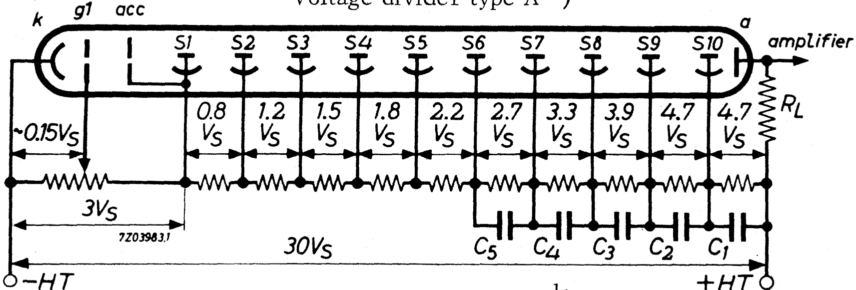
[2]) For an infinitely short light pulse,fully illuminating the photocathode.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

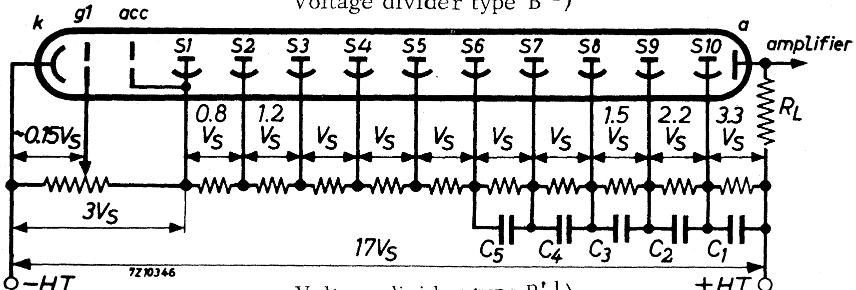
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode

g_1 = focusing electrode

acc = accelerating electrode

S_n = dynode No.n

a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_S (see fig.1); voltage between S_1 and S_2 to be adjusted at about 0.8 V_S; decoupling capacitances C_1 = 100 q/V_S, C_2 = 100 $q/3V_S$, C_3 = 100 $q/9V_S$, C_4 = 100 $q/27V_S$ etc. with q = quantity of electricity transported by the anode.

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling to a scintillator;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1;
3. The potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig. 1. The optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

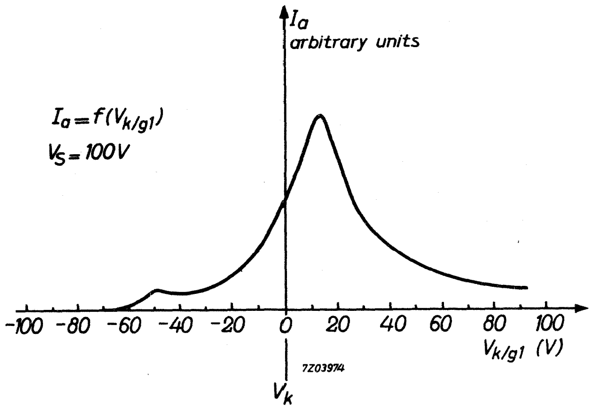


Fig.1 Anode current variation with the adjustment of g_1

4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

B. The multiplier system consists of 10 stages, providing a total current amplification of 10^7 at about 3000 V

When high frequency signals are to be detected the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

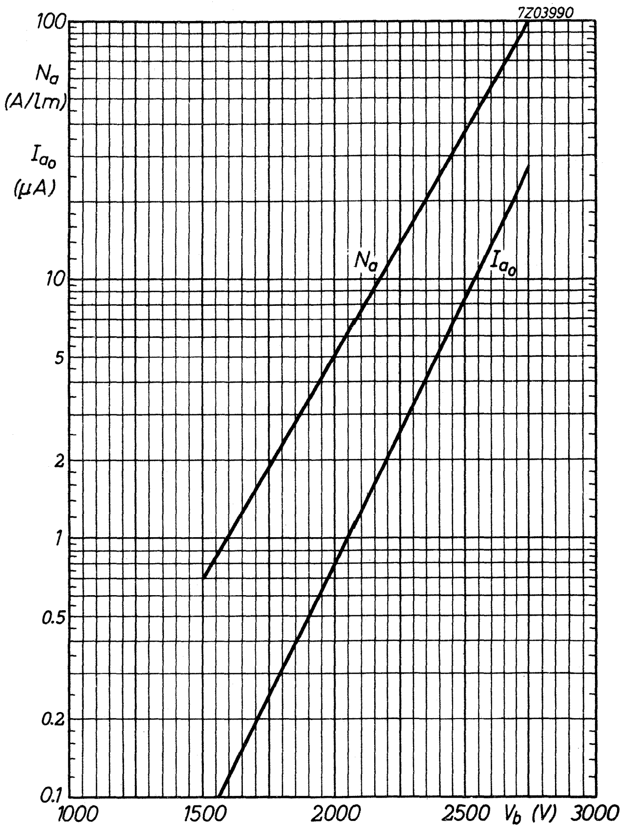

7Z03990
100
N_a
(A/lm)
I_{a_0}
(μA)
10
5
2
1
0.5
0.2
0.1
1000
1500
2000
2500
V_b (V)
3000
N_a
I_{a_0}

Fig. 2

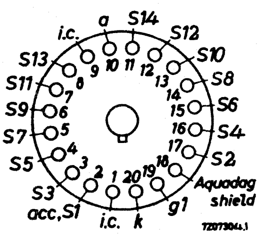
14 STAGE PHOTOMULTIPLIER TUBE

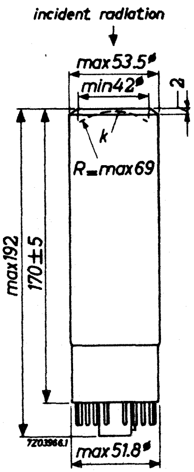
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. The polished optical quartz window gives it a sensitivity that extends into the ultra-violet region and guarantees a very low background because of the absence of ^{40}K radiation.

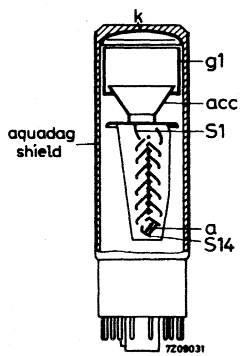
QUICK REFERENCE DATA			
Spectral response		bialkali type DU	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^8	
Anode pulse rise time		2	ns
Quantum efficiency (at 4000 Å)		25	%
Efficiency for single photons (at 2100 V)	min.	15	%
Collection efficiency		80	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type	FE1003
Mu-metal shields [1]	type	56130
		56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material			K-Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature			69	mm
Spectral response curve (see page 10)			type DU	
Wavelength at maximum response			4000 ± 300	Å
Luminous sensitivity [2]	N_k	min.	45	μA/lm
Radiant sensitivity at 4370 Å			75	mA/W
Quantum efficiency at 4000 Å	η_q	av.	25	%

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g1/acc,S1}$	25	pF
Anode to final dynode	$C_{a/S14}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No. 18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high tension insulation between the aquadag shield and the mu-metal shield.

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K. Because of the resistivity of DU-types photocathodes the value of the cathode sensitivity is only an approximation (See also the "operational considerations").

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for G = 10^8	V_b	av.	2100	V
		max.	2500	V
Anode dark current at G = 10^8 [1]	I_{a_o}	av.	0.2	μA
		max.	1	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Efficiency for single photons at 4240 Å [3]	$\eta_{s.p.}$	min.	15	%
Supply voltage for $\eta_{s.p.}$ = 15%	V_b	av.	2100	V
Background noise at V_b = 2100 V [1][3]	B	av.	600	counts/s
		max.	3000	counts/s

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	300	mA
Anode pulse rise time at V_b = 2500 V [2]		2	ns
Anode pulse width at half height at V_b = 2500 V [2]		3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	0.8	ns
Total transit time at V_b = 2500 V [2]		43	ns
Maximum peak currents		0.5 to 1.0	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V [2]	2	ns
Anode pulse width at half height at V_b = 2500 V [2]	3	ns
Transit time spread	0.5	ns
Total transit time at V_b = 2500 V [2]	39	ns

[1]) At an ambient temperature of 25 °C.

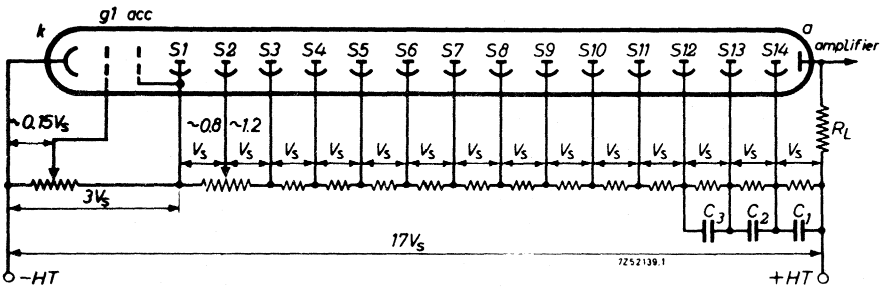
[2]) For an infinitely short light pulse, fully illuminating the photocathode.

[3]) Measured with a threshold at the anode of the photomultiplier of 4.25×10^{-13} C.
Anode coupling capacitor = 10 nF and R_L = 100 kΩ.

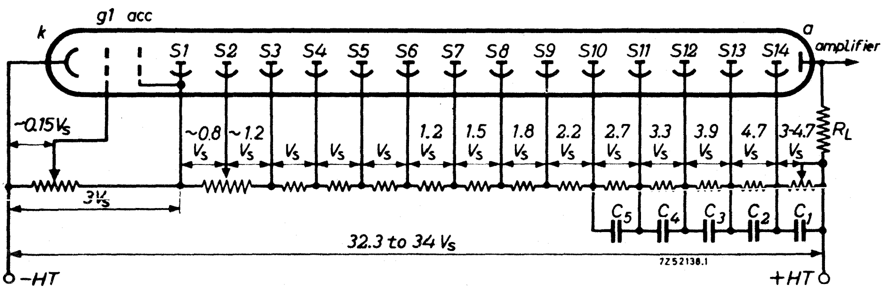
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1])	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2])	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

RECOMMENDED CIRCUITS

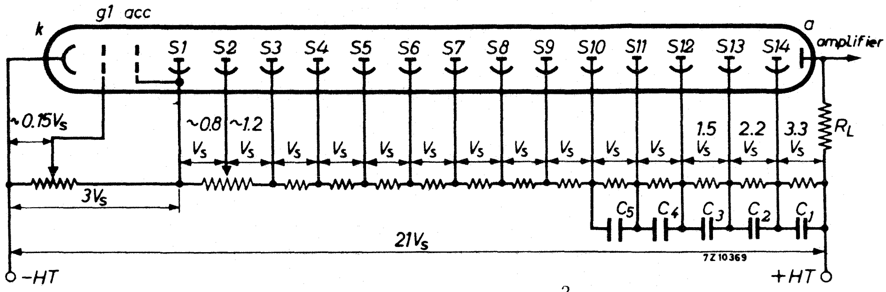


Voltage divider type A [3])



Voltage divider type B [3])

For notes see page 5



Voltage divider type B'[3])

RECOMMENDED CIRCUITS (continued)

k = cathode

g_1 = focusing electrode

acc = accelerating electrode

S_n = dynode No.n

a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

1) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 5.10^8 whichever is lowest.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

3) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of DU-type photocathodes it is recommended not to expose the tube to top high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at $-100\ ^{o}C$. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, amplitude fluctuation or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling.
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.1; the optimum value of the potential is about 0.15 V_s;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

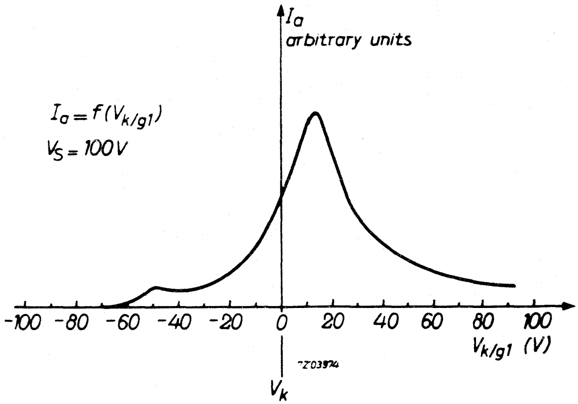


Fig.1 Anode current variation with the adjustment of g_1.

OPERATIONAL CONSIDERATIONS

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2100 V (see fig.4).

The tube is capable of producting very strong peak currents (up to 1 A). Actually the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is linear then up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig. 3 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

OPERATIONAL CONSIDERATIONS (continued)

C. The single photon efficiency is measured with the tube circuited in voltage divider A and with a monochromatic light flux (λ = 424 nm) small enough to ensure that the interactions of the photons with the photocathode result in single photoelectron pulses. The supply voltage is adjusted to obtain **a gain of abt. 10^8.**

The threshold at the anode of the tube is 4.25×10^{-13} C. The effect of the background noise of the photomultiplier can be minimized by making use of two tubes operating in coincidence. For this purpose particularly well matched pairs of photomultipliers are available with type number 56DUVP/A. The high voltages for these two tubes are equal within ± 15 V at identical values of the single photon efficiency. Moreover they have a low value of $B_1 \times B_2$ (B_1 and B_2 being the value of the background noise of each tube).

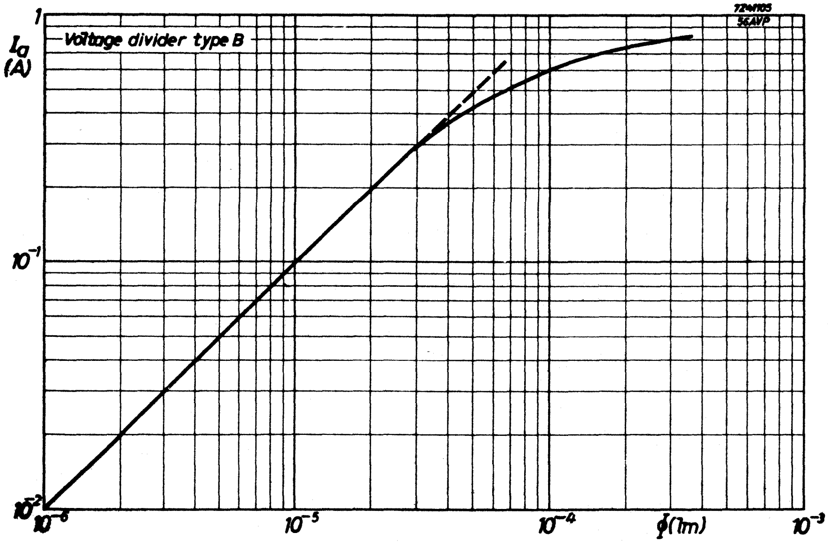


Fig.2

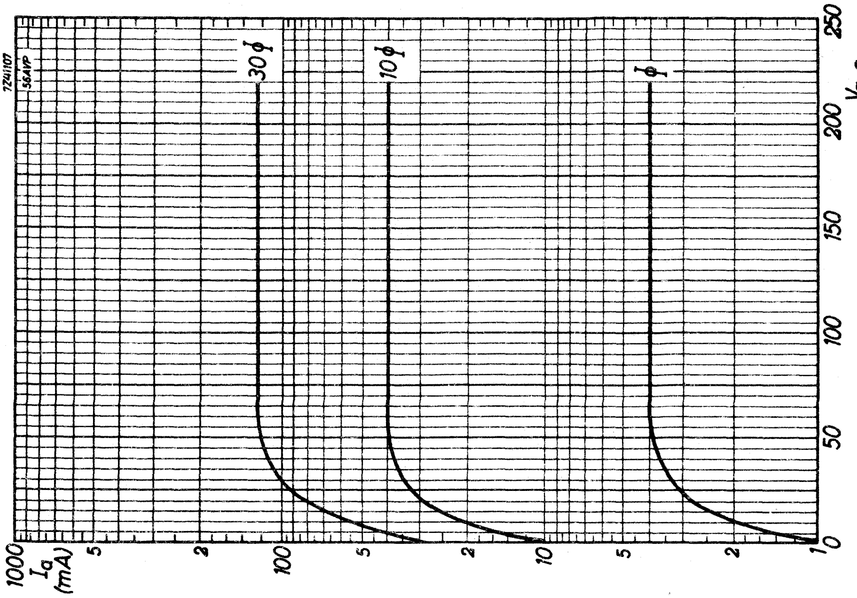

7Z41107
56AVP
1000
I_a (mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-S14}
30 ϕ
10 ϕ
ϕ

Fig.3

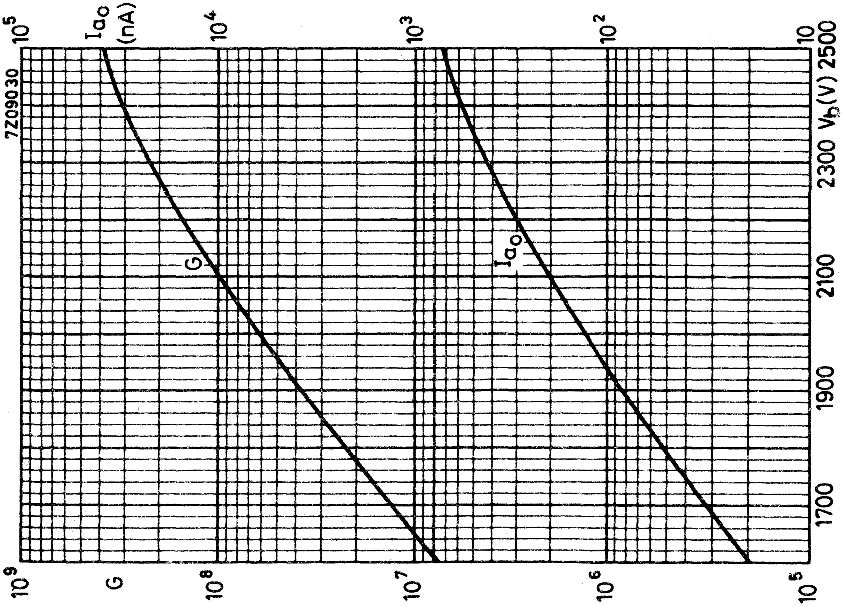

7Z09030
10^9
G
10^8
10^7
10^6
10^5
10^5
I_{a_0} (nA)
10^4
10^3
10^2
10
1700
1900
2100
2300
2500 V_b(V)
G
I_{a_0}

Fig.4

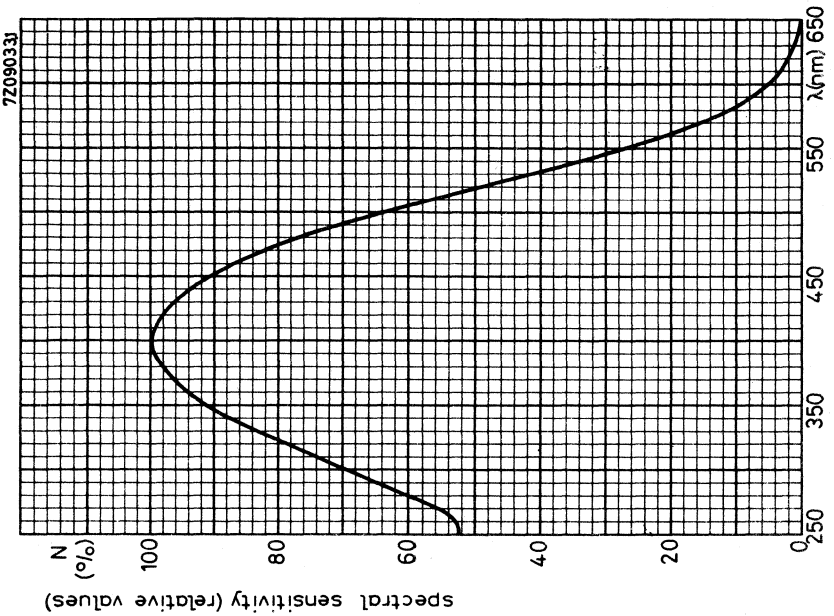


Fig.5

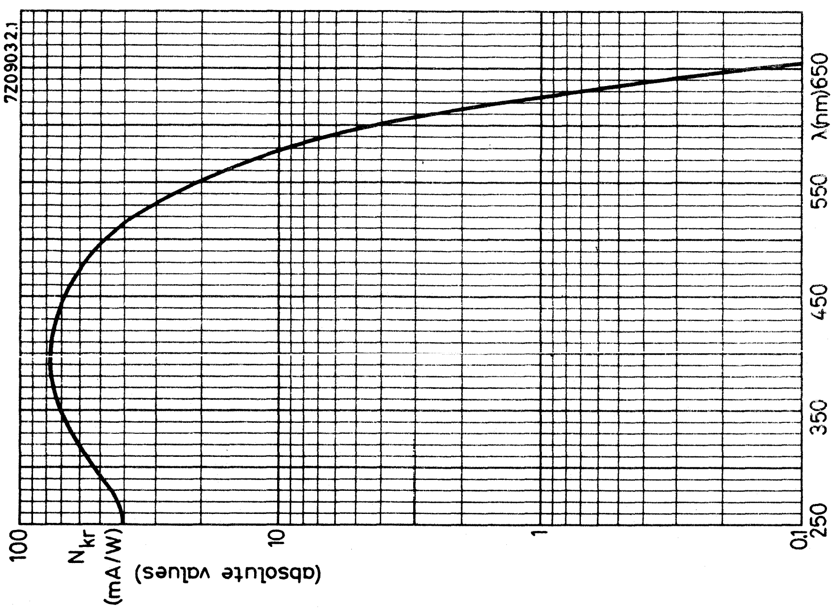


Fig.6

spectral response curve type DU

14 STAGE PHOTOMULTIPLIER TUBE

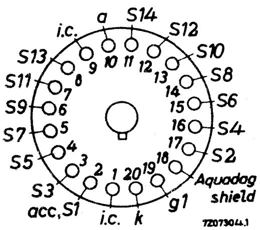
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. It has a very high single photon efficiency and a low background noise.
The polished optical quartz window gives it a sensitivity that extends into the ultra-violet region and guarantees a very low background because of the absence of ^{40}K radiation.

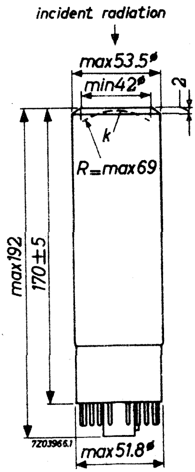
QUICK REFERENCE DATA			
Spectral response		bialkali type DU	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^{8}	
Anode pulse rise time		2	ns
Quantum efficiency (at 400 nm)		25	%
Efficiency for single photons (at 2100 V)	min.	20	%
Background noise (at 2100 V)	max.	1000	counts/s
Collection efficiency		80	%

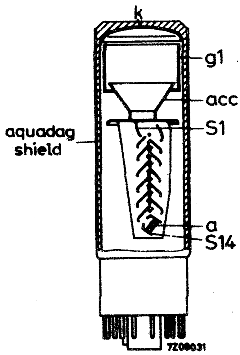
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 20-pin (Jedec B20-102)







Data based on pre-production tubes.

ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130
	56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		K-Cs-Sb	
Minimum useful diameter		42	mm
Radius of curvature		69	mm
Spectral response curve (see page 10)		type DU	
Wavelength at maximum response		400 ± 30	nm
Luminous sensitivity [2]	N_k	min. 45	μA/lm
Radiant sensitivity at 437 nm		75	mA/W
Quantum efficiency at 400 nm	η_q	av. 25	%

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No. 1 to accelerator electrode	$C_{g_1/acc,S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No. 18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high tension insulation between the aquadag shield and the mu-metal shield.

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K. Because of the resistivity of DU-types photocathodes the value of the cathode sensitivity is only an approximation (See also the "operational considerations").

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2100	V
		max.	2500	V
Anode dark current at $G = 10^8$ 1)	I_{a_o}	av.	0.2	μA
		max.	1	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Efficiency for single photons at 424 nm 3)	$\eta_{s.p.}$	min.	20	%
Supply voltage for $\eta_{s.p.}$ = 20 %	V_b	av.	2100	V
Background noise at V_b = 2100 V 1)3)	B	max.	1000	counts/s

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	300	mA
Anode pulse rise time at V_b = 2500 V 2)		2	ns
Anode pulse width at half height at V_b = 2500 V 2)		3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	0.8	ns
Total transit time at V_b = 2500 V 2)		43	ns
Maximum peak currents		0.5 to 1.0	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)	2	ns
Anode pulse width at half height at V_b = 2500 V 2)	3	ns
Transit time spread	0.5	ns
Total transit time at V_b = 2500 V 2)	39	ns

1) At an ambient temperature of 25 °C.

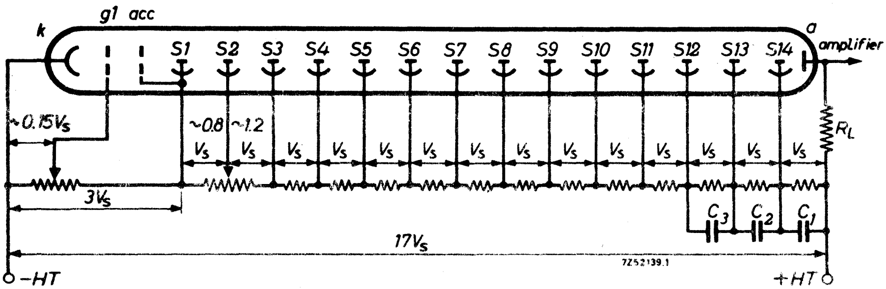
2) For an infinitely short light pulse, fully illuminating the photocathode.

3) Measured with a threshold at the anode of the photomultiplier of 4.25×10^{-13} C. Anode coupling capacitor = 10 nF and R_L = 100 kΩ.

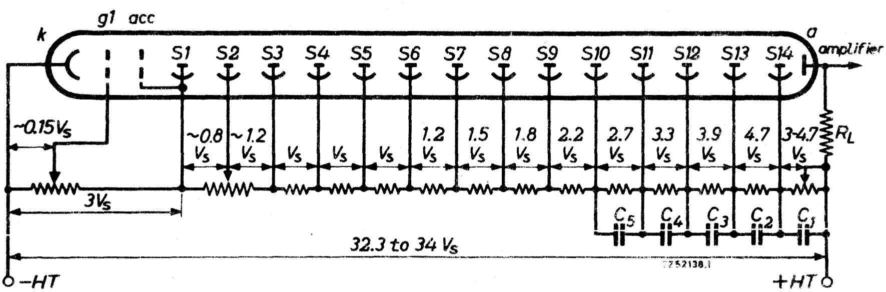
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	$V_{k/S1}$	max.	800	V
		min.	250	V
Voltage between grid No. 1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

RECOMMENDED CIRCUITS



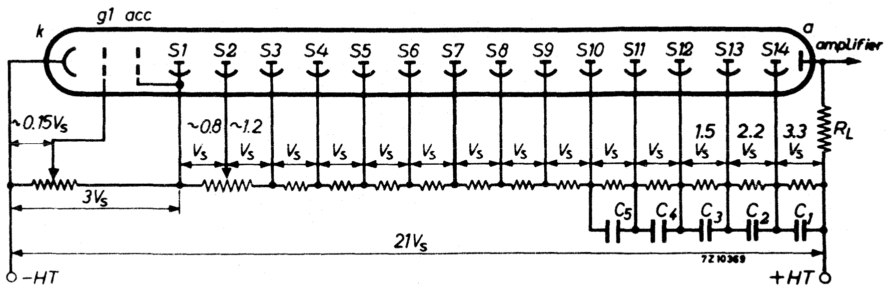
Voltage divider type A [3]



Voltage divider type B [3]

For notes see page 5

RECOMMENDED CIRCUITS (continued)



Voltage divider type B' [1])

k = cathode

g_1 = focusing electrode

acc = accelerating electrode

S_n = dynode No. n

a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

[1]) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 5.10^8 whichever is lowest.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

[3]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No. 18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of DU-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high-tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, amplitude fluctuation or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling.
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig. 1; the optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

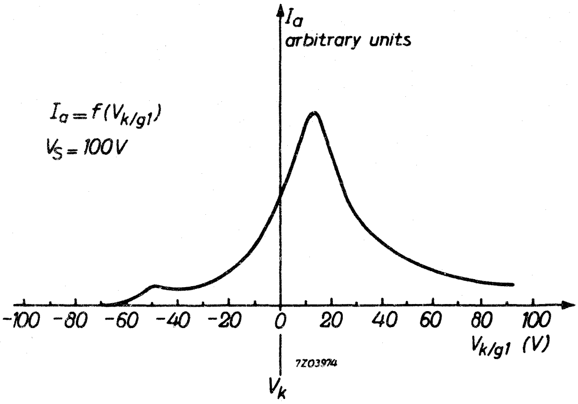


Fig. 1 Anode current variation with the adjustment of g_1.

OPERATIONAL CONSIDERATIONS (continued)

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2100 V (see fig. 4).

The tube is capable of producting very strong peak currents (up to 1 A). Actually the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

Fig. 2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is linear then up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig. 3 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

OPERATIONAL CONSIDERATIONS (continued)

C. The single photon efficiency is measured with the tube circuited in voltage divider A and with a monochromatic light flux (λ = 424 nm) small enough to ensure that the interactions of the photons with the photocathode result in single photoelectron pulses. The supply voltage is adjusted to obtain **a gain of abt.** 10^8.

The threshold at the anode of the tube is 4.25×10^{-13} C. The effect of the background noise of the photomultiplier can be minimized by making use of two tubes operating in coincidence. For this purpose particularly well matched pairs of photomultipliers are available with type number 56DUVP/03/A. The high voltages for these two tubes are equal within ±15 V at identical values of the single photon efficiency. Moreover they have a low value of $B_1 \times B_2$ (B_1 and B_2 being the value of the background noise of each tube).

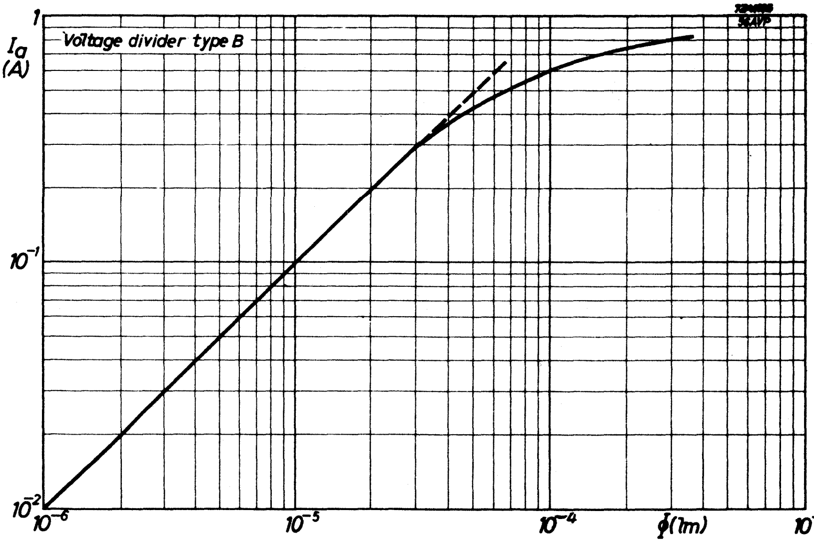


Fig.2

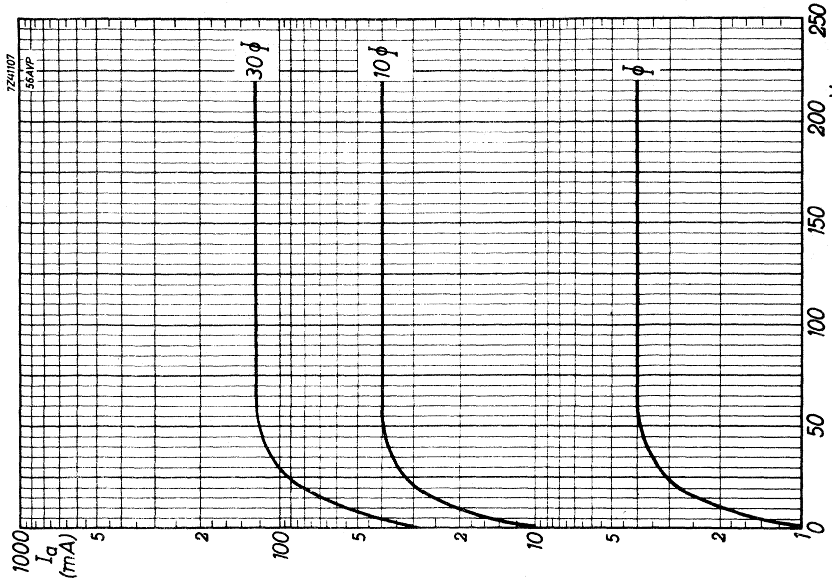

7Z41107
56AVP
1000
Ia (mA)
100
10
1
5
2
0
50
100
150
200
250
Va-S14
30 ϕ
10 ϕ
ϕ

Fig.3

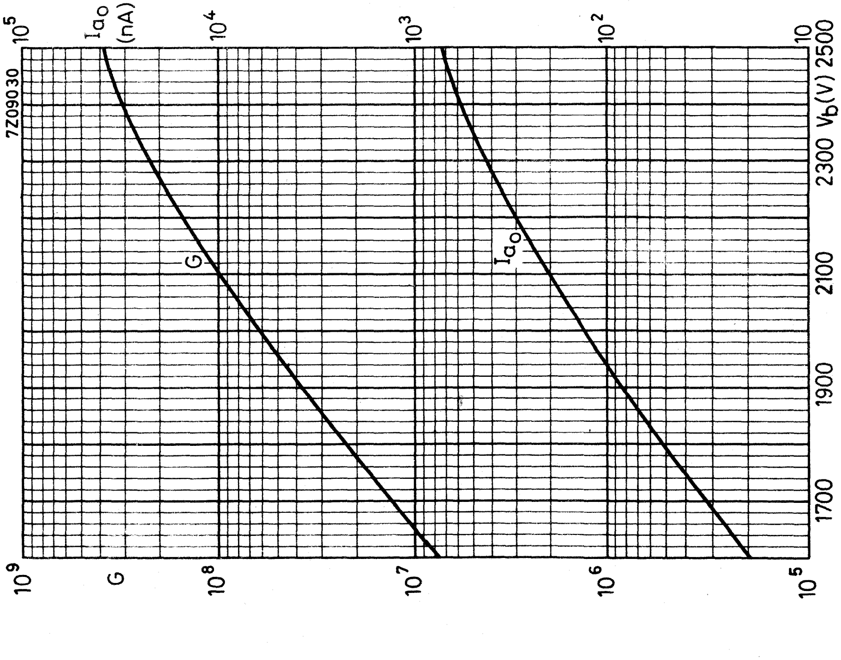

7Z09030
10^9
G
10^8
10^7
10^6
10^5
10^5
Iao (nA)
10^4
10^3
10^2
10
1700
1900
2100
2300
2500
Vb(V)
G
Iao

Fig.4

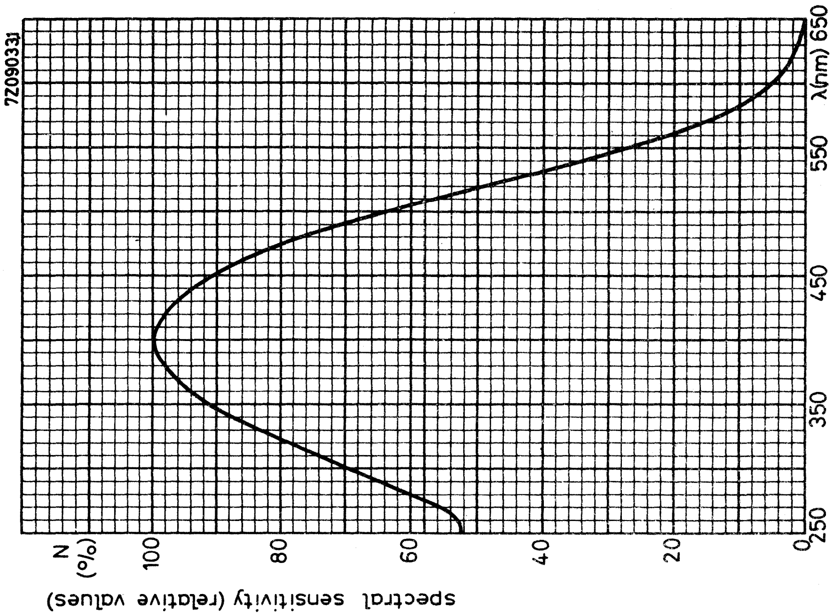


Fig.5

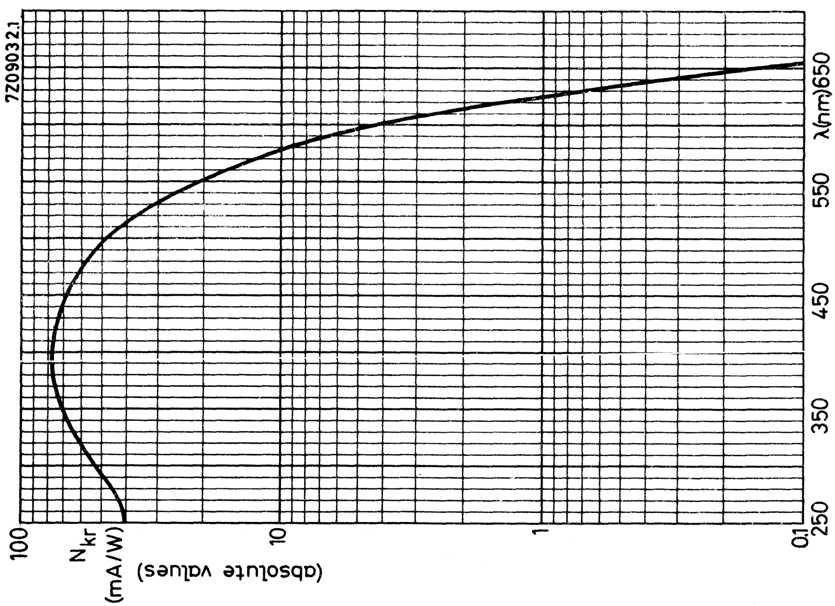


Fig.6

spectral response curve type DU

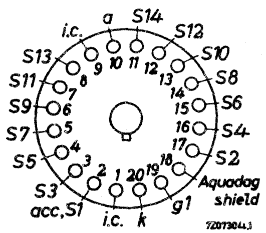
14 STAGE PHOTOMULTIPLIER TUBE

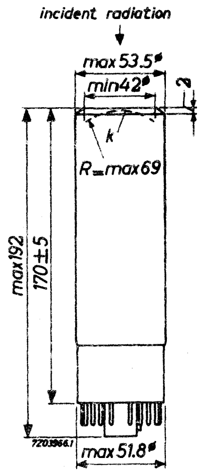
The tube is intended for use in spectrometry and other applications where very low luminous fluxes are to be measured (single photon counting) and for detection of soft β-radiation.
If features a high quantum efficiency and a very good collection efficiency.
Its fast time characteristics make the tube especially useful for fast coincidence measurements, thus reducing the background noise considerably.

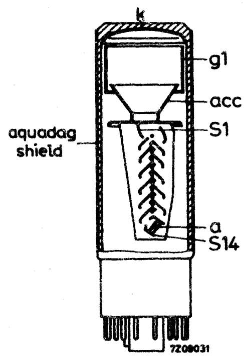
QUICK REFERENCE DATA			
Spectral response		bialkali type D	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^8	
Anode pulse rise time		2	ns
Quantum efficiency (at 400 nm)		25	%
Efficiency for single photons (at 2100 V)	min.	15	%
Collection efficiency		80	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (JEDEC B20-102)







ENVELOPE

Material: Glass with low activity (Pyrex 7740)

ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130
	56131

GENERAL

Photocathode

Description	semi-transparent, head-on, curved surface			
Cathode material			K-Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature			69	mm
Spectral response curve (see page 10)			type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity [2]	N_k	min.	45	μA/lm
Radiant sensitivity at 437 nm			75	mA/W
Quantum efficiency at 400 nm	η_q	av.	25	%

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc, S_1}$	25	pF
Anode to final dynode	$C_{a/S14}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No. 18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K. Because of the resistivity of D-type photocathodes the value of the cathode sensitivity is only an approximation (See also the "operational considerations").

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. max.	2100 2500	V V
Anode dark current at $G = 10^8$ [1]	I_{a_o}	av. max.	0.2 1	μA μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Efficiency for single photons [3]	$\eta_{s.p.}$	min.	15	%
Supply voltage for $\eta_{s.p.} = 15\%$ [3]	V_b	av.	2100	V
Background noise at $V_b = 2100$ V [1][3]	B	av. max.	600 3000	counts/s counts/s

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at $V_b = 2500$ V [2]			2	ns
Anode pulse width at half height at $V_b = 2500$ V [2]			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V		max.	0.8	ns
Total transit time at $V_b = 2500$ V [2]			43	ns
Maximum peak currents			0.5 to 1.0	A

With voltage divider B'

Anode pulse rise time at $V_b = 2500$ V [2]			2	ns
Anode pulse width at half height at $V_b = 2500$ V [2]			3	ns
Transit time spread			0.5	ns
Total transit time at $V_b = 2500$ V [2]			39	ns

1) At an ambient temperature of 25 °C.

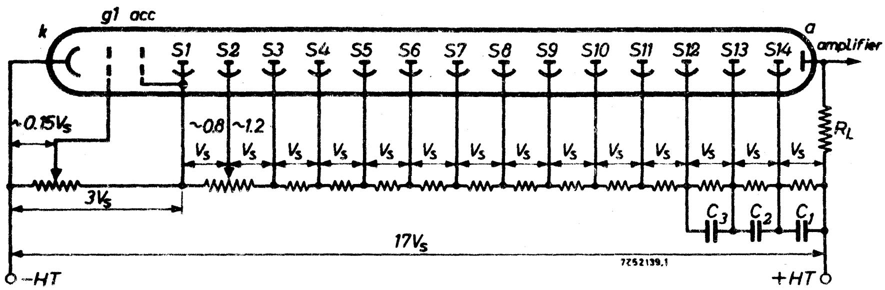
2) For an infinitely short light pulse, fully illuminating the photocathode.

3) Measured with a threshold at the anode of the photomultiplier of 4.25×10^{-13} C. Anode coupling capacitor = 10 nF and $R_L = 100$ kΩ.

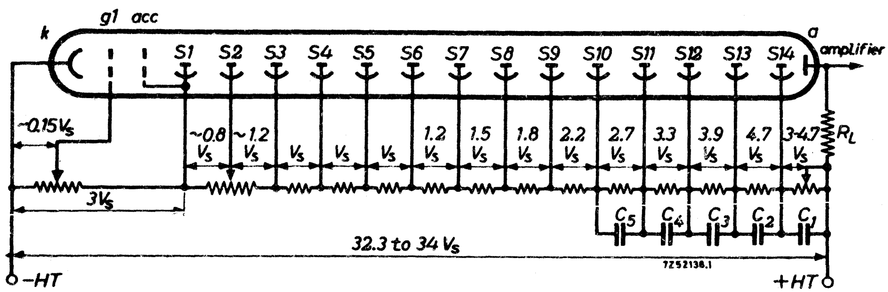
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1]	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

RECOMMENDED CIRCUITS

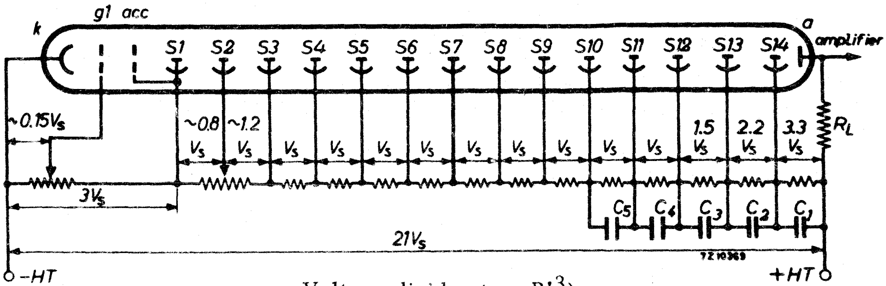


Voltage divider type A [3]



Voltage divider type B [3]

For notes see page 5



Voltage divider type B'[3])

RECOMMENDED CIRCUITS (continued)

k = cathode

g_1 = focusing electrode

acc = accelerating electrode

S_n = dynode No.n

a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

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1) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 5.10^8 whichever is lowest.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

3) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of **radiation.** It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc,

To reduce transit-time fluctuations, geometrical time spread, amplitude fluctuation or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling.
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.1; the optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

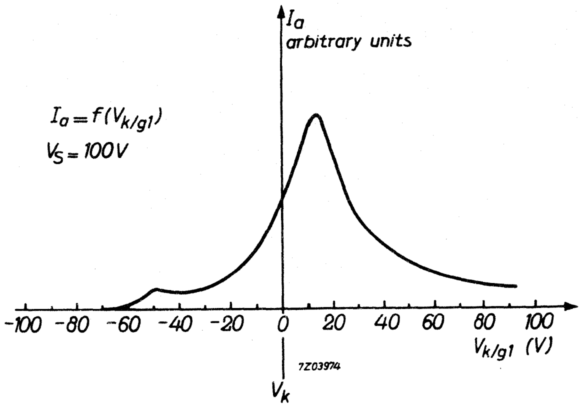


Fig.1 Anode current variation with the adjustment of g_1

OPERATIONAL CONSIDERATIONS (continued)

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2100 V (see fig.4).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is linear then up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig.3 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

OPERATIONAL CONSIDERATIONS (continued)

C. The single photon efficiency is measured with the tube circuited in voltage divider A and with a monochromatic light flux (λ = 424 nm) small enough to ensure that the interactions of the photons with the photocathode result in single photoelectron pulses. The supply voltage is adjusted to obtain **a gain of abt.** 10^8.

The threshold at the anode of the tube is 4.25×10^{-13} C. The effect of the background noise of the photomultiplier can be minimized by making use of two tubes operating in coincidence. For this purpose particularly well matched pairs of photomultipliers are available with type number 56DVP/A. The high voltages for these two tubes are equal within ± 15 V at identical values of the single photon efficiency. Moreover they have a low value of $B_1 \times B_2$ (B_1 and B_2 being the value of the background noise of each tube).

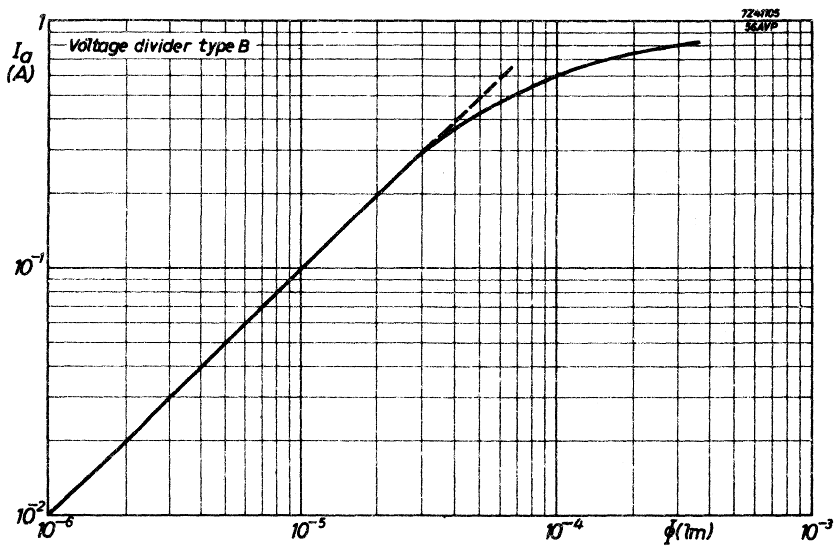


Fig. 2

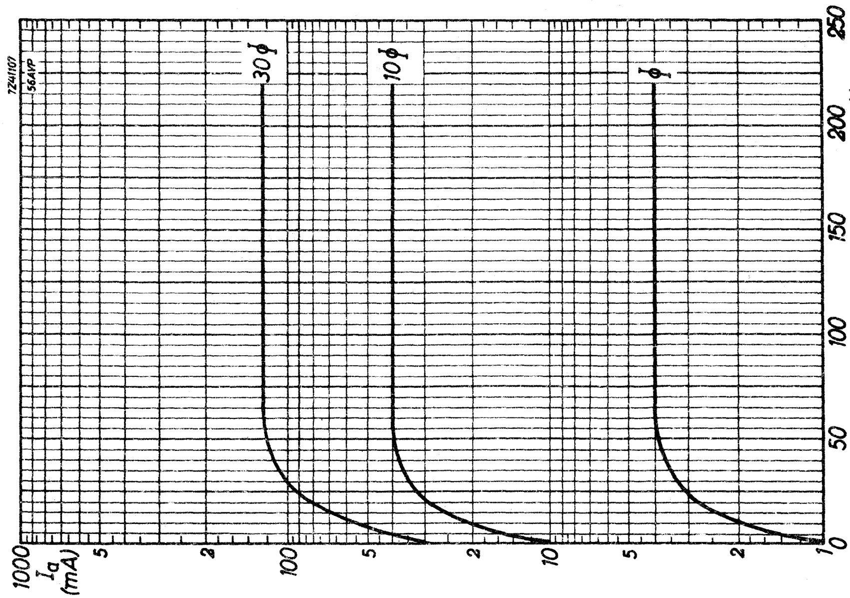

7Z41107
56AVP
I_a (mA)
V_{a-S14}
30 Φ
10 Φ
Φ
1000
100
10
1
0
50
100
150
200
250

Fig. 3

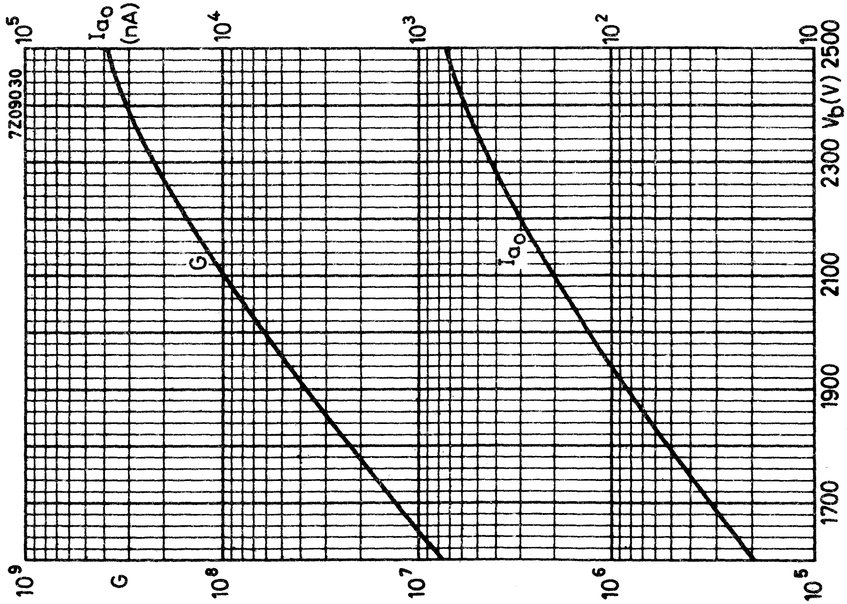

7Z09030
I_{ao} (nA)
G
I_{ao}
V_b(V)
1700
1900
2100
2300
2500
10^9
10^8
10^7
10^6
10^5
10^5
10^4
10^3
10^2
10

Fig. 4

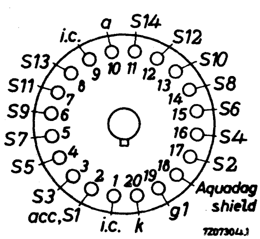
14 STAGE PHOTOMULTIPLIER TUBE

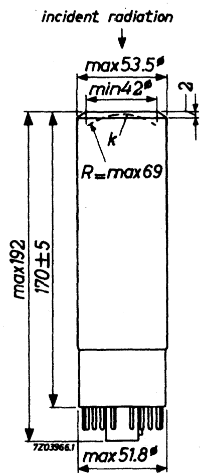
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. It has a very high single photon efficiency and a low background noise.
Its fast time characteristics make the tube especially useful for fast coincidence measurements, thus reducing the background noise considerably.

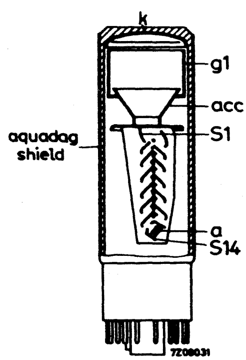
QUICK REFERENCE DATA			
Spectral response		bialkali type D	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^8	
Anode pulse rise time		2	ns
Quantum efficiency (at 400 nm)		25	%
Efficiency for single photons (at 2100 V)	min.	20	%
Background noise (at 2100 V)	max.	1000	counts/s
Collection efficiency		80	%

DIMENSIONS AND CONNECTIONS

Base: 20-pin (JEDEC B20-102)







ENVELOPE

Material: Glass with low activity (Pyrex 7740)

ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 56131

GENERAL

Photocathode

Description			semi-transparent, head-on, curved surface	
Cathode material			K-Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature			69	mm
Spectral response curve (see page 10)			type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity [2]	N_k	min.	45	μA/lm
Radiant sensitivity at 437 nm			75	mA/W
Quantum efficiency at 400 nm	η_q	av.	25	%

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc, S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No. 18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K. Because of the resistivity of D-type photocathodes the value of the cathode sensitivity is only an approximation (See also the "operational considerations").

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2100	V
		max.	2500	V
Anode dark current at $G = 10^8$ 1)	I_{a_o}	av.	0.2	μA
		max.	1	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Efficiency for single photons at 424 nm 3)	$\eta_{s.p.}$	min.	20	%
Supply voltage for $\eta_{s.p.} = 20\%$	V_b	av.	2100	V
Background noise at $V_b = 2100$ V 1)3)	B	max.	1000	counts/ s

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at $V_b = 2500$ V 2)			2	ns
Anode pulse width at half height at $V_b = 2500$ V 2)			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V		max.	0.8	ns
Total transit time at $V_b = 2500$ V 2)			43	ns
Maximum peak currents			0.5 to 1.0	A

With voltage divider B'

Anode pulse rise time at $V_b = 2500$ V 2)			2	ns
Anode pulse width at half height at $V_b = 2500$ V 2)			3	ns
Transit time spread			0.5	ns
Total transit time at $V_b = 2500$ V 2)			39	ns

1) At an ambient temperature of 25 °C.

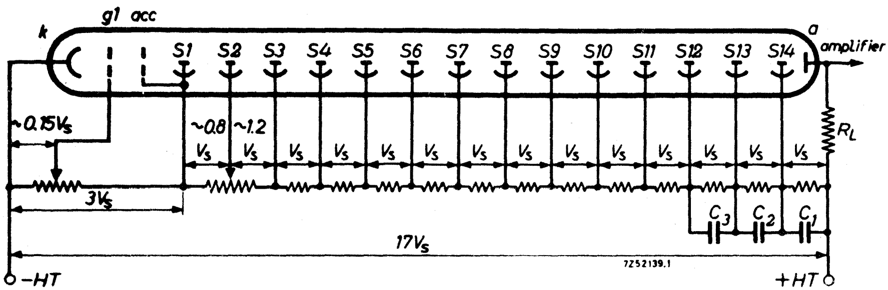
2) For an infinitely short light pulse, fully illuminating the photocathode.

3) Measured with a threshold at the anode of the photomultiplier of 4.25×10^{-13} C. Anode coupling capacitor = 10 nF and R_L = 100 kΩ.

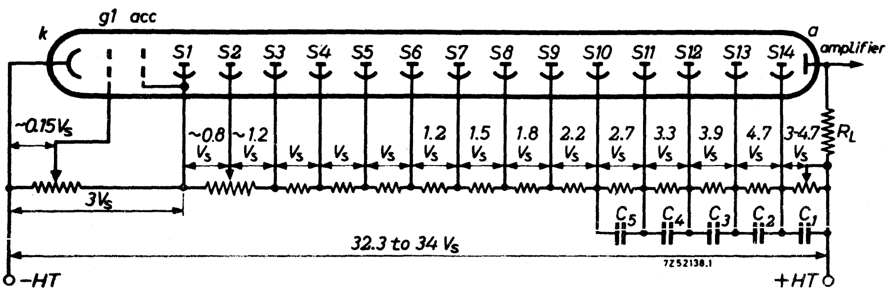
LIMITING VALUES (Absolute max. rating system)

Supply voltage [1])	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	800 250	V V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [2])	$V_{a/S_{14}}$	max. min.	500 80	V V

RECOMMENDED CIRCUITS

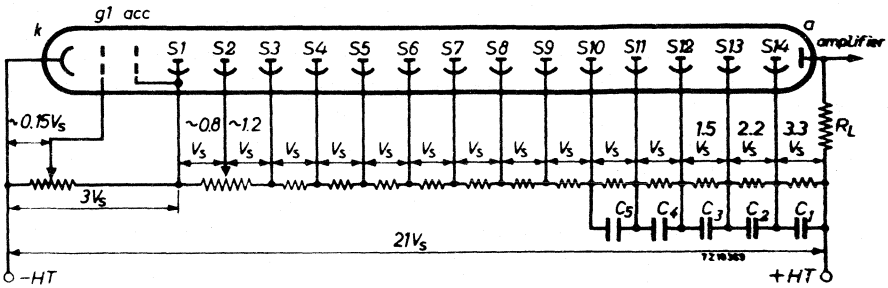


Voltage divider type A [3])



Voltage divider type B [3])

For notes see page 5



Voltage divider type B' 3)

RECOMMENDED CIRCUITS

k = cathode

g_1 = focusing electrode

acc = accelerating electrode

S_n = dynode No. n

a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

1) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 5.10^8 whichever is lowest.

2) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

3) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages msut be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, amplitude fluctuation or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling.
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.1; the optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output amplitude.
4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

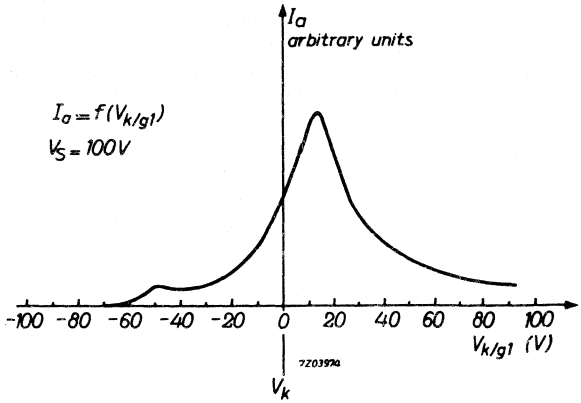


Fig.1 Anode current variation with the adjustment of g_1

OPERATIONAL CONSIDERATIONS (continued)

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2100 V (see fig.4).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is linear then up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In Fig. 3 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions tha gain of the tube is smaller for voltage divider type B than for one according to type A.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

OPERATIONAL CONSIDERATIONS

C. The single photon efficiency is measured with the tube circuited in voltage divider A and with a monochromatic light flux (λ = 424 nm) small enough to ensure that the interactions of the photons with the photocathode result in single photoelectron pulses. The supply voltage is adjusted to obtain a gain of abt. 10^8.

The threshold at the anode of the tube is 4.25×10^{-13} C. The effect of the background noise of the photomultiplier can be minimized by making use of two tubes operating in coincidence. For this purpose particularly well matched pairs of photomultipliers are available with type number 56DVP/03/A. The high voltages for these two tubes are equal within ±15 V at identical values of the single photon efficiency. Moreover they have a low value of $B_1 \times B_2$ (B_1 and B_2 being the value of the background noise of each tube).

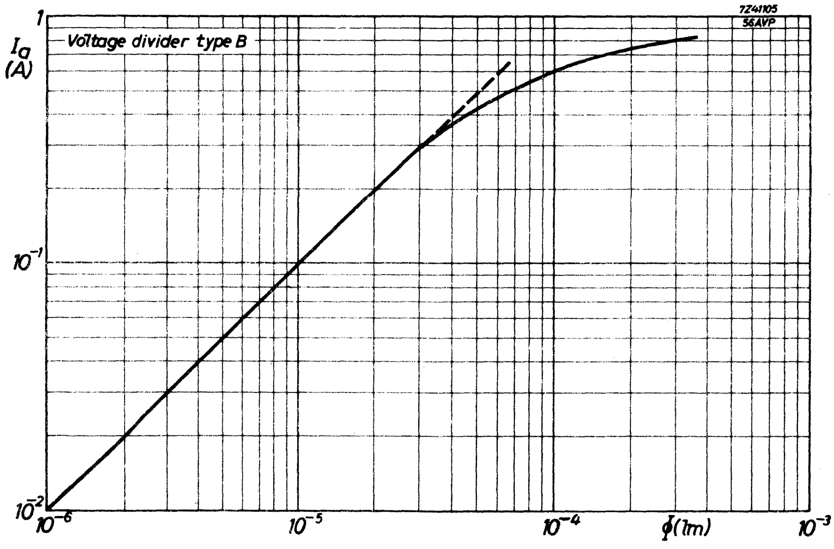


Fig. 2

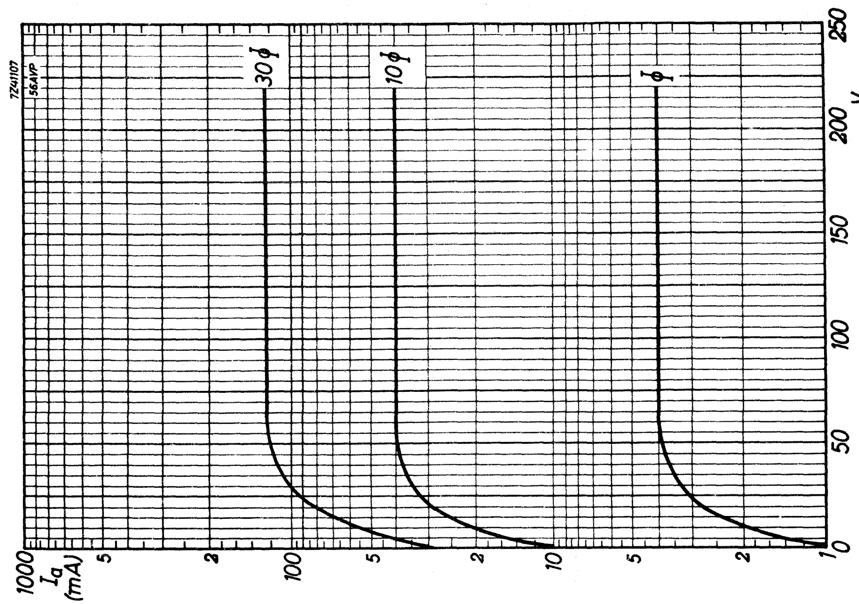

7Z41107
56AVP
30 ϕ
10 ϕ
ϕ
1000
Ia
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
Va-S14

Fig.3

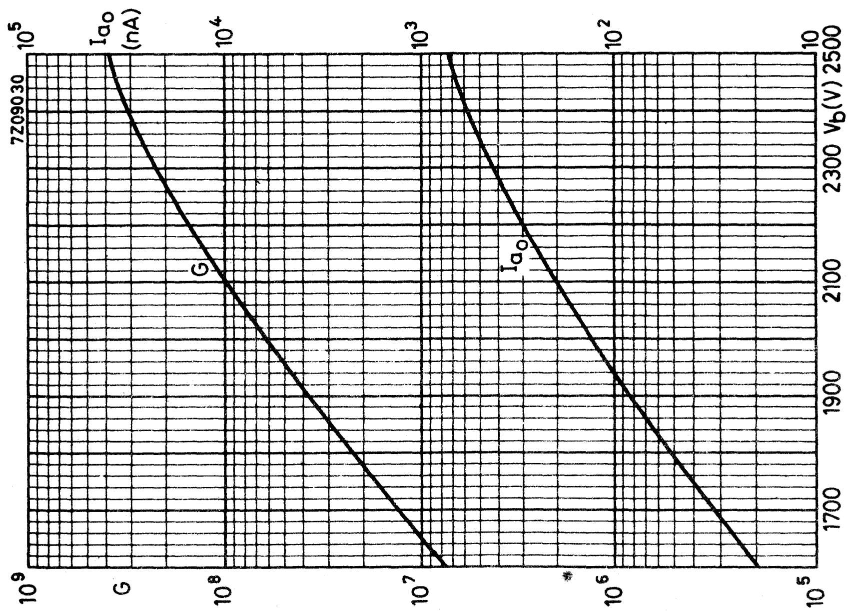

7Z09030
10^5
Iao
(nA)
10^4
10^3
10^2
10
G
Iao
10^9
G
10^8
10^7
10^6
10^5
1700
1900
2100
2300
2500
Vb(V)

Fig.4

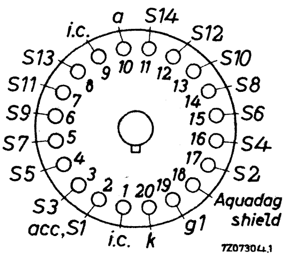
14 STAGE PHOTOMULTIPLIER TUBE

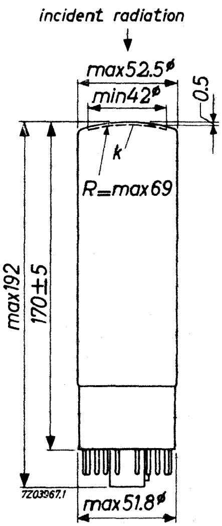
The tube is intended for use in ultraviolet photometry within the wavelength range 180 nm to 300 nm and has a depressed sensitivity for visible light.

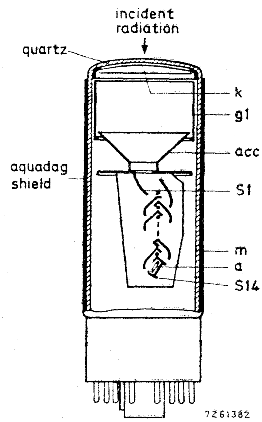
QUICK REFERENCE DATA		
Spectral response	type SBU	
Useful diameter of the photocathode	42	mm
Gain (at 2100 V)	10^8	

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type FE1003
Mu-metal shield	type 56130 or 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		Cs-Te	
Minimum useful diameter		42	mm
Radius of curvature		67 ± 2	mm
Spectral response curve (See Applications directions)		type SBU	
Wavelength at maximum response		235 ± 30	nm
Radiant sensitivity at 235 nm, t_{amb} = 25 °C		15	mA/W

Multiplier system

Number of stages	14	
Dynode material	Ag-Mg-O-Cs	

CAPACITANCES

Anode to final dynode	$C_{a/S14}$	7	pF
Anode to all other electrodes	C_a	9.5	pF
Focusing electrode to accelerator and dynode 1	$C_{g1/g2\,S1}$	25	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for G = 10^8	V_b	av.	2100	V
		max.	2500	V
Anode dark current at G = 10^8 (t_{amb} = 25 °C)	I_{a_o}	max.	100	nA
Linearity between anode pulse amplitude and input light pulse at V_b = 2500 V			up to I_{ap} = 100	mA

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to I_{ap} =	300	mA	
Anode pulse rise time at V_b = 2500 V		2	ns	2)
Anode pulse width at half height (V_b = 2500 V)		3.5	ns	2)
Transit time difference between the centre of the photocathode and the edge at V_b = 2500 V	max.	0.8	ns	
Total transit time at V_b = 2500 V		43	ns	
Maximum peak current	0.5 to	1	A	

With voltage divider B'

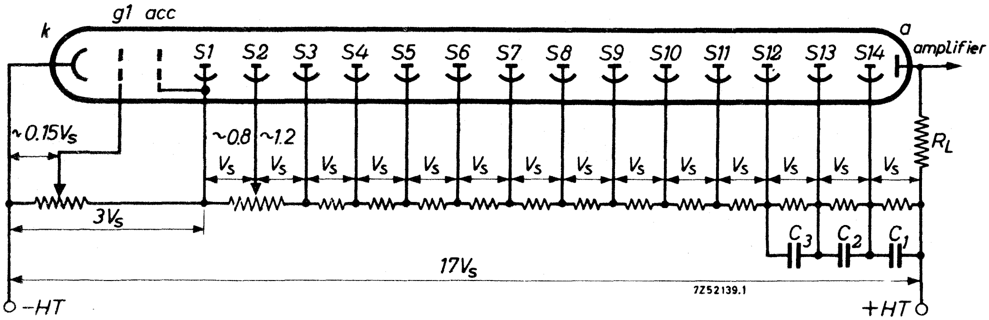
Anode pulse rise time at V_b = 2500 V	2	ns	2)
Anode pulse width at half height (V_b = 2500 V)	3	ns	2)
Total transit time at V_b = 2500 V	39	ns	

LIMITING VALUES (Absolute max. rating system)

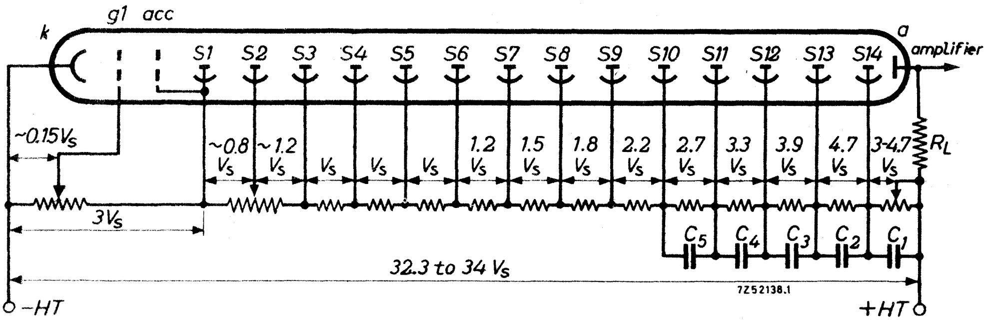
Supply voltage	V_b	max.	2500	V
Continuous anode current	I_a	max.	200	µA
Voltage between cathode and first dynode + accelerator	$V_{k/S1}$	max.	800	V
Voltage between cathode and focusing electrode	V_{kg1}	max.	100	V
Voltage between consecutive dynodes	$V_{Sn/Sn+1}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 1)	$V_{a/S}$	max.	500	V
		min.	80	V
Ambient temperature	t_{amb}	max.	100	°C

1) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.
2) For an infinitely short light pulse, fully illuminating the cathode.

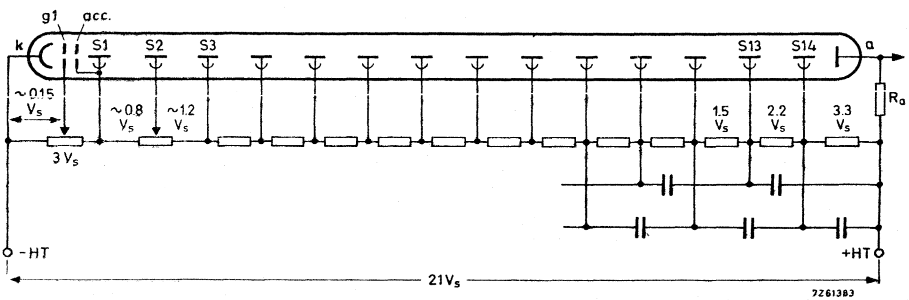
RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B



Voltage divider type B'

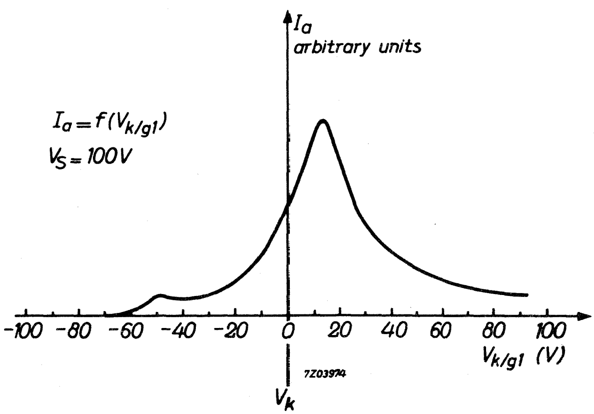
OPERATIONAL CONSIDERATIONS

Peak anode currents

To make full use of the good properties of the tube one must keep the time constant at the output small; since capacitances cannot be controlled, the load resistance must be kept small. Also, the load resistance should be matched to the coaxial cable (impedance, for instance, 75 Ω); otherwise an amplifier will be needed and this will be an expensive unit in view of the short rise time of the anode current pulse. The photomultiplier will have to deliver signals of the order of 10 V, which correspond to peak anode currents of some hundreds of milliamps. The I_{a_p} - Φ diagram Fig. 1 shows that the 56SBUVP can deliver anode currents up to 300 mA, which are directly proportional to the light current, if voltage divider B is employed and if the $V_{as\ 14}$ is properly adjusted (see Fig. 2)
In many cases it is not really necessary to have the anode current in direct proportion with the light current; on the other hand it is possible to derive such light-current proportional signals from the dynodes before saturation sets in.

Focusing electrode

The anode current can be controlled by the focusing electrode voltage. The resulting electric field between the photocathode and the focusing electrode can be given such a form that only the electrons emitted from the centre area of the photocathode reach the multiplier system.
So the "active" cathode area is restricted to a minimum, resulting in a proportionally lower dark current.
The maximum anode current is obtained with a focusing voltage $V_{k/g_1} \approx$ 20 V (see Fig. below).



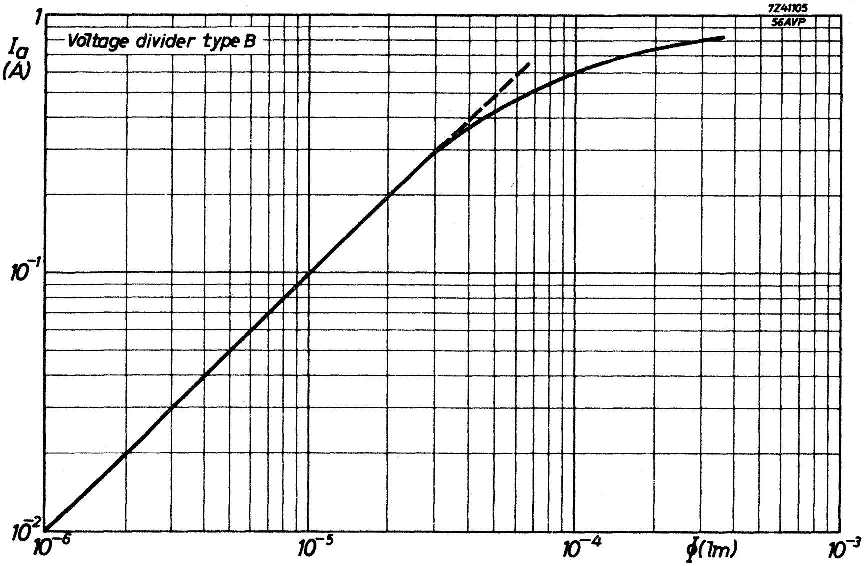
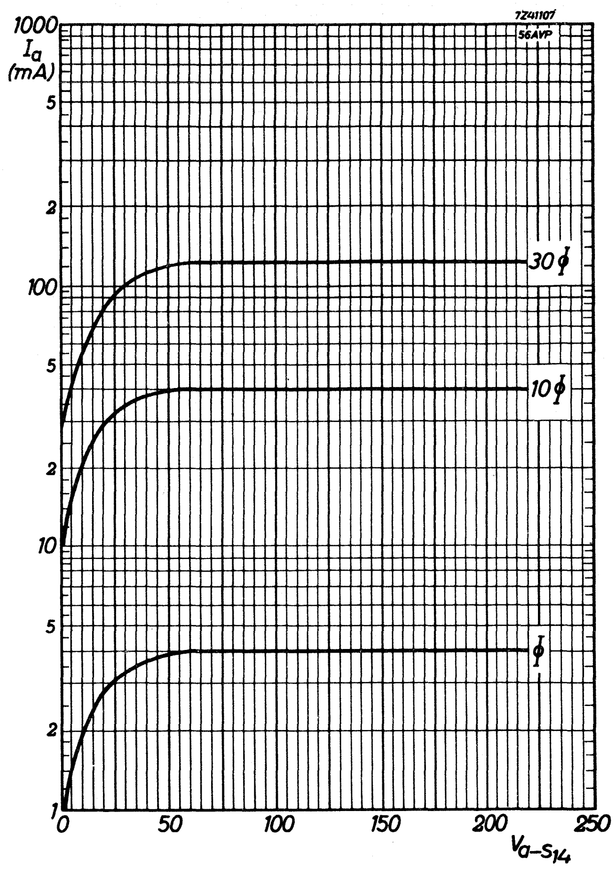

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
ϕ(lm)
10^{-3}

Fig. 1



7Z41107
56AVP
1000
I_a (mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 ϕ
10 ϕ
ϕ

Fig. 2

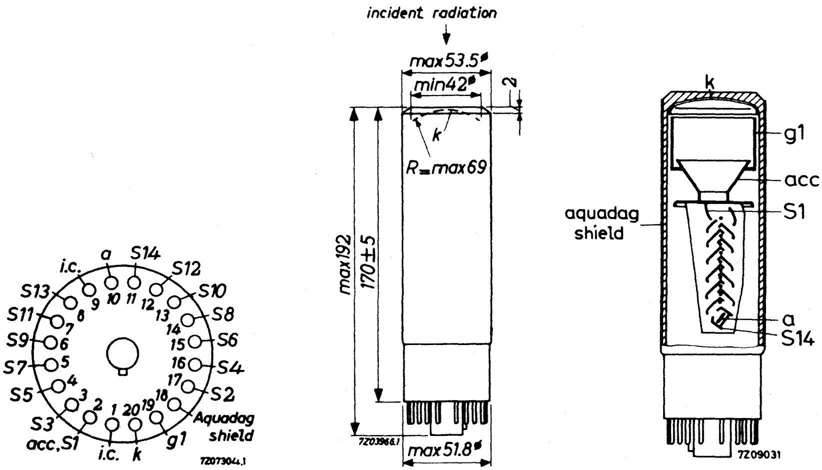
14 STAGE PHOTOMULTIPLIER TUBE

The tube is intended for use in applications such as telecommunication and ranging and in optical experiments where a high-sensitivity in the whole visible and ultraviolet region is required combined with a high degree of time definition.

QUICK REFERENCE DATA		
Spectral response	type TU (extended S20)	
Window material	quartz	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (JEDEC B20-102)



ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		Sb-K-Na-Cs	
Minimum useful diameter		42	mm
Radius of curvature		max. 69	mm
Spectral response curve [2]		type TU (extended S20)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [3]	N_k	av. 115 min. 90	μA/lm μA/lm
Radiant sensitivity at 4200 Å		65	mA/W
at 7000 Å		12	mA/W

Multiplier system

Number of stages	14	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc, S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

[2]) See spectral response curve in front of this section.

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for G = 10^8	V_b	av.	2500	V
		max.	2750	V
Anode dark current at G = 10^8 1)	I_{a_o}	max.	5	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	0.8	ns
Total transit time at V_b = 2500 V 2)			43	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

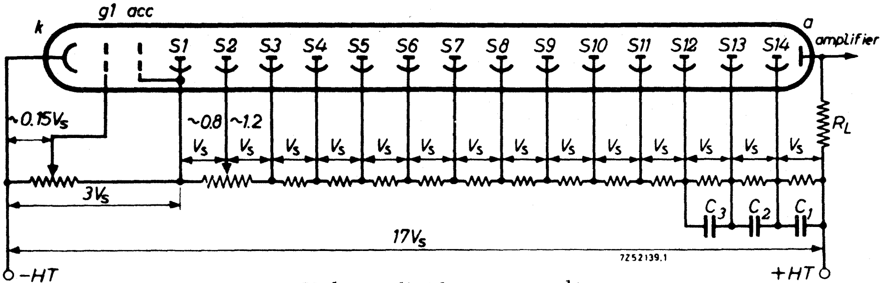
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3	ns
Total transit time at V_b = 2500 V 2)			39	ns

LIMITING VALUES (Absolute max. rating system)

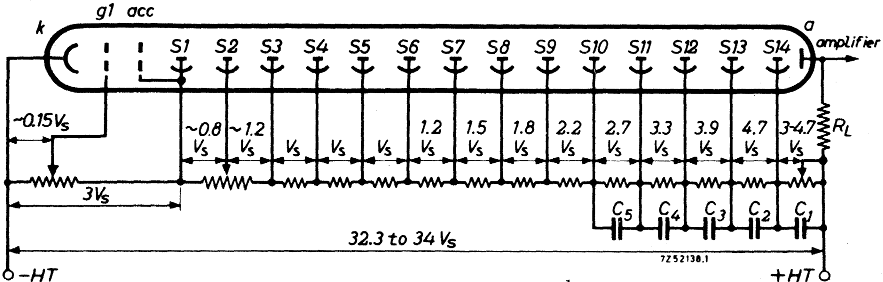
Supply voltage 3)	V_b	max.	2750	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

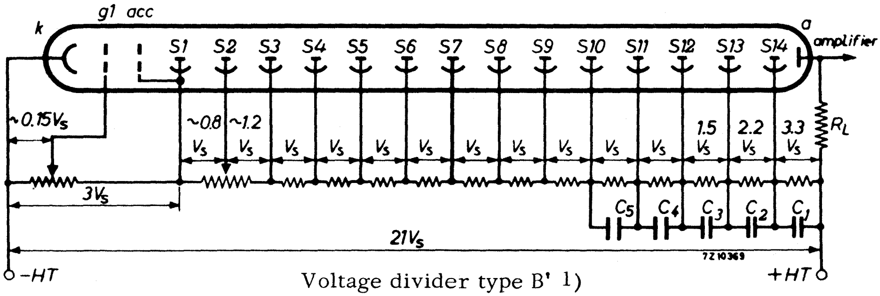
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s (see fig. 1); voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s; C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling to a scintillator;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1;
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig.1 the optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

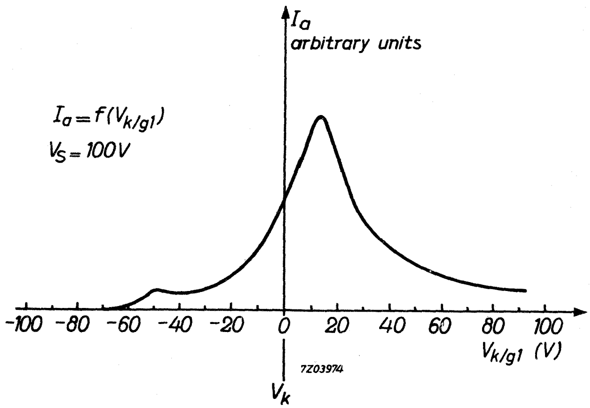


Fig.1 Anode current variation with the adjustment of g_1

4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2500 V (see Fig.2).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

OPERATIONAL CONSIDERATIONS (continued)

Fig.3 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.4 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. In practice, therefore, it will be preferable to use the type A distribution, or a distribution between A and B (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} and so on, maintaining the same progression.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

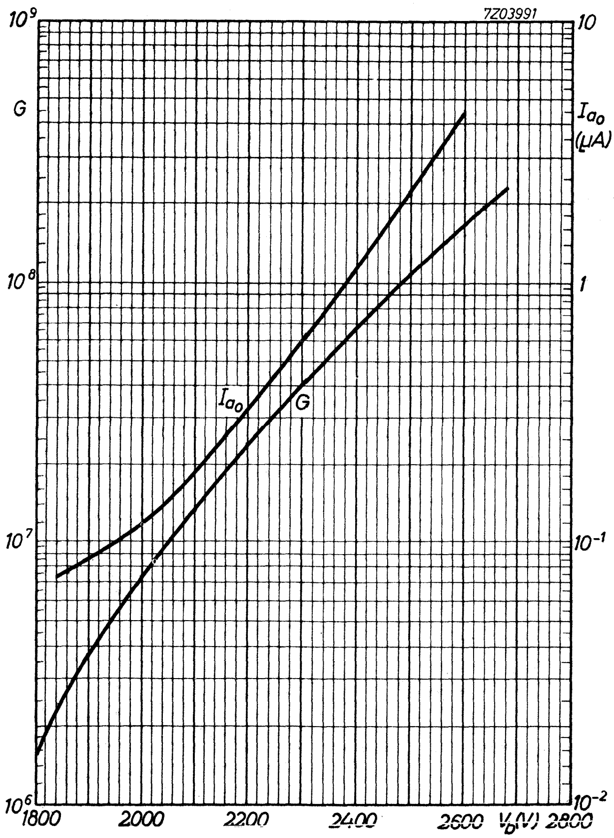

7Z03991
10^9
G
10^8
10^7
10^6
10
I_{a_0} (μA)
1
10^{-1}
10^{-2}
I_{a_0}
G
1800
2000
2200
2400
2600
V_b(V)
2800

Fig. 2

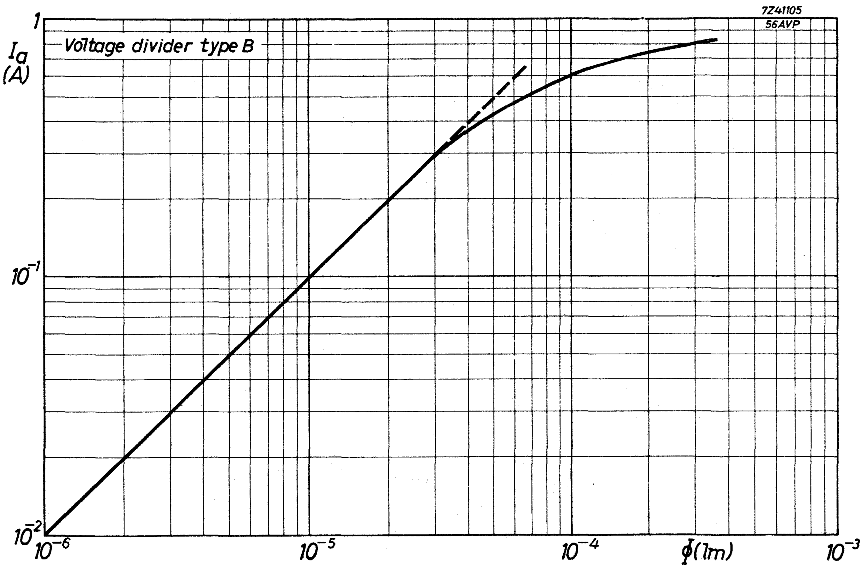

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
Φ(lm)
10^{-3}

Fig.3

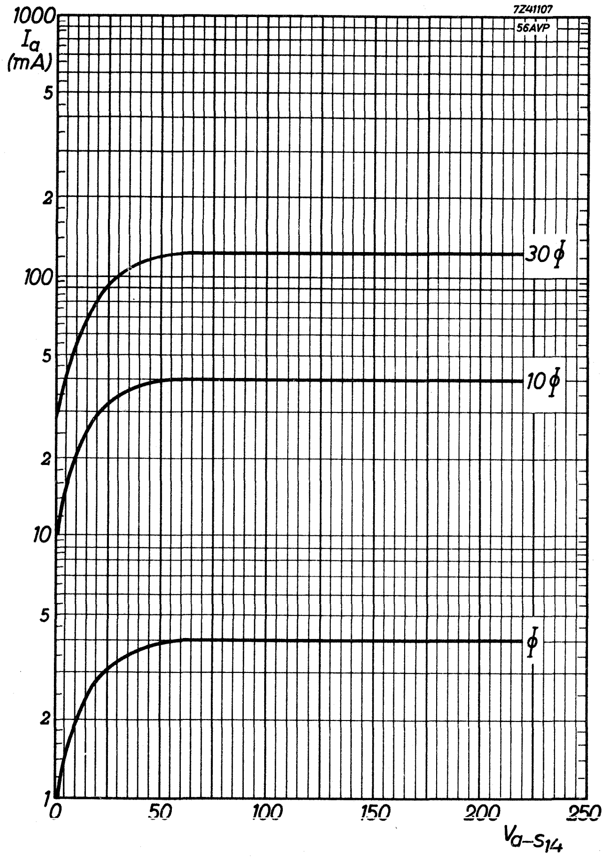

7Z41107
56AVP
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 ϕ
10 ϕ
ϕ

Fig. 4

14 STAGE PHOTOMULTIPLIER TUBE

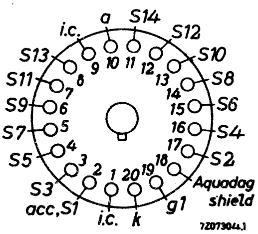
The tube is intended for use in laser-technics working in the orange, yellow and green range.

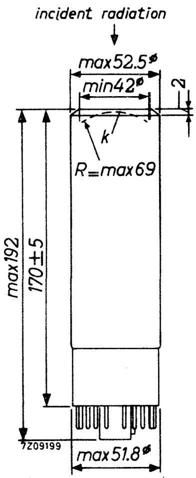
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

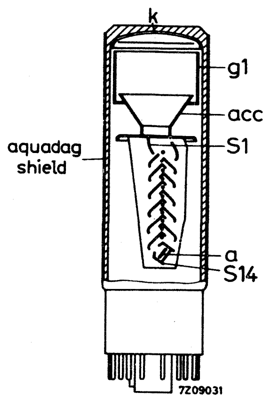
DIMENSIONS AND CONNECTIONS

Base: 20-pin (Jedec B20-102)

Dimensions in mm







ACCESSORIES

Socket	type	FE1003
Mu-metal shields [1]	type	56130
	type	56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material		Sb-K-Na-Cs		
Minimum useful diameter			42	mm
Radius of curvature		max.	69	mm
Spectral response curve [2]		type T (S20)		
Wavelength at maximum response		4200 ± 300		Å
Luminous sensitivity [3]	N_k	av.	115	μA/lm
		min.	90	μA/lm
Radiant sensitivity at 4200 Å			65	mA/W
at 7000 Å			12	mA/W

Multiplier system

Number of stages		14
Dynode material		Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc,S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

---

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

2) See spectral response curve in front of this section.

3) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. max.	2500 2750	V V
Anode dark current at $G = 10^8$ [1]	I_{a_o}	max.	5.0	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V [2]			2	ns
Anode pulse width at half height at V_b = 2500 V [2]			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	0.8	ns
Total transit time at V_b = 2500 V [2]			43	ns
Maximum peak currents			0.5 to 1	A

With voltage divider B'

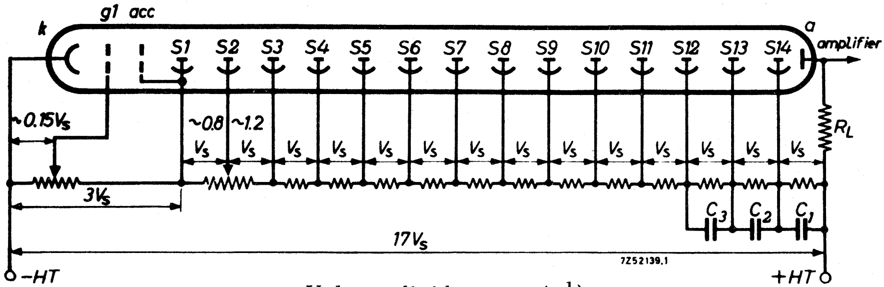
Anode pulse rise time at V_b = 2500 V [2]			2	ns
Anode pulse width at half height at V_b = 2500 V [2]			3	ns
Total transit time at V_b = 2500 V [2]			39	ns

LIMITING VALUES (Absolute max. rating system)

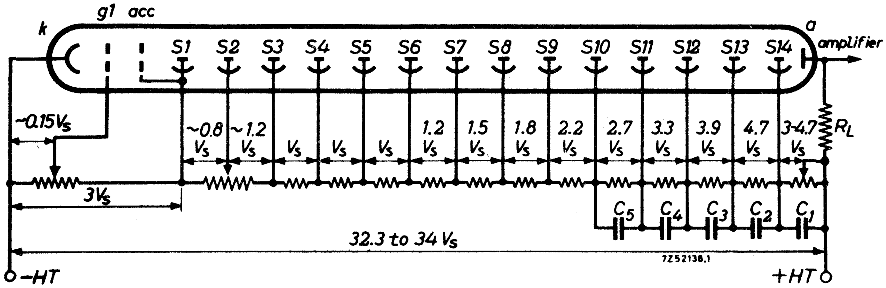
Supply voltage [3]	V_b	max.	2750	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	800 250	V V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode [4]	$V_{a/S_{14}}$	max. min.	500 80	V V

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

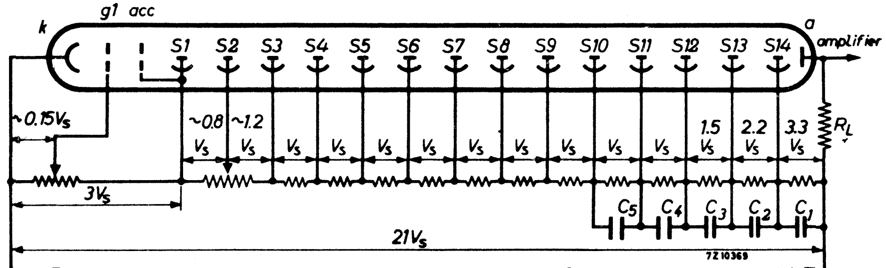
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s (see fig.1); voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 q/3V_s, C_3 = 100 q/9V_s, C_4 = 100 q/27V_s etc. with q = quantity of electricity transported by the anode.

[1]) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of three elements:

the photocathode k;
the focusing electrode g_1;
the accelerating electrode acc.

To reduce transit-time fluctuations, geometrical time spread, pulse amplitude spread or dark current, this system has the following advantages:

1. the photocathode is curved, though the outer window surface is flat, thus facilitating optical coupling to a scintillator;
2. a high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator (internally connected to the first dynode) voltage of 350 V ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1;
3. the potential of electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   a. the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); for this adjustment, see Fig. 1 the optimum value of the potential is about 0.15 V_S;
   b. the slightest transit-time fluctuations (the most homogeneous extraction field);
   c. the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

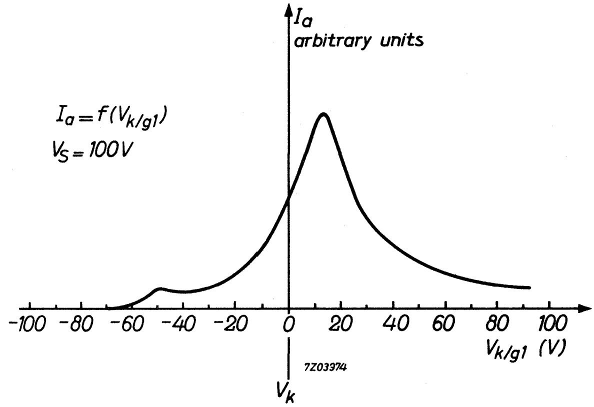


Fig.1 Anode current variation with the adjustment of g_1

4. Collection on the first dynode is controlled by the potential of the second dynode (see recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2500 V (see Fig.6).

The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low-load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

OPERATIONAL CONSIDERATIONS (continued)

Fig.3 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.4 the anode current variation is plotted against anode-to-final-dynode voltage.

It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. In practice, therefore, it will be preferable to use the type A distribution, or a distribution between A and B (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} and so on, maintaining the same progression.

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influences.

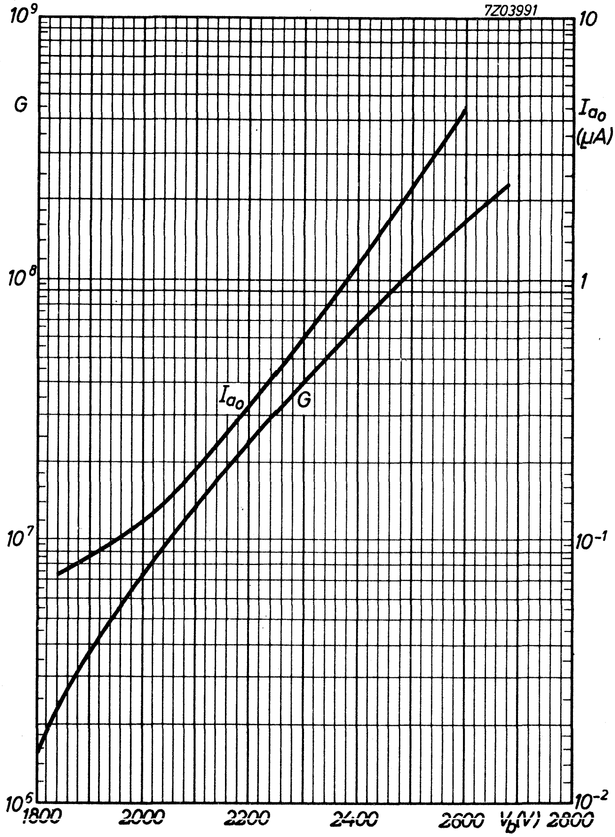

7Z03991
10^9
G
10^8
10^7
10^6
10
I_{a_0}
(μA)
1
10^{-1}
10^{-2}
I_{a_0}
G
1800
2000
2200
2400
2600
V_b(V)
2800

Fig. 2

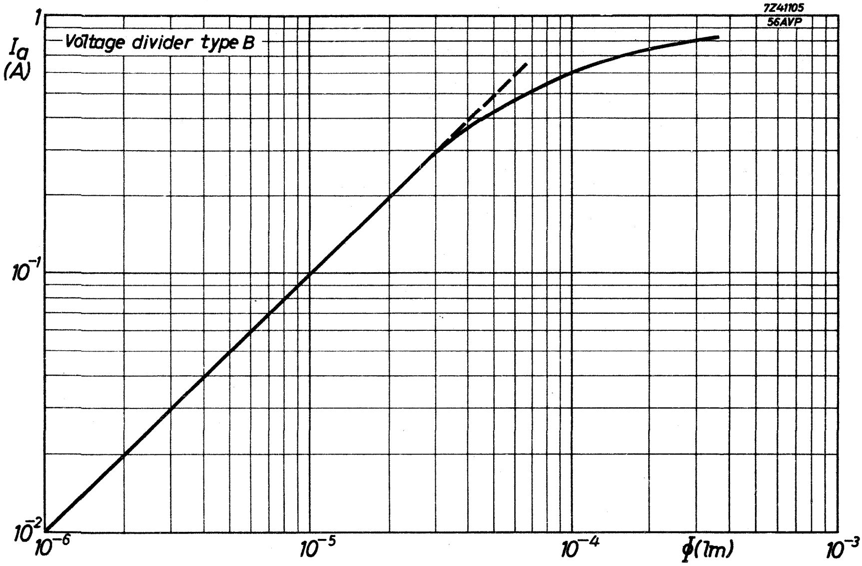

7Z41105
56AVP
Voltage divider type B
I_a (A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
ϕ (lm)
10^{-3}

Fig. 3

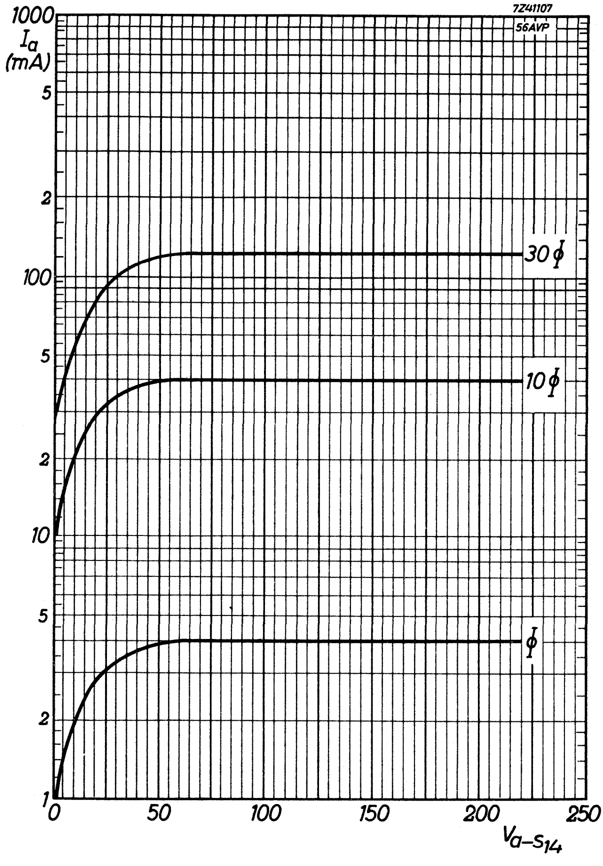

7Z41107
56AVP
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 ϕ
10 ϕ
ϕ

Fig. 4

Recommended replacement type 56DUVP

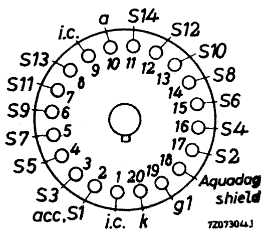
14 STAGE PHOTOMULTIPLIER TUBE

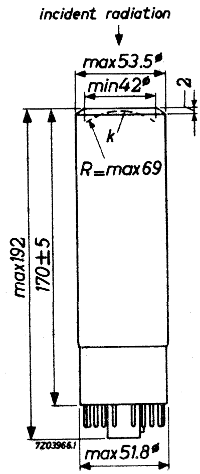
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the ultraviolet region.

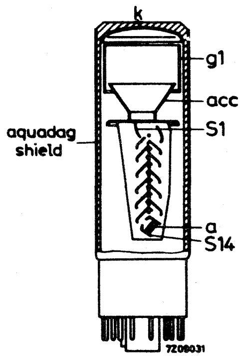
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	42	mm
Gain (at 2200 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS — Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type FE1003
Mu-metal shields [1]	type 56130 type 56131

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material			Cs-Sb	
Minimum useful diameter			42	mm
Radius of curvature		max.	69	mm
Spectral response curve [2]		type	U (S13)	
Wavelength at maximum response			4000 ± 300	Å
Luminous sensitivity [3]	N_k	av. min.	65 45	μA/lm μA/lm
Radiant sensitivity at 4000 Å			55	mA/W

Multiplier system

Number of stages		14
Dynode material		Ag-Mg-O-Cs

Capacitances

Grid No.1 to accelerator electrode	$C_{g_1/acc, S_1}$	25	pF
Anode to final dynode	$C_{a/S_{14}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

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[1] To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

[2] See spectral response curve in front of this section.

[3] Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for G = 10^8	V_b	av.	2200	V
		max.	2500	V
Anode dark current at G = 10^8 1)	I_{ao}	av.	0.5	μA
		max.	5.0	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

With voltage divider B

Linearity between anode pulse amplitude and input light pulse		up to	300	mA
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3.5	ns
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	0.8	ns
Total transit time at V_b = 2500 V 2)			43	ns
Maximum peak current			0.5 to 1	A

With voltage divider B'

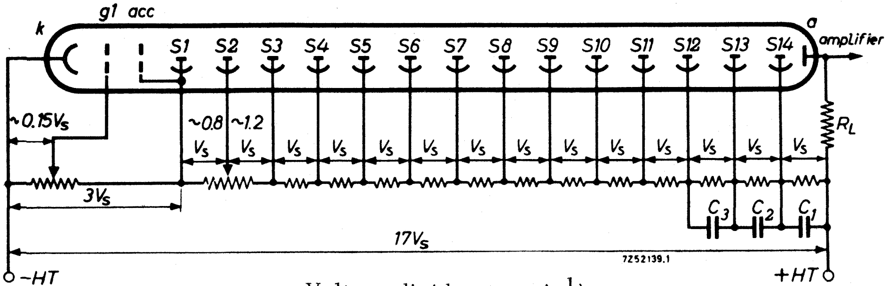
Anode pulse rise time at V_b = 2500 V 2)			2	ns
Anode pulse width at half height at V_b = 2500 V 2)			3	ns
Total transit time at V_b = 2500 V 2)			39	ns

LIMITING VALUES (Absolute max. rating system)

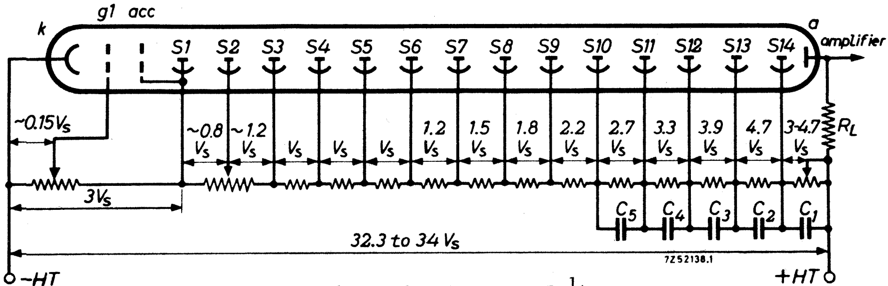
Supply voltage 3)	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

1) At an ambient temperature of 25 °C.
2) For an infinitely short light pulse, fully illuminating the photocathode.
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
4) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

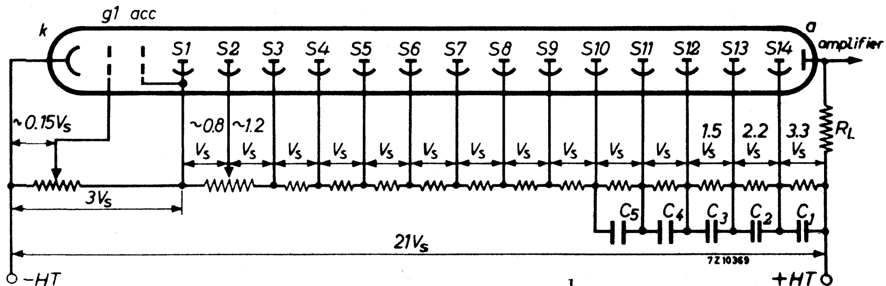
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 0.15 V_s; voltage between S_1 and S_2 to be adjusted at about 0.8 V_s; decoupling capacitances C_1 = 100 q/V_s, C_2 = 100 $q/3V_s$, C_3 = 100 $q/9V_s$, C_4 = 100 $q/27V_s$ etc. with q = quantity of electricity transported by the anode.

1) To avoid electric field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to a voltage near to the cathode voltage. If the cathode is connected to the negative H.T., precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

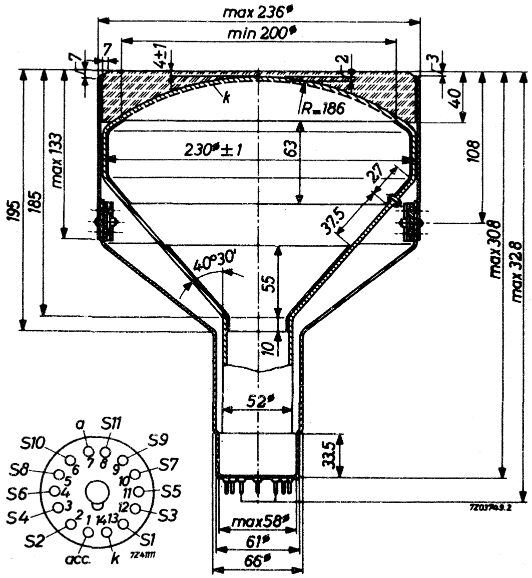
11 STAGE PHOTOMULTIPLIER TUBE

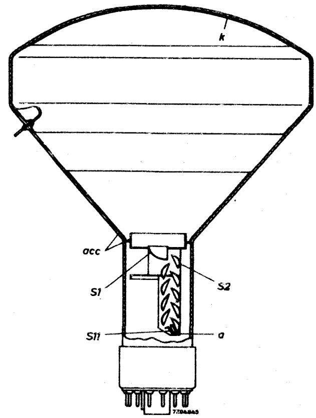
The tube is intended for use in applications such as total body radiation measurements, uranium prospecting with very large scintillators, Cerenkov light measurements in large transparent objects.

QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	200	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 56132

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface [1]	
Cathode material		Cs-Sb	
Minimum useful diameter		200	mm
Radius of curvature		186	mm
Spectral response curve [2]		type A (S11)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [3]	N_k	av. 50 min. 35	μA/lm μA/lm
Radiant sensitivity at 4200 Å		45	mA/W

Multiplier system

Number of stages		11	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{11}}$	3	pF
Anode to all other electrodes	C_a	5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av. 250 min. 60	A/lm A/lm
Anode dark current at N_a = 60 A/lm [4]	I_{a_o}	max. 1	μA
Linearity between anode pulse amplitude and input light pulse		up to 30	mA

---

1) The tube is delivered with a plane-concave acrylate adaptor and with a metal envelope.

2) See spectral response curve in front of this section

3) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

4) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 2500 V [1]		6	ns
Anode pulse width at half height at V_b = 2500 V [1]		20	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 2500 V		4	ns
Total transit time at V_b = 2500 V [1]		75	ns

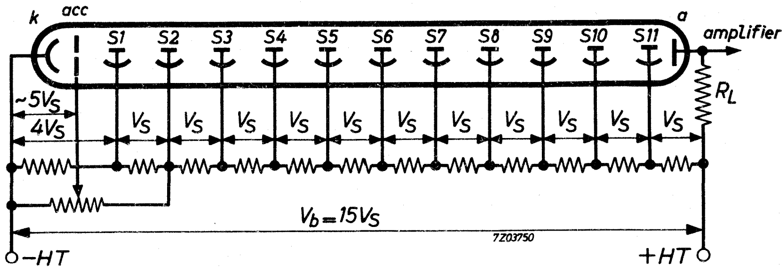
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2500	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	1000 200	V V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	max.	1000	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max. min.	300 80	V V

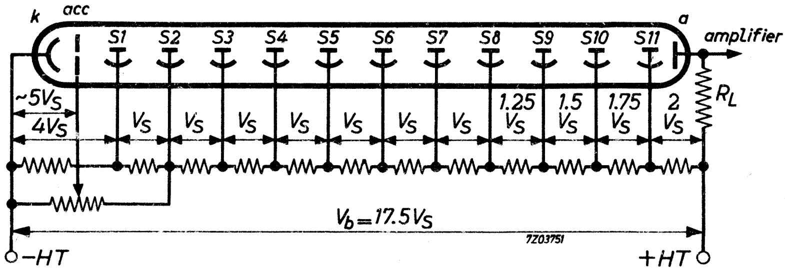
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 1 mA will be sufficient.

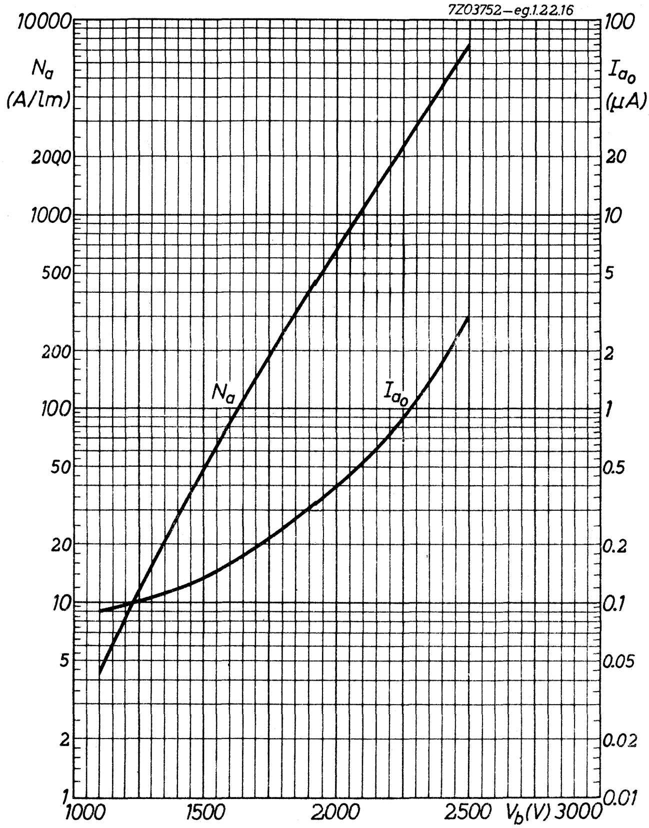
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

The accelerating electrode has a separate external connection to allow adjustment for optimum photoelectron collection on the first dynode. This adjustment is very important to obtain a good time response.

In pulse techniques, such as scintillation counting, it is advisable to decouple the last two or three stages by means of capacitors of 100 pF and 200 pF (the highest value at the last stage).

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03752—eg.1.2.2.16
10000
N_a
(A/lm)
2000
1000
500
200
100
50
20
10
5
2
1
100
I_{a_0}
(μA)
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
N_a
I_{a_0}
1000
1500
2000
2500
V_b(V)
3000

14 STAGE PHOTOMULTIPLIER TUBE

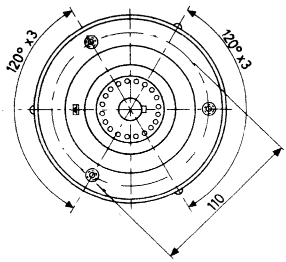
The tube is intended for use in nuclear-physics applications where a high degree of time definition is required (fast coincidences, Cerenkov counters).

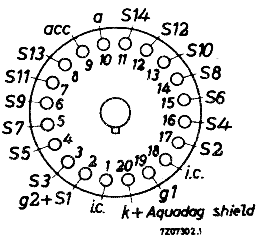
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	110	mm
Gain (at 2400 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

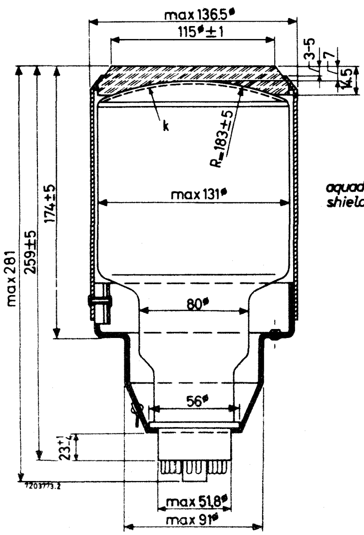
DIMENSIONS AND CONNECTIONS

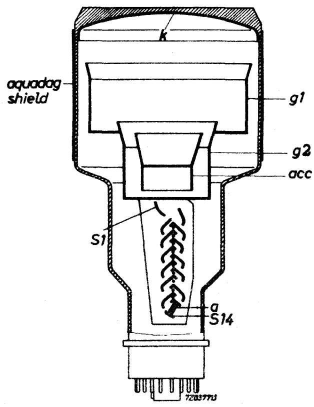
Dimensions in mm

Base: 20-pin (Jedec B20-102)









ACCESSORIES

Socket	type	FE1003
Mu-metal shield (for tube with metal container)	type	56133
(for tube without metal container)	type	56129

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface [1]
Cathode material		Cs-Sb
Minimum useful diameter		110 mm
Radius of curvature		183 ± 5 mm
Spectral response curve [2]		type A (S11)
Wavelength at maximum response		4200 ± 300 Å
Luminous sensitivity [3]	N_k	av. 70 μA/lm min. 45 μA/lm
Radiant sensitivity at 4200 Å		60 mA/W

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Anode to final dynode	$C_{a/S14}$	5 pF
Anode to all other electrodes	C_a	7 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. 2400 V max. 3000 V
Anode dark current at $G = 10^8$ [4]	I_{ao}	av. 2 μA max. 12 μA
Linearity between anode pulse amplitude and input light pulse		up to 100 mA

---

[1]) The tube is delivered with a plane-concave acrylate adaptor and with a metal envelope.

[2]) See spectral response curve in front of this section

[3]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[4]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 300	mA
Anode pulse rise time at V_b = 2800 V [1]	2	ns
Anode pulse width at half height at V_b = 2800 V [1]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Transit time spread	1	ns
Total transit at time V_b = 2800 V [1]	46	ns
Maximum peak currents	0.5 to 1	A

With voltage divider B'

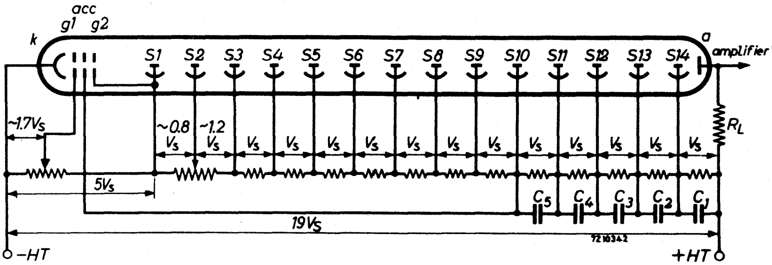
Anode pulse rise time at V_b = 2800 V [1]	2	ns
Anode pulse width at half height at V_b = 2800 V [1]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Transit time spread	1	ns
Total transit time at V_b = 2800 V [1]	43	ns

LIMITING VALUES (Absolute max. rating system)

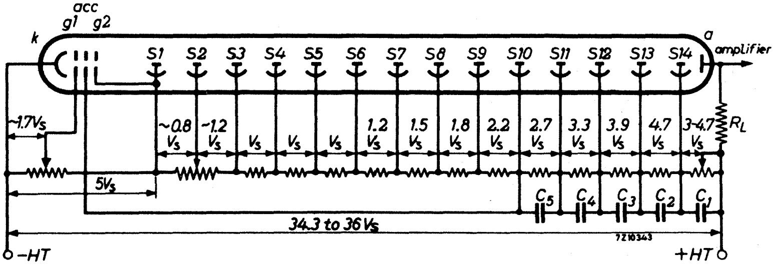
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$		1400 to 1800	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

1) For an infinitely short light pulse, fully illuminating the photocathode.
2) Or the voltage at which the tube circuited in the voltage divider A has a gain of of about 10^9, whichever is lowest.
3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

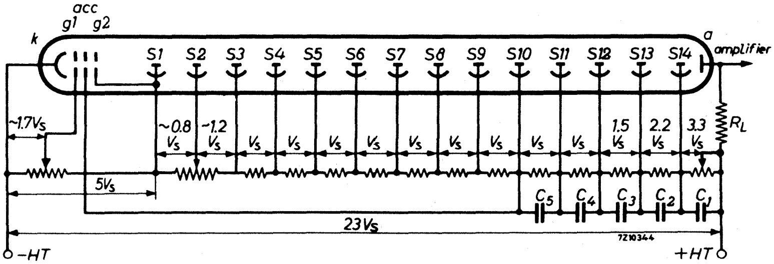
RECOMMENDED CIRCUITS



Voltage divider type A 1)



Voltage divider type B 1)



Voltage divider type B' 1)

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 1.7 V_S; voltage between S_1 and S_2 to be adjusted at about 0.8 V_S; decoupling capacitances $C_1 = 100q/V_S$, $C_2 = 100q/3V_S$, $C_3 = 100q/9V_S$, $C_4 = 100q/27V_S$ etc. with q = quantity of electricity transported by the anode.

1) If the cathode is connected to negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the metal envelope or mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value of C_1 will be 2.10^{-9} F.

In the case of high counting rates and large peak power outputs, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc.

To reduce transit-time fluctutations and geometrical time spread, this system has the following advantages:

1. The photocathode is curved, with a curvature radius of 183 mm. To facilitate optical coupling to scintillators the tube is delivered with an acrylate plane-concave adaptor.
2. A high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator voltage of about 1500 V (to be connected to the tenth or eleventh dynode) ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.
3. The potential of the electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:
   (a) the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about $1.7\,V_S$;
   (b) the slightest transit-time fluctuations (the most homogeneous extraction field);
   (c) the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

4. Collection on the first dynode is controlled by the potential of the second dynode (see Recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2400 V (see fig.1). The tube is capable of producing very strong peak currents (up to 1 A) Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.3 the anode current variation is plotted against anode-to-final dynode voltage.

It should be noted that for equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.
In practice, therefore, it will be preferable to use the A type distribution, or a distribution between A and B, (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} etc., maintaining the same progression).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influence.

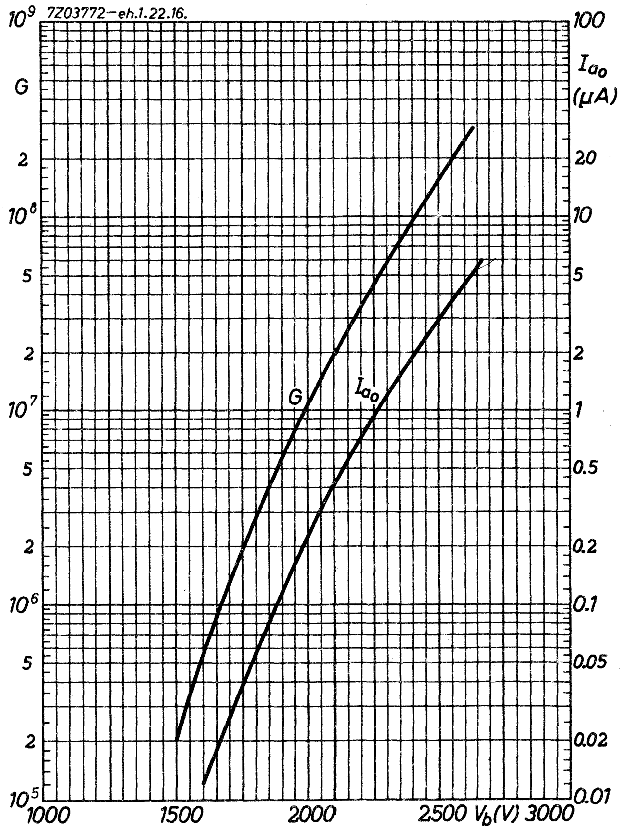

7Z03772-eh.1.22.16.
G
I_{a_0} (μA)
G
I_{a_0}
10^9
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
100
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1000
1500
2000
2500
V_b(V)
3000

Fig.1

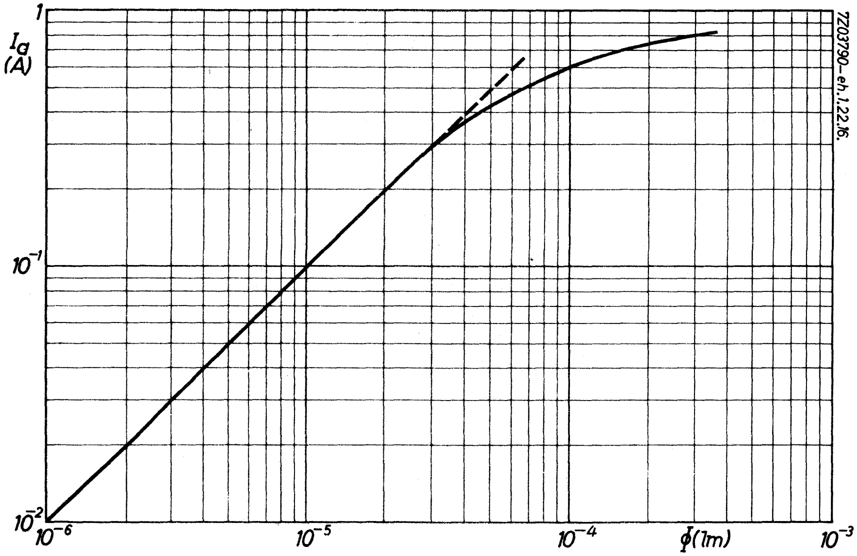
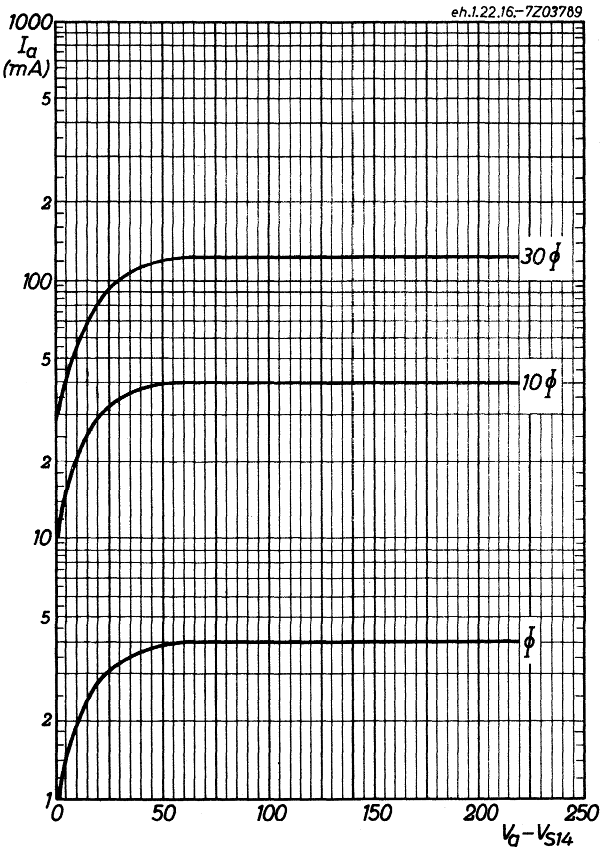


Fig.2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1000
I_a (mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 Φ
10 Φ
Φ

Fig. 3

14 STAGE PHOTOMULTIPLIER TUBE

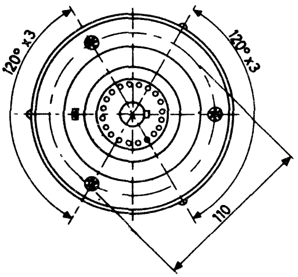
The tube is intended for use in nuclear-physics applications where very low luminous fluxes are to be measured and where a high degree of time definition is required.

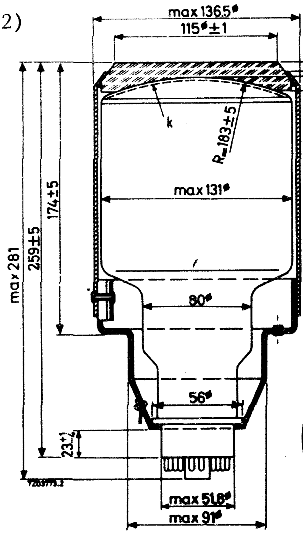
QUICK REFERENCE DATA		
Spectral response	bi-alkali type D	
Useful diameter of the photocathode	110	mm
Gain (at 2250 V)	10^8	
Anode pulse rise time	2	ns
Quantum efficiency (at 400 nm)	25	%

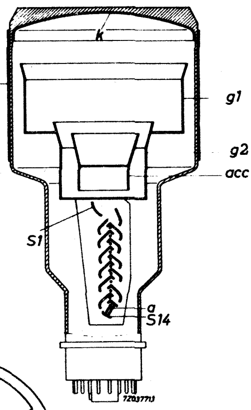
DIMENSIONS AND CONNECTIONS

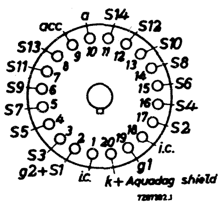
Dimensions in mm

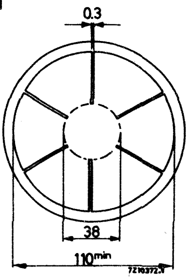
Base: 20-pin (Jedec B20-102)











top view

ACCESSORIES

Socket	type FE1003
Mu-metal shield (for tube with metal container)	type 56133
(for tube without metal container)	type 56129

Data based on pre-production tubes

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface [1]		
Cathode material			K-Cs-Sb	
Minimum useful diameter			110	mm
Radius of curvature			183 ± 5	mm
Spectral response curve			See page 10 type D	
Wavelength at maximum response			400 ± 30	nm
Luminous sensitivity [2]	N_k	min.	45	μA/lm
Radiant sensitivity at 437 nm			75	mA/W
Quantum efficiency at 400 nm	η_q	av.	25	%

Multiplier system

Number of stages			14	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S14}$		5	pF
Anode to all other electrodes	C_a		7	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av.	2250	V
		max.	3000	V
Anode dark current at $G = 10^8$ [3]	I_{a_o}	max.	2	μA
Linearity between anode pulse amplitude and input light pulse		up to	100	mA

---

1) The tube is delivered with a plane-concave acrylate adaptor and with a metal envelope.
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K. Because of the resistivity of D-type of photocathodes the value of the cathode sensitivity is only an approximation. (See also the "Operational Considerations")
3) At an ambient temperature of 25 °C.

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	300	mA
Anode rise time at V_b = 2800 V [1]		2	ns
Anode pulse width at half height at V_b = 2800 V [1]		3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V		1	ns
Total transit time at V_b = 2800 V [1]		46	ns
Maximum peak currents		0.5 to 1	A

With voltage divider B'

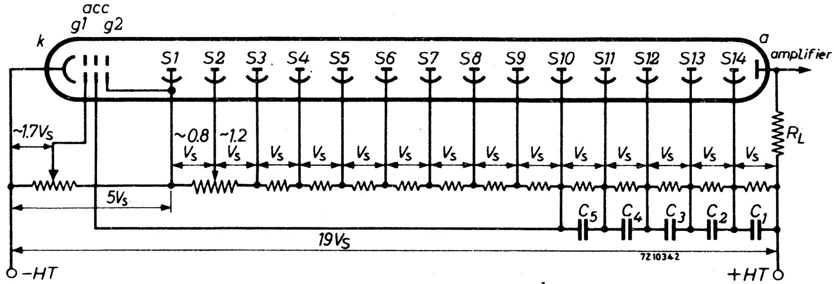
Anode pulse rise time at V_b = 2800 V [1]		2	ns
Anode pulse width at half height at V_b = 2800 V [1]		3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V		1	ns
Transit time spread		1	ns
Total transit time at V_b = 2800 V [1]		43	ns

LIMITING VALUES (Absolute max. rating system)

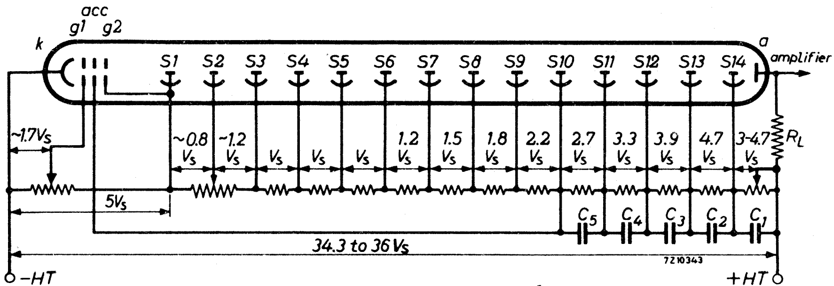
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max. min.	800 250	V V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	$14\ V_s$ to	18	V_s
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	500 80	V V
Voltage between anode and final dynode [3]	$V_{a/S_{14}}$	max. min.	500 80	V V

1) For an infinitely short light pulse, fully illuminating the photocathode.
2) Or the voltage at which the tibe circuited in the voltage divider A has a gain of about 5×10^8, whichever is lowest.
3) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

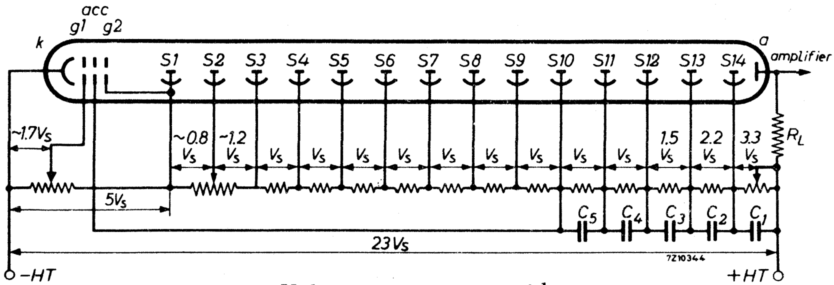
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 1.7 V_S; voltage between S_1 and S_2 to be adjusted at about 0.8 V_S; decoupling capacitances $C_1 = 100q/V_S$, $C_2 = 100q/3V_S$, $C_3 = 100q/9V_S$, $C_4 = 100q/27V_S$ etc. with q = quantity of electricity transported by the anode.

[1]) If the cathode is connected to negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the metal envelope or mu-metal shield.

OPERATIONAL CONSIDERATIONS

Because of the resistivity of D-type photocathodes it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10 nA at room temperature and 0.1 nA at −100 °C. The resistivity of the photocathode increases with decreasing temperature.

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value of C_1 will be 2.10^{-9} F.

In the case of high counting rates and large peak power outputs, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc.

To reduce transit-time fluctuations and geometrical time spread, this system has the following advantages:

1. The photocathode is curved, with a curvature radius of 183 mm. To facilitate optical coupling to scintillators the tube is delivered with an arcrylate plane-concave adaptor.

2. A high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator voltage of about 1500 V (to be connected to the tenth or eleventh dynode) ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.

3. The potential of the electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:

   (a) the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about 1.7 V_S;

   (b) the slightest transit-time fluctuations (the most homogeneous extraction field);

   (c) the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

4. Collection on the first dynode is controlled by the potential of the second dynode. (See recommended circuits).

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2250 V (see fig.1). The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.2 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.3 the anode current variation is plotted against anode-to-final dynode voltage.

It should be noted that for equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.
In practice, therefore, it will be preferable to use the A type distribution, or a distribution between A and B, (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} etc., maintaining the same progression).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influence.

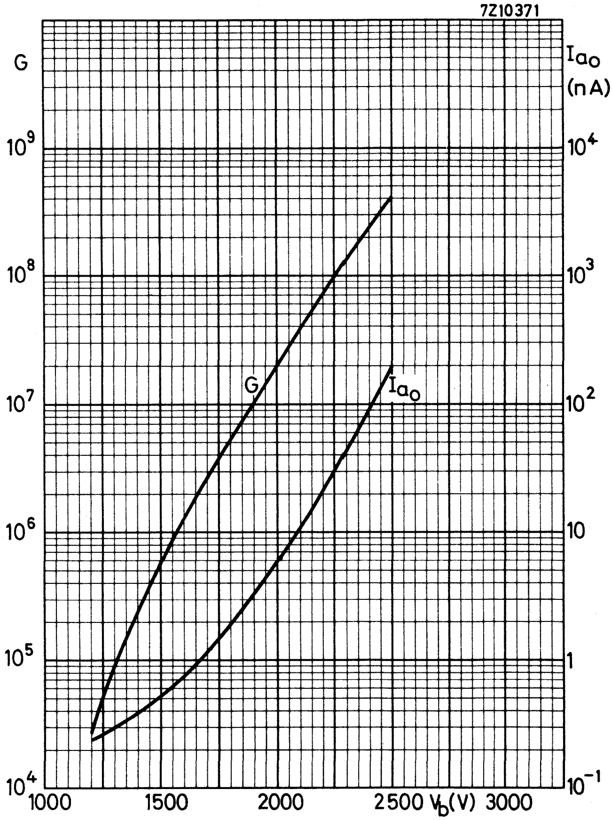

7Z10371
G
I_{a_0}
(nA)
10^9
10^8
10^7
10^6
10^5
10^4
10^4
10^3
10^2
10
1
10^{-1}
G
I_{a_0}
1000
1500
2000
2500
V_b(V)
3000

fig.1

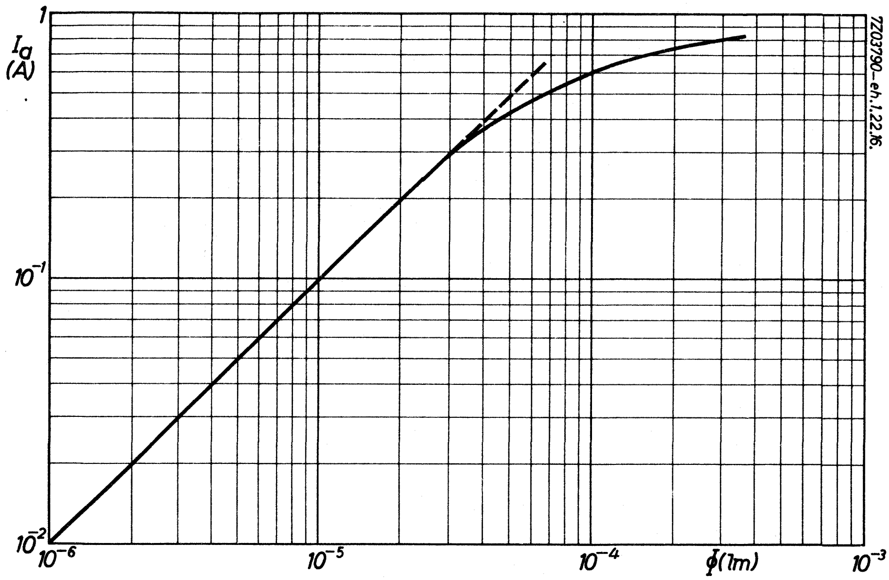


fig. 2

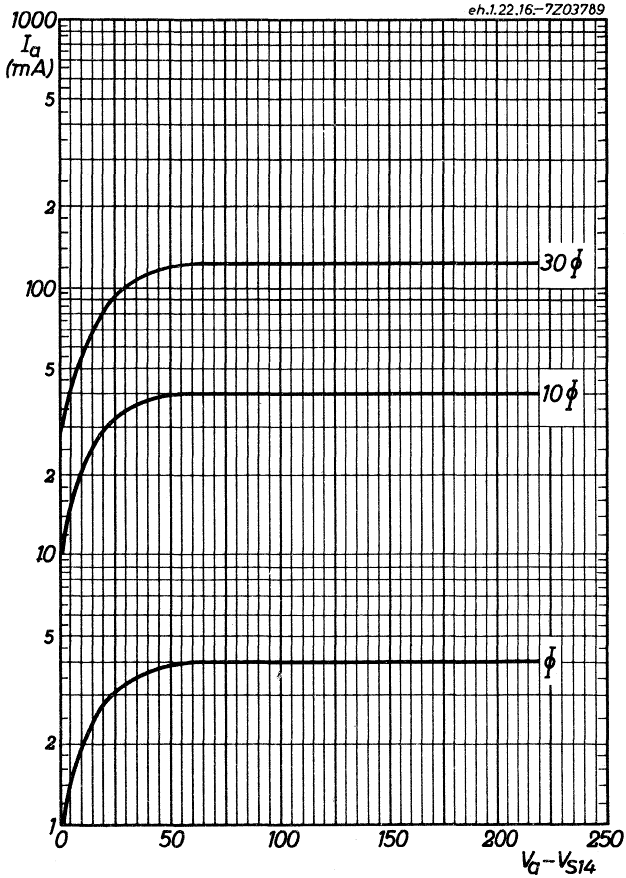

eh.1.22.16.-7Z03789
1000
I_a (mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 ϕ
10 ϕ
ϕ

fig. 3

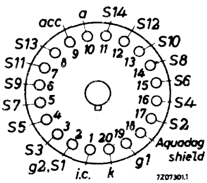
14 STAGE PHOTOMULTIPLIER TUBE

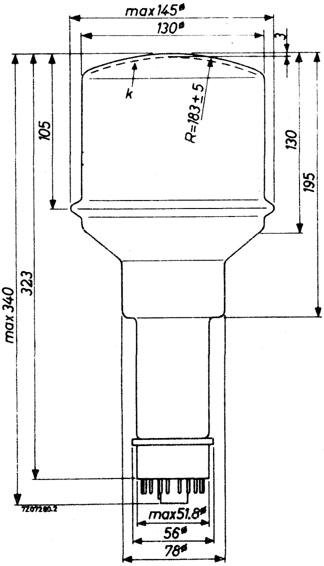
The tube is intended for use in nuclear-physics applications where a high degree of time definition is required, combined with a good sensitivity in the ultra-violet region.

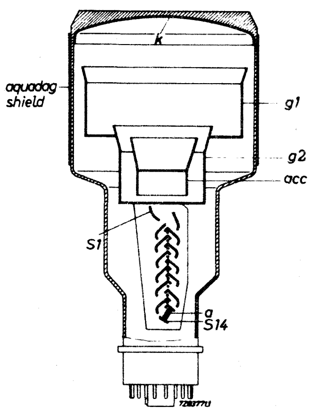
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	110	mm
Gain (at 2400 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)







ACCESSORIES

Socket	type FE1003
Mu-metal shield [1]	type 56133
Quartz adaptor	type 56137

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface
Cathode material		Cs-Sb
Minimum useful diameter		110 mm
Spectral response curve [2]		type U (S13)
Wavelength at maximum response		4000 ± 300 Å
Luminous sensitivity [3]	N_k	av. 70 µA/lm min. 45 µA/lm
Radiant sensitivity at 4000 Å		60 mA/W

Multiplier system

Number of stages	14
Dynode material	Ag-Mg-O-Cs

Capacitances

Anode to final dynode	C_a/S_{14}	5 pF
Anode to all other electrodes	C_a	7 pF

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^8$	V_b	av. 2400 V max. 3000 V
Anode dark current at $G = 10^8$ [4]	I_{a_o}	av. 2 µA max. 12 µA
Linearity between anode pulse amplitude and input light pulse		up to 100 mA

[1][2][3][4] See page 3.

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 300	mA
Anode pulse rise time at V_b = 2800 V [5]	2	ns
Anode pulse width at half height at V_b = 2800 V [5]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Total transit time at V_b = 2800 V [5]	46	ns
Maximum peak currents	0.5 to 1	A

With voltage divider B'

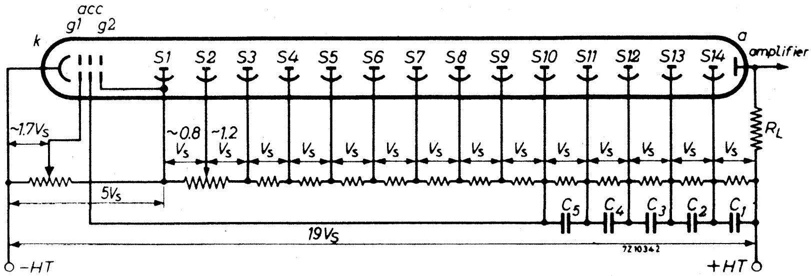
Anode pulse rise time at V_b = 2800 V [5]	2	ns
Anode pulse width at half height at V_b = 2800 V [5]	3	ns
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	1	ns
Transit time spread	1	ns
Total transit time at V_b = 2800 V [5]	43	ns

LIMITING VALUES (Absolute max. rating system)

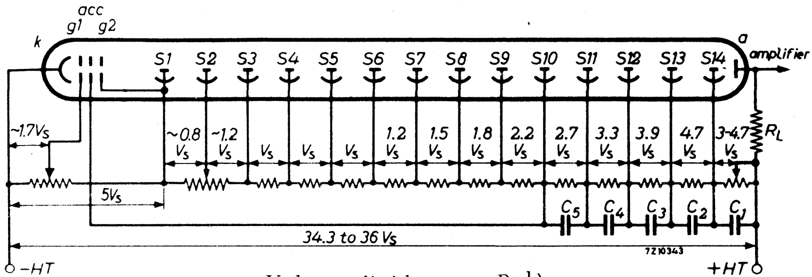
Supply voltage [6]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$		1400 to 1800	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [7]	$V_{a/S_{14}}$	max.	500	V
		min.	80	V

1) To avoid electric-field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to the cathode. If the cathode is connected to the negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.
2) See spectral response curve in front of this section.
3) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K.
4) At an ambient temperature of 25 °C.
5) For an infinitely short light pulse, fully illuminating the photocathode.
6) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.
7) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

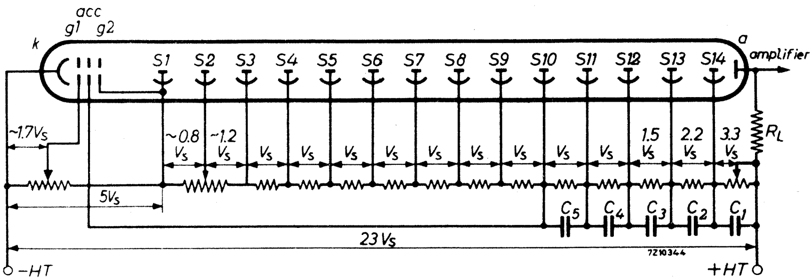
RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode
g_2 = focusing electrode
acc = accelerating electrode
S_n = dynode No.n
a = anode

voltage between k and g_1 to be adjusted at about 1.7 V_S; voltage between S_1 and S_2 to be adjusted at about 0.8 V_S; decoupling capacitances $C_1 = 100q/V_S$, $C_2 = 100q/3V_S$, $C_3 = 100q/9V_S$, $C_4 = 100q/27V_S$ etc. with q = quantity of electricity transported by the anode.

[1]) To avoid electric-field distortion in the electron optical system the aquadag shield (pin No.18) must be connected to the cathode. If the cathode is connected to the negative HT, precautions should be taken to ensure a high-tension insulation between the aquadag shield and the mu-metal shield.

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of about 3 mA will be sufficient.

The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value of C_1 will be 2.10^{-9} F.

In the case of high counting rates and large peak power outputs, and to avoid a high-tension supply of large power, it is possible to supply the first stages with a high tension of small output and the end stages with an average voltage of high output.

A. The electron optical input system consists of four elements:

the photocathode k;
the focusing electrode g_1;
the focusing electrode g_2;
the accelerating electrode acc.

To reduce transit-time fluctuations and geometrical time spread, this system has the following advantages:

1. The photocathode is curved, with a curvature radius of 183 mm. To facilitate optical coupling to scintillators, a quartz adaptor can be delivered with the tube.

2. A high and homogeneous extraction field at the cathode reduces as much as possible the influence of the initial electron velocities. A cathode-to-accelerator voltage of about 1500 V (to be connected to the tenth or eleventh dynode) ensures a field strength of about 40 V/cm. This field is homogenized at the cathode surface by the focusing electrode g_1.

3. The potential of the electrode g_1 to the photocathode can be adjusted in order to obtain one of the following characteristics:

   (a) the most satisfactory collection (i.e. for a given luminous flux the largest obtainable anode signal); the optimum value of the potential is about $1.7\ V_s$;

   (b) the slightest transit-time fluctuations (the most homogeneous extraction field);

   (c) the most satisfactory uniformity of collection giving the most constant output pulse amplitude.

OPERATIONAL CONSIDERATIONS (continued)

4. Collection on the first dynode is controlled by the potential of the second dynode.

B. The multiplier system consists of 14 stages, providing a total current amplification of 10^8 at about 2400 V (see fig.1). The tube is capable of producing very strong peak currents (up to 1 A). Actually, the time constant at the output of the multiplier must be very small. Therefore it is necessary, taking into account the parasitic capacitances, to use a low load resistance. It is advisable to use a resistance-matched coaxial cable (e.g. 75 or 100 Ω). With this load the tube easily delivers pulses of tens of volts, so that an amplifier is rendered superfluous.

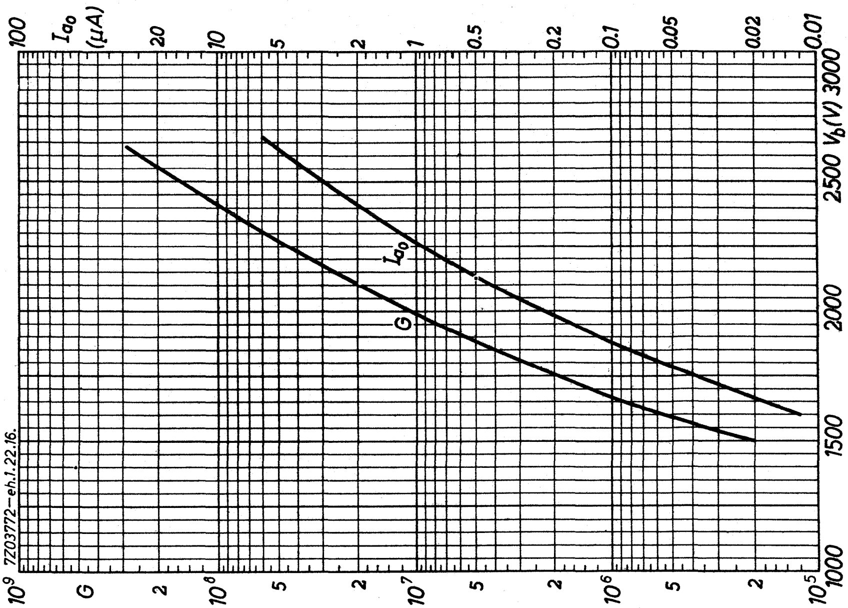
It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine the energy of the incident radiation, it is possible to select from one of the dynodes a signal proportional to the incident flux. In fact, when ascending the dynodes progressively, starting from the anode, the current is divided at each stage by d-1, d representing the secondary-emission coefficient of each stage ($d \approx 3.5$). It is therefore possible to locate a dynode, the current of which is lower than, or equal to, the saturation limit of the dynodes.

Fig.3 illustrates the variation of the anode current as a function of the incident flux, the voltage divider being of type B. The anode current is then linear up to 300 mA.

Care should be taken that the anode voltage is adjusted to its optimum value. In fig.2 the anode current variation is plotted against anode-to-final dynode voltage.

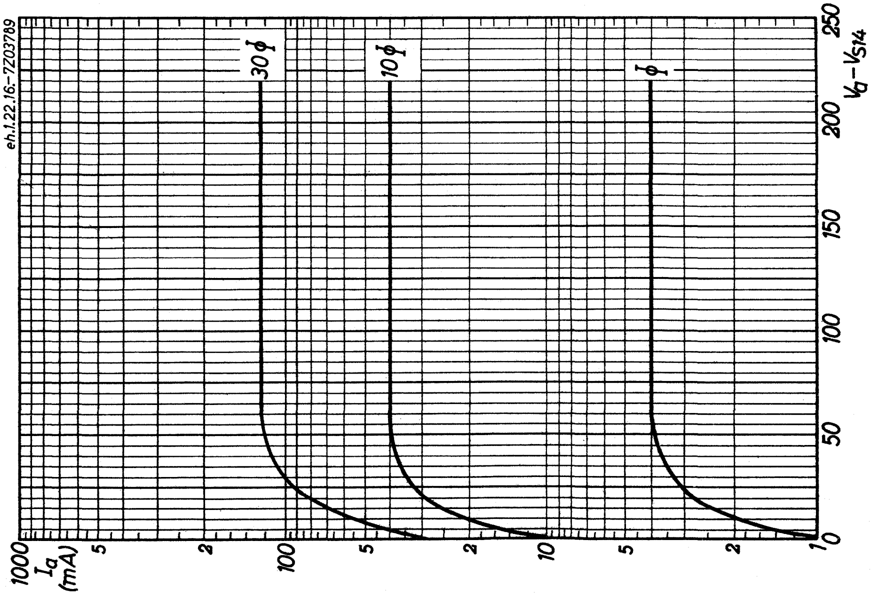
It should be noted that for equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A.
In practice, therefore, it will be preferable to use the A type distribution, or a distribution between A and B, (e.g. starting with 1.2 V_s between S_8 and S_9, 1.5 V_s between S_9 and S_{10} etc., maintaining the same progression).

It is advisable to screen the tube with a mu-metal cylinder against magnetic-field influence.



7Z03772-eh.1.22.16.
I_{ao} (µA)
100
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
G
10^9
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
V_b(V)
1000
1500
2000
2500
3000
I_{ao}
G

Fig.1



eh.1.22.16.-7Z03789
I_a (mA)
1000
5
2
100
5
2
10
5
2
1
$V_a - V_{S14}$
0
50
100
150
200
250
30 Φ
10 Φ
Φ

Fig.2

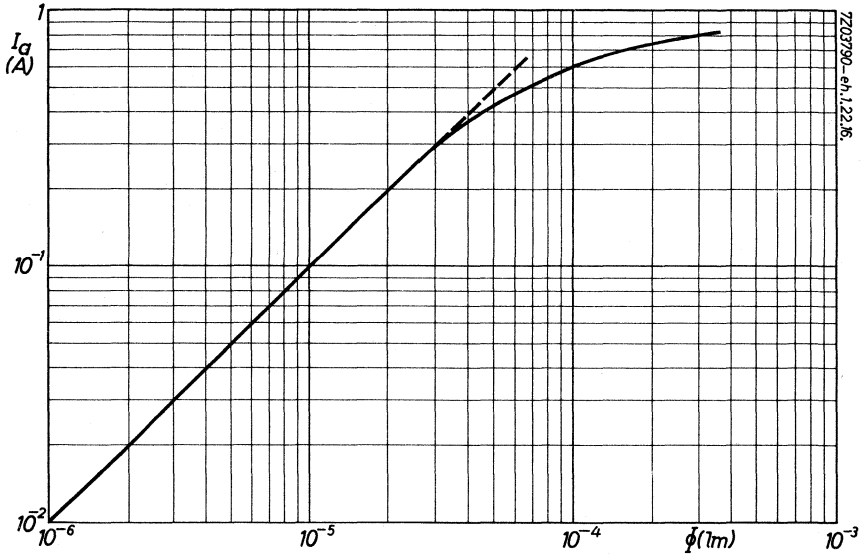


Fig.3

Recommended replacement type 60DVP

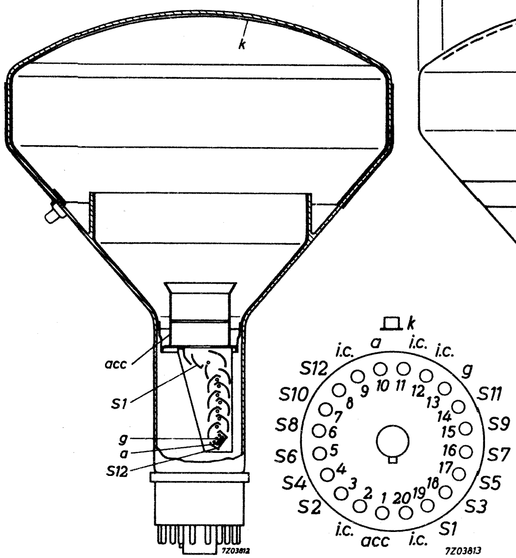
12 STAGE PHOTOMULTIPLIER TUBE

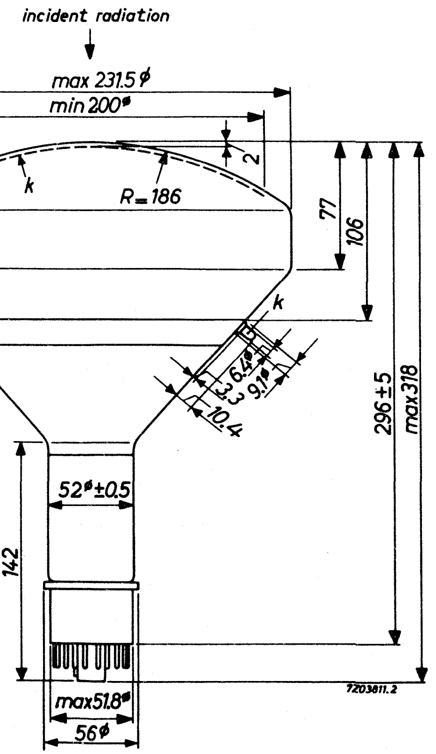
The tube is intended for use in large solid or liquid scintillator detectors, when a high time resolution is required.

QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	200	mm
Gain (at 3000 V)	10^8	
Anode pulse rise time	2.1	ns
Linearity	up to 300	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)





ACCESSORIES

Socket	type FE1003
Mu-metal shield	type 56132

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface		
Cathode material			Cs-Sb	
Minimum useful diameter			200	mm
Radius of curvature			186	mm
Spectral response curve [1]		type	A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	20	μA/lm
		min.	35	μA/lm
Radiant sensitivity at 4200 Å			45	mA/W

Multiplier system

Number of stages	12	
Dynode material	Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{12}	7	pF
Anode to all other electrodes	C_a	8	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Linearity between anode pulse amplitude and input light pulse		up to	100	mA
Anode dark current at $G = 10^8$ [3]	I_{a_o}	max.	20	μA
Supply voltage for $G = 10^8$	V_b	av.	3000	V
		max.	3500	V

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 300	mA
Anode pulse rise time at V_b = 3000 V [1]	2.1	ns
Anode pulse width at half height at V_b = 3000 V [1]	3.5	ns
Transit time difference between the centre of the photocathode and 80 mm out of the centre at V_b = 3000 V	2	ns
Transit time spread	2.2	ns
Total transit time at V_b = 3000 V [1]	48	ns
Maximum peak current	0.5 to 1	A

LIMITING VALUES (Absolute max. rating system)

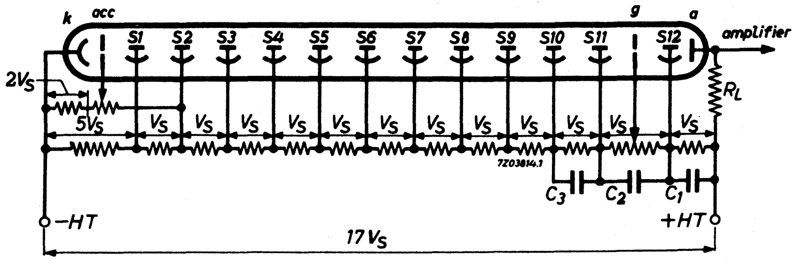
Supply voltage [2]	V_b	max.	3500	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	1000	V
		min.	350	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{12}}$	max.	500	V
		min.	80	V

[1]) For an infinitely short light pulse, fully illuminating the photo cathode.

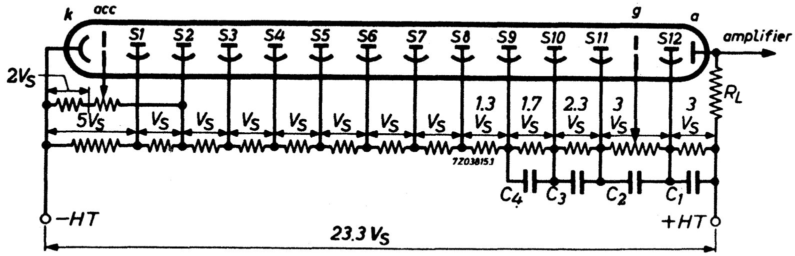
[2]) Or the voltage at which the tube circuited in the voltage divider A has a gain of 5.10^8, whichever is lowest.

[3]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

The accelerator to be adjusted for maximum gain
The grid to be adjusted for fastest response

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

12 STAGE PHOTOMULTIPLIER TUBE

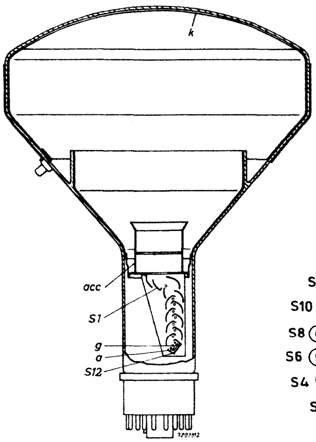
The tubes are intended for use in large solid or liquid scintillator detectors, where a high time resolution is required.
The 60DVP/H is supplied with a plano-concave glass adapter, optical coupling silicon grease and metal envelope. A plexiglass adapter can be supplied on request.

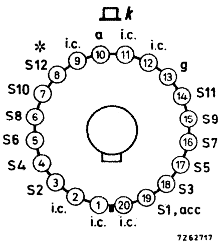
QUICK REFERENCE DATA		
Spectral response	type D	
Useful diameter of the photocathode	200	mm
Gain (at 3000 V)	10^8	
Anode pulse rise time	2,5	ns
Linearity	up to 200	mA

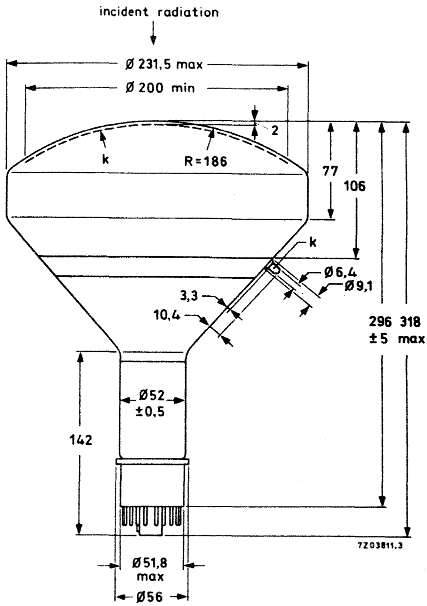
To be read in conjunction with "General Operational Recommendations Photomultiplier tubes".

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 20-pin (Jedec B20-102)

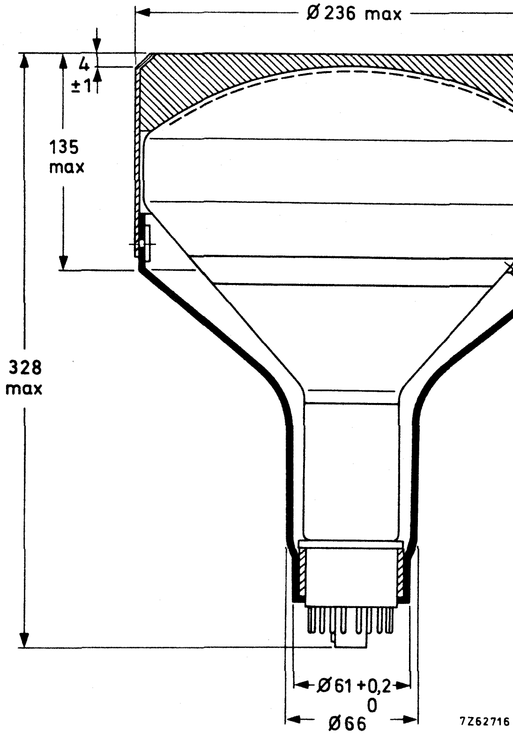






60DVP

*A series resistor of 51 Ω, $\frac{1}{2}$ W is built into the base.



60DVP/H

ACCESSORIES

Socket	type FE1003
Mu-metal shield	type 56132

It is strongly recommended to screen the tube with a mu-metal shield against the influence of magnetic fields.

The 60DVP/H is supplied with plano-concave glass adapter, optical coupling silicon grease and metal envelope. The silicon grease should be applied to the adapter-photomultiplier interface before operation. A plexiglass adapter can be supplied on request.

WEIGHT

Net weight 60DVP	approx. 1000 g

GENERAL

Photocathode

Description		semi-transparent, head-on, curved surface	
Cathode material		K-Cs-SB	
Useful diameter		> 200	mm
Spectral response curve [1]		type D	
Wavelength at maximum response		400 ± 30	nm
Luminous sensitivity [2]	N_k	65	μA/lm
Radiant sensitivity (at 437 nm) [3]	N_{kr}	75	mA/W
		> 60	mA/W
Window material	type	B-40	
Window shape		curved	
Radius of curvature		186	mm
Window thickness	approx.	2	mm

Multiplier system

Dynode structure		in-line, electrostatic focused	
Number of stages		12	
Dynode material		Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S12}$	< 7	pF
Anode to all other electrodes	C_a	< 8	pF

Notes see page 6.

TYPICAL CHARACTERISTICS

With voltage divider A

Anode dark current at $G = 10^7$	5) 6)	I_{a_o}	typ. <	0,5 10	nA nA
Supply voltage for $G = 10^8$		V_b	typ. <	3300 3700	V V
Background noise	5) 6) 7)			1000	c/s

With voltage divider B

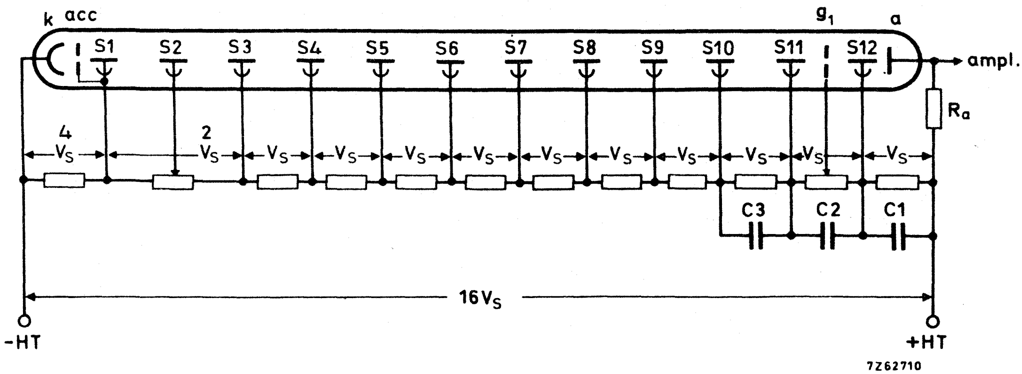
Linearity between anode pulse amplitude and input light pulse			up to	200	mA
Anode pulse rise time at V_b = 3000 V				2,5	ns
Anode pulse width at half height at V_b = 3000 V				4	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 3000 V				2	ns
Transit time fluctuations	8)			2,2	ns
Total transit time at V_b = 3000 V				45	ns

LIMITING VALUES (Absolute max. rating system)

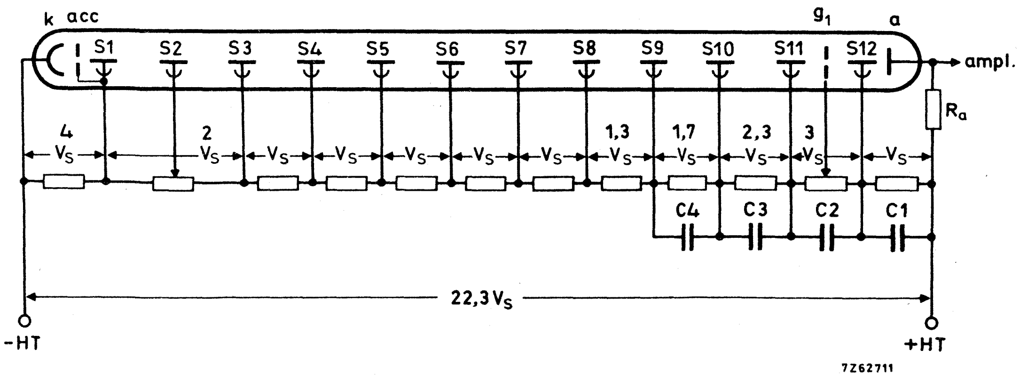
Supply voltage, voltage divider A	9)	V_b	max.	3700	V
voltage divider B		V_b	max.	4000	V
Continuous anode current		I_a	max.	0,1	mA
Voltage between first dynode and cathode		$V_{S1/k}$	max. min.	1000 300	V V
Voltage between consecutive dynodes (except between S12 and S11)		$V_{S_n/S_{n-1}}$	max. min.	400 60	V V
Voltage between S12 and S11		V_{S12}/V_{S11}	max.	600	V
Voltage between anode and final dynode	10)	$V_{a/S12}$	max. min.	600 80	V V
Ambient temperature, operating	11)	t_{amb}	max. min.	70 −25	°C °C

Notes see page 6.

RECOMMENDED CIRCUITS



Voltage divider type A



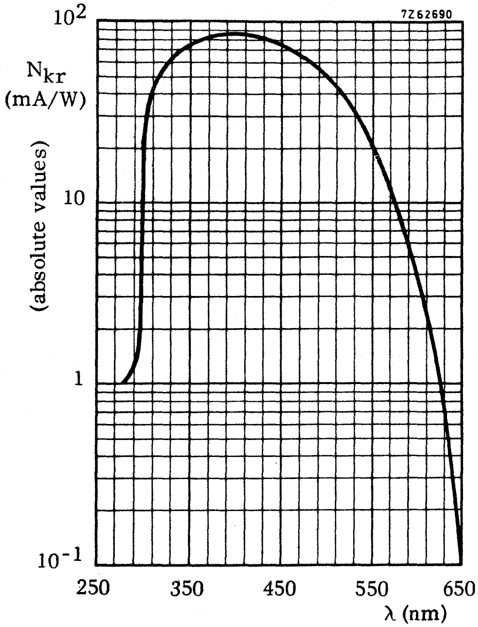
Voltage divider type B

The grid voltage to be adjusted for fastest response

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

NOTES

1) Because of the resistivity of the D-type photocathode, it is recommended not to expose the tube to too high radiation intensities. It is advisable to limit the cathode peak current to 10 nA at room temperature and to 0,1 nA at −100 °C. The resistivity of the photocathode increases as the temperature decreases.
2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K.
3) The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 437 ± 5 nm.
5) During normal operation it is recommendable to connect the photocathode to earth potential and the anode to positive high voltage.
   As it is sometimes necessary to have the photocathode at positive high potential and the anode at earth potential, precautions should be taken to ensure a high voltage insulation between the photomultiplier and the mu-metal shield greater than 10^{15} Ω. In this case, the background and dark current may be higher than normal and somewhat unstable.
6) At an ambient temperature of 25 °C.
7) The measurement is made at a detection threshold of 4,24 x 10^{-13} C.
8) Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.
9) Or the voltage at which the tube has a gain of 5 x 10^8, whichever is lowest.
10) When calculating the anode voltage, the voltage across the load resistance should be taken into account.
11) The temperature range is limited by mainly mechanical stresses which may arise in the base. For temperatures below −30 °C type 60DVP/UB (= 60DVP without base) is recommended.



Spectral response curve Type D

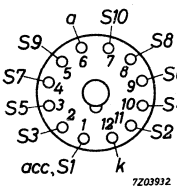
10 STAGE PHOTOMULTIPLIER TUBE

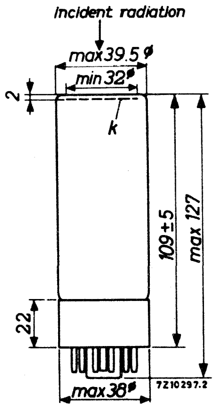
The tube is intended for use in applications such as scintillation counting, flying spot scanners, different kinds of optical and industrial instruments.

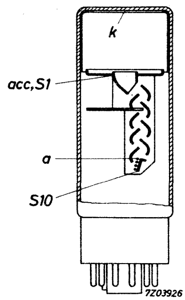
QUICK REFERENCE DATA		
Spectral response	type Super A	
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type FE1002
Mu-metal shield	type 56127

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			32	mm
→ Spectral response curve [1]			type Super A	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
→ Radiant sensitivity at 437 nm			80	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{10}		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	250	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	10	nA
		max.	50	nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

---

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

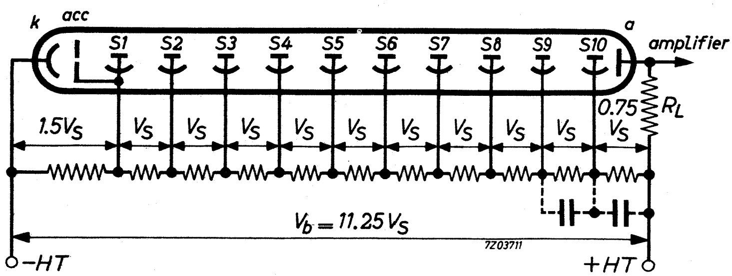
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1800 V [1]		3.5	ns
Anode pulse width at half height at V_b = 1800 V [1]		6.5	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		3	ns
Total transit time at V_b = 1800 V [1]		33	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max. min.	300 80	V V

RECOMMENDED CIRCUITS



Voltage divider type A

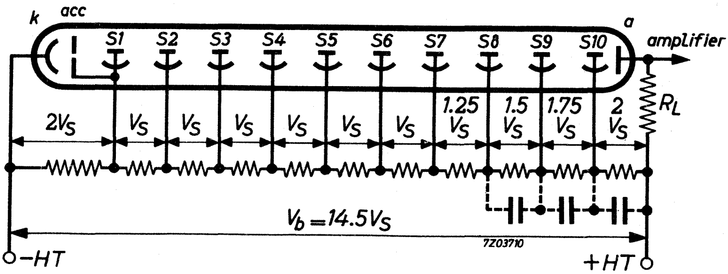
k	=	cathode	S_n	=	dynode No.n
acc	=	accelerating electrode	a	=	anode

---

[1] For an infinitely short light pulse, fully illuminating the photocathode.

[2] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

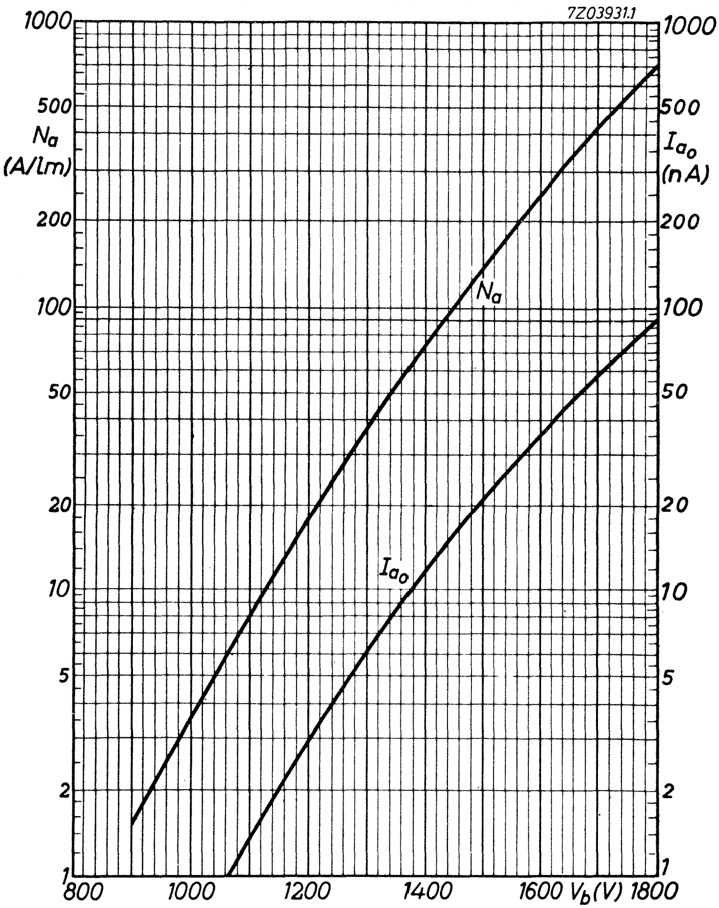
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to de-couple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03931.1
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
1000
500
I_{a_o}
(nA)
200
100
50
20
10
5
2
1
N_a
I_{a_o}
800
1000
1200
1400
1600 V_b(V) 1800

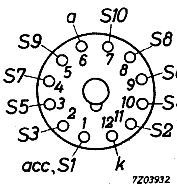
10 STAGE PHOTOMULTIPLIER TUBE

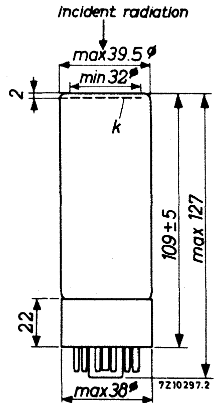
The tube is intended for use in applications such as infra-red telecommunication and ranging, and in optical instruments operating in the far red and near infra-red region (astronomical measurements, spectrometry, optical pyrometry, infra-red radiation intensity control instruments).

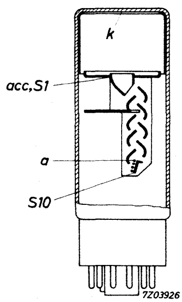
QUICK REFERENCE DATA		
Spectral response curve	type	C (S1)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	100	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (Jedec B12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material		Ag-O-Cs		
Minimum useful diameter			32	mm
Spectral response curve [1]		type C (S1)		
Wavelenght at maximum response			8000 ± 1000	Å
Luminous sensitivity [2]	N_k	av.	25	μA/lm
		min.	15	μA/lm
Infra-red luminous sensitivity [3]	N_k	av.	3	μA/lm
		min.	1.4	μA/lm
Radiant sensitivity at 8000 Å			2.5	mA/W

Multiplier system

Number of stages			10	
Dynode material		Ag-Mg-O-Cs		

Capacitances

Anode to final dynode	C_a/S_{10}		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	100	A/lm
		min.	20	A/lm
Anode dark current at N_a = 20 A/lm [4]	I_{a_o}	max.	10	μA
Linearity between anode pulse amplitude and input light pulse		up to	5	mA

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) The infra-red lumen is the flux resulting from one lumen yielded by a tungsten ribbon lamp (colour temperature 2854 °K) going through an infra-red filter Corning CS94 No.2540, fusion 1613 thickness 2.61

[4]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

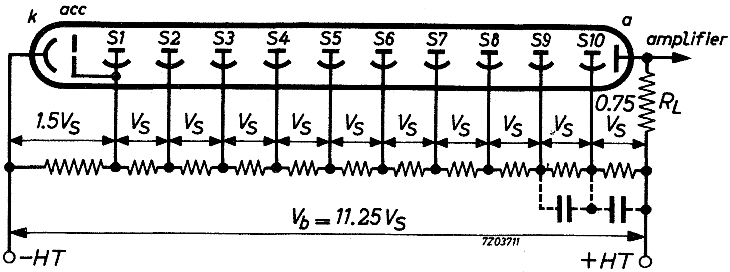
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	10	mA
Anode pulse rise time at V_b = 1800 V [1]		3.5	ns
Anode pulse width at half heigth at V_b = 1800 V [1]		6.5	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		3	ns
Total transit time at V_b = 1800 V [1]		33	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	30	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



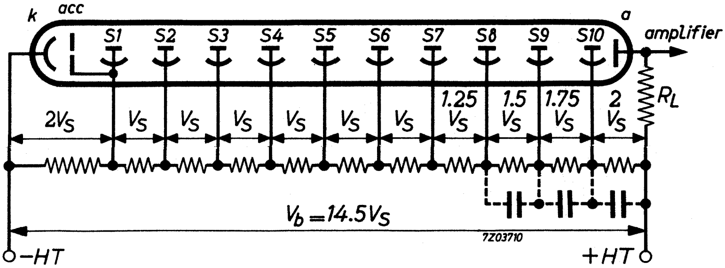
Voltage divider type A

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

[1] For an infinitely short light pulse, fully illuminating the photocathode.

[2] When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

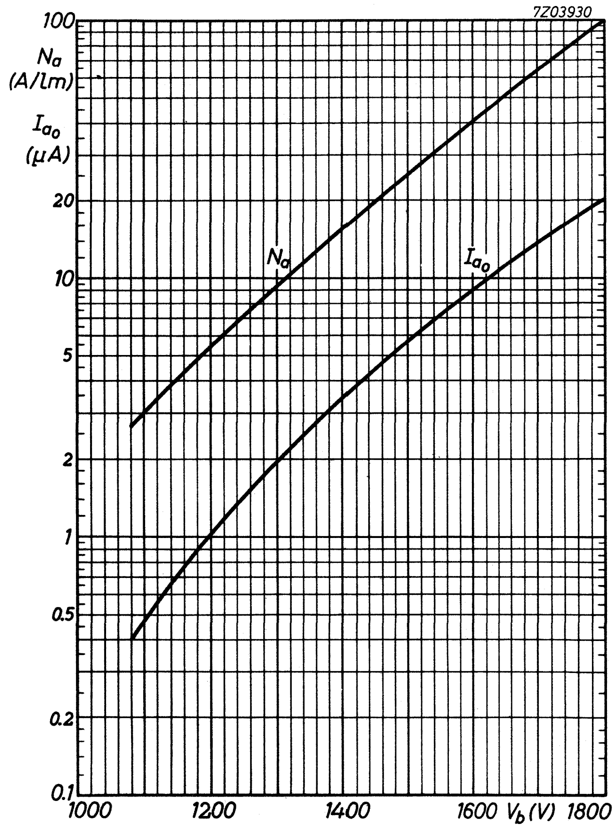
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03930
100
N_a
(A/lm)
I_{a_0}
(μA)
20
10
5
2
1
0.5
0.2
0.1
1000
1200
1400
1600 V_b (V) 1800
N_a
I_{a_0}

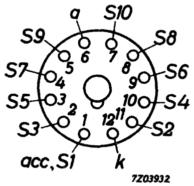
10 STAGE PHOTOMULTIPLIER TUBE

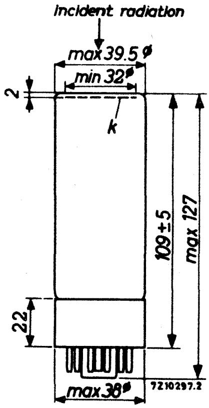
The tube is intended for optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

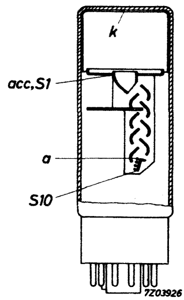
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (Jedec B 12-43)







ACCESSORIES

Socket	type	FE1002
Mu-metal shield	type	56127

GENERAL

Photocathode

Descirption		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			32	mm
Spectral response curve [1]			type U (S13)	
Wavelength at maximum response			4000 ± 300	Å
Luminous sensitivity [2]	N_k	av.	70	μA/lm
		min.	40	μA/lm
Radiant sensitivity at 4000 Å			60	mA/W

Multiplier system

Number of stages			10	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	$C_{a/S_{10}}$		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	700	A/lm
		min.	250	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	10	nA
		max.	50	nA
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

---

[1]) See spectral response curve in front of this section

[2]) Measured with a tungsten ribbon lamp having a colour temperature of 2854 °K

[3]) At an ambient temperature of 25 °C

TYPICAL CHARACTERISTICS (continued)

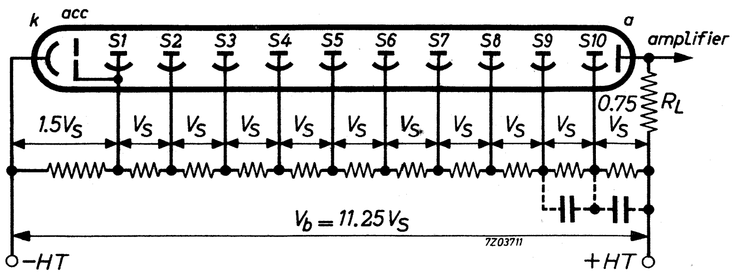
With voltage divider B

Linearity between anode amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1800 V [1]		3.5	ns
Anode pulse width at half height at V_b = 1800 V [1]		6,5	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		3	ns
Total transit time at V_b = 1800 V [1]		33	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



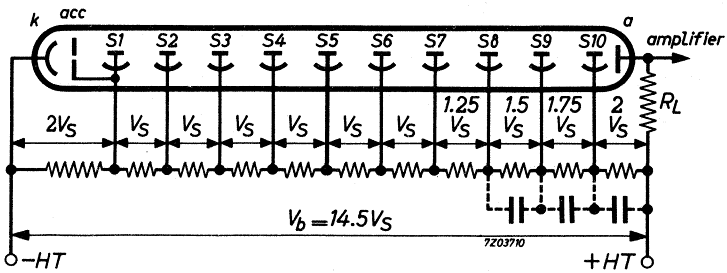
Voltage divider type A

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

[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

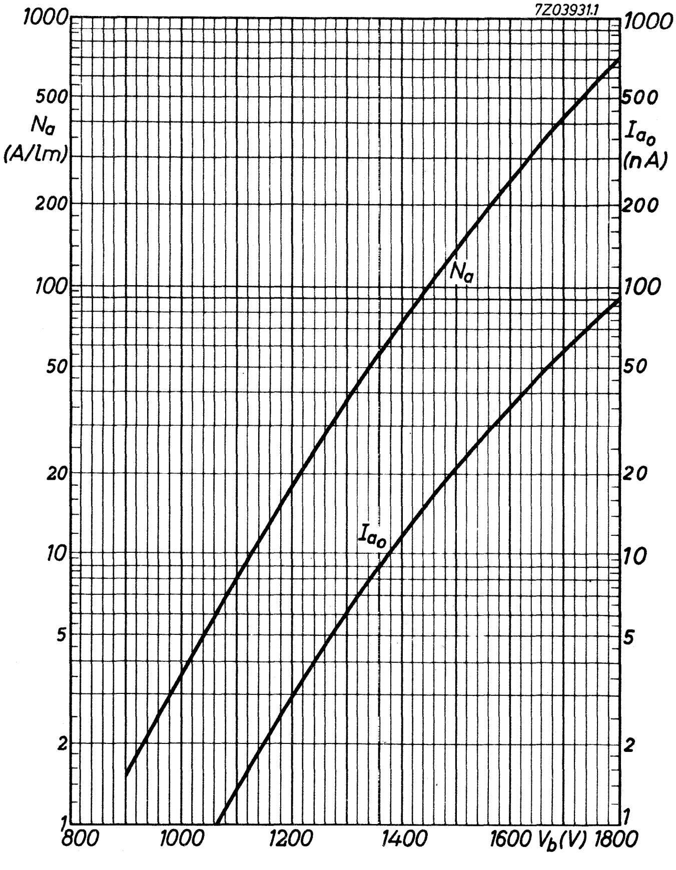
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.


7Z03931.1
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
800
1000
1200
1400
1600
1800
V_b(V)
1000
500
I_{a_0}
(nA)
200
100
50
20
10
5
2
1
N_a
I_{a_0}

11 STAGE PHOTOMULTIPLIER TUBE

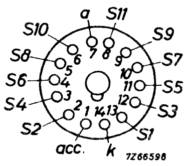
The tube is intended for use in applications such as gamma-ray spectrometry.

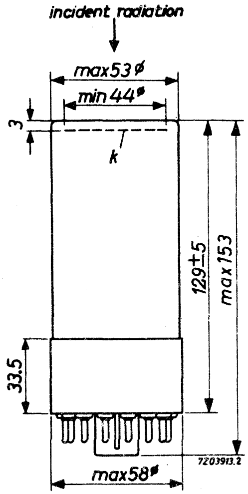
QUICK REFERENCE DATA		
Spectral response	type Super A	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm
Energy resolution for ^{137}Cs (0,661 MeV)	8.5	%

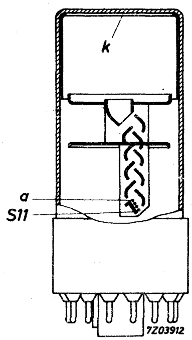
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type	FE1001
Mu-metal shield	type	56128

GENERAL

Photocathode

Description		semi-transparent, head-on, flat surface		
Cathode material			Cs-Sb	
Minimum useful diameter			44	mm
Spectral response curve [1]			type Super A	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	80	μA/lm
		min.	70	μA/lm
Radiant sensitivity at 4200 Å			65	mA/W

Multiplier system

Number of stages			11	
Dynode material			Ag-Mg-O-Cs	

Capacitances

Anode to final dynode	C_a/S_{11}		3	pF
Anode to all other electrodes	C_a		5	pF

TYPICAL CHARACTERISTICS

With voltage divider A

Anode sensitivity at V_b = 1800 V	N_a	av.	400	A/lm
		min.	250	A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av.	15	nA
		max.	50	nA
Energy resolution for ^{137}Cs (0.661 MeV) [4]		av.	8.5	%
		max.	9.0	%
Linearity between anode pulse amplitude and input light pulse		up to	30	mA

---

1) See spectral response curve in front of this section

2) Measured with a tungsten ribbon lamp having a colour temperature of 2854 K

3) At an ambient temperature of 25 °C

4) Measured with a 1.5 in x 1 in NaI(Tl) crystal

TYPICAL CHARACTERISTICS (continued)

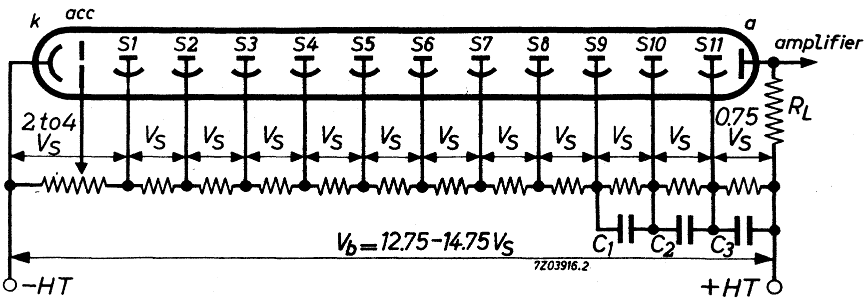
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		5	ns
Anode pulse width at half height at V_b = 1500 V [1]		14	ns
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4	ns
Total transit time at V_b = 1500 V [1]		45	ns

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	0.1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	200	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max.	300	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

C1 = 220 pF   C2 = 470 pF   C3 = 1000 pF

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

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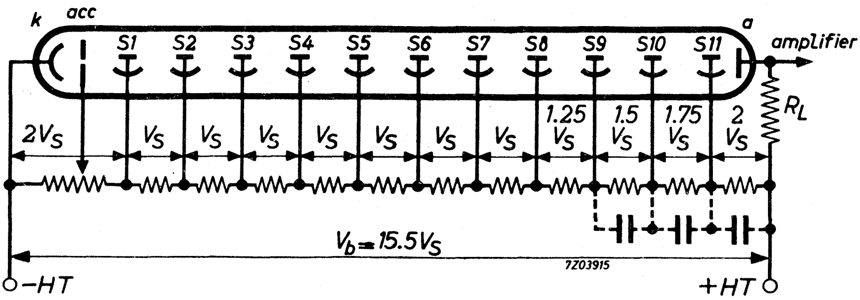
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[2]) When calculating the anode voltage, the voltage drop in the load resistance should not be overlooked.

RECOMMENDED CIRCUITS (continued)



Voltage divider type B

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

OPERATIONAL CONSIDERATIONS

To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

For moderate intensities of radiation a bridge current of approx. 0.5 mA will be a practical value.

The best results in γ-ray spectrometry will be achieved with a voltage of 4 times "Vs" between the cathode and the first dynode; however, the limiting values must not be exceeded. At a high tension of about 1200 V the tube will work most favourably.

When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will be back at its normal value after several hours of operation.

It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

Channel electron multipliers

GENERAL EXPLANATORY NOTES
CHANNEL ELECTRON MULTIPLIERS

PRINCIPLES OF OPERATION

A channel electron multiplier is a small, curved, glass tube, the inside wall of which is coated with high-resistance material. If a potential is applied between the ends of the tube, the resistive surface becomes a continuous dynode, electrically analogous to the separate dynodes of a conventional photomultiplier together with the resistive chain used to establish the separate dynode potentials.

The channel electron multiplier operates in vacuum. For space research, the environmental vacuum is sufficient, and there is then no window separating the multiplier from the radiation source. In the laboratory, the multiplier must be used in a vacuum chamber.

An electron entering the low-potential end of the channel multiplier generates secondary electrons on collision with the wall of the tube. These are accelerated along the tube until they strike the wall again, where they generate further secondary electrons. This avalanching process produces a large number of electrons at the positive end of the tube. This is illustrated in Fig. 1.

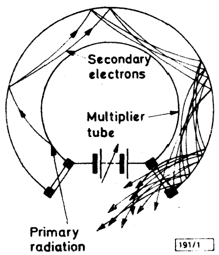


Fig. 1. Illustration of electron multiplication

A channel multiplier thus responds to an input of one electron by producing an output pulse of charge. This pulse may contain up to about 10^8 electrons and its duration (full width at half height) is about 10 nanoseconds. The amplitude of the resulting voltage pulse depends of course upon the values of resistance and capacitance in the anode circuit of the multiplier. The gain (Fig. 2) is an exponential and very steep function of voltage for values below 10^7. Above 10^7, saturation effects are observed which will be discussed below.

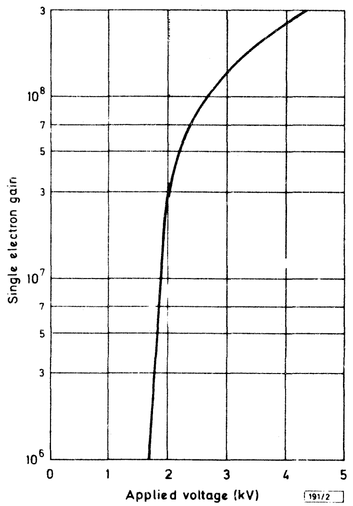


Fig. 2. Variation of gain with applied voltage

The multiplier will respond to ions, β particles, X-rays, or any other sufficiently energetic radiation. The detection efficiency of a channel multiplier is different for different forms and energies of excitation, but any particle or quantum capable of exciting an electron from the dynode surface has a finite probability of detection. Since the resistive coating is continuous, many electron paths are possible, and the number of stages of multiplication is thus indeterminate. The electron trajectories are scaled in proportion to the dimensions of the channel for a given applied voltage. Thus, if the length-to-diameter ratio is preserved, the same multiplication processes go on, and the same gain is achieved, irrespective of the absolute length of the channel. In practice, it is necessary for the length-to-diameter ratio to exceed about 30 : 1. Channels are almost invariably curved, and the gain is then less critically dependent on the length-to-diameter ratio. The ratios actually used are between 50 : 1 and 100 : 1.

IONIC FEEDBACK

The tube forming the channel multiplier is curved because the gain of a straight tube would be sensitive to changes in ambient pressure. When the first cloud of electrons nears the output end of the multiplier, it is sufficiently dense to ionise a considerable number of the residual gas atoms in the tube. These positive ions drift under the influence of the applied field towards the more negative potential at the input end of the channel.

If the channel is straight, the ions may acquire considerable energy before they collide with the wall of the tube. Consequently they may release from the wall electrons which initiate a further process of multiplication through the tube, resulting in a spurious output pulse. This process is repeated, and thus a sequence of "after pulses" may be observed. This pulse train lasts typically for about a microsecond, until the capacity of the channel is exhausted and the pulse train dies out.

In a curved tube, the ions strike the wall of the tube before they have acquired sufficient energy to release secondary electrons. Electron multiplication is unaffected however, since electrons need acquire an energy of only about 50 eV to release secondary electrons from the wall. The output of the curved multiplier is therefore independent of the ambient pressure, provided it does not exceed 5×10^{-4} torr. Above this pressure, spurious pulses occur, and effects similar to those seen with straight channels are observed.

SATURATION DUE TO SPACE CHARGE

One of the more significant aspects of the behaviour of a channel multiplier is the saturation effect caused by space-charge limitation. When the total amount of charge in the electron cloud in a channel multiplier reaches about 3×10^8 electrons, the gain cannot increase further. The space charge repels the emitted secondary electrons so that they strike the wall before acquiring sufficient energy from the field to make useful multiplying collisions. The space-charge limit is unaffected by the channel diameter. Increasing the applied voltage increases the amplitude of those pulses which would not otherwise have reached 3×10^8 electrons, but as the maximum charge output cannot exceed this level, the amplitude of all pulses tends to the same value. The multiplier thus has a narrow pulse-height distribution. When it is operated in the saturated mode, it is analogous to a Geiger counter, producing a pulse of a given amplitude irrespective of the manner of its excitation. It is unable in this condition to give information about the number of particles simultaneously striking the input or about their energy.

When the multiplier is not operated in its saturated mode, that is when the gain is less than 10^7, there is some proportionality between input and output. However, there is a spread of pulse amplitudes because of the many possible electron paths through the multiplier. The pulse-amplitude distribution is exponential: smaller pulses are more probable than larger ones by an amount exponentially dependent on the amplitude.

SATURATION DUE TO FIELD DISTORTION

In a straight channel, ionic feedback gives rise to a pulse train about 1 microsecond in duration which may contain a total charge of more than 10^9 electrons. The pulse train dies out only when the field inside the channel is distorted by wall-charging to such an extent that the multiplication process can no longer sustain feedback.

The field is restored during a "dead time", after which an output pulse can again be observed. The dead time depends on the resistance of the channel and may be some tens of microseconds.

The dead-time effect may be caused by a single event in a straight channel. This is not possible, however, in curved channels because the probability of ionic feedback is very low, and the pulse train is replaced by a single pulse of about 10 nanoseconds duration which is space-charge limited to about 3×10^8 electrons. Consequently, the curved channel may produce two pulses of the same amplitude separated in time only by the pulse duration. However, if the mean pulse repetition rate is high, the field inside the channel is distorted. A state of dynamic equilibrium is achieved: the mean gain is reduced so that the average rate of flow of charge in the output pulses is less than the current flowing in the channel wall.

The same considerations apply when a channel multiplier is used as a current amplifier. The amplification is linear only so long as the output current is less than about 1% of the standing current in the wall of the amplifier. For example, a channel of resistance $10^9\,\Omega$ operated at 1.5 kV cannot produce an output current of more than 1.5×10^{-8} A while maintaining a linear current-transfer characteristic.

DEFINITIONS

RESISTANCE

The resistance of a channel electron multiplier depends on the size of the channel and on the material used in the wall of the channel. The multipliers fall into two categories:

(i) Those with an internal surface film of metallic lead. These multipliers have nominal resistances of $10^9\,\Omega$.

(ii) Those with an internal coating of a vanadium-phosphate glass. These multipliers have a relatively high resistance (10^{10} to $10^{11}\,\Omega$).

The lower-resistance multipliers have the higher count-rate capability, while the higher-resistance multipliers have a low power consumption (one to ten milliwatts), which is useful when large numbers of multipliers are needed for satellite experiments.

BACKGROUND OR SPONTANUOUS PULSE COUNT RATE

The background or spontaneous pulse count rate is the number of pulses detected per second above a specified equivalent threshold when the input end of the multiplier is closed. The equivalent threshold is the amount of charge produced by the multiplier which, when amplified, just appears above the threshold of the discriminator used for pulse counting. The count is made with a multiplier voltage and equivalent threshold as specified in the data sheets.

STARTING VOLTAGE

As the voltage applied to the channel is increased, the gain rises and the output pulses become larger. The pulses are not all the same size, but as the gain increases, more of them exceed the equivalent threshold. This process continues until all the pulses are above the threshold. The observed count rate is plotted against voltage in Fig. 3 and this graph shows a steeply rising portion followed by a plateau.

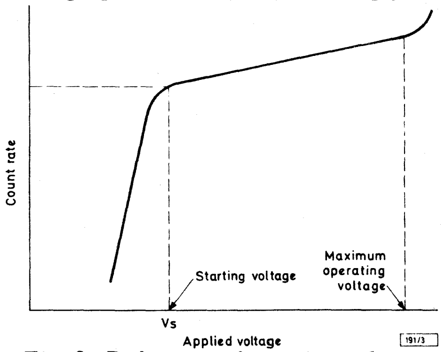


Fig. 3. Definition of starting voltage

The starting voltage is the voltage at which the pulse count rate is 90% of the plateau value, where the plateau is defined as the region over which the count rate changes by less than 10% for each applied kilovolt.

For the purposes of determining the starting voltage, the plateau counting rate is taken at the midpoint of the plateau. The mid-point is either halfway between the lower and upper voltages or between the lower voltage and the maximum permissible operating voltage, whichever is the less.

The starting voltage is measured using an input source adjusted to give a fixed count rate at a high applied voltage. The count rate and voltage, together with the equivalent threshold, are given in the data sheets.

GAIN

The pulse, or electron, gain G of a channel electron multiplier is defined by:

$$\text{Gain} = \frac{\text{Charge in the output pulse}}{\text{Electronic charge}}$$

The gain is dependent on the voltage applied to the multiplier, and also on the rate of incidence of electrons at the input. Hence, in specifying gain, it is necessary to stipulate the applied voltage and the count rate. These are given in the **data sheets.**

OUTPUT

The output pulse corresponding to one input electron will consist of G electrons. The corresponding charge in the output pulse will thus be $G \times 1.6 \times 10^{-19}$ coulombs, where 1.6×10^{-19} coulombs is the electronic charge. The charge in the output pulse raises the potential across the input capacitance of a pulse amplifier, and this voltage change is referred to as the pulse height (usually in millivolts).

This expression of output as a voltage is common practice, but the capacitance to be charged must also be known.

When a channel multiplier is used for direct current amplification, the output current must be collected at a separate electrode. If it is used for pulse counting, the output can be detected at the positive terminal of the multiplier; in this case, the multiplier is a two-terminal device.

PULSE HEIGHT DISTRIBUTION

The nominal gain of a channel multiplier will not be achieved every time an electron produces an output pulse: there is a variation in gain because of the statistical nature of the multiplication process. However, the spread is not usually very great at high values of gain, and it is expressed in terms of the resolution of the pulse height distribution.

A typical distribution showing pulse height as abscissa and the frequency of occurrence of that pulse height as ordinate is given in Fig. 4. The distribution is seen to be Gaussian. The resolution is defined as the ratio of the full width of the distribution at half maximum frequency to the modal pulse height. The resolution depends on applied voltage and gain. Values for various multipliers are quoted in the **data sheets.**

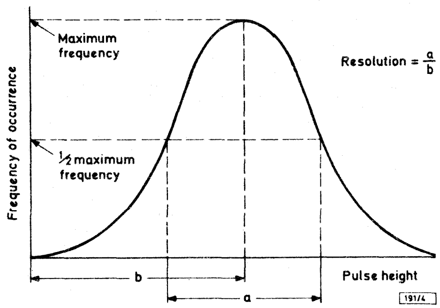


Fig. 4. Definition of resolution of pulse distribution height.

INPUT APERTURE

Larger input apertures can be achieved without increasing the overall dimensions of the multiplier by fitting a cone-shaped flared end. Because the response of a channel multiplier depends on the angle of incidence of the input flux, it is not practicable to quote dimensions of effective apertures which are valid in all situations. The effective aperture of standard multipliers is not necessarily the same as the geometrical aperture, but may be smaller.

CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass planar spiral tube.

QUICK REFERENCE DATA		
The B310AL has an open-ended output.		
The B310 BL has a closed output.		
The B310AL/01 and B310BL/01 are bakable versions.		
Typical gain	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain, see note 1)	1.0	1.3	– $\times 10^8$	
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	1.1	1.25	–	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B310AL, B310BL	max.	120	°C
B310AL/01, B310BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 1.0 g

MOUNTING POSITION

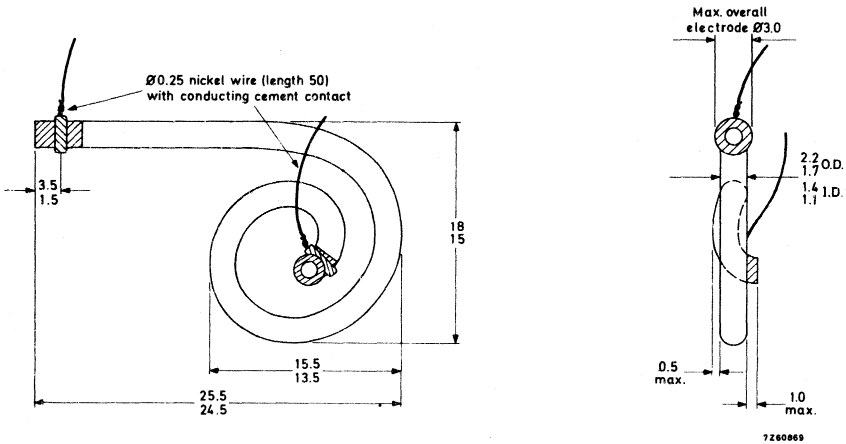
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

[1]) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

[2]) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass planar spiral tube with a rectangular-section input cone 2.0 x 8.0 mm.

QUICK REFERENCE DATA		
The B312AL has an open-ended output.		
The B312BL has a closed output.		
The B312AL/01 and B312BL/01 are bakable versions.		
Typical gain (at 3.0 kV)	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain, see note 1)	1.0	1.3	-	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	-	0.2	0.5	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	-	50	70	%
Effective input aperture	1.7 x 7.5	2.0 x 8.0	-	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B312AL, B312BL	max.	120	°C
B312AL/01 and B312BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 1.0 g

MOUNTING POSITION

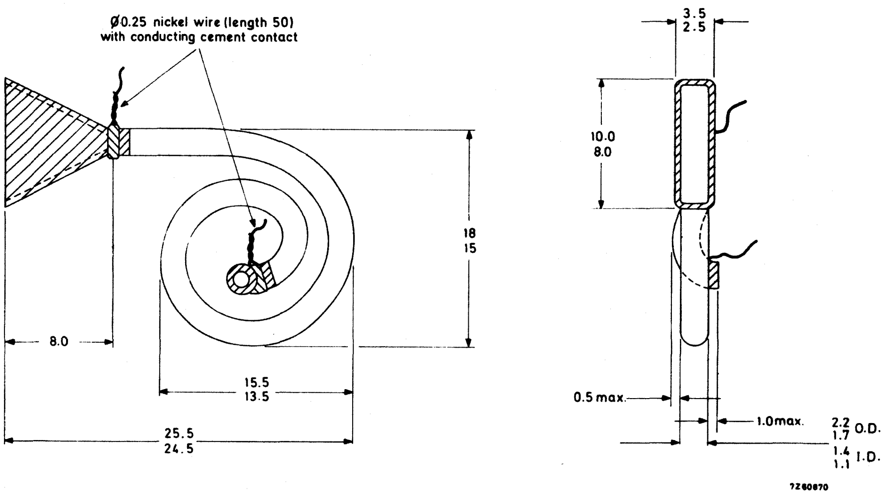
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

2) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass planar spiral tube with a 5.0 mm diameter input cone.

QUICK REFERENCE DATA		
The B318AL has an open-ended output.		
The B318BL has a closed output.		
The B318AL/01 and B318BL/01 are bakable versions.		
Typical gain (at 3.0 kV)	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain, see note 1)	1.0	1.3	-	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	-	0.25	0.5	pulse/s
Starting voltage with equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain 1.0×10^8	-	50	70	%
Effective cone diameter	4.0	5.0	-	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B318AL, B318BL	max.	120	°C
B318AL/01, B318BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 1.3 g

MOUNTING POSITION

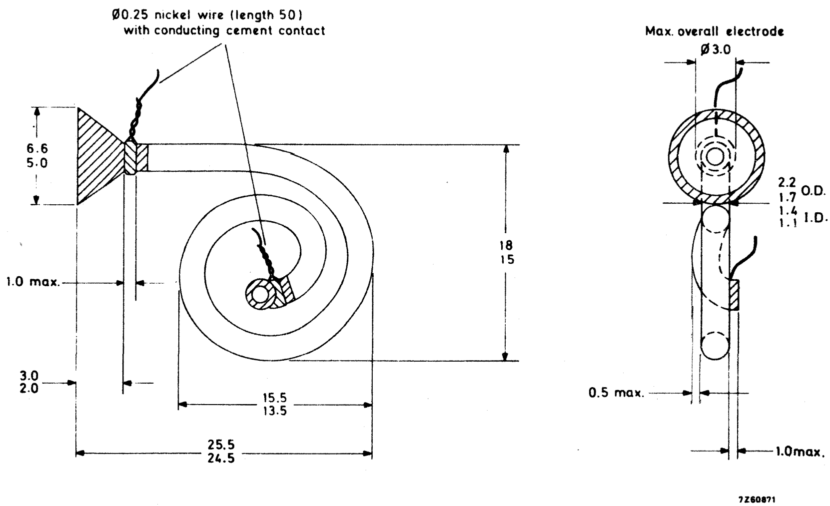
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

2) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass C-shaped tube.

QUICK REFERENCE DATA		
The B330AL has an open-ended output. The B330BL has a closed output. The B330AL/01 and B330BL/01 are bakable versions.		
Typical gain (at 3.0 kV)	1.5×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain, see note 1)	1.0	1.5	-	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	-	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	-	50	70	%
Effective input diameter	1.1	1.25	-	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B330AL, B330BL	max.	120	°C
B330AL/01, B330BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 1.3 g

MOUNTING POSITION

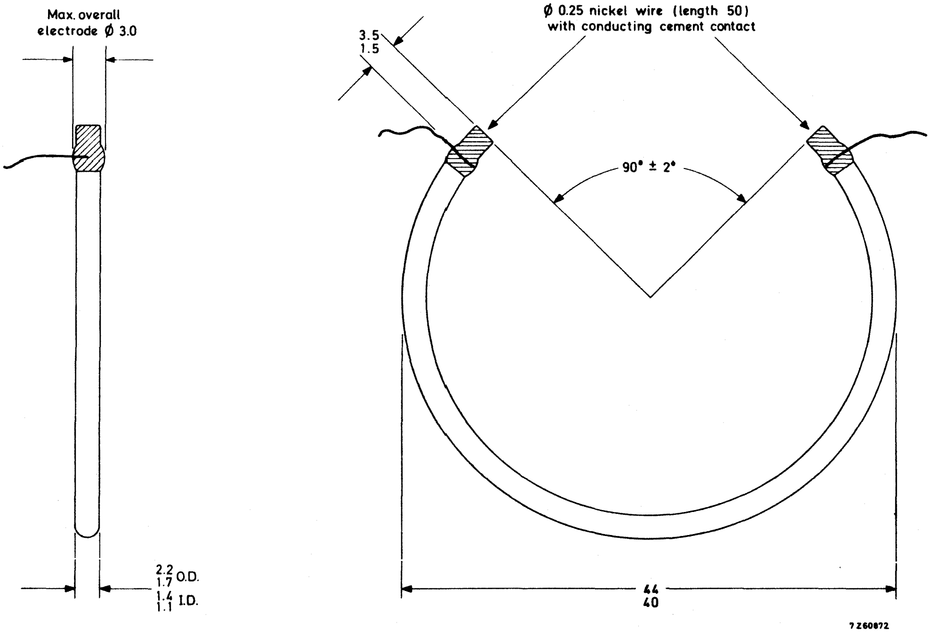
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

[1]) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

[2]) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass planar spiral tube.

QUICK REFERENCE DATA		
The B410AL has an open-ended output. The B410BL has a closed output The 410AL/01 and B410BL/01 are bakable versions.		
Typical gain (at 2.5 kV)	1.5×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	3.5	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain, see note 1)	1.0	1.5	-	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	-	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	-	50	70	%
Effective input diameter	2.0	2.2	-	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	3.5	kV
Temperature, operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B410AL, B410BL	max.	120	°C
B410AL/01, B410BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 3.0 g

MOUNTING POSITION

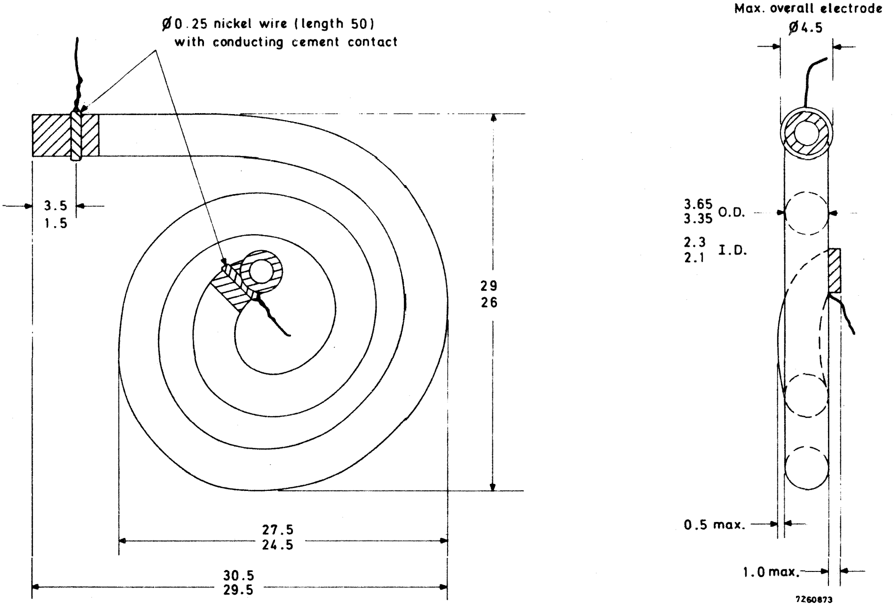
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

2) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER

Channel electron multiplier in the form of a glass planar spiral tube with a 10 mm diameter input cone.

QUICK REFERENCE DATA		
The B419AL has an open-ended output.		
The B419BL has a closed output.		
The B419AL/01 and B419BL/01 are bakable versions.		
Typical gain (at 2.5 kV)	1.7×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	3.5	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain, see note 1)	1.0	1.7	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.25	0.5	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	9.0	10.0	–	mm

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	3.5	kV
Temperature, operating and storage	max.	70	°C
Bake temperatures, see note 2)			
B419AL, B419BL	max.	120	°C
B419AL/01, B419BL/01	max.	400	°C
Ambient pressure with high voltage applied	max.	50	mN/m^2
		3.7×10^{-4}	torr

WEIGHT 4.0 g

MOUNTING POSITION

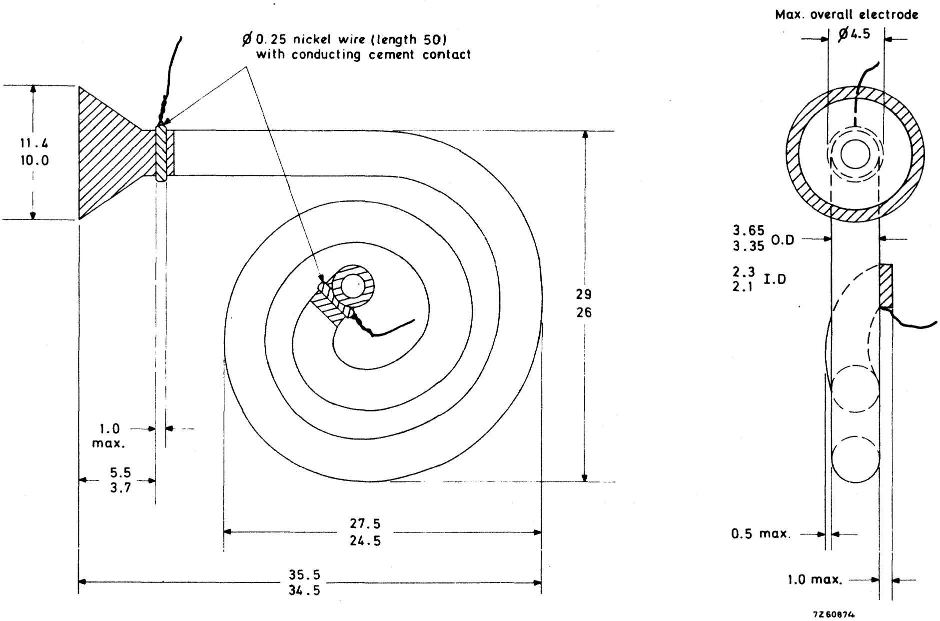
Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1) The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500 V.

2) Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C will reduce gain by approximately a factor of 2.

DIMENSIONS AND CONNECTIONS Dimensions in mm



CHANNEL ELECTRON MULTIPLIER PLATE

An array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc		27.1 ± 0.1	mm
Useful diameter	min.	26.5	mm
Thickness of disc		1.6 ± 0.1	mm
Channel diameter		40	μm
Channel pitch		50	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes	approx.	10^8	Ω
Current gain at 1.0 kV	min.	1000	
Current output at 1.0 kV linear operation	max.	1.0	μA

The plates are cut such that the channel electron multipliers form an angle of 13° to the perpendicular axis of the plate.

APPLICATIONS

These devices must operate in a vacuum, and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments the environmental vacuum is adequate for their operation, and they have considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satelites.

In laboratory use they must be incorporated in a vacuum chamber, where they will have important applications in field ion microscopy, electron microscopy and allied areas of work.

Data based on pre-production devices.

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	2.0	kV
Temperature, operating and storage (see note)	max.	70	°C
Bake temperature	max.	300	°C
Ambient pressure with high voltage applied	max.	13.3	mN/m^2
		1.0×10^{-4}	torr
Diameter of plate clamping rings	max.	26.6	mm

Note - The plate should be stored in a dry or vacuum environment.

CHANNEL ELECTRON MULTIPLIER PLATE

An array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc		$53.0\ ^{+0}_{-0.2}$	mm
Useful diameter	min.	51.8	mm
Thickness of disc		1.6 ± 0.1	mm
Channel diameter		40	μm
Channel pitch		50	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes	approx.	10^7	Ω
Current gain at 1.0 kV	min.	1000	

For linear relationship between input and output the output current must not exceed 0.1 of the standing current.

The plates are cut such that the channel electron multipliers form an angle of 13° to the perpendicular axis of the plate.

APPLICATIONS

These devices must operate in a vacuum, and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space ecperiments the environmental vacuum is adequate for their operation.

In laboratory use they must be incorporated in a vacuum chamber, where they will have important applications in field ion microscopy, electron microscopy and allied areas of work.

Data based on pre-production devices

LIMITING VALUES (Absolute max. rating system)

Operating voltage	max.	2.0	kV
Temperature, operating and storage (see note)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3	mN/m^2
		1.0×10^{-4}	torr
Diameter of plate clamping rings	max.	52.4	mm

Note - The plate should be stored in a dry or vacuum environment.

Scintillators

ZnS-SCINTILLATOR FOR α AND $\alpha + \beta$ RADIATION DETECTION

SAM scintillators comprise an acrylate disc, covered at one side with a thin aluminized scintillationfoil.
Zinc sulphide activated with silver is used as scintillating material.
The scintillator surface may be touched. Only high pressures or abrasive products can damage the film locally.
The SAF type consists of the same scintillating layer deposited on cellulose acetate-foil instead of acrylate.

CHARACTERISTICS

Time constant of fluorescence [1]	0.1 to 1	µs
Wavelenght of maximum emission	4500	Å
Maximum ambient temperature	40	°C
Detection efficiency, minimum	47.5	%
average	60	%
(measured with a thin ^{241}Am source 5.45 - 5.48 MeV, ϕ 9 mm, distance 7 mm from the scintillator)		
Mass per unit area of the ZnS layer	12	mg/cm^2
Mass per unit area of the metal-coating	500 to 600	µg/cm^2

SCINTILLATORS FOR ALPHA-BÊTA DETECTION

Type SPABM consisting of a metallized film of ZnS deposited on a thin foil of SPF (thickness $\geq$ 0.2 mm) can be delivered with or without acrylate support.

UNMETALLIZED SCINTILLATORS

Types SA and SPAB (unmetallized SAM and SPABM) can be ordered.

SPECIAL SCINTILLATORS

All types can be made resistant to a salty atmosphere for at least 100 hours on request.

[1]) With a good approximation the decay of fluorescence can be calculated with:

$$\frac{I_t}{I_0} = \frac{1}{(1 + At)^2}$$

where $A = 3$ to 4.10^6
t = time in s

Standard dimensions:

Discs:

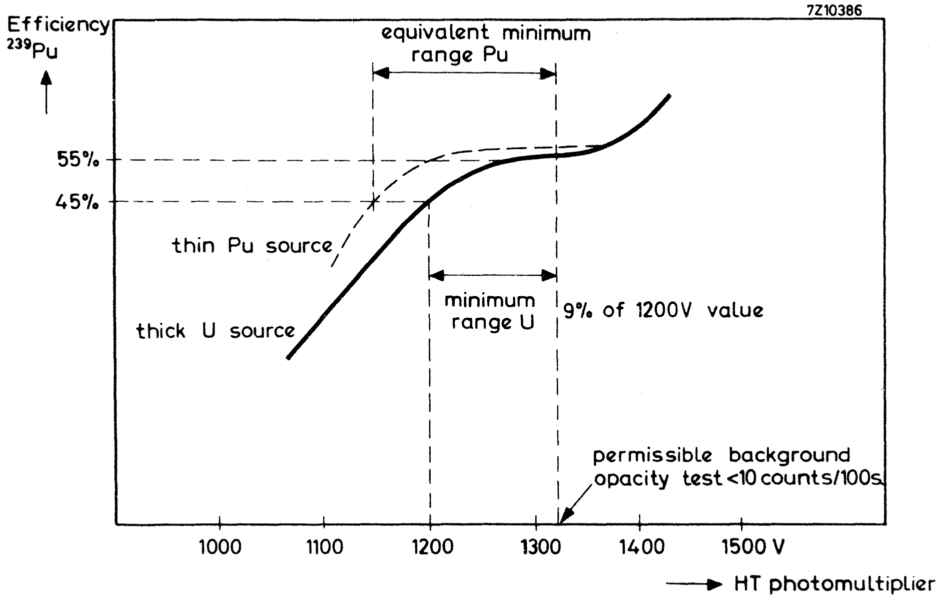
Type	Diameter (mm)	Thickness (mm)	Matching photomultiplier
SAM40	40	3	150AVP
SAM50	50	3	XP1000
SAM70	70	3	XP1030
SAM125	125	3	54AVP

Sheet:

SAM223/127	lenght : 223 mm width : 127 mm thickness : 3 mm

Foil:

SAF4400/70	lenght : 4400 mm width : 70 mm thickness : 0.23 mm



Quality control points with a thick U source and
equivalent values for a thin Pu source

Na I (Tl) CRYSTAL SCINTILLATOR FOR γ AND X-RAYS DETECTION AND SPECTROMETRY

SIS scintillators consist of Thallium activated sodium iodide crystals.
The crystals are mounted in aluminium with glass windows.

CHARACTERISTICS

Time constant of fluorescence	$0{,}25.10^{-6}$	s
Time constant of phosphorescence	$2{,}5.10^{-3}$	s
Wavelength of maximum emission	4250	Å
Density	3.67	
Refractive index	1.77	
Maximum temperature gradient	10	$^{o}C\ min^{-1}$

SCINTILLATORS FOR GAMMA-SPECTROMETRY

The types with dimensions up till 44 x 50 can be realized with a resolution of $\leq$ 9% for the peak of a ^{137}Cs gamma ray source.
For bigger dimensions and well-type crystals: < 10%.
The typenumber of this spectrometry quality is followed by SP.

SCINTILLATORS FOR X-RAY DETECTION AND COUNTING

Thin SIS mounts can be ordered (thickness of the crystal $\leq$ 5 mm) with a Be window (thickness 0.20 mm).

SPECIAL SCINTILLATORS

Anticoincidence mounts can be made on request.
(SIS crystal with or without mounting in a SPF scintillator).

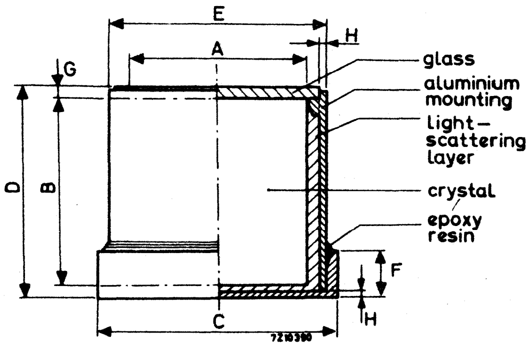
Standard dimensions of the crystal:

Type	Diameter A (mm)	Thickness B (mm)	Matching photomultiplier
SIS 12x12	12	12	XP1110/XP1115
SIS 19x19	19	19	XP1110/XP1115 XP1180/150AVP
SIS 25x25	25	25	150AVP
SIS 32x25	32	25	150AVP
SIS 38x25	38	25	XP1000/XP1001 150AVP/XP1010
SIS 44x50	44	50	XP1000/XP1001 150AVP
SIS 50x50	50	50	XP1030/XP1031
SIS 63x63	63	63	XP1030/XP1031
SIS 75x75	75	75	XP1030/XP1031 54AVP
SIS 100x75	100	75	54AVP
SIS 100x100	100	100	54AVP
Well-type: SIS 44x50P	44	50	Dimensions of the well: diameter 17 mm depth 39 mm

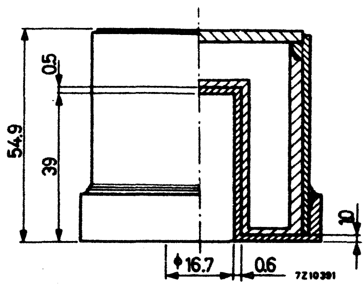
Other dimensions on request.

Dimensions of the mounted crystal:

Type	dimensions (mm)					
	C	D	E	F	G	H
SIS 12x12	20.2	16.8	16.2	5.5	1.2	0.5
SIS 19x19	26.2	23.8	22.2	5.5	1.2	0.5
SIS 25x25	33.2	29.8	29.2	5.5	1.2	0.5
SIS 32x25	40.2	31.0	36.2	5.5	1.8	0.5
SIS 38x25	43.7	31.0	42.2	6.5	2.0	0.5
SIS 44x50	52.2	54.8	48.2	6.5	2.5	0.5
SIS 50x50	58.2	54.8	54.2	6.5	2.5	1.0
SIS 63x63	71.2	67.8	67.2	6.5	3.0	1.0
SIS 75x75	83.2	79.8	79.2	6.5	3.0	1.0
SIS 100x75	dimensions and shape according to customers specifications				5.0	1.0
SIS 100x100					5.0	1.0
SIS 125x50						
SIS125x75						



Well-type: SIS 44x50P



All other dimensions: see type SIS 44

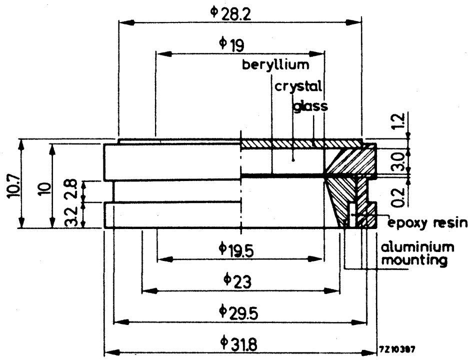
Scintillators for X-ray detection and counting

Standard dimensions of the crystal:

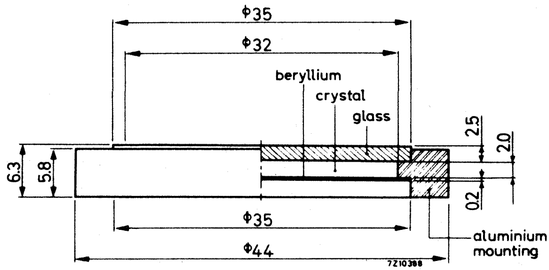
type	diameter (mm)	thickness (mm)
SIS 19x3	19	3
SIS 32x2	32	2
SIS 44x2	44	2

Thickness of the Be window is 0.2 mm

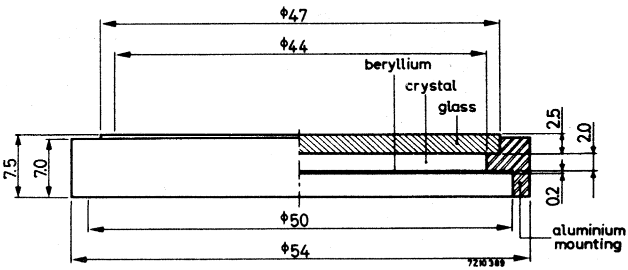
SIS 19x3

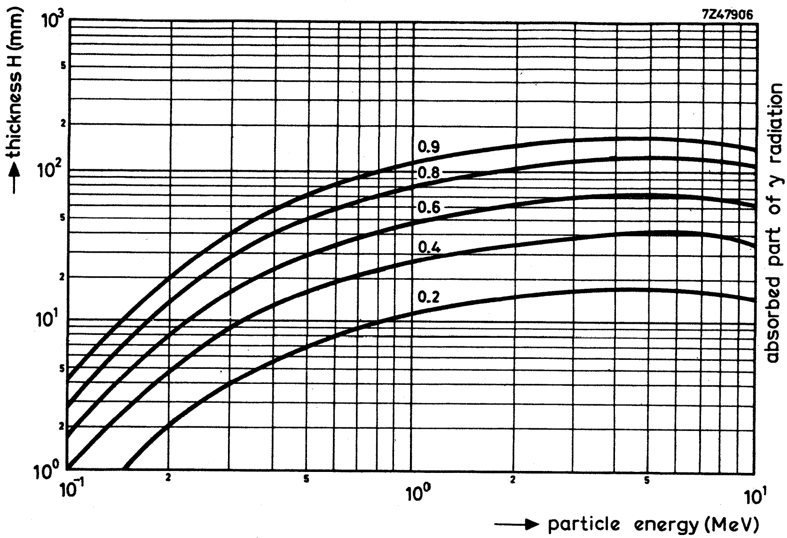


SIS 32x2



SIS 44x2





Absorption of γ radiation in the crystal

FLUORESCENT PLASTIC SCINTILLATOR FOR α, β, γ, PROTRONS, FAST NEUTRONS AND COSMIC RAYS DETECTION

SPF scintillators are composed of polystyrene with p-terphenyl and 1-1'4-4' tetraphenylbutadiene.
The p-terphenyl is the fluorescent agent, while the TPB corrects its emission spectrum in order to adapt it to the spectral sensitivity of the photomultiplier. The light output is 55% to 65% anthracene.

SPP has a special composition resulting in a light output which is 30% higher than with SPF and a decay constant of 2.2 ns.

SPT combines the scintillation characteristics of SPP with very good mechanical characteristics. It can be easily mounted without any particular precautions and it can be polished without difficulties. The decay constant is 2.1 ns.

Special scintillators

- Scintillators with a titanium dioxide reflective coating.
- Aluminized scintillators for β-detection. The light-tight metal cover can have a mass per unit area between 130 $\mu g/cm^2$ and 6 mg/cm^2. (Types SPFM, SPPM, SPTM).
- Plastic scintillators with a film of ZnS for α-β detection (See type SAM).
- Fast scintillators with UV-emission (345 nm)- Type SPFUV.
- Scintillators for increased temperatures (continuous use at 85 °C)- Type SPHT.
- Scintillator foil for α and β detection with a thickness between 5 μm and 100 μm. Standard dimensions 100 mm x 100 mm with an acrylate support, thickness 3 mm.
- Scintillator filaments with a diameter between 0.3 mm and 3 mm and a length up to 1 m.

CHARACTERISTICS

	SPF	SPP	SPT	
Decay constant with ^{60}Co source	3.6 ± 0.06	2.14 ± 0.06	2.10 ± 0.06	ns
Relative light output (compared with SPF 32/25 and a ^{239}Pu source)	1	1.30	1.22	
Wavelength of maximum emission	440	425	425	nm
Density	1.05	1.02	1.04	
Refractive index	1.594	1.585	1.592	
Ratio no. of H-atoms to no. of C-atoms	0.998	1.103	1.036	
Softening point	85	75	80	°C
Spectrum width at half max.	80	50	50	nm

Standard dimensions:

Disc and cylinders:

Type	Diameter (mm)	Standardized thicknesses (x) (mm)	Matching photomultiplier
SP. 25/x	25	0.2-0.5-1-1.5-3-20-100	XP1180
SP. 40/x	40	0.2-1.5-3-40-100-200	150AVP/XP1010
SP. 50/x	50	0.2-0.5-1-1.5-3-5-15-20-40-80	56AVP XP1000/XP1020/XP1021
SP. 70/x	70	0.2-1-1.5-3-200	XP1030
SP. 125/x	125	0.2-0.5-1-1.5-2-3-5-20-80-100-200	54AVP/58AVP/XP1040

Sheets and blocks:

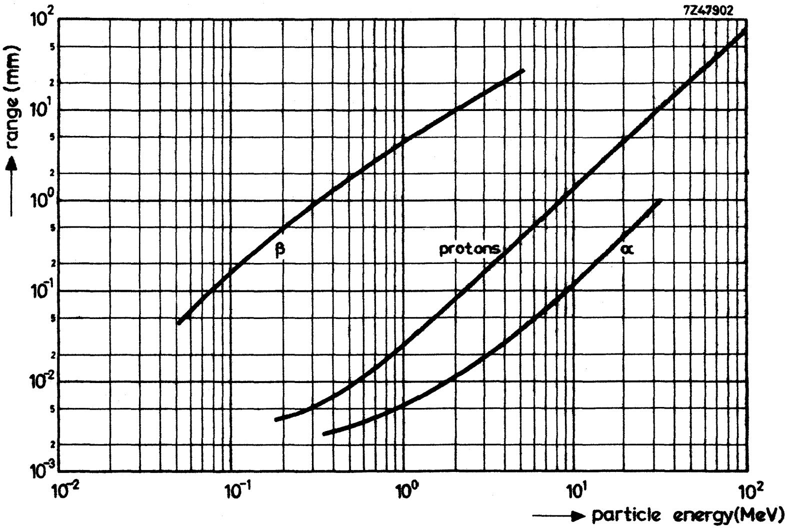
Type	Length (mm)	Width (mm)	Standardized thicknesses (x) (mm)
SP. 350/350/x	350	350	1-2-3-4-5-10
SP. 500/500/x	500	500	10-15
SP. 800/500/x	800	500	10-15-20-30
SP. 1500/1000/x	1500	1000	10-15

Other dimensions

Scintillators of one piece can be made up till 100 kg.
Bigger blocks (up till 1000 kg) can be manufactured by welding more pieces together.
Discs and cylinders available up to 450 mm Ø.

Special forms

All forms can be prepared to customers specifications.



Range of particles in dependence of energy for SPF

PLASTIC HORNYAK SCINTILLATOR FOR FAST NEUTRONS MEASUREMENT IN NUCLEAR REACTORS

SPH scintillators are composed of a styrene monomer polymerized with zinc sulphide. The action of neutrons causes the styrene to produce recoil protons which ionize the zinc sulphide, thus producing scintillations.

CHARACTERISTICS

Time constant of fluorescence [1]	0.1 to 1	μs
Wavelength of maximum emission	4500	Å
Softening point	80 - 85	°C
Response to fast neutrons (scintillator thickness 15 mm)	1.5	%
Ratio no. of H-atoms to no. of C-atoms	≈ 1.0	

SENSITIVITY TO GAMMA RAYS AND SLOW NEUTRONS

Because this sensitivity is low the luminous pulses produced by these two types of radiation have a very much smaller amplitude. It is therefore possible to eliminate them almost completely by choosing the threshold of the discriminator which follows the photomultiplier at such a high level that only the pulses from fast neutrons are counted.

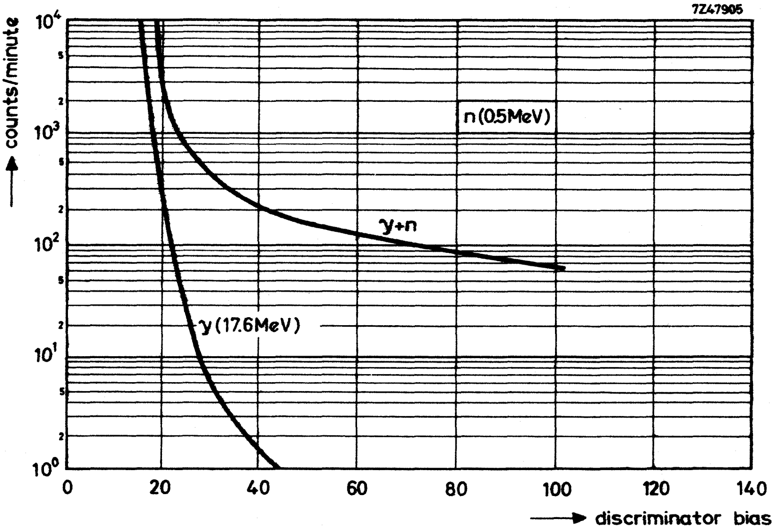
Available dimensions:

Discs with a diameter between 25 mm and 125 mm are available according to customers specifications.

[1]) With a good approximation the decay of fluorescence can be calculated with:

$$\frac{I_t}{I_o} = \frac{1}{(1 + At)^2}$$

where $A = 3$ to 4.10^6
t = time in s



Response curve with a Ra-Be source

Photoscintillators

32 mm PHOTOSCINTILLATOR

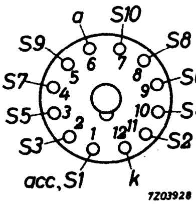
Photoscintillator intended for X-ray spectrometry.

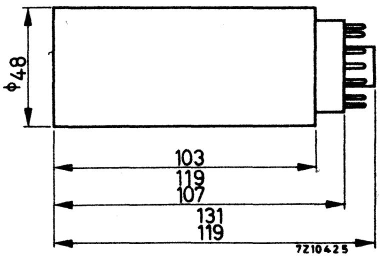
QUICK REFERENCE DATA	
Photomultiplier tube	XP 1010
Scintillator	Na I(Tl) 32 x 2 mm with Be window 0.2 mm
Voltage divider	not incorporated

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (Jedec B12-43)





Envelope

Material: stainless steel

ACCESSORIES

Socket FE1002

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

Na I (Tl) crystal with Be window	type SIS 32 x 2	
diameter	32	mm
thickness (crystal)	2	mm
thickness (window)	0.2	mm

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

32mm PHOTOSCINTILLATOR

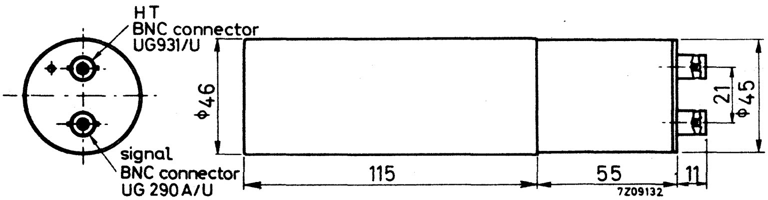
Photoscintillator intended for X-ray spectrometry.

QUICK REFERENCE DATA	
Photomultiplier tube	XP1010
Scintillator	NaI(Tl) 32 x 2 mm with Be window 0.2 mm
Voltage divider	incorporated

DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel



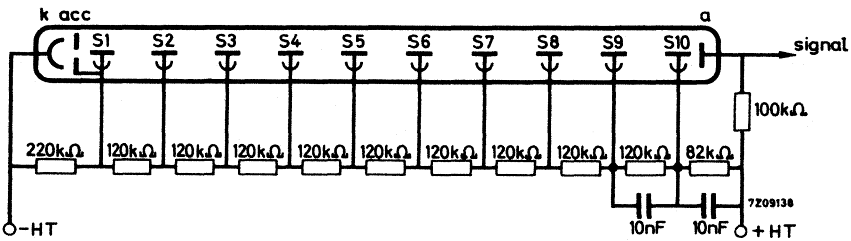
PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

NaI(T1) crystal with Be window	type SIS 32x2	
diameter	32	mm
thickness (crystal)	2	mm
thickness (window)	0.2	mm

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

32mm PHOTOSCINTILLATOR

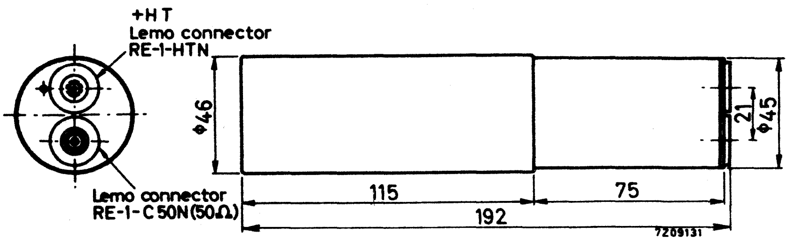
Watertight photoscintillator intended for X-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	XP1010	
Scintillator	NaI(Tl)	32 x 2 mm with Be window 0.2 mm
Voltage divider	incorporated	

DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel



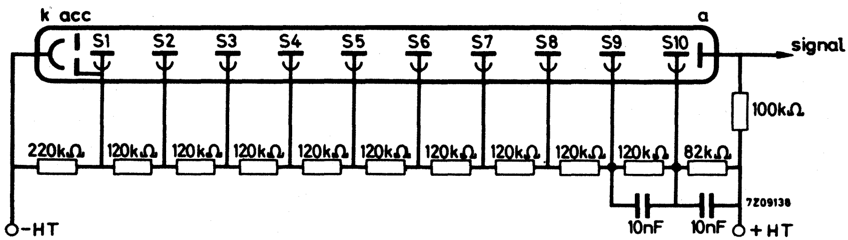
PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

NaI(Tl) crystal with Be window	type	SIS 32x2
diameter	32	mm
thickness (crystal)	2	mm
thickness (window)	0.2	mm

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

32mm PHOTOSCINTILLATOR

Photoscintillator intended for use in medical applications (X-ray).

QUICK REFERENCE DATA			
Photomultiplier tube		XP1010	
Scintillator	NaI (Tl)	32 x 6	mm
	with Al window	0.2	mm
Voltage divider	incorporated		

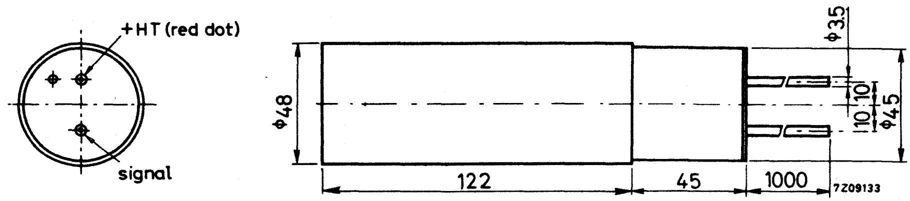
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connectors

Coaxial flexible leads (50 Ω)



PHOTOMULTIPLIER TUBE

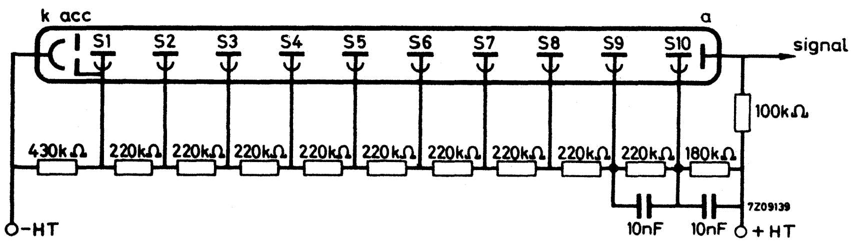
For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes" A mu-metal shield is incorporated.

SCINTILLATOR

NaI (T1) crystal with Al window

diameter	32	mm
thickness (crystal)	6	mm
thickness (window)	0.2	mm

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

32mm PHOTOSCINTILLATOR

Photoscintillator with possibility to mount a collimator and intended for use in medical applications (X-ray).

QUICK REFERENCE DATA	
Photomultiplier tube	XP1010
Scintillator	NaI (Tl) 32 x 6 mm with Al window 0.2 mm
Voltage divider	incorporated

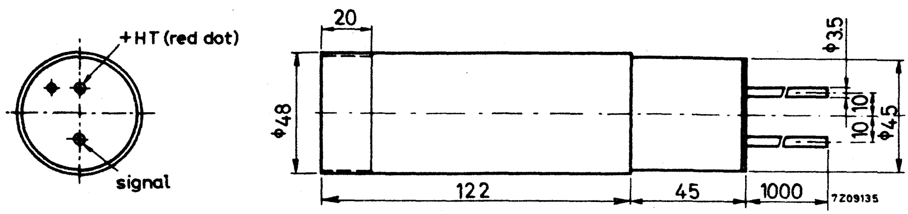
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



PHOTOMULTIPLIER TUBE

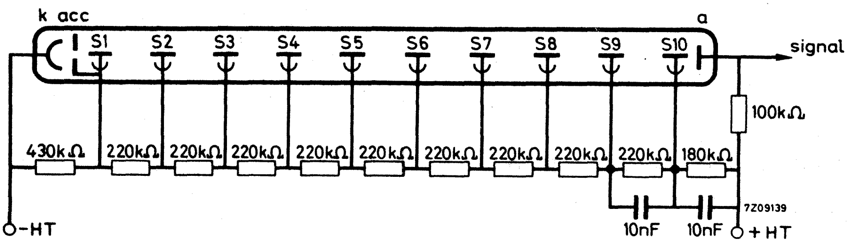
For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

NaI (Tl) crystal with Al window

diameter	32	mm
thickness (crystal)	6	mm
thickness (window)	0.2	mm

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

32mm PHOTOSCINTILLATOR

Probe with accomodation for interchangeable NaI (Tl) scintillators intended for medical applications.

QUICK REFERENCE DATA	
Photo multiplier tube	XP1010
Scintillator	not incorporated
Voltage divider	incorporated

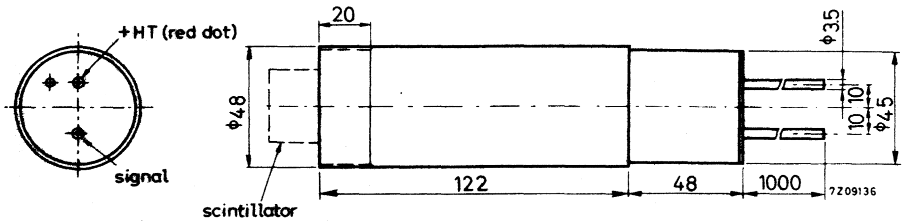
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



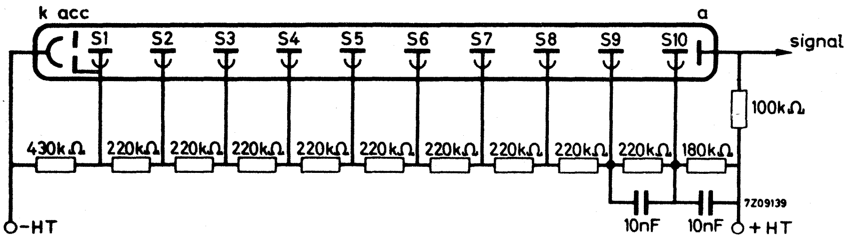
PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

The NaI (Tl) scintillator must be ordered separately.
The maximum diameter is 25 mm, the thickness depends on the application.
The scintillators are delivered in an adapted mount which can be screwed into the probe.

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

14mm PHOTOSCINTILLATOR

Basic miniature probe with accommodation for alpha, beta, gamma and fast neutron scintillators.

QUICK REFERENCE DATA	
Photomultiplier tube	XP1110/01
Scintillator	not incorporated
Voltage divider	incorporated

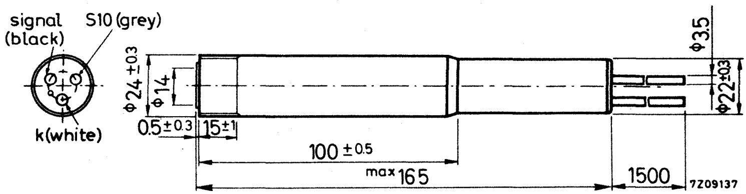
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



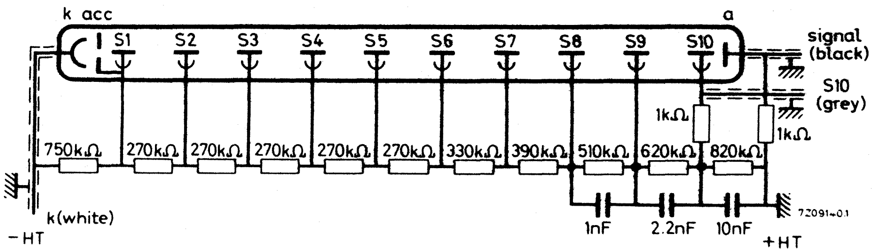
ACCESSORIES

Scintillators and mounting cap should be ordered separately.

PHOTOMULTIPLIER TUBE

For data of the photomultiplier XP1110/01 see under type XP1110 Handbook section "Photomultiplier tubes".
Type XP1110/01 = type XP1110 but selected for a gain of 10^7.
A mu-metal shield is incorporated.

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage V_b max. 1800 V

OPERATIONAL CONSIDERATIONS

For multi-channel detection to analyze high-energy particles the signal at S10 can be used for commanding an auxiliary circuit (gate, logic circuit etc.).

14mm PHOTOSCINTILLATOR

Basic miniature probe for photometric applications.

QUICK REFERENCE DATA	
Photomultiplier tube	XP1110
Scintillator	not incorporated
Voltage divider	incorporated

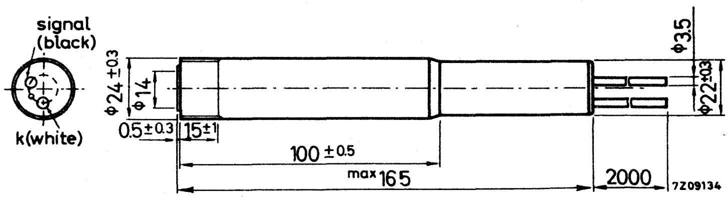
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

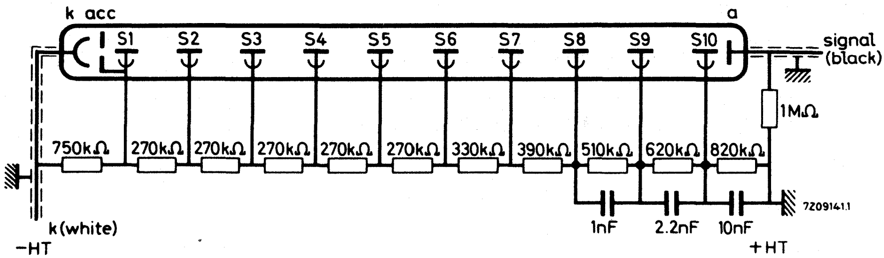
Coaxial flexible leads (50 Ω)



PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1110 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

44mm PHOTOSCINTILLATOR

Watertight photoscintillator intended for gamma detection and counting in liquids. A pre-amplifier is incorporated.

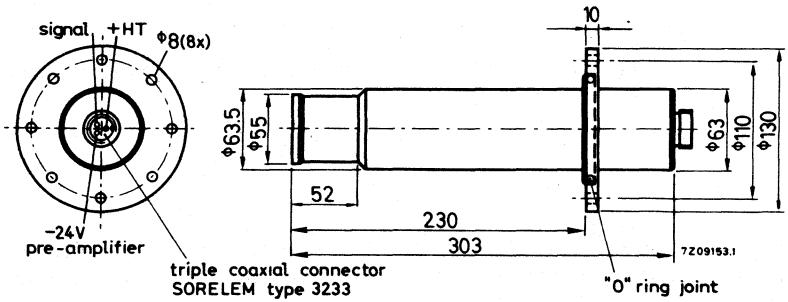
QUICK REFERENCE DATA	
Photomultiplier tube	53AVP
Scintillator	NaI(Tl) 44 x 50 mm with stainless steel window 0.5 mm
Voltage divider	incorporated
Pre-amplifier	incorporated

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Envelope

Material: stainless steel



PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube 53AVP see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

NaI(Tl) crystal with stainless steel window	type SIS 44 x 50		
diameter		44	mm
thickness (crystal)		50	mm
thickness (window)		0.5	mm
gamma threshold	≈	50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b max.	1800	V

OPERATIONAL CONSIDERATIONS

The photoscintillator is ready for use after applying a stabilized D.C. voltage to the HT connection and a D.C. voltage of −24 V to the pre-amplifier connection.

The photoscintillator is measured with a 5μCi ^{137}Cs source placed along the axis of the scintillator, at a distance of 15 cm.

The threshold of the detection circuit at the output of the pre-amplifier has an average value of 40 mV.

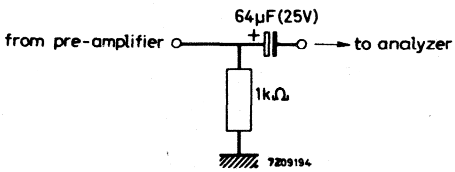
The average plateau length for a count rate of approx. 500 counts/s is 300 V.

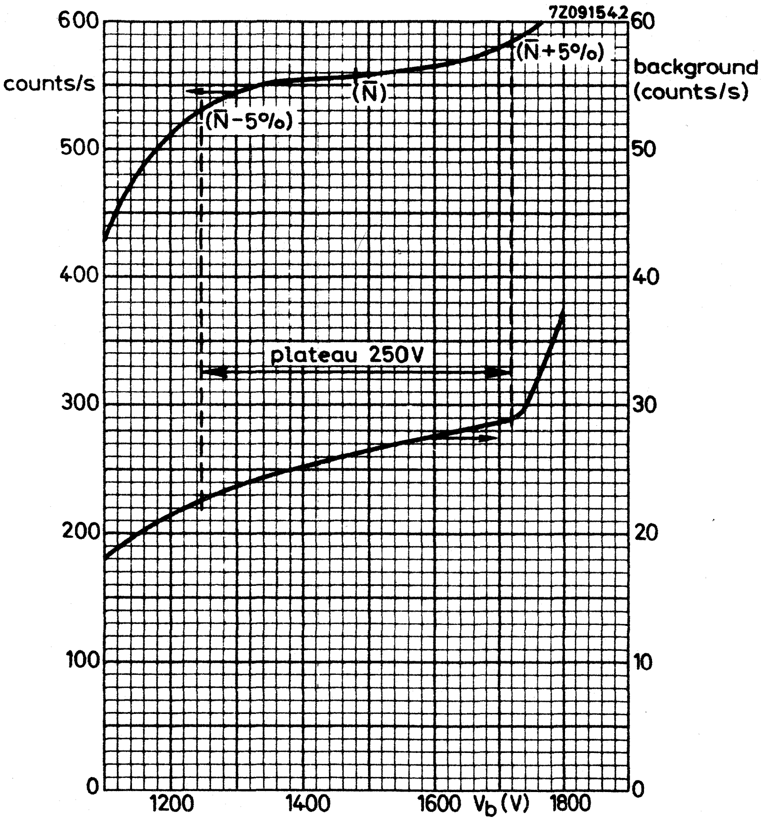
The background at the middle of the plateau, measured with a shield of 50 mm Pb, is 50 counts/s.

The average voltage at the middle of the plateau is 1500 V.

REMARKS

If the photoscintillator is used with a multi-channel analyzer having a negative D.C. input carrier signal, it is necessary to connect the following circuit between the signal output terminal of the PS1531 and the input terminal of the analyzer to prevent damage to the electrolytic capacitor in the output stage of the pre-amplifier of the PS1531.





average plateau and background curves

14mm PHOTOSCINTILLATOR

Basic miniature probe with accommodation for SPF scintillators coupled with a light guide.
It is intended for general purpose as well as for use in high energy physics.

QUICK REFERENCE DATA	
Photomultiplier tube	12-stage version of type XP1115
Scintillator	not incorporated
Voltage divider	incorporated
Output connection	50 Ω

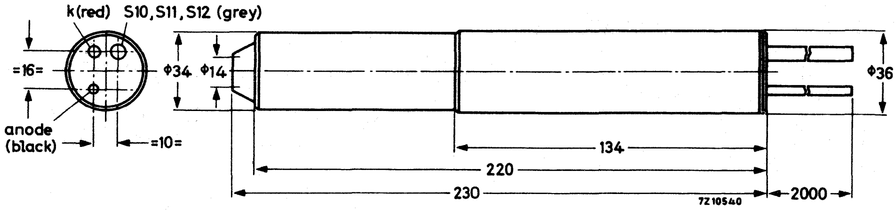
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: soft iron and aluminium.

Connections

Coaxial flexible leads (50 Ω)



1 anode lead (length 2 m) provided with RADIALL connector MINIQUICK 15300
1 cathode lead (length 2 m) provided with RADIALL connector MINIQUICK 24070
1 dynode lead (length 2 m) without connector.
(see also "Voltage divider", page 2)

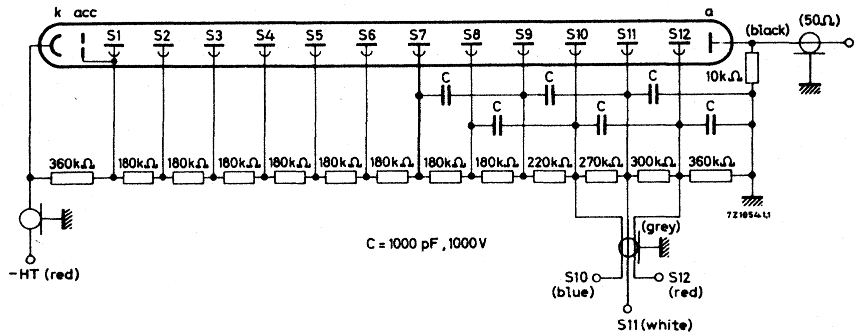
ACCESSORIES

Scintillator, light guide and plastic coupling piece should be ordered separately.

PHOTOMULTIPLIER TUBE

The photomultiplier mounted in this photoscintillator is a special high-gain version of type XP1115 (12 dynodes instead of 10).
A Mu-metal shield is incorporated.

VOLTAGE DIVIDER



LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2500	V

OPERATIONAL CONSIDERATIONS

1. For high current measurements it is possible to use a very well stabilized H.T. supply for the dynodes S_{10}, S_{11} and S_{12}.

2. The lightguide to be used with this photoscintillator must have a diameter of 14 mm and a minimum length of 40 mm.

14mm PHOTOSCINTILLATOR

Basic miniature probe with accommodation for SPF scintillators coupled with a light guide.
It is intended for general purpose as well as for use in high energy physics.

QUICK REFERENCE DATA	
Photomultiplier tube	12-stage version of type XP1115
Scintillator	not incorporated
Voltage divider	incorporated
Output connections	100 Ω

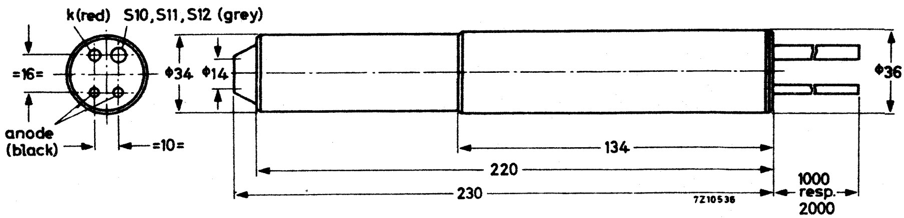
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: soft iron and aluminium

Connections

Coaxial flexible leads (100 Ω) with connectors



2 anode leads (length 1 m) provided with LEMO connectors type PC1C100
1 cathode lead (length 2 m) provided with LEMO connector type FE1HTN
1 dynode lead (length 2 m) provided with LEMO connector type FIIM4x13
(See also voltage divider page 2)

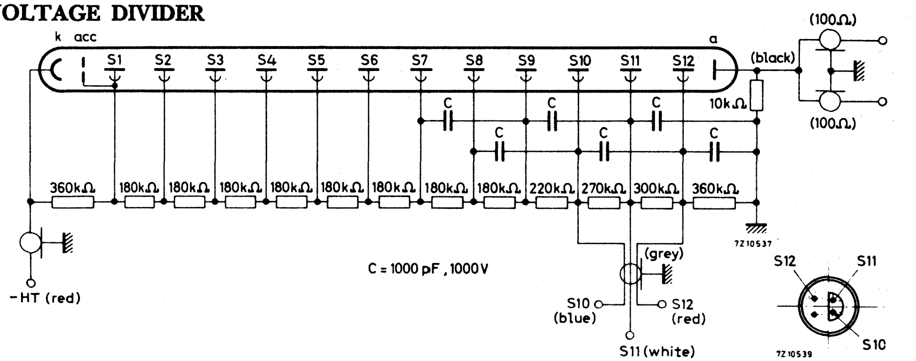
ACCESSORIES

Scintillator, light guide and plastic coupling piece should be ordered separately.

PHOTOMULTIPLIER TUBE

The photomultiplier mounted in the photoscintillator is a special high-gain version of type XP1115 (12 dynodes instead of 10).
A Mu-metal shield is incorporated.

VOLTAGE DIVIDER



LEMO-connection
F II M4 x 13

LIMITING VALUES (Absolute max. rating system)

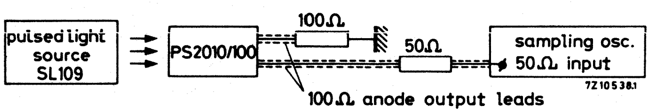
Supply voltage	V_b	max.	2500	V

OPERATIONAL CONSIDERATIONS

1. For high current measurements it is possible to use a very well stabilized H.T. supply for the dynodes S_{10}, S_{11} and S_{12}.

2. Characteristics of PS2010/100

   Measuring set up



The pulsed light source SL109 has a light pulse rise time τ_r = max. 0.5 ns and a width at half height max. 0.9 ns.
The H.T. of the photomultiplier is adjusted to obtain a gain resulting in an anode signal having an amplitude of 1 volt across 50 Ω, measured with a sampling oscilloscope (50 Ω input).

OPERATIONAL CONSIDERATIONS (continued)

The 100 Ω anode output is adapted to the 50 Ω oscilloscope input with a 50 Ω plug-in unit.
The 100 Ω pulse calibration output connector is terminated with 100 Ω.
The measured anode output pulse has a FWHM of approximately 7 ns and a rise time of approximately 4 ns.

3. The light guide to be used with this photoscintillator must have a diameter of 14 mm and a minimum length of 40 mm.

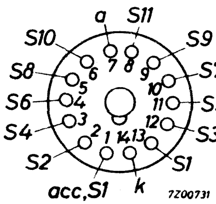
44 mm PHOTOSCINTILLATOR

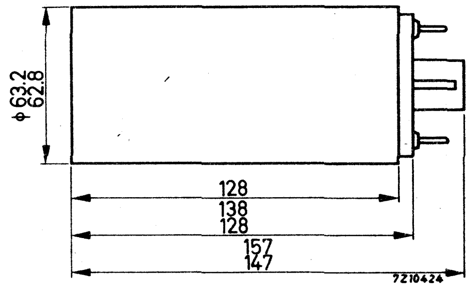
Photoscintillator intended for X-ray spectrometry.

QUICK REFERENCE DATA	
Photomultiplier tube	53AVP/02
Scintillator	NaI(Tl) 44 x 2 mm
Voltage divider	not incorporated

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: stainless steel

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier 53AVP/02 see under type 53AVP Handbook section "Photomultiplier tubes"
Type 53AVP/02 is a specially selected 53AVP for X-ray spectrometry use.
A mu-metal shield is incorporated.

SCINTILLATOR

NaI(Tl) crystal with Be window	type SIS 44 x 2	
diameter	44	mm
thickness (crystal)	2	mm
thickness (window)	0.2	mm

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b max. 1800	V

130 × 202 mm PHOTOSCINTILLATOR

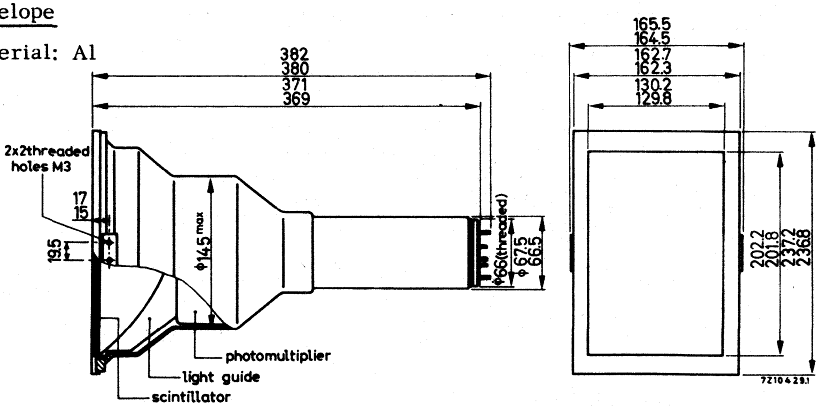
Photoscintillator intended for alpha and beta-counting. It is insensitive to light.

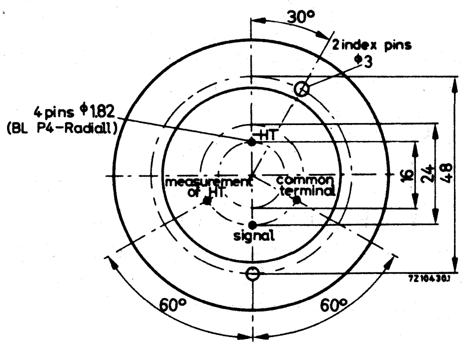
QUICK REFERENCE DATA	
Photomultiplier tube	54AVP
Scintillator	SPABM 139 x 209
Voltage divider	incorporated

DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: Al





Photomultiplier tube

For data of the photomultiplier tube 54AVP see Data Handbook, section "Photomultiplier tubes".
A Mu-metal shield is incorporated.

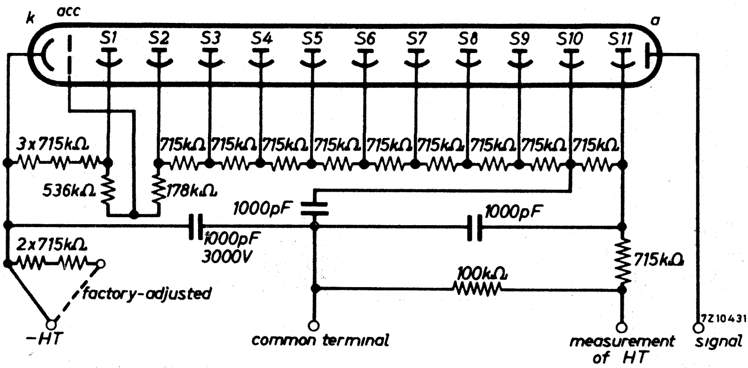
Scintillator

Aluminized film of ZnS deposited on a foil of fluorescent plastic SPF scintillator	type SPABM 139 x 209
effective width	130 mm
effective length	202 mm

Light guide

The scintillator is coupled to the photomultiplier by means of an acrylate light guide.

Voltage divider



OPERATIONAL CONSIDERATIONS

1. Anode load

As no anode load resistor is mounted in this photoscintillator the user is free to use one which is adapted to the related circuitry.
The time constant of the anode load must be so chosen that the maximum count rate to be expected can be handled.

2. Protecting grid

It is advisable to protect the thin light-tight window against mechanical damage by fitting a grid over it. To obtain a good efficiency the transparency of this grid must be at least 80%.
A Mylar foil can be used for further protection.

OPERATIONAL CONSIDERATIONS (continued)

3. Supply voltage

   The supply voltage must be between 1600 and 1950 V.

4. Alpha-efficiency

   With a thin ^{239}Pu source and a Mylar foil having a thickness of 3.6 μm the alpha-efficiency will be at least 13%; without protection this will be approximately 17%. [1)]

5. Beta-efficiency

   With a thin low-activity ^{204}Tl source having an area of 160 cm^2 the beta-efficiency will be at least 5% (without protecting grid 6.25%). [1)]

6. Background

   At an ambient activity less than 20 μR/h the alpha background of the photoscintillator is ≤ 0.1 count/s.

[1)] This efficiency is defined as the counted number of disintegrations divided by the total number of disintegrations of the source. It is given as a percentage.

130 × 202 mm PHOTOSCINTILLATOR

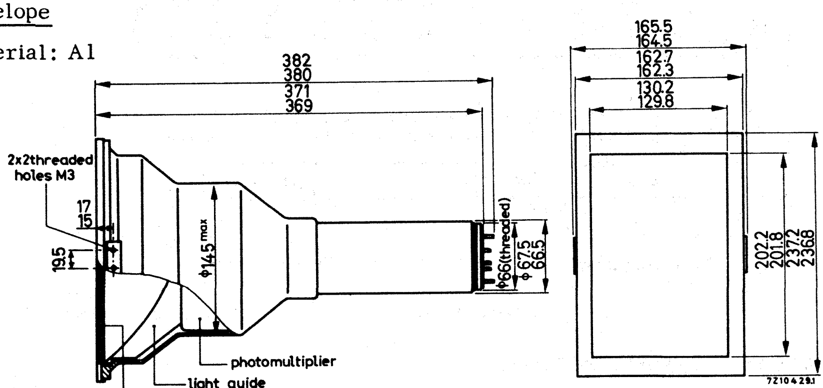
Photoscintillator intended for gamma-counting.
It is insensitive to light.

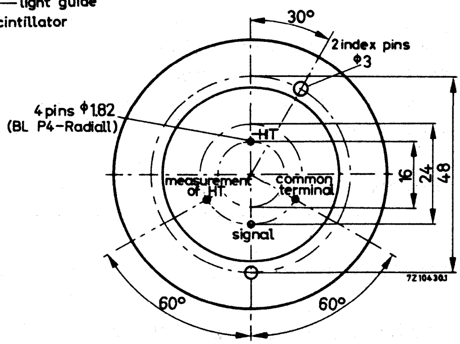
QUICK REFERENCE DATA	
Photomultiplier tube	54AVP
Scintillator	SPF 139 x 209
Voltage divider	incorporated

DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: Al





Photomultiplier tube

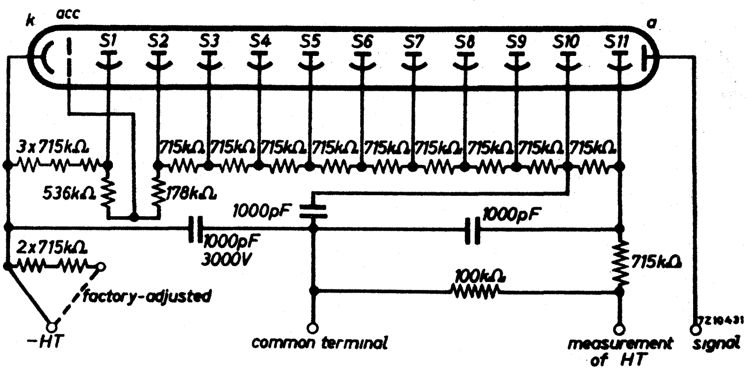
For data of the photomultiplier tube 54AVP see Data Handbook, section "Photomultiplier tubes"
A Mu-metal shield is incorporated.

Scintillator

Fluorescent plastic scintillator	type SPF 139 x 209
effective width	130 mm
effective length	202 mm
effective thickness	80 mm

In front of the scintillator an aluminium foil is mounted to make the photoscintillator insensitive to light.
Thickness of this Al window is 0.4 mm.

Voltage divider



OPERATIONAL CONSIDERATIONS

1. Anode load
   As no anode load resistor is mounted in this photoscintillator the user is free to use one which is adapted to the related circuitry.
   The time constant of the anode load must be so chosen that the maximum count rate to be expected can be handled.
2. Protecting grid
   It is advisable to protect the thin light-tight window against mechanical damage by fitting a grid over it. To obtain a good efficiency the transparency of this grid must be at least 80%.
   A Mylar foil can be used for further protection.
3. Supply voltage
   The supply voltage must be between 1600 and 1950 V.

UNIVERSAL PHOTOSCINTILLATOR BASE ASSEMBLY

The S5600 base assembly is essentially a probe-like mechanical system with provisions for mounting a photomultiplier tube, a voltage divider, a limiter and either a scintillator or a light guide.
The necessary wiring is already present as well as printed wiring boards carrying the limiter and voltage dividers.
The photomultiplier tube, scintillator, light guide or fastening clip must be ordered separately.

QUICK REFERENCE DATA			
H.T. supply of the photomultiplier tube (negative polarity)	max.	2500	V
H.T. supply current	max.	1.20	mA/kV
Limiter supply voltage (positive polarity)		24	V
Limiter supply current		35	mA

TYPE DESIGNATION

S5600/01: Complete assembly with:

- mu-metal and soft-iron shields,
- socket for photomultiplier tube,
- decoupling capacitors for photomultiplier tube,
- 2 printed-wiring boards carrying the voltage divider,
- 1 printed-wiring board carrying the limiter,
- fastening rings for light guide or scintillator

Without photomultiplier tube, scintillator, light guide or fastening clip. This assembly is intended for use with a photomultiplier tube type 56 AVP, 56 DVP, 56DUVP, 56TUVP, 56TVP or 56 UVP.

S5600/02: As S5600/01 but for use with a photomultiplier tube type 56 CVP.

S5600/03: As 5600/01 but for use with a photomultiplier tube type 58AVP, 58DVP, 58UVP, XP1040 or XP1041

DIMENSIONS

S5600/01, S5600/02	overall length	max.	465	mm
	diameter	max.	92	mm
	net weight		4.5	kg
S5600/03 :	overall length	max.	693	mm
	diameter	max.	172	mm
	net weight		15	kg

PHOTOMULTIPLIER TUBE

The photomultiplier tube must be ordered separately.
For tube data see Handbook section "Photomultiplier tubes".

SCINTILLATOR

The plastic scintillator must be ordered separately. The required dimensions should be stated when ordering this scintillator.
For scintillator data see Handbook section "Scintillators" type SPF.

LIGHT GUIDE

The light guide to be ordered separately has a maximum diameter of 40 mm for types S5600/01 and S5600/02 or 100 mm for type S5600/03. The required dimensions should be stated when ordering this light guide.

ACCESSORIES

The following accessories can be ordered separately:

M/5600/01: As S5600/01 but without the printed-wiring boards carrying voltage divider and limiter.

M/5600/02: As S5600/02 but without the printed-wiring boards carrying voltage divider and limiter.

M/5600/03: As S5600/03 but without the printed-wiring boards carrying voltage divider and limiter.

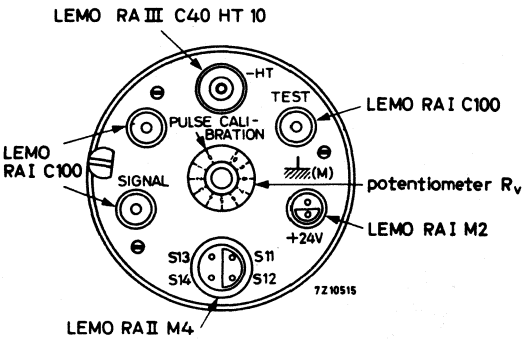
M/5600/AR: As M/5600/01 but without anti-magnetic shields and without fastening rings for light guide or scintillator.

ACCESSORIES (continued)

PS A 100 : Fastening clip for types S5600/01 and S5600/02
PS A 101 : Voltage divider for S5600/02 (2 circuits)
PS A 102 : Two printed-wiring boards without components for mounting a voltage divider at choice.
PS A 103 : Voltage divider for S5600/01 and S5600/03 (2 circuits)
PS A 104 : Limiter with transistors type 2N700A (obsolete)
PS A 104/0: Limiter with transistors BS X 29
PS A 105 : Opaque cap for types S5600/01 and S5600/02
PS A 106 : Fastening rings for light guide or scintillator for types S5600/01 and S5600/02
PS A 116 : Fastening ring for light guide or scintillator for type S5600/03
PS A 107 : Soft-iron shield for types S5600/01 and S5600/02
PS A 117 : Soft-iron shield for type S5600/03
PS A 108 : Foam-plastic ring for types S5600/01 and S5600/02
PS A 118 : Foam-plastic ring for type S5600/03
PS A 109 : Passive printed wiring board to replace limiter PS A 104 in case of direct connection to the anode
TA 60/09 : Mu-metal shield for types S5600/01 and S5600/02
ϕ148-L = 335 : Mu-metal shield for type S5600/03

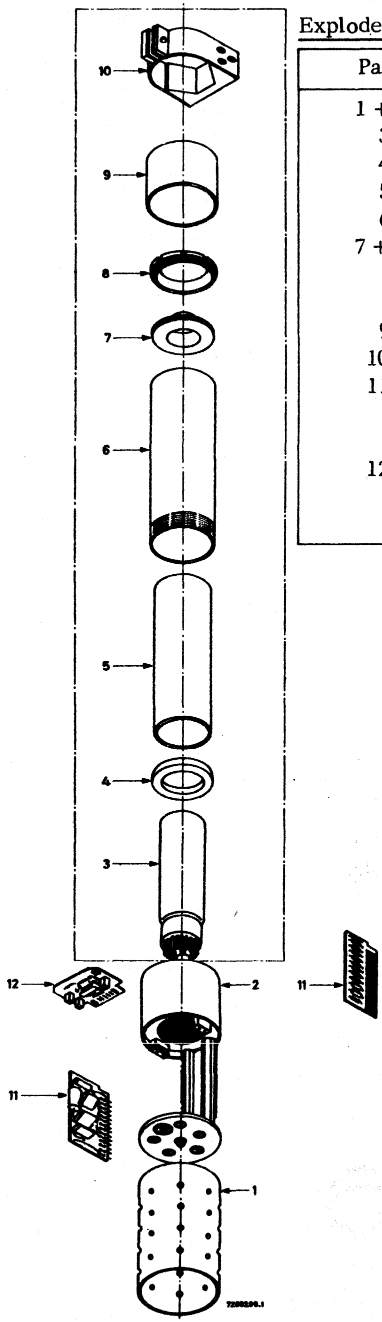
See also pages 4 and 5.

CONNECTIONS



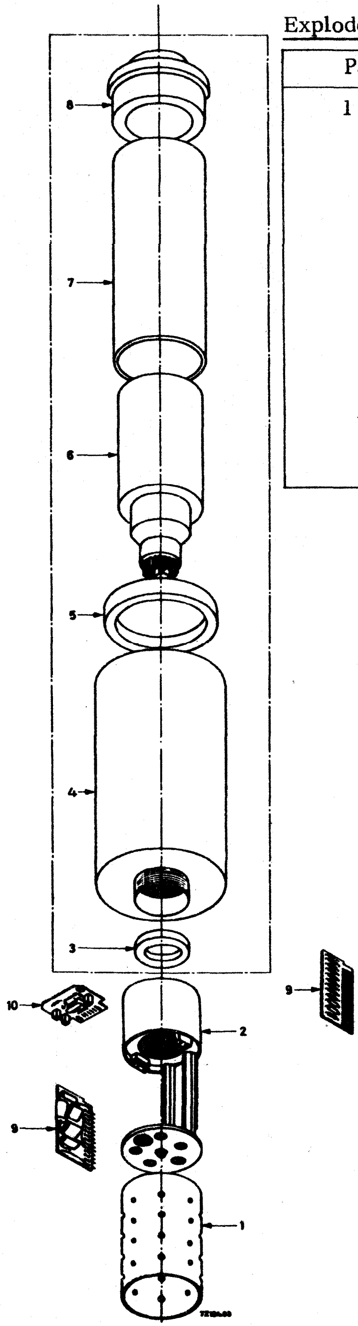
Matching connectors

-HT	: LEMO	F III	C 40	HT10
Dynodes S11 to S14	: LEMO	F II	M4 x 1.3	
+24 V	: LEMO	F I	M2 x 1.3	
Signal, Test, Pulse calibration:	LEMO	F I	C 100	



Exploded view S5600/01 and S5600/02

Part	Typenumber	Description
1 + 2	M/5600/AR	Rear assembly
3	–	Photomultiplier
4	PS A 108	Foam-plastic ring
5	TA 60/09	Mu-metal shield
6	PS A 107	Soft-iron shield
7 + 8	PS A 106	Fastening rings for light guide or scin-tillator
9	PS A 105	Opaque cap
10	PS A 100	Fastening clip
11	PS A 103 or PS A 101	Voltage divider (2 circuits)
12	PS A 104 or PS A 104/0	Limiter



Exploded view S5600/03

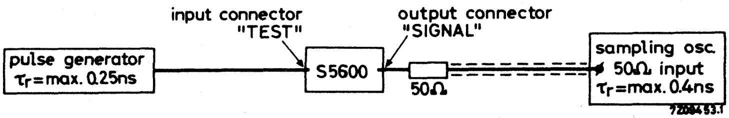
Part	Typenumber	Description
1 + 2	M/5600/AR	Rear assembly
3	PS A 108	Foam-plastic ring
4	PS A 117	Soft-iron shield
5	PS A 118	Foam-plastic ring
6	-	Photomultiplier
7	ϕ148-L = 335	Mu-metal shield
8	PS A 116	Fastening ring for light guide or scintillator
9	PS A 103	Voltage divider (2 circuits)
10	PS A 104 or PS A 104/0	Limiter

OPERATIONAL CONSIDERATIONS

The H.T. supply of the probe must have a negative polarity. The absolute maximum value of the H.T. is 2500 V but, depending on the type of photomultiplier tube used, it must not exceed the value giving a gain of 10^9.
The H.T. supply current is max. 1.20 mA/kV.

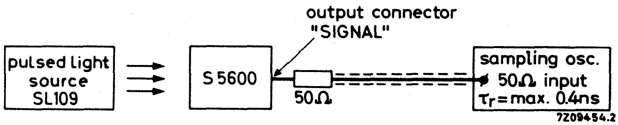
The supply voltage of the limiter must have a positive polarity (V_S = interstage voltage). This voltage is 24 V $\pm$ 1 V at a current of about 35 mA.

Characteristics of the limiter, measured with set-up as below
The amplitude of the output signal V_{op} = 1.6 V, across 100 Ω.
The rise time (τ_r) from 0.1 to 0.9 V_S is max. 2 ns.
Ambient temperature max. 40 °C.



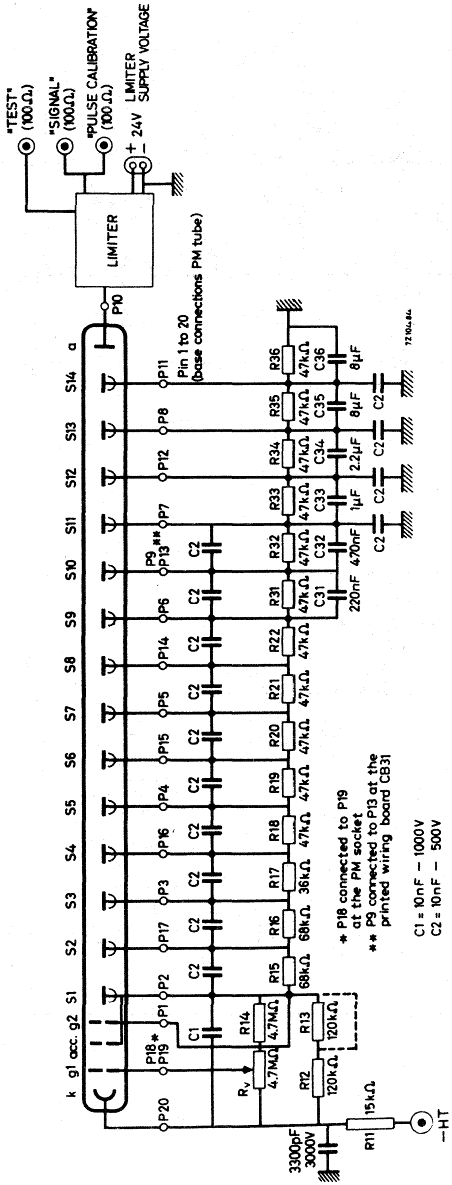
Characteristics of S5600 equipped with a photomultiplier tube type 56AVP or 56DVP

Measuring set-up



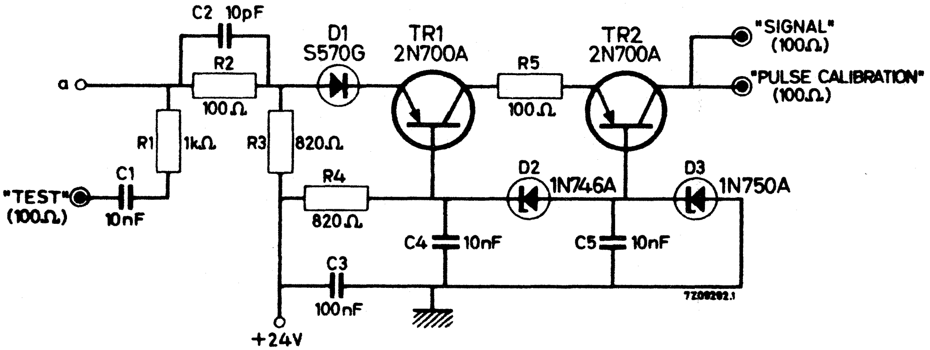
Light pulse rise time τ_r = max. 0.5 ns
Width at half height max. 0.9 ns
H.T. for a gain G = 10^8 : See photomultiplier tube data
Output pulse: τ_r = 4 ns

GENERAL CIRCUIT S5600

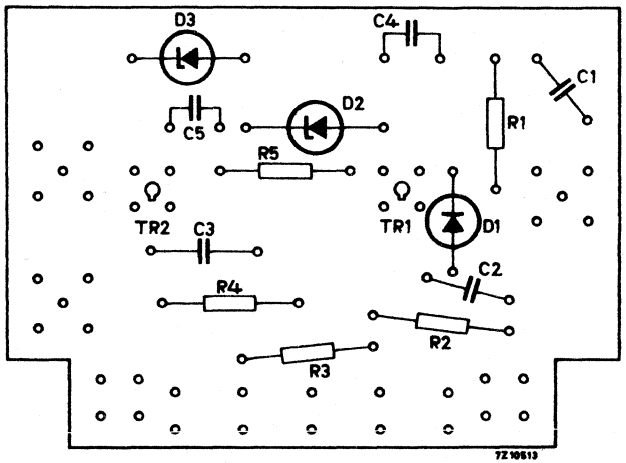


LIMITER PS A 104

Circuit

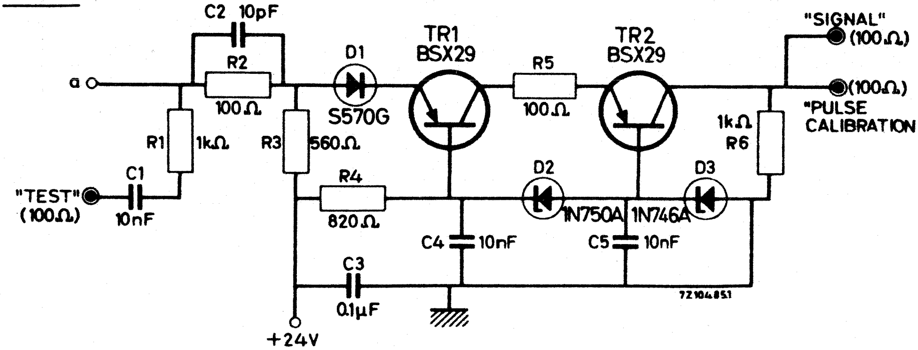


Printed-wiring board

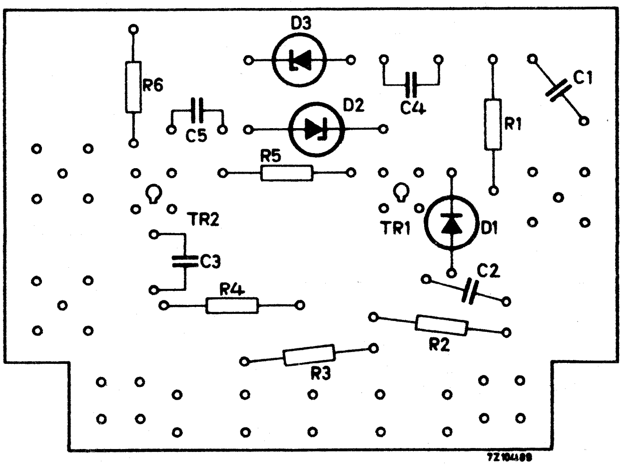


LIMITER PS A 104/0

Circuit

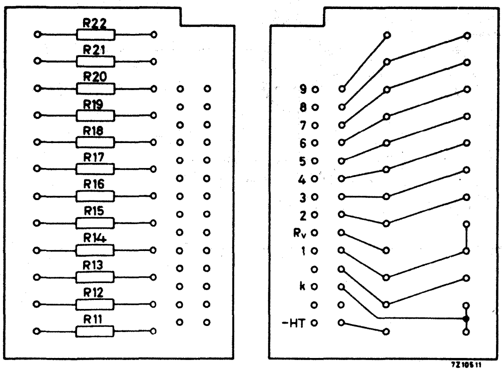


Printed-wiring board

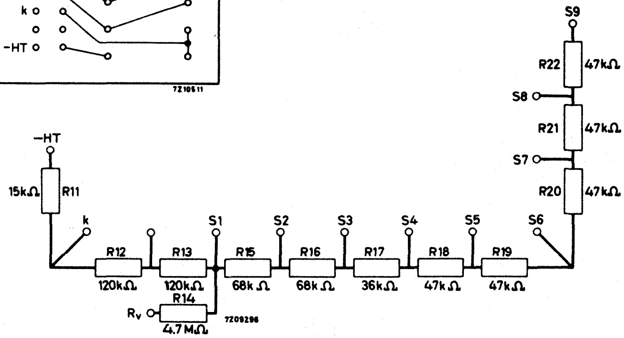


VOLTAGE DIVIDER PS A 101

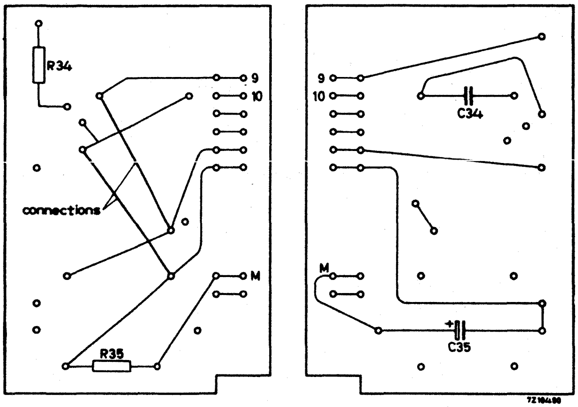
Printed wiring board 1



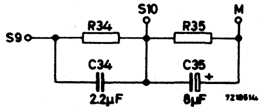
Circuit 1



Printed wiring board 2

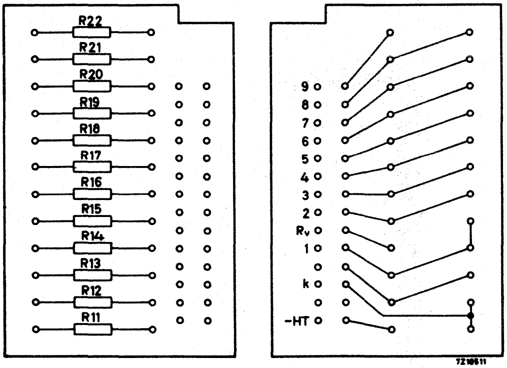


Circuit 2

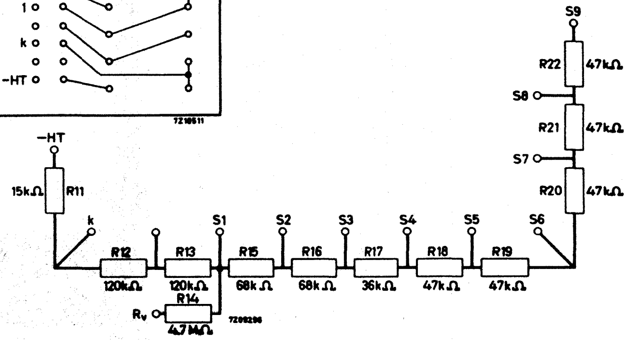


VOLTAGE DIVIDER PS A 103

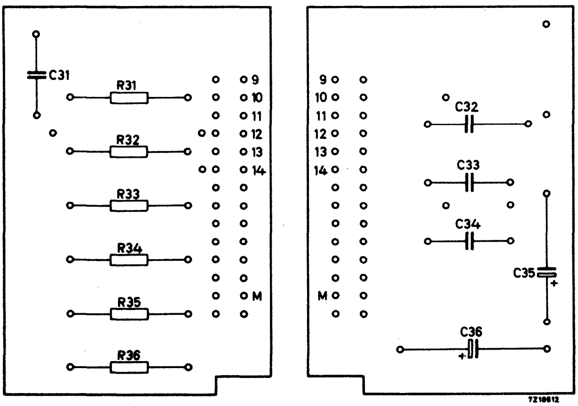
Printed-wiring board 1



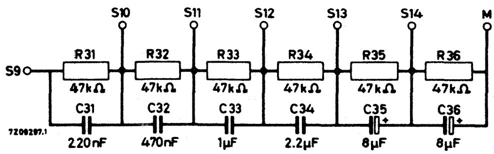
Circuit 1



Printed-wiring board 2

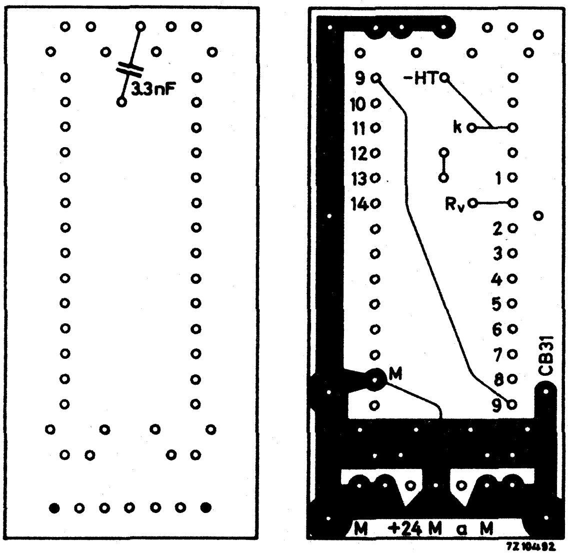


Circuit 2

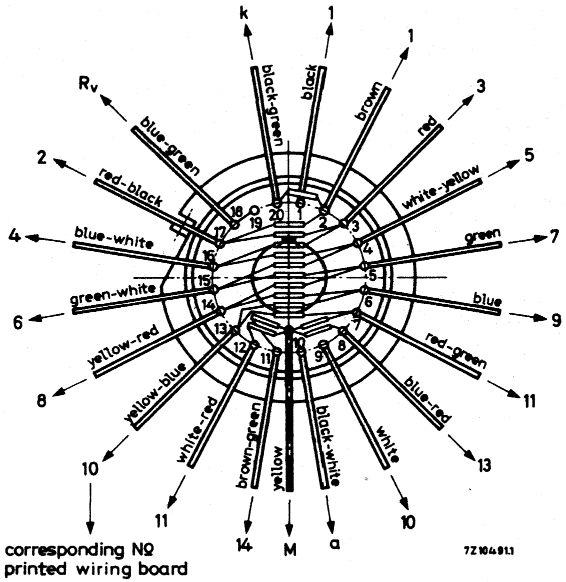


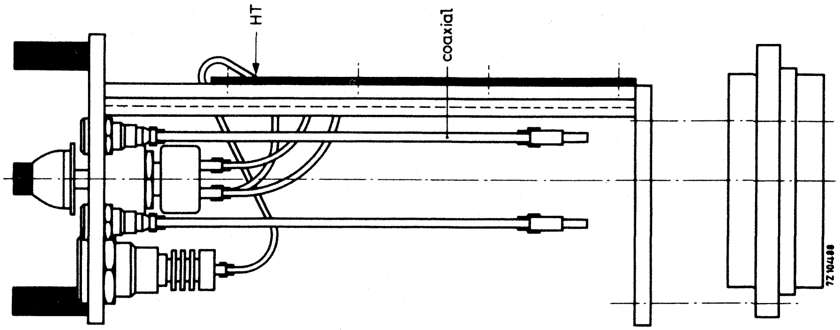
PRINTED-WIRING BOARD CB31

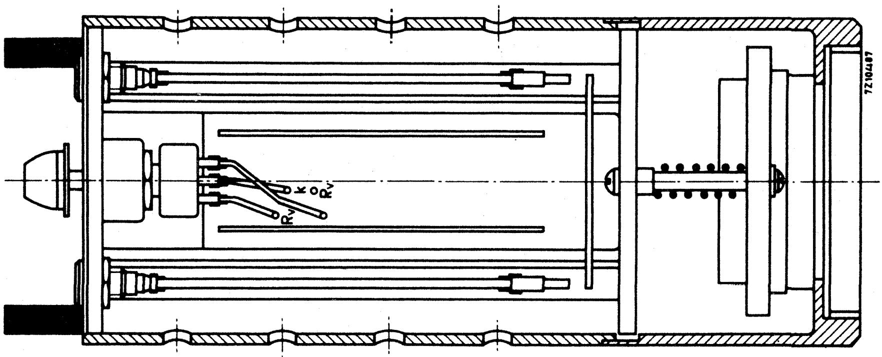
Used in all types S5600



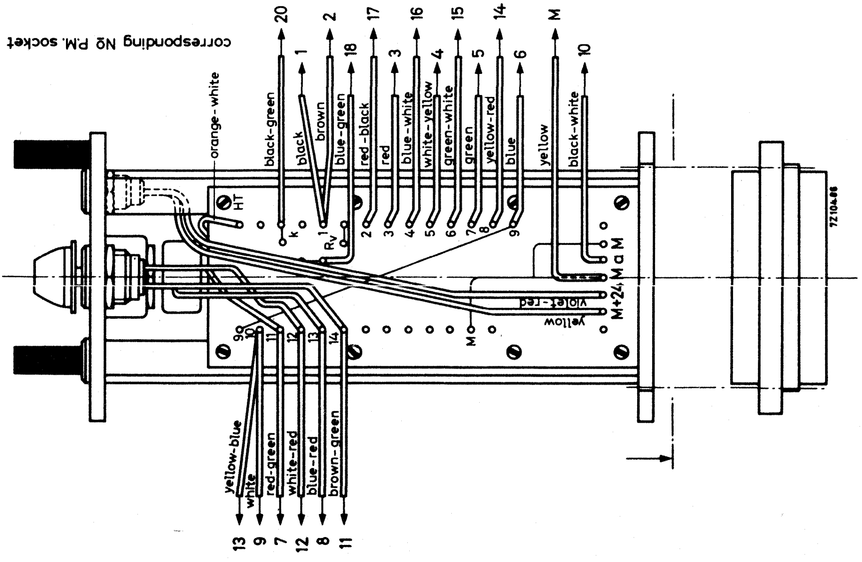
WIRING DIAGRAM PHOTOMULTIPLIER SOCKET







GENERAL WIRING DIAGRAM



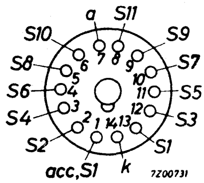
44mm PHOTOSCINTILLATOR

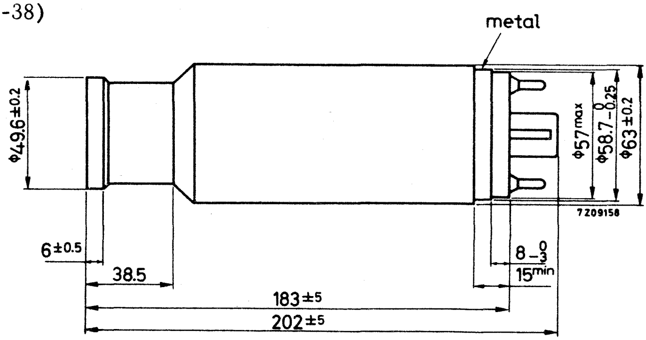
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	153AVP	
Scintillator	NaI(Tl) 44 x 50	mm
	with Al window 0.5	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 9	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube 153AVP see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

NaI(Tl) crystal with Al window	type	SIS 44 x 50	mm
diameter		44	mm
thickness (crystal)		50	mm
thickness (window)		0.5	mm
gamma threshold		≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

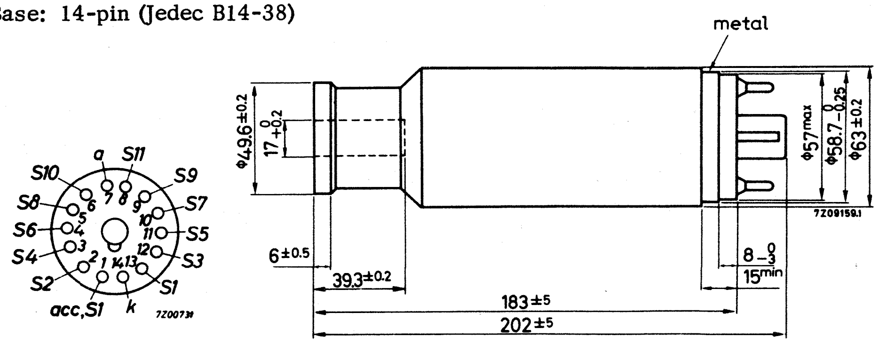
44mm PHOTOSCINTILLATOR

Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	153AVP	
Scintillator	well type NaI(Tl) 44 x 50	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 10	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)



Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube 153AVP see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

Well-type NaI(Tl) crystal with Al window		type	SIS 44 x 50P
Crystal			
diameter		44	mm
thickness		50	mm
Well			
useful diameter		16.7	mm
useful depth		39.3	mm
Window			
thickness		0.5	mm
gamma threshold	≈	10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

44mm PHOTOSCINTILLATOR

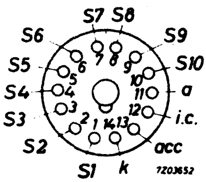
Photoscintillator intended for gamma-ray spectrometry.

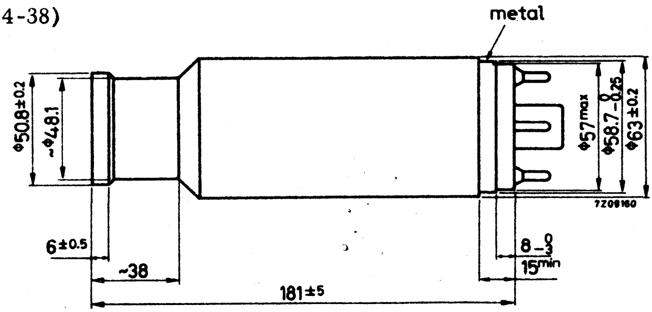
QUICK REFERENCE DATA			
Photomultiplier tube		XP1001	
Scintillator		NaI (Tl) 44 x 50	mm
		with Al window 0.5	mm
Voltage divider		not incorporated	
Resolution (^{137}Cs : 661 keV)	≤	8	%
Peak/valley ratio (^{60}Co)	≥	8	

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1001 see Handbook section "Photomultiplier tubes"
A mu-metal shield is incorporated.

SCINTILLATOR

Na I (Tl) crystal with Al window	type	SIS 44 x 50	mm
diameter		44	mm
thickness (crystal)		50	mm
thickness (window)		0.5	mm
gamma threshold		≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

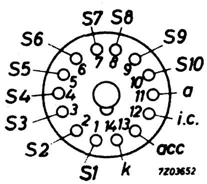
44mm PHOTOSCINTILLATOR

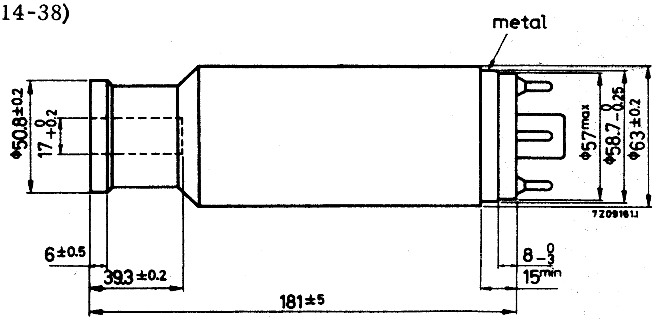
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA	
Photomultiplier tube	XP1001
Scintillator	well type Na I (Tl) 44 x 50 mm
Voltage divider	not incorporated
Resolution (^{137}Cs : 661 keV)	≤ 10 %

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1001 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

Well-type NaI (Tl) crystal with Al window	type SIS 44 x 50P	
Crystal		
diameter	44	mm
thickness	50	mm
Well		
useful diameter	16.7	mm
useful depth	39.3	mm
Window		
thickness	0.5	mm
gamma threshold	≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

75 mm PHOTOSCINTILLATOR

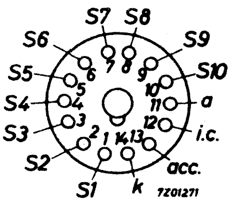
Photoscintillator intended for gamma-ray spectrometry.

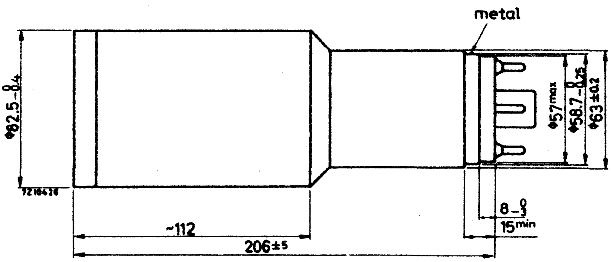
QUICK REFERENCE DATA		
Photomultiplier tube	XP1031	
Scintillator	NaI(Tl) 75 x 63 with Al window 0.5	mm mm
Voltage divider	not incorporated	
Resolution (^{137}Cs: 661 keV)	≤ 9	%

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1031 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

NaI(Tl) crystal with Al window	type SIS 75 x 63	
diameter	75	mm
thickness (crystal)	63	mm
thickness (window)	0.5	mm
gamma threshold	≈ **10**	**keV**

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V

75mm PHOTOSCINTILLATOR

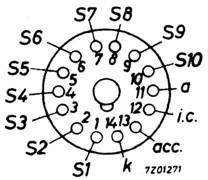
Photoscintillator intended for gamma-ray spectrometry.

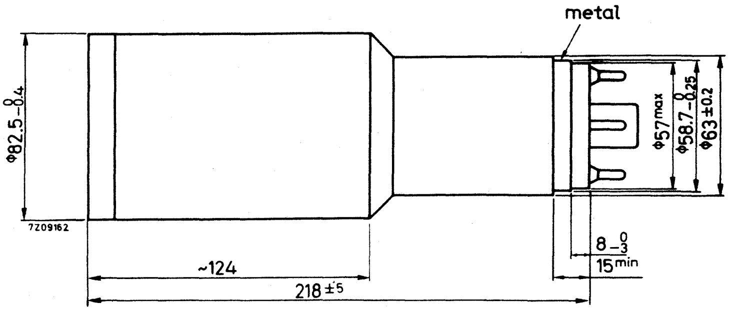
QUICK REFERENCE DATA		
Photomultiplier tube	XP1031	
Scintillator	Na I (Tl) 75 x 75 with Al window 0.5	mm mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 8.5	%
Peak/valley ratio (^{60}Co)	≥ 8	

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1031 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

Na I (Tl) crystal with Al window	type	SIS 75 x 75
diameter	75	mm
thickness (crystal)	75	mm
thickness (window)	0.5	mm
gamma threshold	≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2000	V

75mm PHOTOSCINTILLATOR

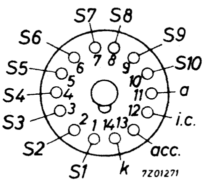
Photoscintillator intended for gamma-ray spectrometry.

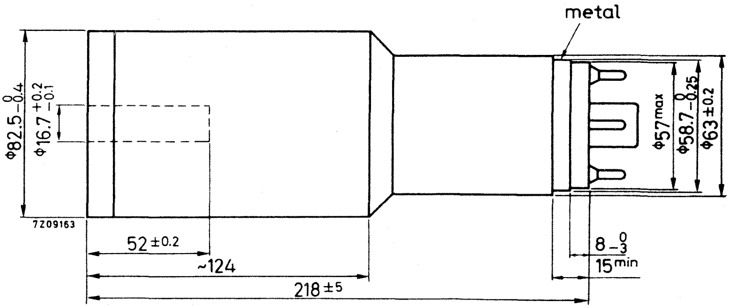
QUICK REFERENCE DATA		
Photomultiplier tube	XP1031	
Scintillator	well type NaI (Tl) 75 x 75	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 11	%

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1031 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

Well-type NaI (Tl) crystal with Al window	type	SIS 75 x 75P	
Crystal			
diameter		75	mm
thickness		75	mm
Well			
useful diameter		16.7	mm
useful depth		52	mm
Window			
thickness		0.5	mm
gamma threshold	≈	10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V

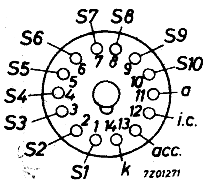
75mm PHOTOSCINTILLATOR

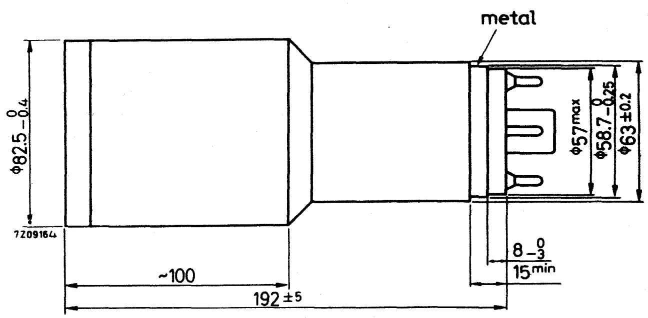
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	XP1031	
Scintillator	NaI (Tl) 75 x 50 with Al window 0.5	mm mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 9.5	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 14-pin (Jedec B14-38)





Envelope

Material: Al

ACCESSORIES

Socket: FE1001

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1031 see Handbook section "Photomultiplier tubes".
A mu-metal shield is incorporated.

SCINTILLATOR

NaI (Tl) crystal with Al window		type SIS 75 x 50	
diameter		75	mm
thickness (crystal)		50	mm
thickness (window)		0.5	mm
gamma threshold		≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2000	V

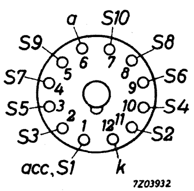
38mm PHOTOSCINTILLATOR

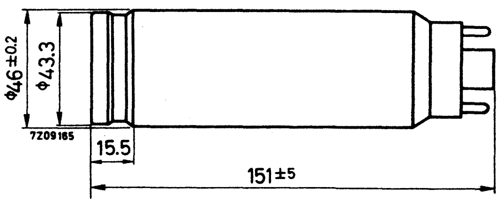
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	selected 150AVP	
Scintillator	NaI (Tl) 38 x 25	mm
	with Al window 0.5	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 9	%

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (Jedec B12-43)





ACCESSORIES

Socket FE1002

PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube 150AVP see Handbook section "Photomultiplier tubes".
The 150AVP used is selected to meet the requirement for resolution of 9%.
A mu-metal shield is incorporated.

SCINTILLATOR

NaI (Tl) crystal with Al window	type	SIS 38 x 25
diameter	38	mm
thickness (crystal)	25	mm
thickness (window)	0.5	mm
gamma threshold	≈ 10	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

Radiation counter tubes

Some devices are labelled

Mainteneance type

or

Obsolescent type

Maintenance types	- still in production but to be avoided when designing new equipment.
Obsolescent types	- will be supplied until present stocks are exhausted.

RADIATION COUNTER TUBES

SURVEY OF TYPES

Type number	Application
End-window types	
18504	β, γ
18505	α, β, γ
18506	β, γ
18515	α, β
18515/01	α, β
18526	α, β, γ
18527	α, β, γ
18536	α, β
18536/01	α, β
18546	β
Cylinder counter tubes	
ZP1100	γ
18503	γ
18509	γ-count or current $\leq$ 300 R/h, $\beta >$ 0,5 MeV
18520	γ
19529	γ-count or current $\leq$ 1000 R/h, $\beta >$ 0,5 MeV
18545	γ
18550	γ-count or current, $\beta >$ 0,25 MeV
18553	$\beta >$ 0,3 MeV, γ
18555	$\beta >$ 0,3 MeV, γ
Liquid counter tubes	
ZP1080	dip counter; β, γ
ZP1083	dip counter; β, γ
Cosmic-ray guard tubes	
18518	in anti-coincidence with 18536
X-ray window counter tubes	
18507	X-ray end window counter 2,5 to 20 keV, 0,06 to 0,5 nm
18511	X-ray, side window proportional counter, 2,5 to 40 keV, 0,03 to 0,5 nm

RADIATION COUNTER TUBES
LIST OF SYMBOLS

Anode supply voltage	V_b
Voltage at the beginning of the plateau	V_{b_1}
Voltage at the end of the plateau	V_{b_2}
Plateau length (= $V_{b_2} - V_{b_1}$)	V_{pl}
Starting voltage	V_{ign}
Count rate (= counts/unit of time)	N
Count rate at V_{b_1}	N_1
Count rate at V_{b_2}	N_2
Background	N_o
Plateau slope (= $\frac{N_2 - N_1}{\frac{1}{2}(N_1 + N_2)} \times \frac{1}{V_{pl}} \times 100\ \%$)	S_{pl}
Dead time	τ
Capacitance (anode to cathode)	C_{ak}
Ambient temperature	t_{amb}
Gas multiplication factor	A

GENERAL OPERATIONAL RECOMMENDATIONS
RADIATION COUNTER TUBES

1. GENERAL

1.1 A radiation counter tube is a gas-filled device which reacts to individual ionizing events, thus enabling them to be counted.

1.2 A radiation counter tube basically consists of an electrode at a positive potential (anode), surrounded by a metal cylinder at a negative potential (cathode). The cathode forms part of the envelope or is enclosed in a glass envelope. Quanta or particles may enter the counter tube either through a foil (the window) or through the cylinder wall itself.

1.3 Typical quanta or particles are:

alpha rays,
beta rays,
X- or gamma rays,
thermal neutrons.

1.4 The gas filling normally consists of a mixture of rare gases and a quenching agent (self-quenched counter tube).

1.5 Quenching is the process of terminating a pulse of ionization current in a counter tube.

1.5.1 For tubes provided with a quenching agent the voltage drop across the load resistor, normally used, is sufficient for terminating the discharge.

2. CAPACITANCE

The capacitance of a counter tube is the capacitance between anode and cathode, the connections being completely shielded.

3. OPERATING CHARACTERISTICS

3.1 Starting voltage. This is the minimum anode supply voltage applied to a radiation counter tube at which pulses of 1 V amplitude appear across the tube.

3.2 Operating voltage. This is the anode supply voltage at which the radiation counter tube should be used.
If this is not quoted the middle of the minimum plateau (i.e. $\frac{V_{b_1}+V_{b_2}}{2}$) should be regarded as the recommended operating voltage.

3.3 Plateau. The range of anode supply voltage values for which the count rate varies relatively little under constant conditions of irradiation. Unless otherwise stated, the plateau is measured at a count rate of approximately 100 counts/s.

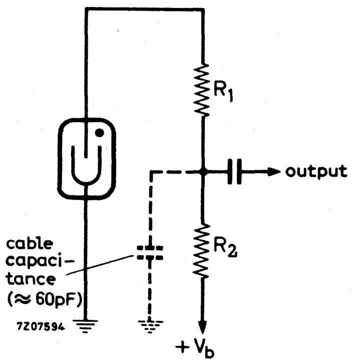
3.4 Plateau slope. The percentage change in count rate for a given change (usually 1 V) in anode supply voltage.

3.5 Background. The count rate of a counter tube in the absence of the radiation which the tube is meant to measure.

3.6 Dead time. This is the time interval after the initiation of a voltage pulse during which (assuming no interference by an external circuit) a subsequent ionizing event does not produce a discharge.
Unless otherwise stated the dead time curve is given at a count rate of 100 counts/s.

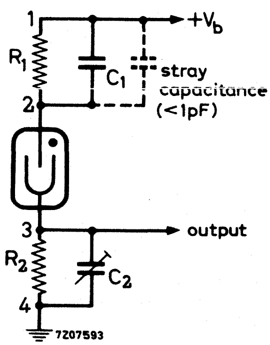
4. MEASURING CIRCUITS

4.1 Measuring circuit A



Note: The value of R_1 should not be lower than the value specified by the manufacturer and mounted close to the anode connector.

4.2 Measuring circuit B



Notes:

1. The input resistance and the input capacitance of the measuring equipment are incorporated in R_2 and C_2, respectively.
2. R_1 should be as specified by the manufacturer and mounted close to the anode connector.
3. When applying a rectangular pulse at "1" with the tube inserted but short-circuited, capacitor C_2 should be adjusted so that the pulse at "3" is undistorted. Under these conditions R_1 (C_1 + stray capacitance) = R_2C_2.
4. The measuring equipment consists of a cathode follower with a pulse shaper, a limiting amplifier and a scaler.

   Unless otherwise stated the measurements of a certain type are carried out in the measuring circuit given in the data sheet and with a ^{60}Co source, at

   $$V_b = \frac{V_{b_1}+V_{b_2}}{2} \text{ and at } t_{amb} = 25\ ^{o}C.$$

5. OPERATIONAL NOTES

5.1 Pulse amplitude. The pulse amplitude of the radiation counter tubes may be estimated generally at $P \geqq b\ (V_b - V_{ign})$. In this formula V_b is the anode supply voltage and V_{ign} the starting voltage of the tube. The factor b originates from the tap on the anode resistor, as indicated in the recommended measuring circuit. The influence of the connected capacitive load is thus minimized.

5.2 Scaler. The resolving time of the scaler should be smaller than the minimum dead time of the counter tube. For normal use and at moderate count rates an input sensitivity of approximately 0.5 V will be sufficient. At very high count rates the mean level of the anode voltage of the counter tube will drop appreciably below V_b, and the pulse amplitude will decrease accordingly so that the smallest pulses will be lost at the input of the scaler. In this case it is possible to increase the sensitivity of the measuring equipment by means of a pulse amplifier combined with pulse shaper.

5.3 Pulse shaper and amplifier. The circuit should have a resolving time shorter than the minimum dead time of the counter tube. The pulse amplitude should not be influenced by the pulse shaper. Pulse amplification should be sufficiently high and the rise time of the amplifier should be considerably smaller than the rise time of the pulse from the counter tube.

5.4 Load. Normally the tubes should be operated with an anode resistor having a value as indicated in the data sheets, or a higher value. Decreasing the resistance of the anode resistor not only decreases the dead time, but also the plateau length. In general a decrease of the resistance below the indicated minimum value causes the tube to oscillate.
The anode resistor should be connected directly to the anode connector of the tube, thus preventing parasitic capacitances of leads from considerably increasing the capacitive load on the tube. An increase in the capacitive load has the tendency of increasing the pulse amplitude, the pulse duration, the dead

time and the plateau slope, whereas the plateau length will be shortened appreciably. Shunt capacitances of 20 pF or more may destroy the tube.

5.5 Count rate. After every pulse the counter tube is temporarily insensitive during a period called the dead time. Consequently, the pulses that occur during this period are not counted. At a count rate of N counts/s the tube will be insensitive during $100N\tau\%$ of the time, so that approximately $100N\tau\%$ of the counts will be lost. If the counting losses may not be greater than 1%, N should be less than $1/100\tau$ counts/s. The maximum count rate is approximately $1/\tau$ For continuous stable operation it is recommended that the count rate be adjusted to a value in the linear part of the count rate/dose rate curve.

5.6 Count rate/dose rate curves are measured with ^{60}Co at an operating voltage in the middle of the plateau.

5.7 Current/dose rate curves are measured with ^{60}Co

6. LIMITING VALUES

6.1 The limiting values of radiation counter tubes are given in the absolute maximum rating system.

Absolute maximum rating system (in accordance with I.E.C. publication 134)

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 values 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.

6.2 Ambient temperature. The ambient temperature is the temperature of the surroundings of the tube.

7. MOUNTING

7.1 Unless otherwise stated, any mounting position is permissible.

7.2 Low-capacitance mounting of the tube is required (shortest possible connection between anode connector and load resistor; low capacitance between anode and cathode leads.

7.3 No attempt should be made to solder directly to the stainless steel cathode, as this will destroy the tube.

8. STORAGE AND HANDLING

8.1 The tube should not be stored at ambient temperatures outside the limits given under the heading "Limiting values" on the data sheets.

8.2 In order to prevent leakage between anode and cathode the tube should be dry and well cleaned.

8.3 At a low ambient temperature care should be taken to avoid condensing of water vapour on the connectors.

8.4 Some types of radiation counter tubes have thin windows and/or thin cathode walls. In order to prevent damage, these tubes should be handled and mounted with utmost care. The mica-window types are provided with a cap to protect the window when they are not in operation.

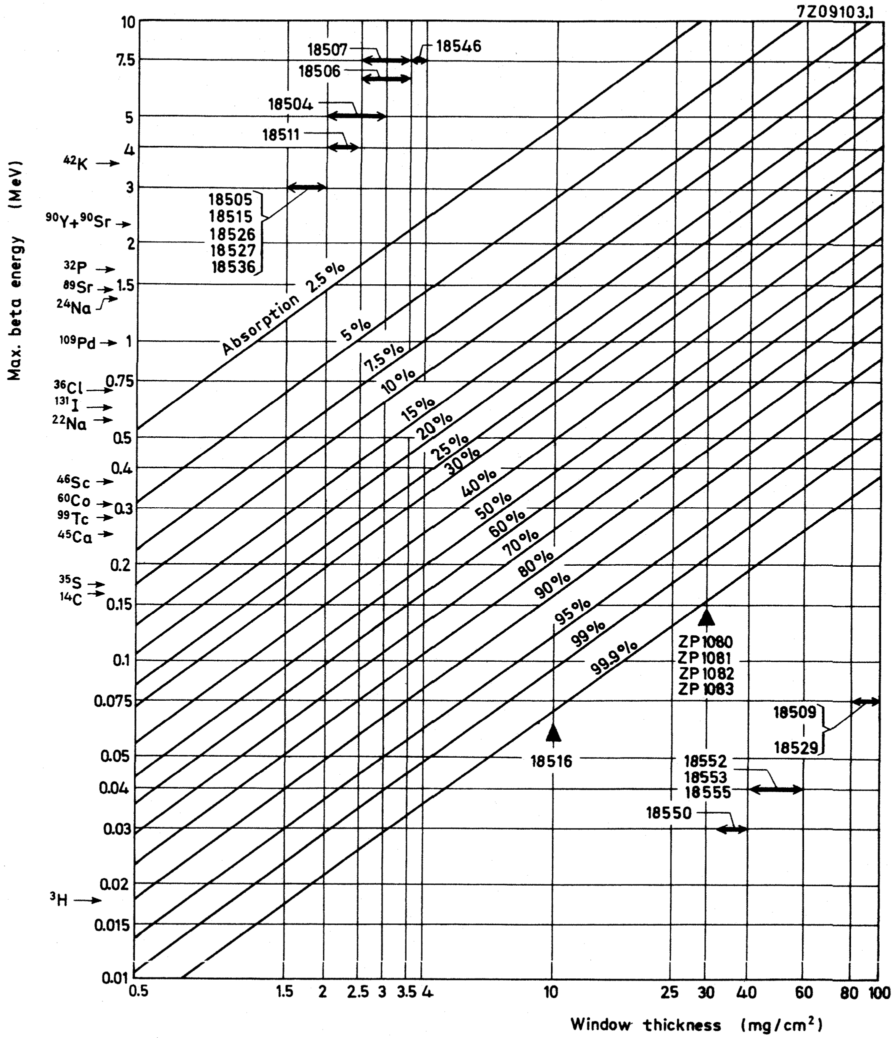
9. OUTSIDE PRESSURE

9.1 In tubes provided with a window the gas pressure outside the tube should be neither lower than 25 cm Hg nor higher than the atmospheric pressure (unless otherwise stated) and variations in pressure should be gradual.

9.2 Care should be taken not to expose tubes having very thin envelopes to pressures substantially higher than atmospheric.

10. OUTLINE DIMENSIONS

The outline dimensions are given in mm.



Beta-ray absorption in window or wall

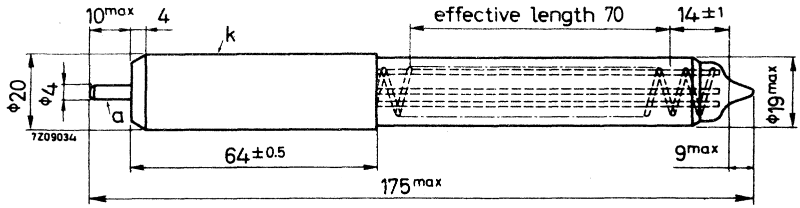
BETA AND GAMMA RADIATION COUNTER TUBE

Glass wall halogen quenched β and γ radiation dip-counter tube with a DIN base.

QUICK REFERENCE DATA		
Glass wall thickness	30	mg/cm^2
Operating voltage	450 to 600	V
Anode resistor, mounted in the base	3.9	MΩ

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base matched to socket DIN 44421



GLASS WALL

Thickness	30	mg/cm^2
Effective length	70	mm

FILLING Ne, A, halogen

CAPACITANCES

Anode to cathode	C_{ak}	1.5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of Fig. 1

Starting voltage	V_{ign}	max.	360	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 600		V
Plateau slope	S_{pl}	max.	0.15	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 525 V	N_o	max.	50	counts/min
Dead time at V_b = 525 V	τ	max.	60	µs
Sensitivity (10 µCi/litre H_2O)				
for ^{90}Sr			32.5×10^3	counts/min
for ^{32}P			20×10^3	counts/min
for ^{137}Cs			5.2×10^3	counts/min
for ^{36}Cl			3.8×10^3	counts/min
for ^{40}K			13×10^3	counts/min

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 2000 c/s	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1 C_{stray} = R_2 C_2$

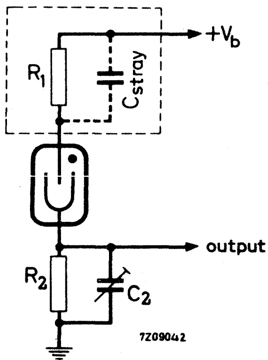
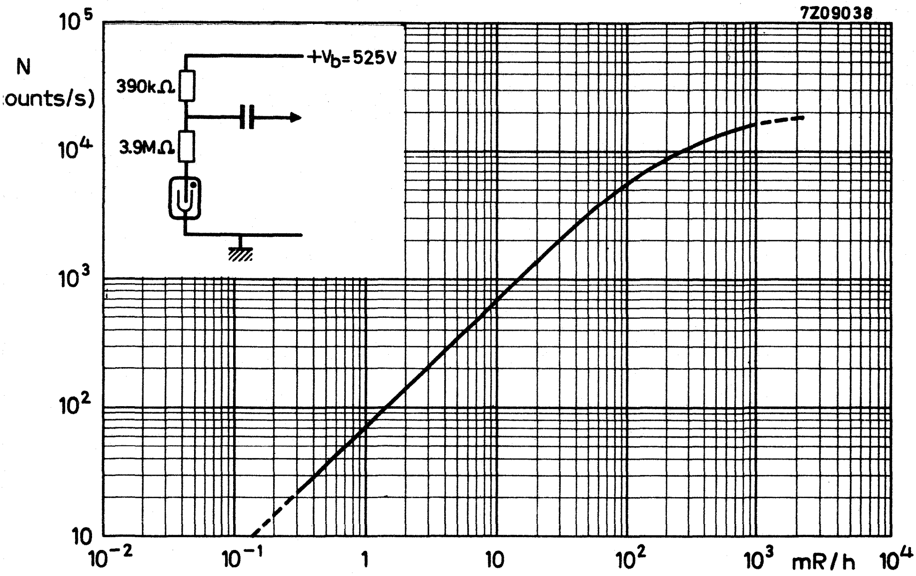


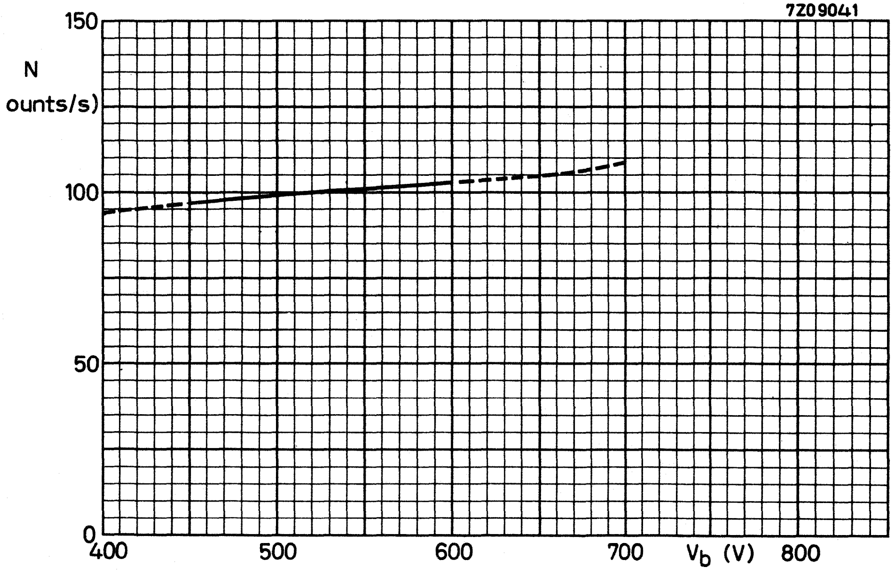
Fig. 1

REMARK

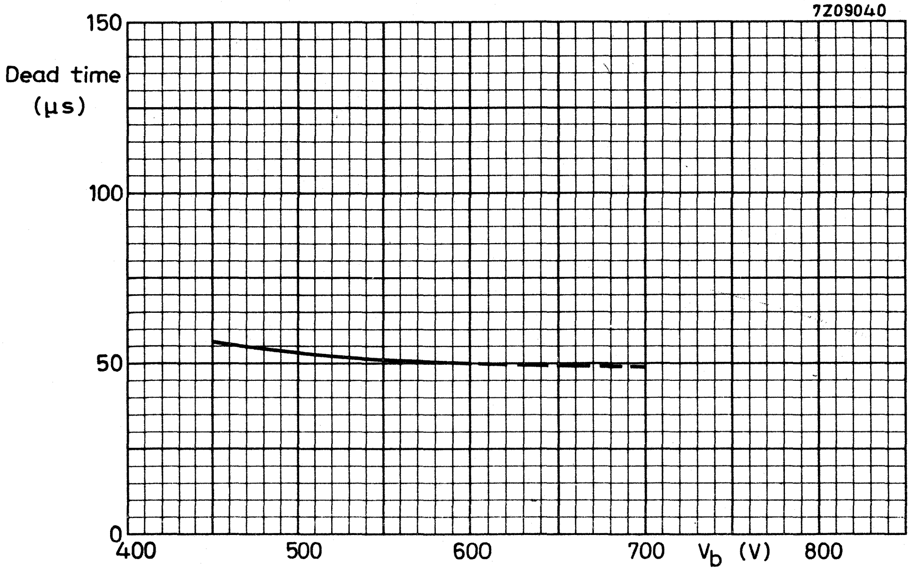
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



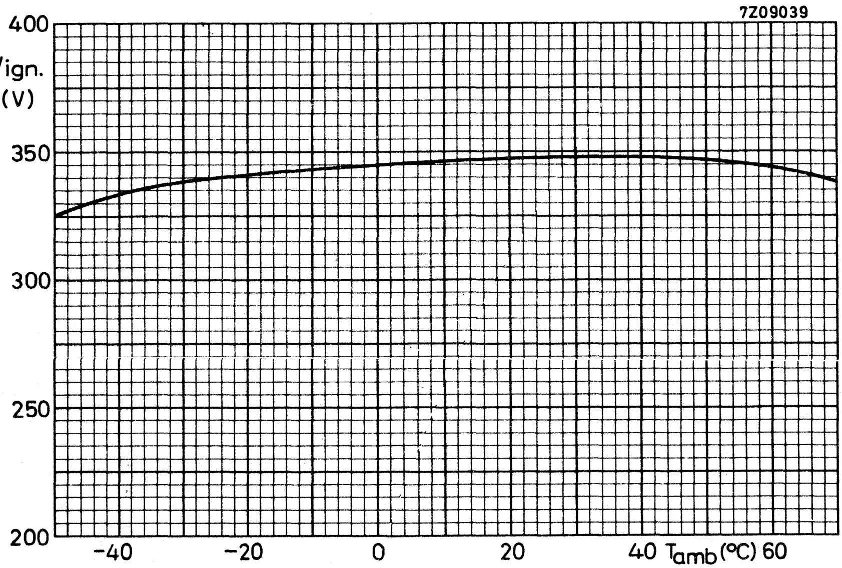
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

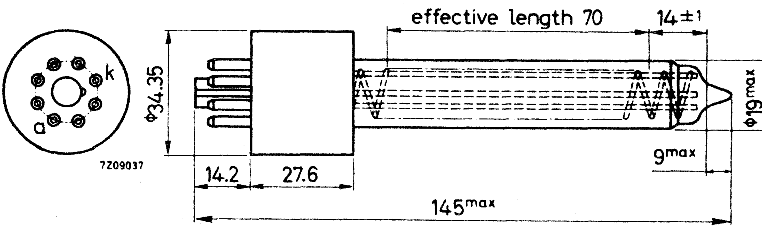
BETA AND GAMMA RADIATION COUNTER TUBE

Glass wall halogen quenched β and γ radiation dip-counter tube with an octal base.

QUICK REFERENCE DATA		
Glass wall thickness	30	mg/cm^2
Operating voltage	450 to 600	V
Anode resistor, mounted in the base	3.9	MΩ

DIMENSIONS AND CONNECTIONS

Dimensions in mm



GLASS WALL

Thickness	30	mg/cm^2
Effective length	70	mm

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of Fig. 1

Starting voltage	V_{ign}	max. 360	V
Recommended operating voltage	V_b	arbitrary within plateau	
Plateau	V_{pl}	450 to 600	V
Plateau slope	S_{pl}	max. 0.15	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 525 V	N_o	max. 50	counts/min
Dead time at V_b = 525 V	τ	max. 60	µs
Sensitivity (10 µCi/litre H_2O)			
for ^{90}Sr		32.5×10^3	counts/min
for ^{32}P		20×10^3	counts/min
for ^{137}Cs		5.2×10^3	counts/min
for ^{36}Cl		3.8×10^3	counts/min

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max. 600	V
Ambient temperature	t_{amb}	min. −50	°C
		max. +75	°C
for continuous operation		max. +50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 2000 c/s — 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1 C_{stray} = R_2 C_2$

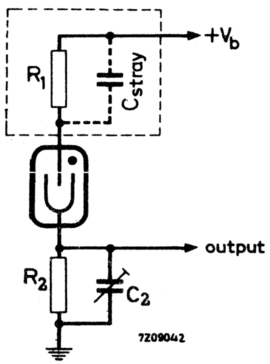
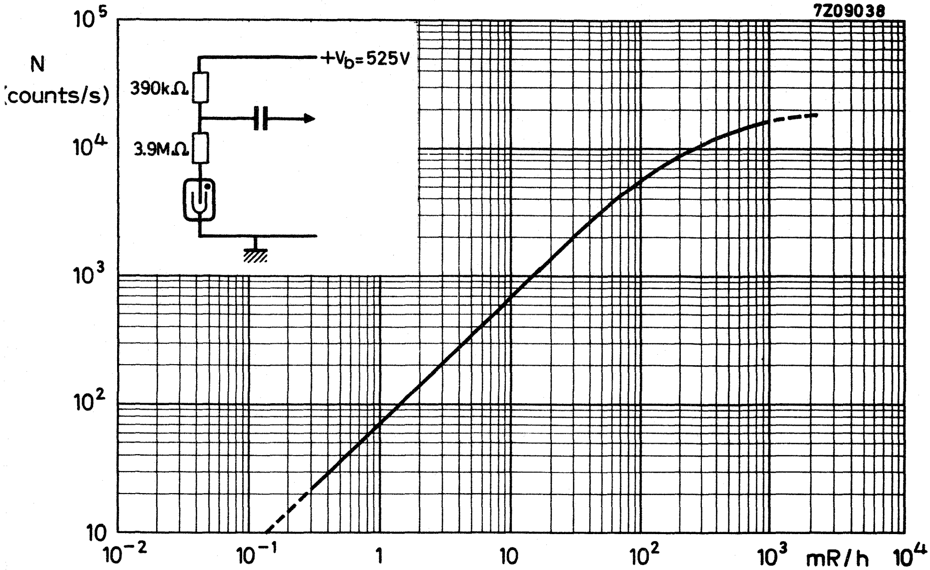


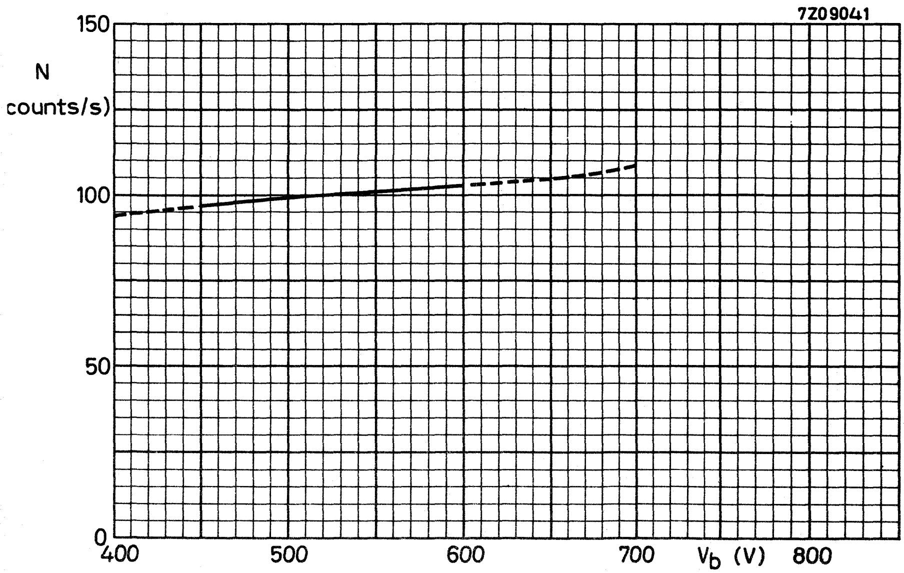
Fig. 1

REMARK

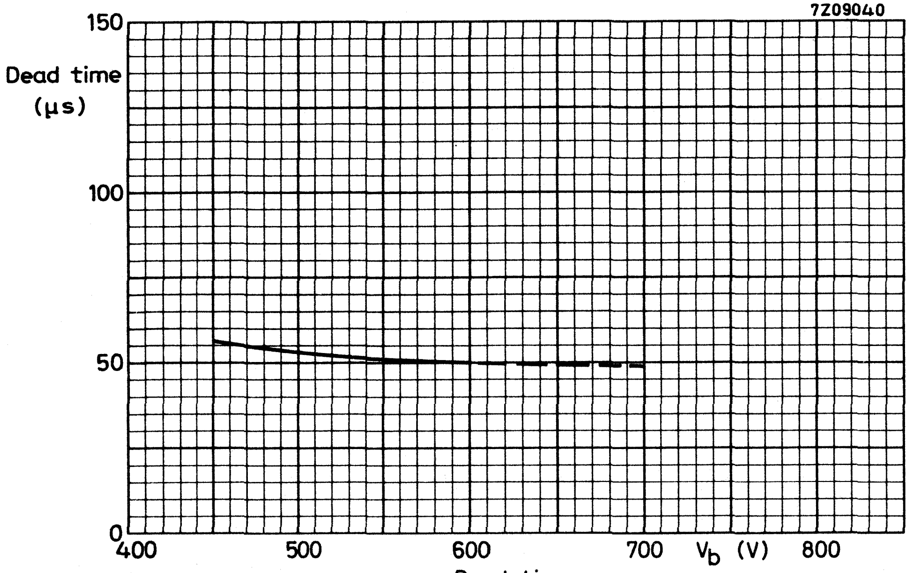
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



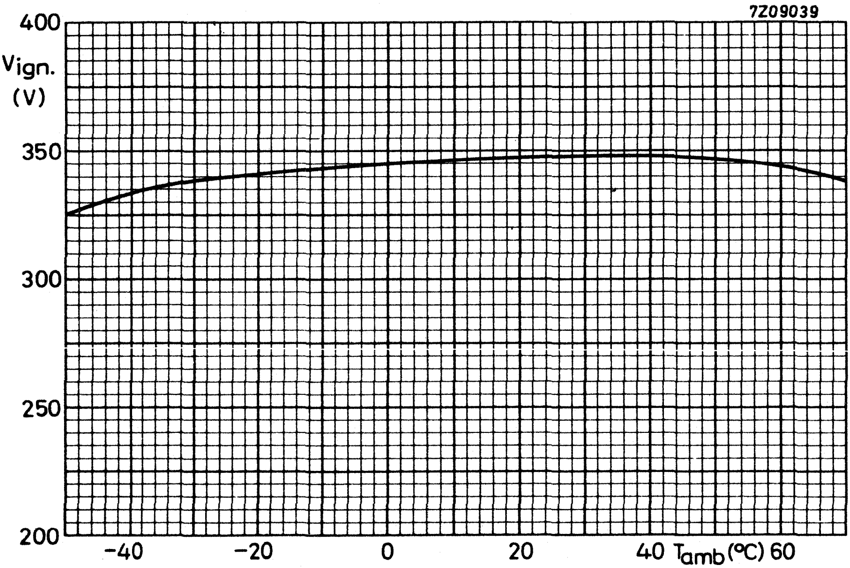
Count rate as function of dose rate



Plateau curve



Dead time curve



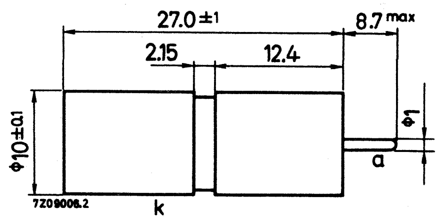
Starting voltage as function of ambient temperature

GAMMA RADIATION COUNTER TUBE

Halogen quenched radiation counter tube for the measurement of γ radiation.
The tube is provided with a filter. The energy response is flat within 15% referred to the 1.33 MeV point.

QUICK REFERENCE DATA		
Dose rate range (γ radiation)	10^{-3} to 3.10^{2}	R/h
Operating voltage	500 to 650	V
Energy range	40 keV to 3	MeV

DIMENSIONS AND CONNECTIONS Dimensions in mm



FILTER

Thickness	2 mm
Material	Sn

CATHODE

Thickness	80 to 100 mg/cm^2
Effective length	16 mm
Material	28% Cr, 72% Fe

FILLING He, Ne, halogen

CAPACITANCES

Anode to cathode	C_{ak} 2.0 pF

Data based on pre-production tubes

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	380	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to	650	V
Plateau slope	S_{pl}	max.	0.15	%/V
Background, shielded with 50 mm Pb at V_b = 575 V	N_o	max.	2	counts/min.
Dead time at V_b = 600 V	τ	max.	15	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	650	V
Ambient temperature	t_{amb}	min.	−40	°C
		max.	+75	°C
for continuous operation		**max.**	**+50**	**°C**

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 4500 c/s 5.10^{10} counts

MEASURING CIRCUITS

R_1 = 2.2 MΩ

R_2 = 56 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

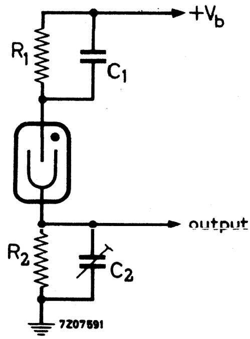
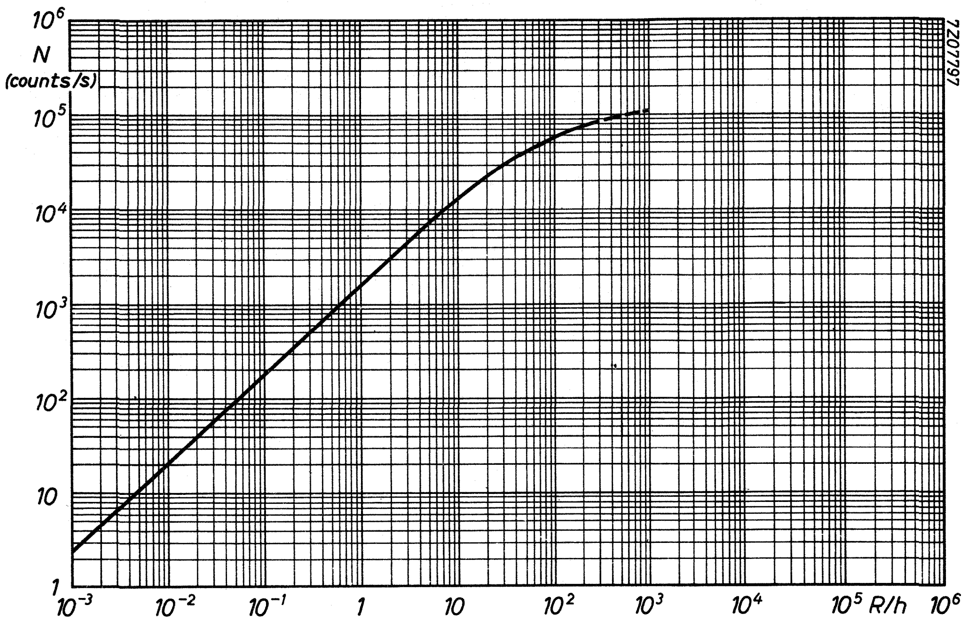
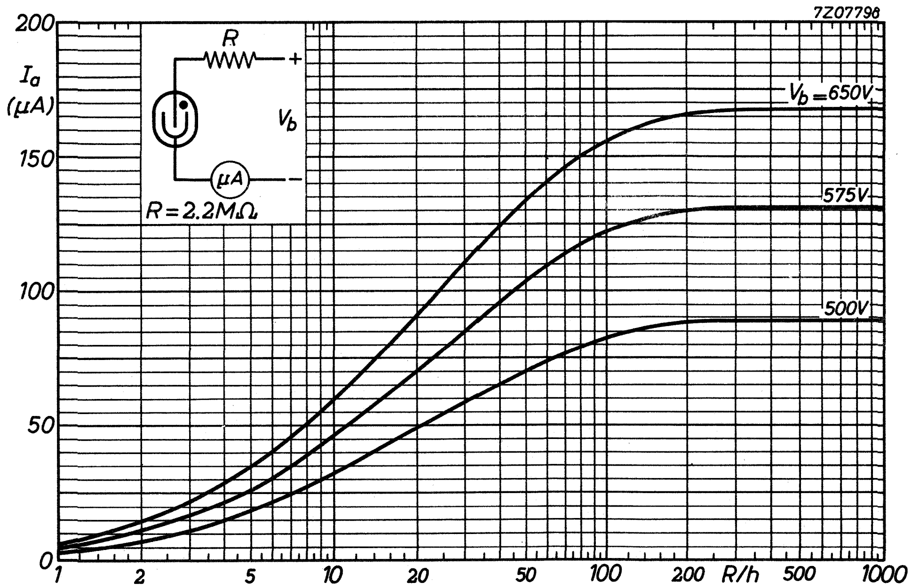


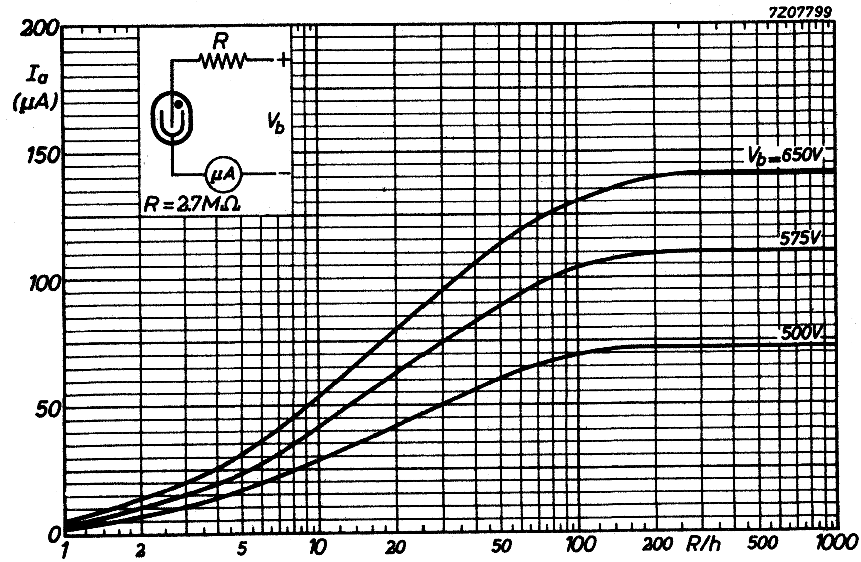
Fig.1



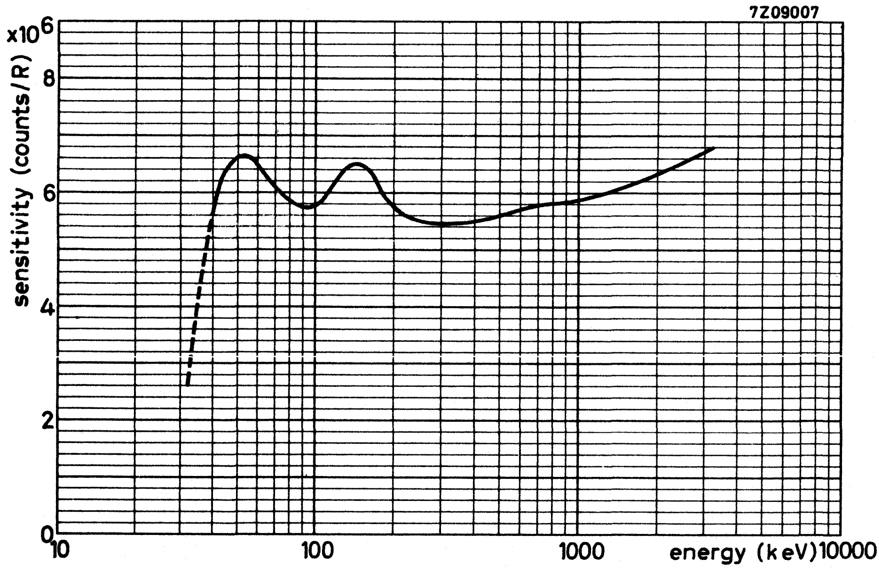
Count rate as function of dose rate



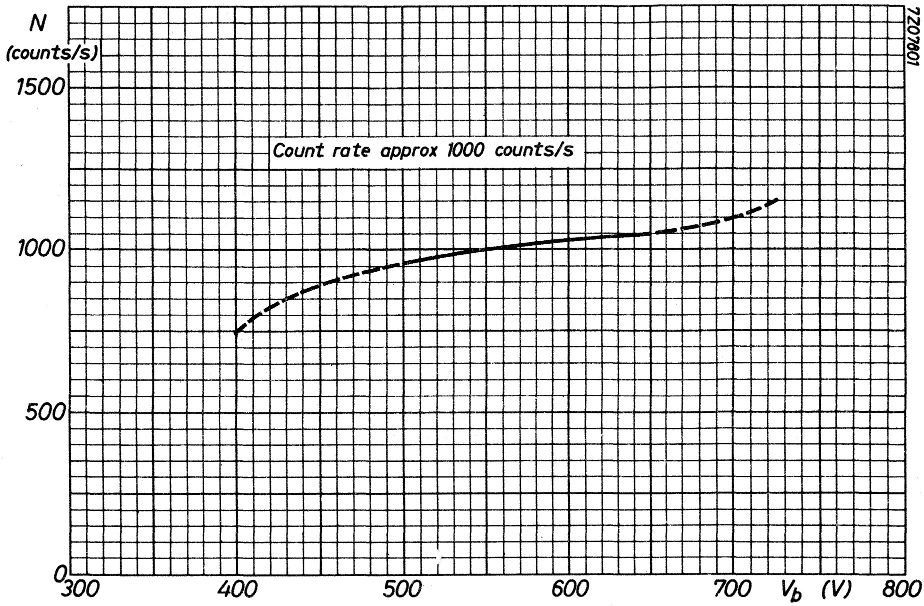
Current as function of dose rate



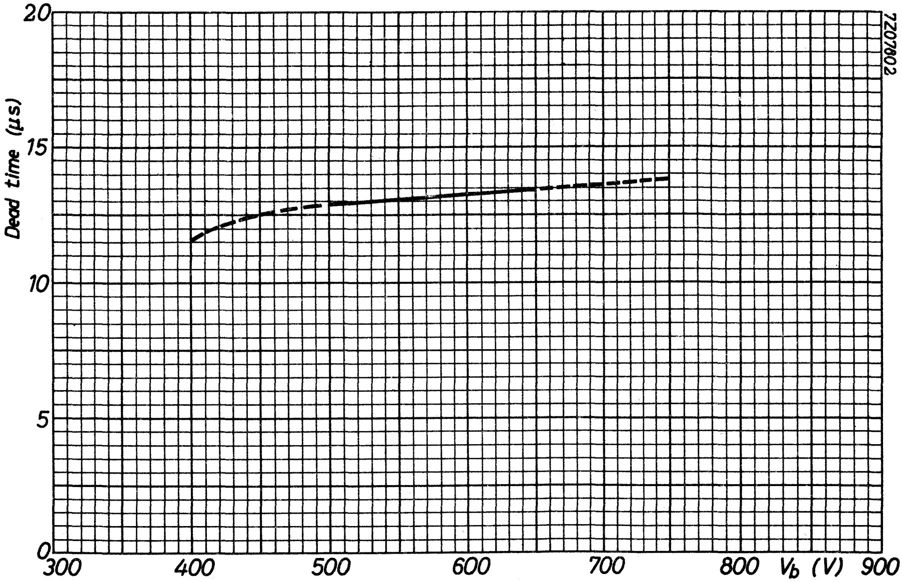
Current as function of dose rate



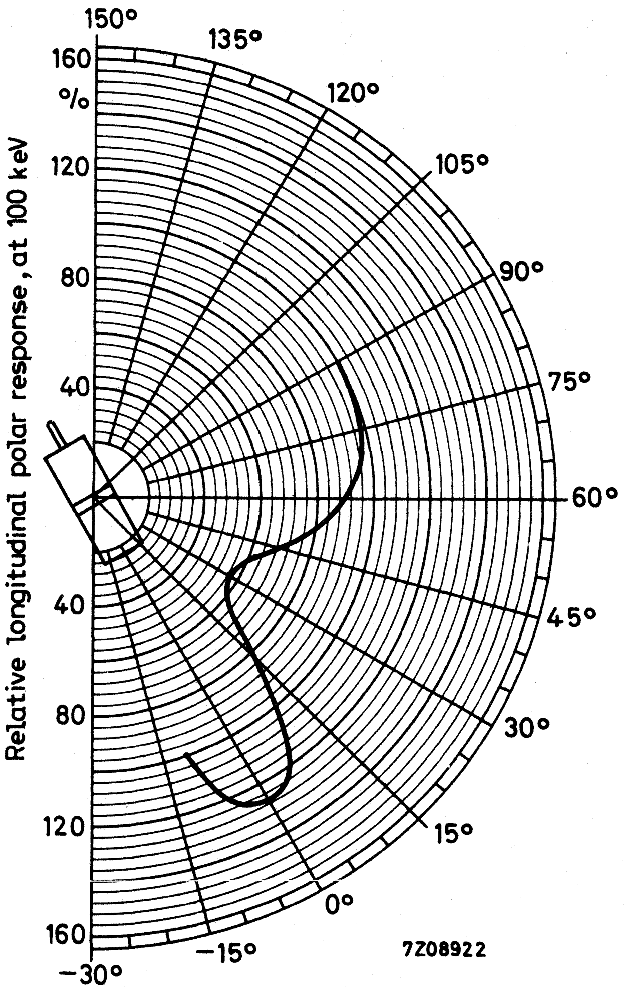
Energy response curve (side response)



Plateau curve



Dead time curve


150°
135°
120°
105°
90°
75°
60°
45°
30°
15°
0°
−15°
−30°
160
%
120
80
40
40
80
120
160
Relative longitudinal polar response, at 100 keV
7Z08922

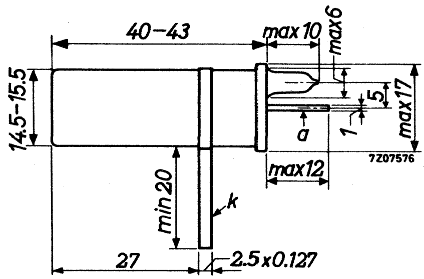
GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-4} to 1	R/h
Operating voltage	400 to 600	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	250	mg/cm^2
Effective length	40	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	2	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) measured in circuit of fig.1

Starting voltage	V_{ign}	max. 325	V [1])
Recommended operating voltage	V_b	arbitrary within plateau	
Plateau	V_{pl}	400 to 600	V
Plateau slope	S_{pl}	max. 0.04	%/V
Background, shielded with 50 mm Pb, at V_b=500V	N_o	max. 10	counts/min.
Dead time at V_b = 500 V	τ	max. 90	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 4.7	MΩ
Anode voltage	V_a	max. 600	V
Ambient temperature	t_{amb}	min. −50	°C
		max. +75	°C
for continuous operation		max. +50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 1200 c/s	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

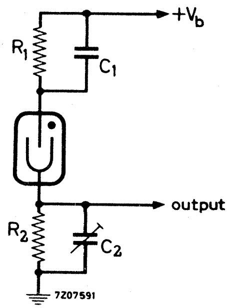
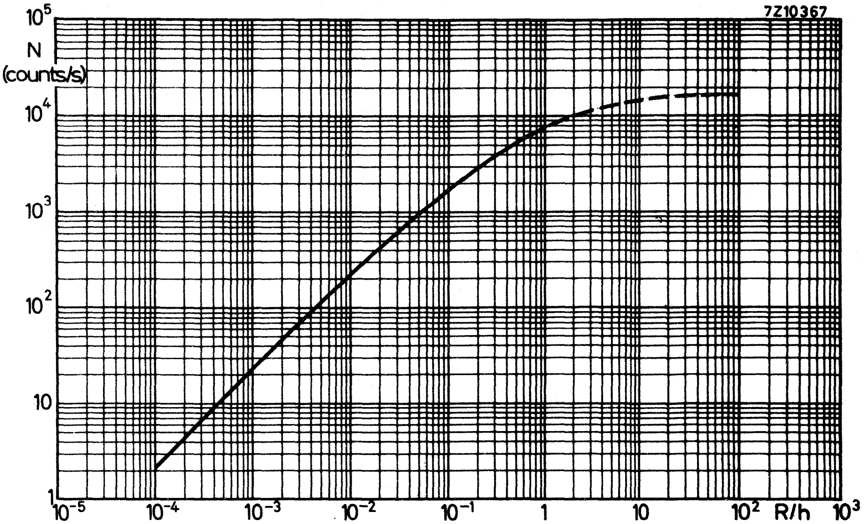
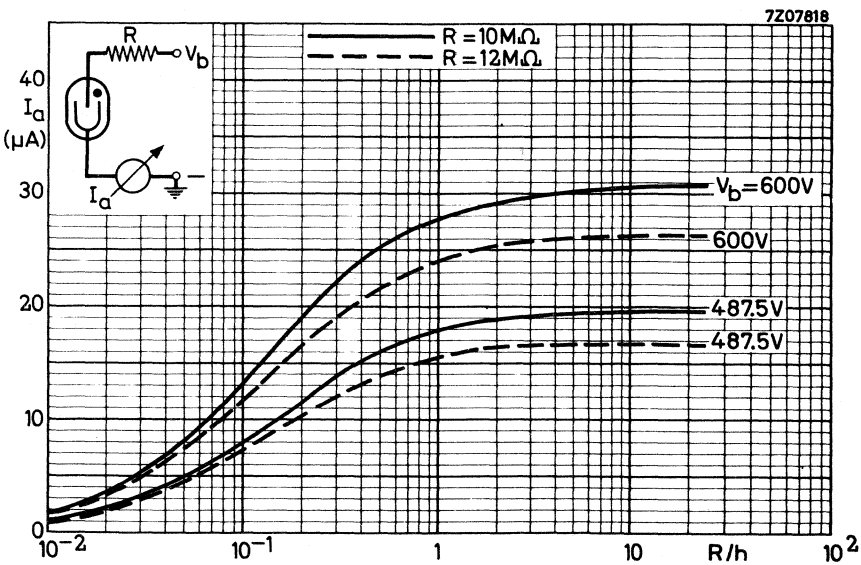


Fig.1

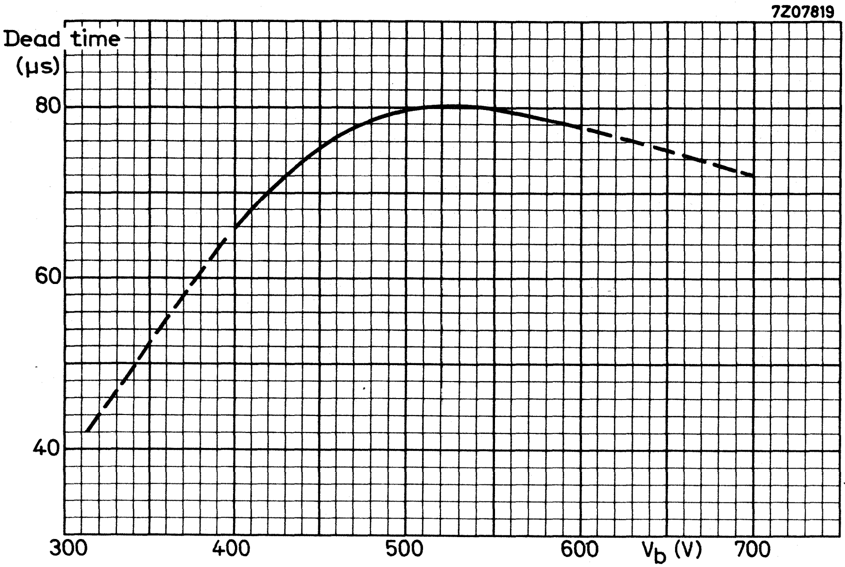
1) Temperature coefficient of starting voltage = 0.5 V/°C



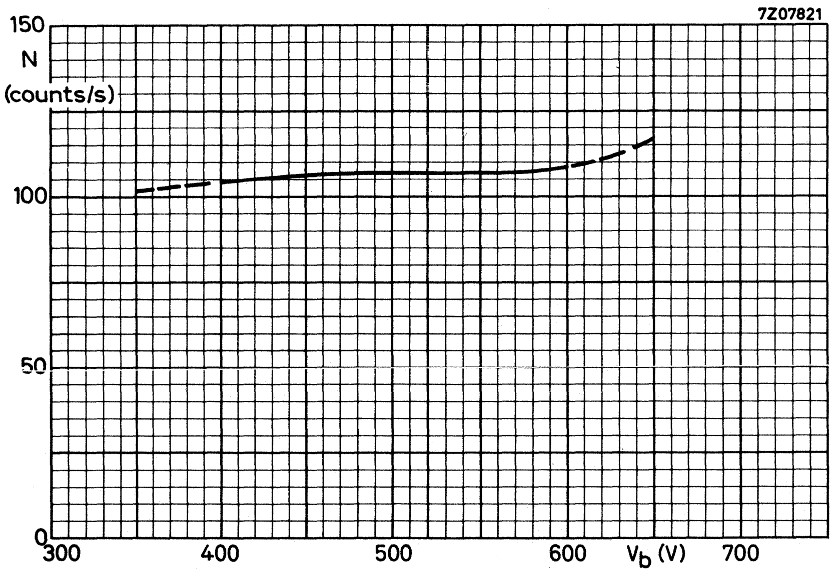
Count rate as function of dose rate



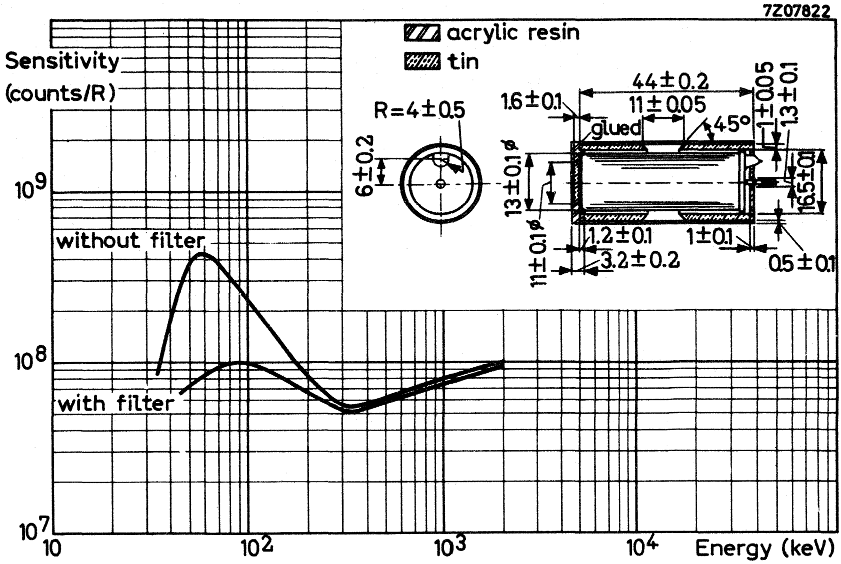
Current as function of dose rate



Dead time curve



Plateau curve



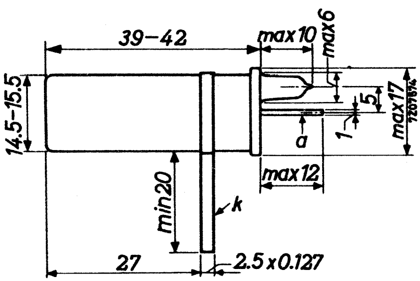
Energy response curve (side response)

BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched β and γ radiation counter tube

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-4} to 1	R/h
Window thickness	2 to 3	mg/cm^2
Window diameter	9	mm
Operating voltage	400 to 600	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2 to 3	mg/cm^2
Effective diameter	9	mm
Material	mica	

CATHODE

Thickness	250	mg/cm^2
Effective length	39	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	2	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) measured in circuit of fig.1

Starting voltage	V_{ign}	max.	325	V [1])
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	400 to 600		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 500V	N_o	max.	10	counts/min.
Dead time at V_b = 500 V	τ	max.	90	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	4.7	MΩ
Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 1200 c/s 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

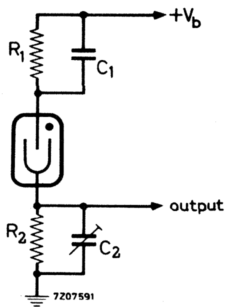
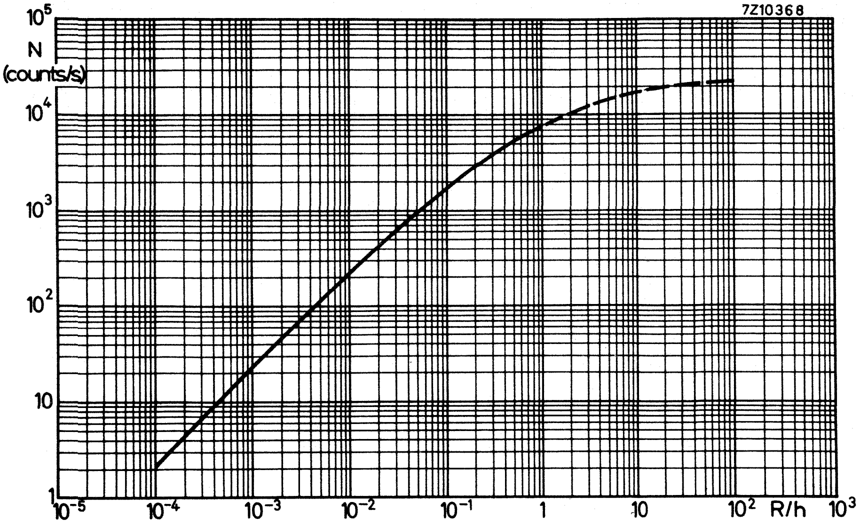
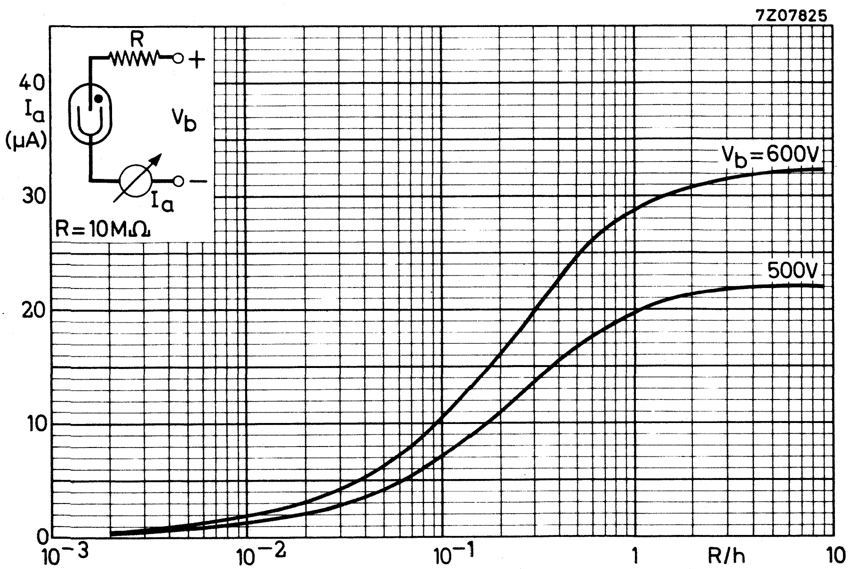


Fig.1

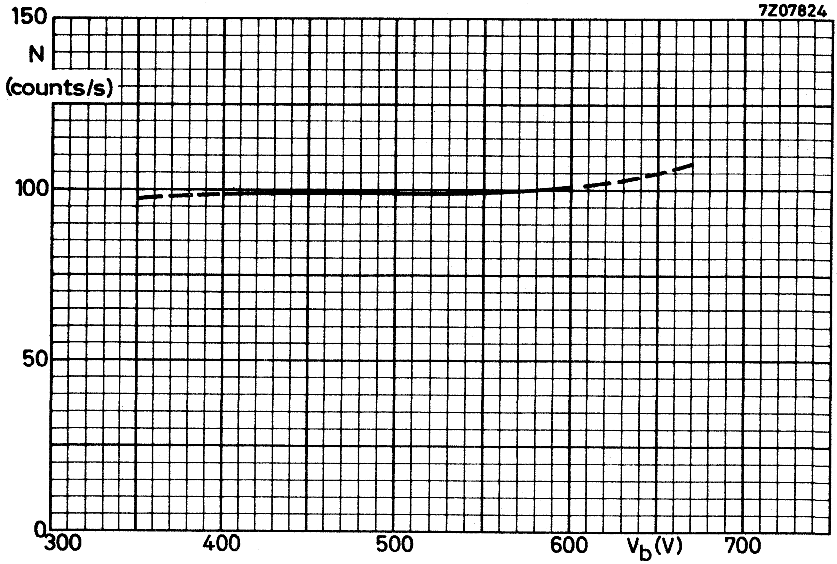
1) Temperature coefficient of starting voltage = 0.5 V/°C



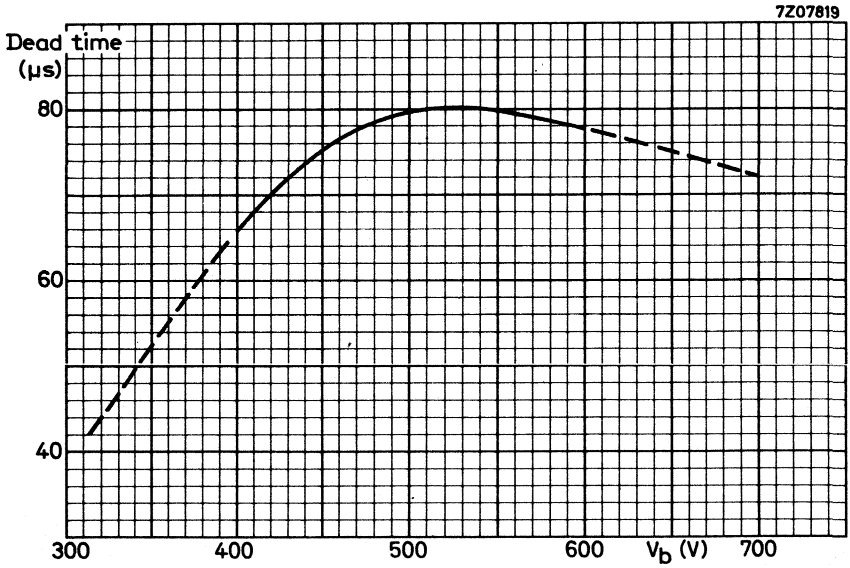
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



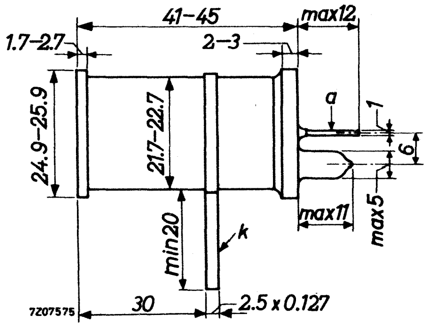
Dead time curve

ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched α, β and γ radiation counter tube

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	19.8	mm
Operating voltage	450 to 700	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	19.8	mm
Material	mica	

CATHODE

Thickness	1.2	mm
Effective length	37	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 2.5 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) measured in circuit of fig.1

Starting voltage	V_{ign}	max.	350	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 700		V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b=575V	N_o	max.	15	counts/min.
Dead time at V_b = 500 V	τ	max.	175	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 500 c/s — 5.10^{10} counts

MEASURING CIRCUIT

R = 10 MΩ

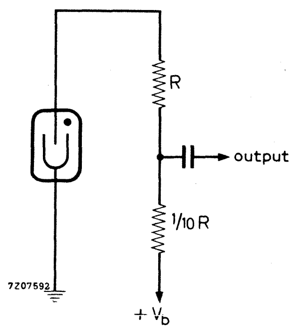
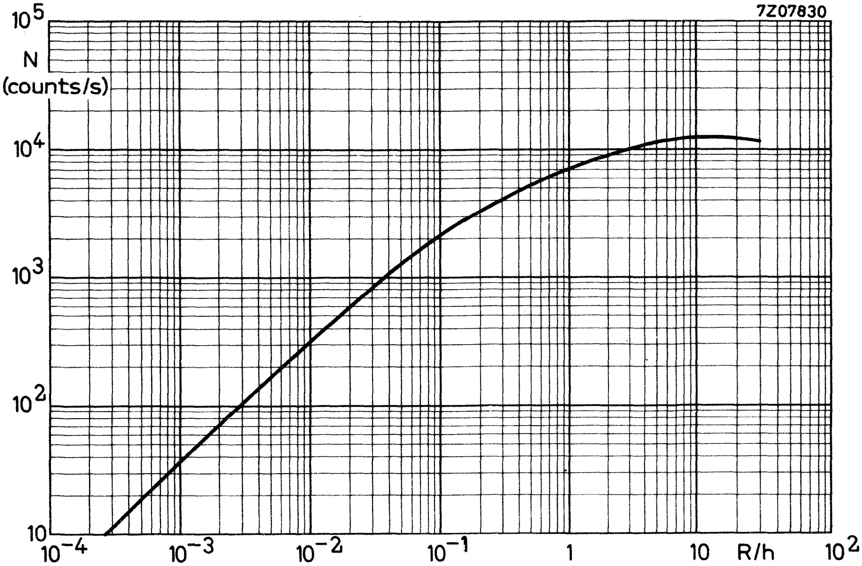
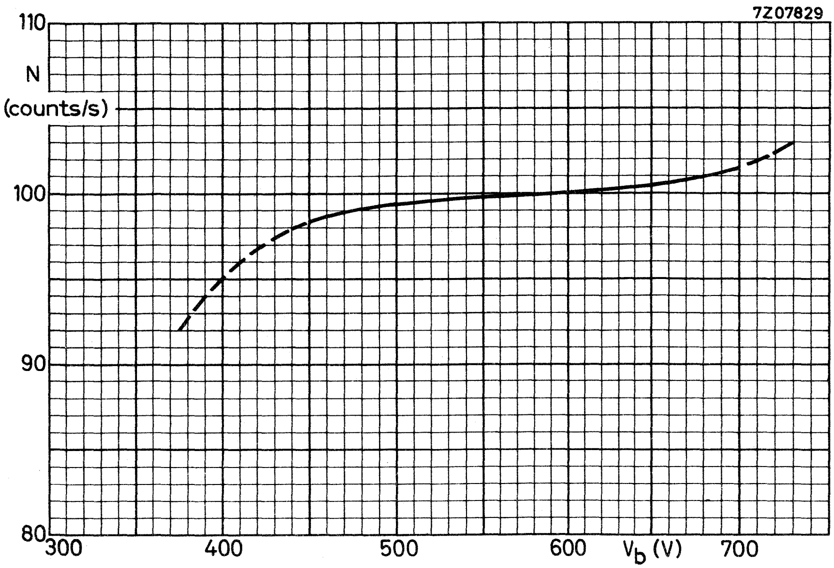


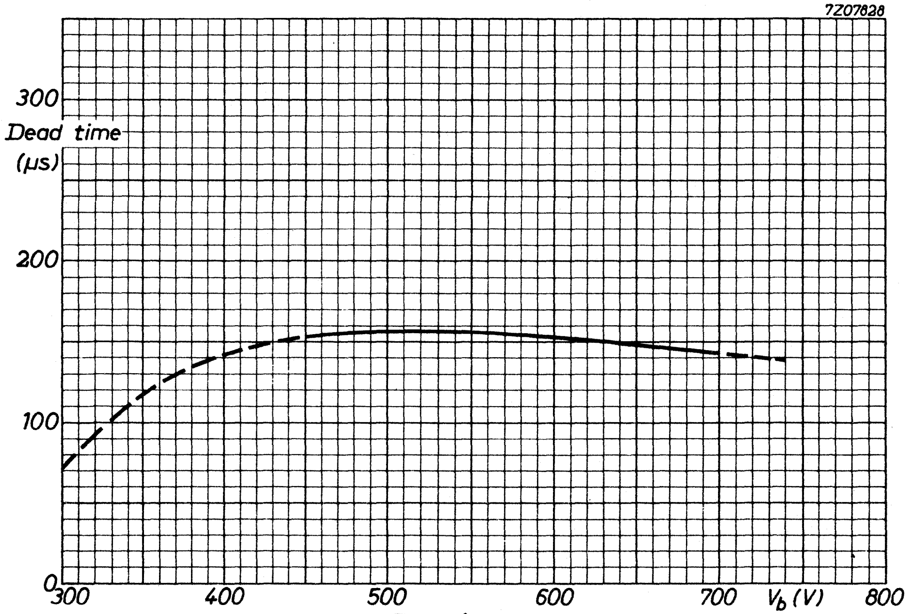
Fig. 1



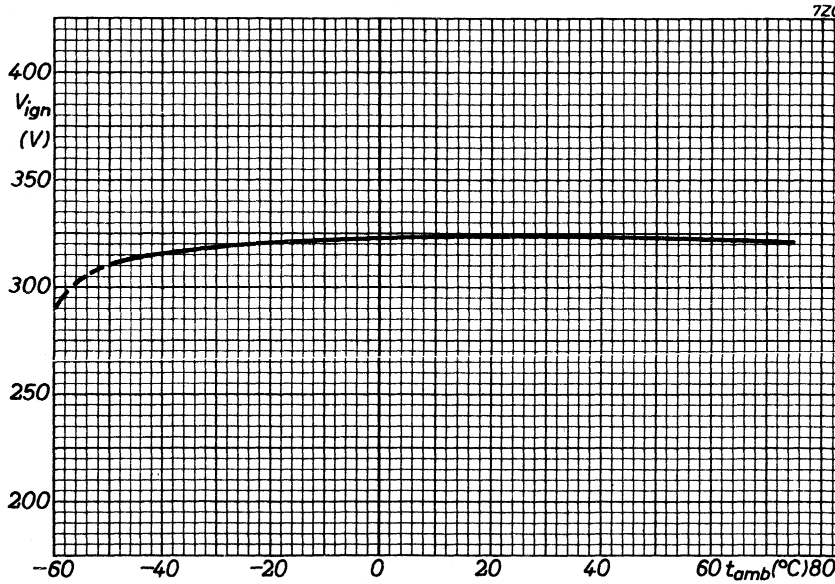
Count rate as function of dose rate



Plateau curve



Dead time curve



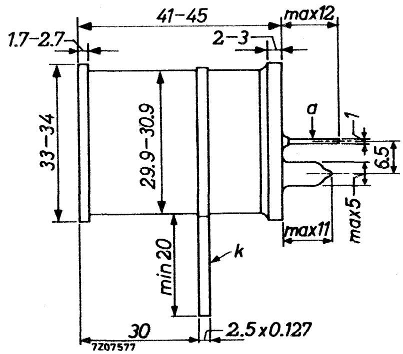
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched β and γ radiation counter tube

QUICK REFERENCE DATA		
Window thickness	2.5 to 3.5	mg/cm^2
Window diameter	27.8	mm
Operating voltage	450 to 700	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2.5 to 3.5	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1.3	mm
Effective length	37	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}		3.5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1.

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to	700	V
Plateau slope	S_{pl}	max.	0.035	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 575 V	N_o	max.	25	counts/min.
Dead time at V_b = 575 V	τ	max.	190	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 2200 c/s — 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

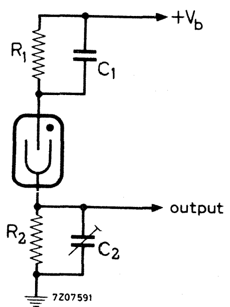
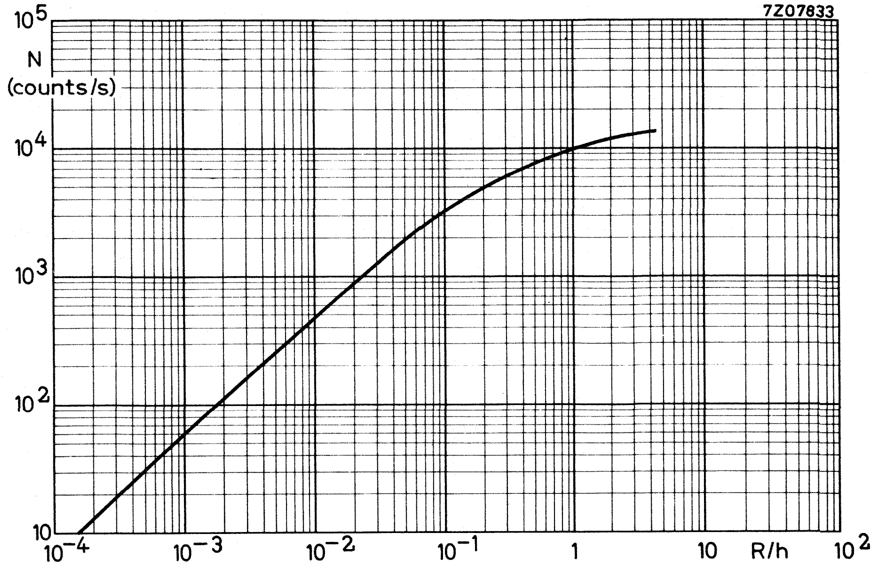
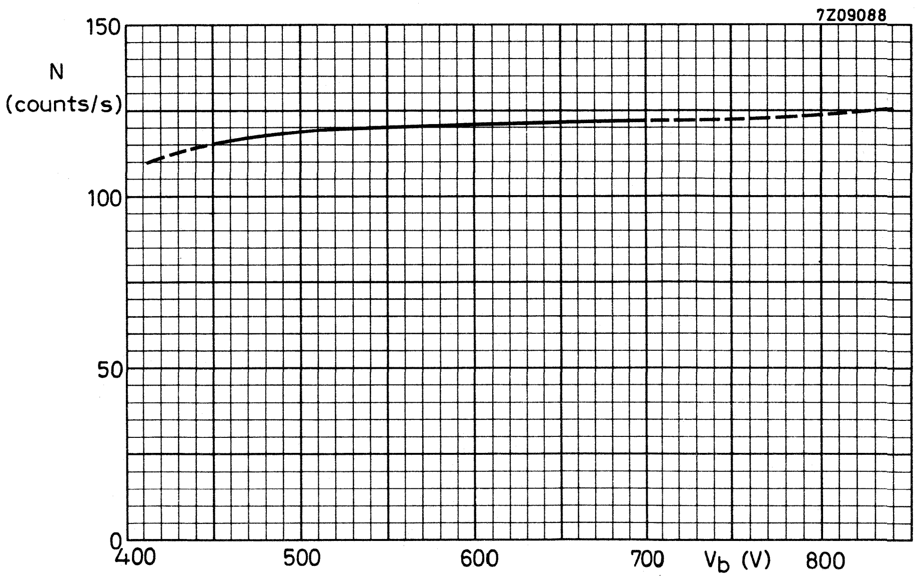


Fig.1

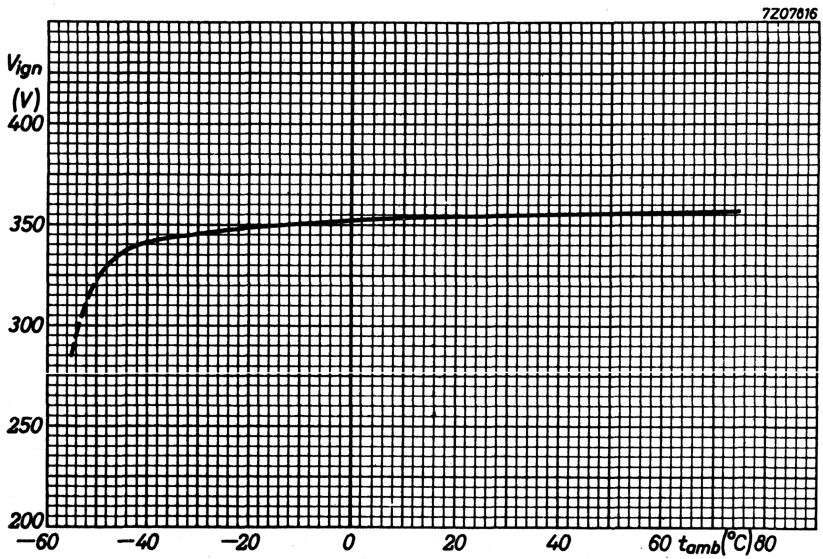


Count rate as function of dose rate (side response)



Plateau curve

Dead time curve



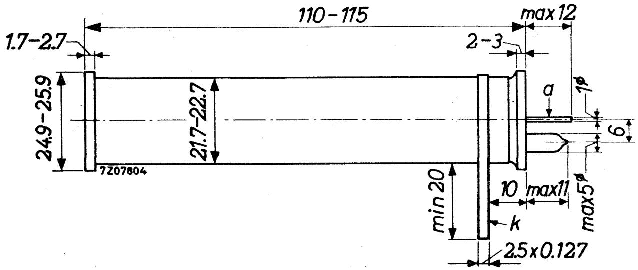
Starting voltage as function of ambient temperature

X-RAY COUNTER TUBE

End window halogen quenched X-ray counter tube.

QUICK REFERENCE DATA		
X-ray energy	2.5 to 20 keV; 0.6 to 5	Å
Window thickness	2.5 to 3.5	mg/cm^2
Operating voltage	1600 to 2000	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2.5 to 3.5 mg/cm^2
Effective diameter	19.8 mm
Material	mica

CATHODE

Thickness	1.2 mm
Effective length	107 mm
Material	28% Cr, 72% Fe

FILLING A, halogen

Gas pressure 60 cm Hg

Air transport in airtight metal boxes only.

CAPACITANCE

Anode to cathode C_{ak} 2.8 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C). Measured in circuit of fig.1.

Starting voltage	V_{ign}	max.	1450	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	1600 to 2000		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b=1800V	N_o	max.	25	counts/min.
Dead time at V_b = 1800 V	τ	max.	110	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	5	MΩ
Anode voltage	V_a	max.	2000	V
Ambient temperature	t_{amb}	min.	0	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 900 c/s 10^{10} counts

MEASURING CIRCUIT

R = 5 MΩ

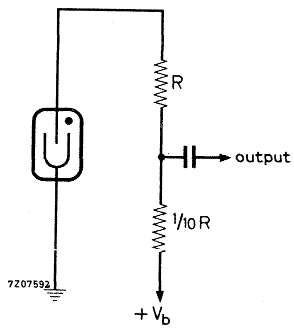
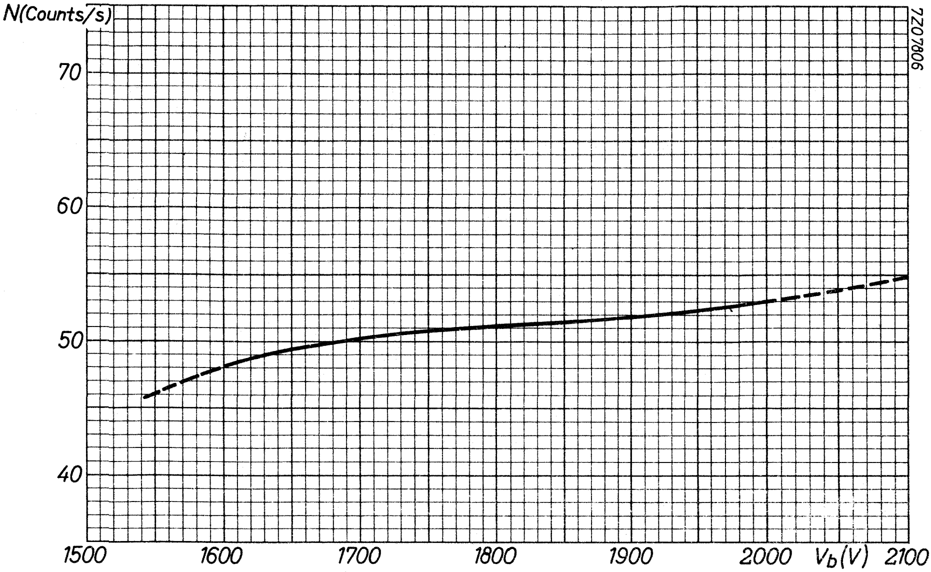
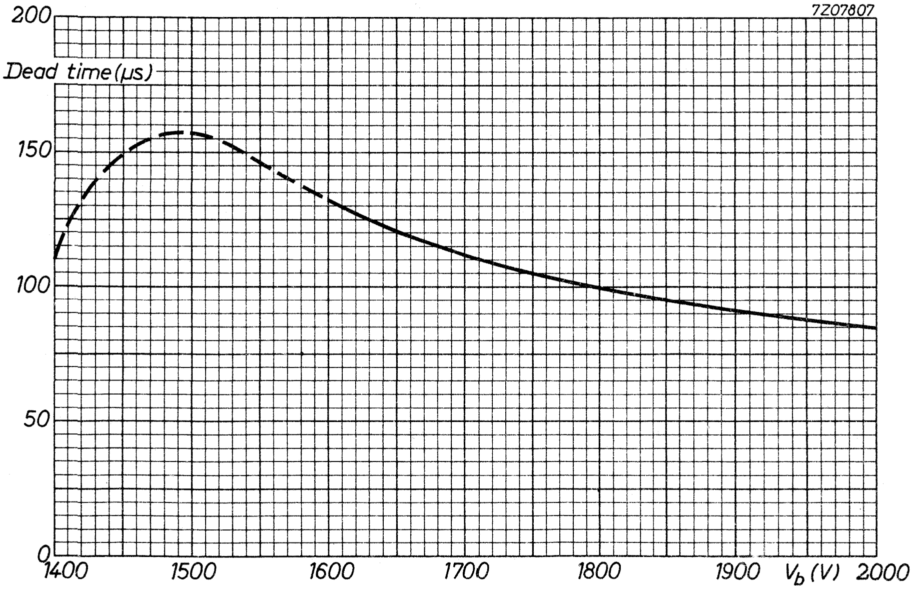


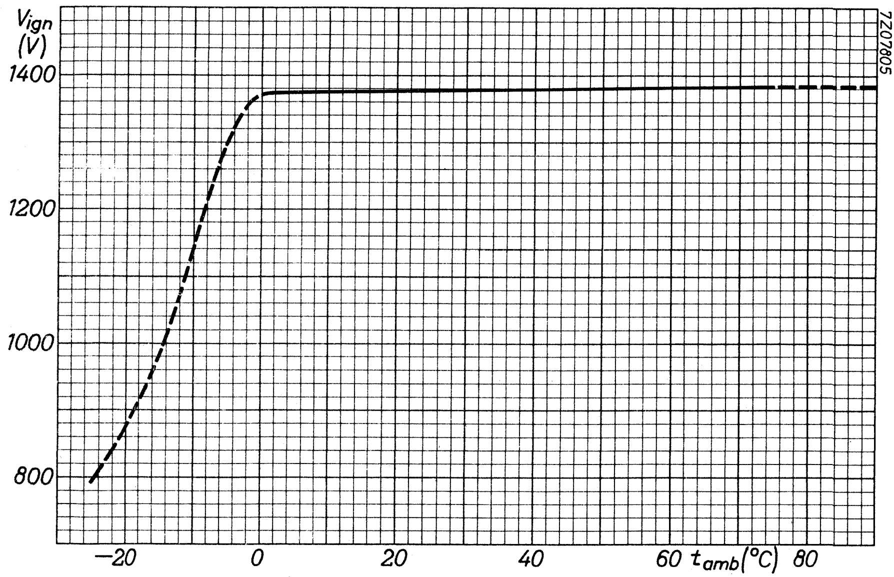
Fig.1



Plateau curve



Dead time curve



Starting voltage as function of temperature

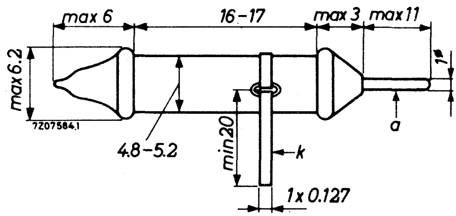
BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched radiation counter tube for the measurement of γ and high energy β (>0.5 MeV) radiation.

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-3} to 3.10^2	R/h
Operating voltage	500 to 650	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	80 to 100	mg/cm^2
Effective length	16	mm
Material	28% Cr, 72% Fe	

FILLING He, Ne, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1

Starting voltage	V_{ign}	max. 380 V
Recommended operating voltage	V_b	arbitrary within plateau
Plateau	V_{pl}	500 to 650 V
Plateau slope	S_{pl}	max. 0.15 %/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b=575V	N_o	max. 2 counts/min.
Dead time at V_b = 600 V	τ	max. 15 μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 2.2 MΩ
Anode voltage	V_a	max. 650 V
Ambient temperature	t_{amb}	min. −40 °C max. +75 °C
for continuous operation		max. +50 °C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 4500 c/s 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 56 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

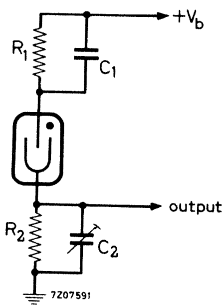
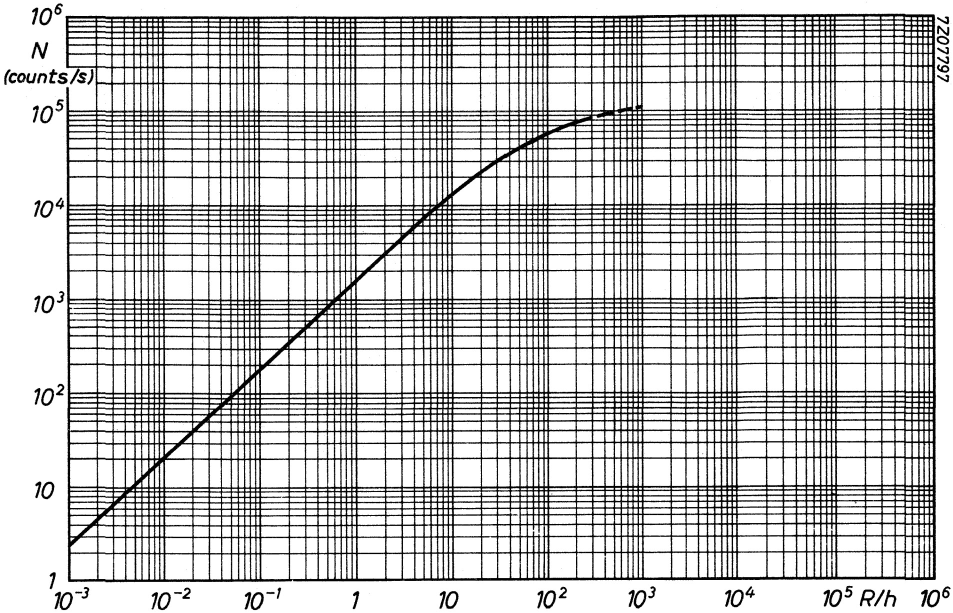
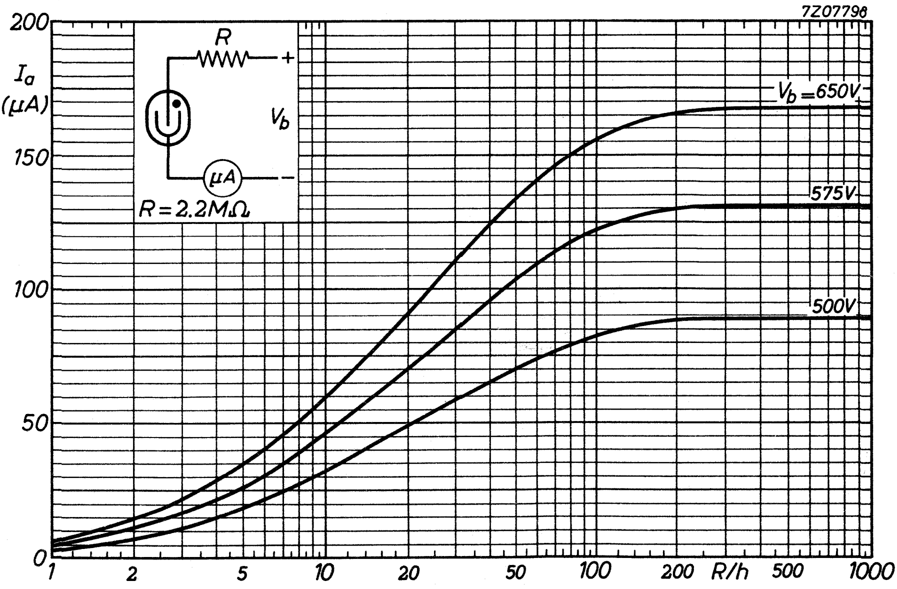


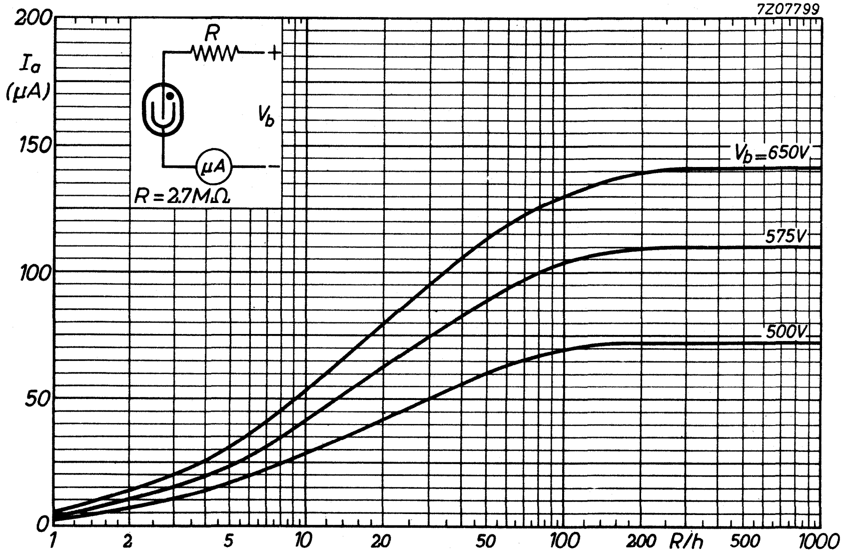
Fig.1



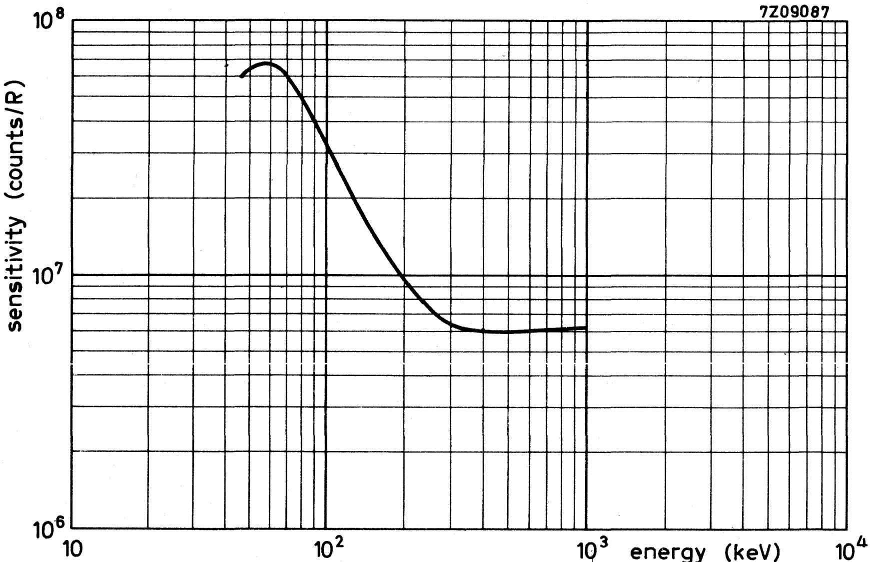
Count rate as function of dose rate



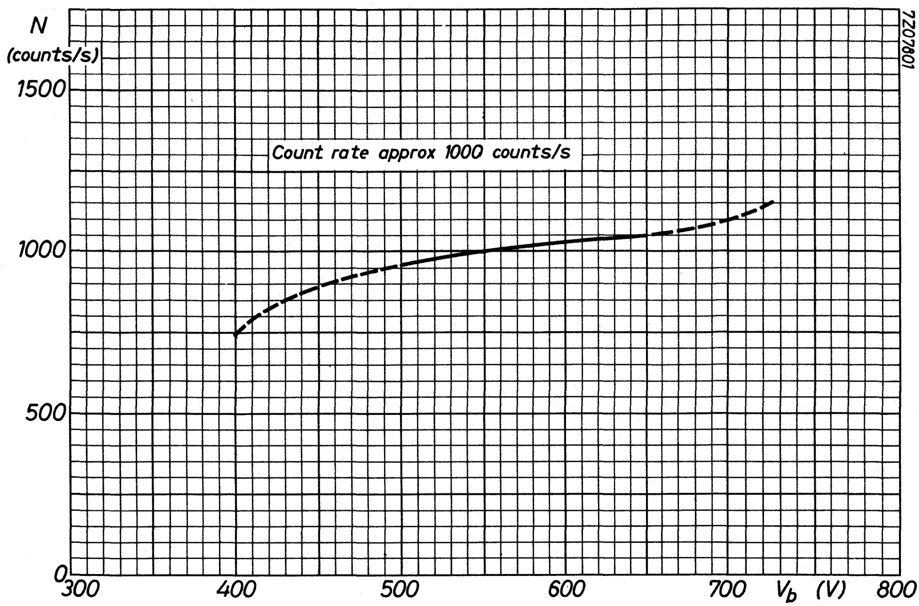
Current as function of dose rate



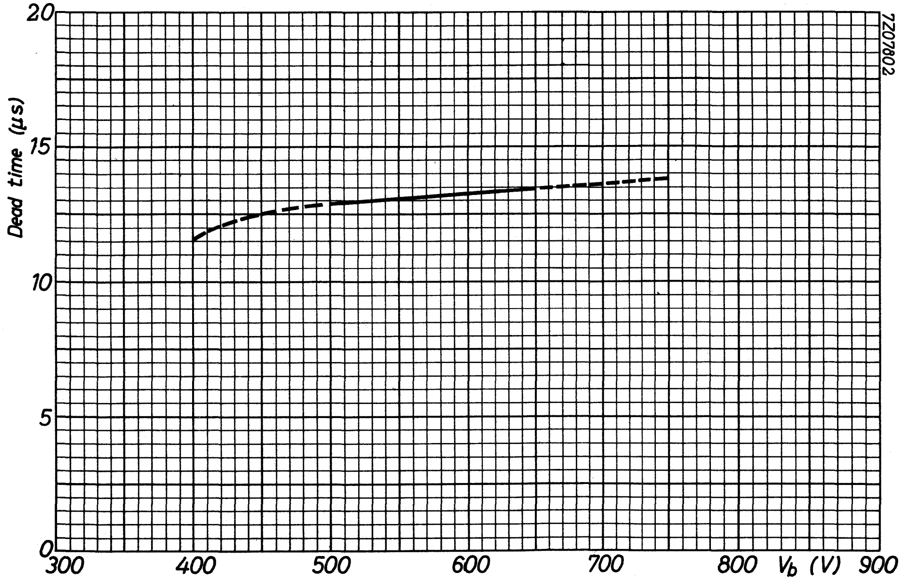
Current as function of dose rate



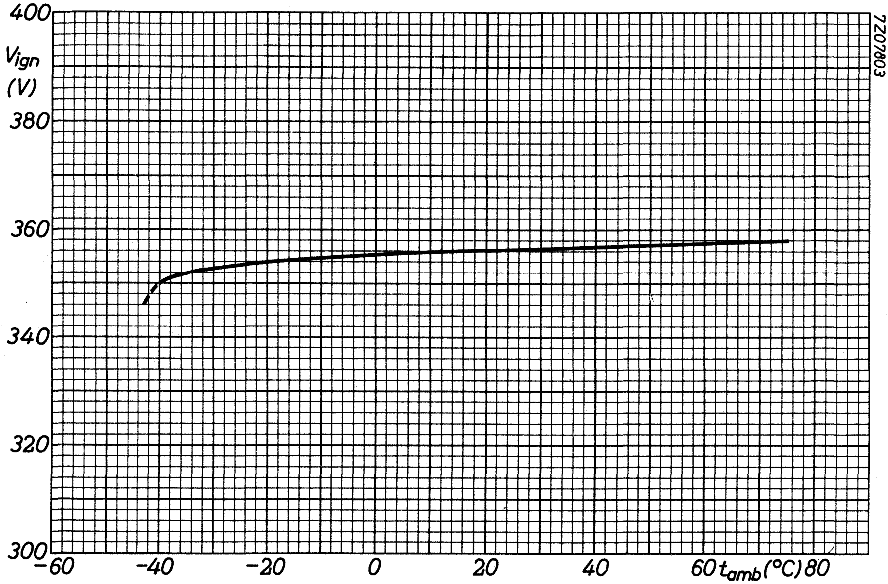
Energy response curve (side response)



Plateau curve



Dead time curve



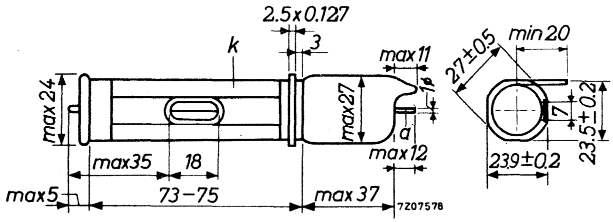
Starting voltage as function of ambient temperature

X-RAY COUNTER TUBE

Side window organic quenched X-ray counter tube

QUICK REFERENCE DATA		
X-Ray energy	2.5 to 40 keV (0.3 to 5	Å)
Window thickness	2 to 2.5	mg/cm^2
Operating voltage	1500 to 1850	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2 to 2.5	mg/cm^2
Dimensions	7x18	mm^2
Material	mica	

CATHODE

Effective length	67	mm
Material	28% Cr, 72% Fe	

FILLING Xenon, organic vapour

Xenon pressure 25 cm Hg

CAPACITANCE

Anode to cathode C_{ak} 2 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1.

Operating voltage	V_b	1500 to 1850	V [1]
Geiger threshold		min. 1900	V
Operating voltage for pulse amplitude V_p = 1 mV	V_b	1460 to 1540	V [2]
Operating voltage for pulse amplitude V_p = 10 mV	V_b	1690 to 1770	V [2]
Energy resolution (See sheet A)	$\Delta P/P$	max. 22	% [2][3]
Integrated background for pulses 50% of the pulse amplitude P (unshielded), at V_b = 1550 V		15	counts/min.[2]

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max. 1850	V
Ambient temperature	t_{amb}	min. −20 max. +50	°C °C

MEASURING CIRCUIT

R_1 = 2.2 kΩ

R_2 = 0.1 MΩ

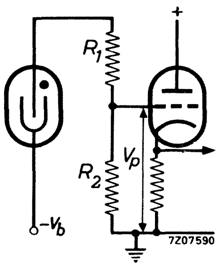
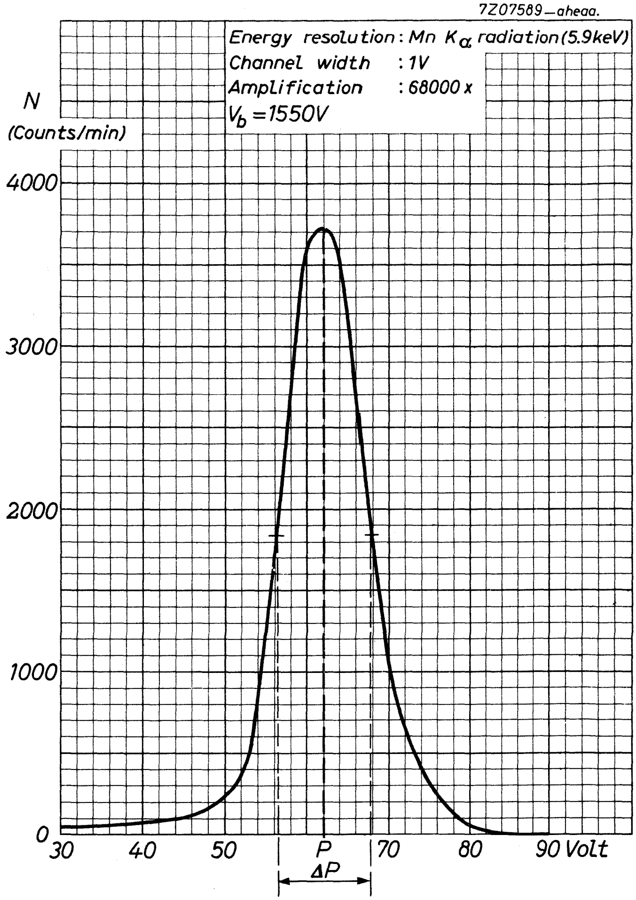


Fig.1

[1] To obtain max. tube life V_b should be kept as low as possible.
[2] For Mn Kα radiation (5.9 keV)
[3] P= average pulse height, ΔP = width of the pulse height distribution at half of the max. value.



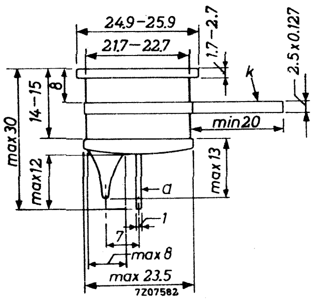
Energy resolution curve

ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube for low level measurements in combination with a guard counter (e.g. type 18518).

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	19.8	mm
Operating voltage	500 to 700	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	19.8	mm
Material	mica	

CATHODE

Thickness	1.2	mm
Effective length	13	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig. I

Starting voltage	V_{ign}	max.	350	V
Recommended operating voltage	V_b	arbitrary within plateau [1]		
Plateau	V_{pl}		500 to 700	V
Plateau slope	S_{pl}	max.	0.09	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	max.	5	counts/min.
Background in anticoincidence circuit with guard counter 18518, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	max.	1.2	counts/min.
Dead time at V_b = 600 V	τ	max.	65	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 4300 c/s 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 4.7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

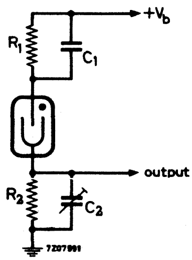
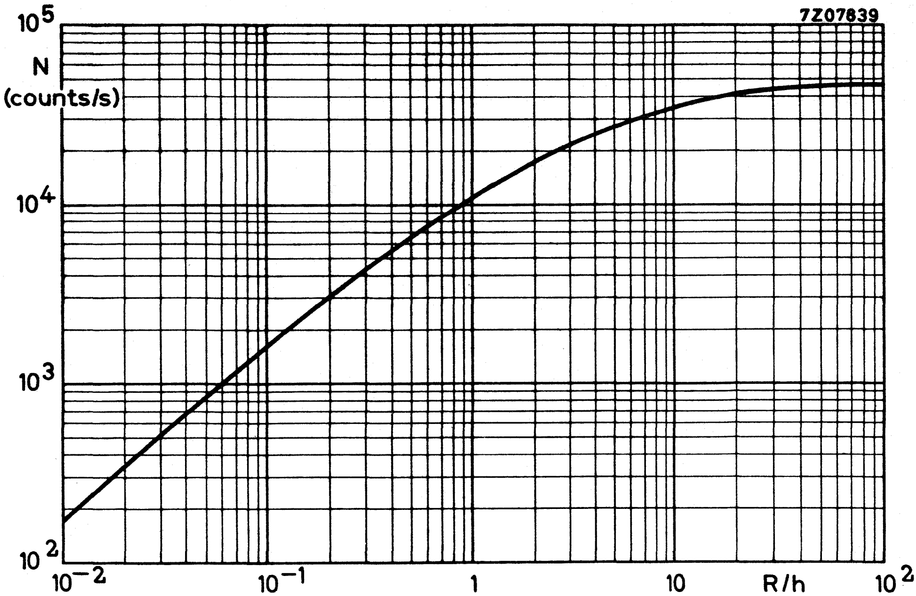


Fig. 1

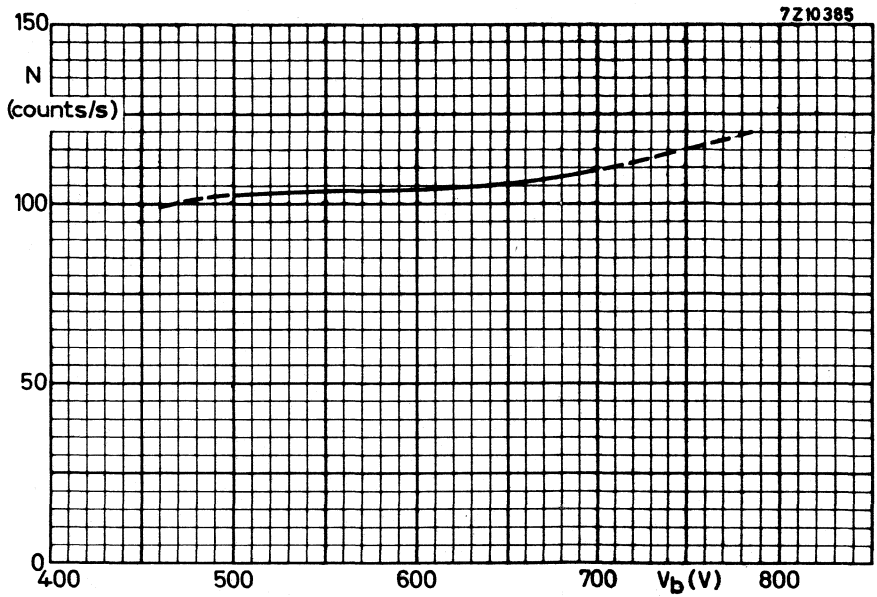
REMARK

In order to prevent leakage the tube should be kept dry and well cleaned.

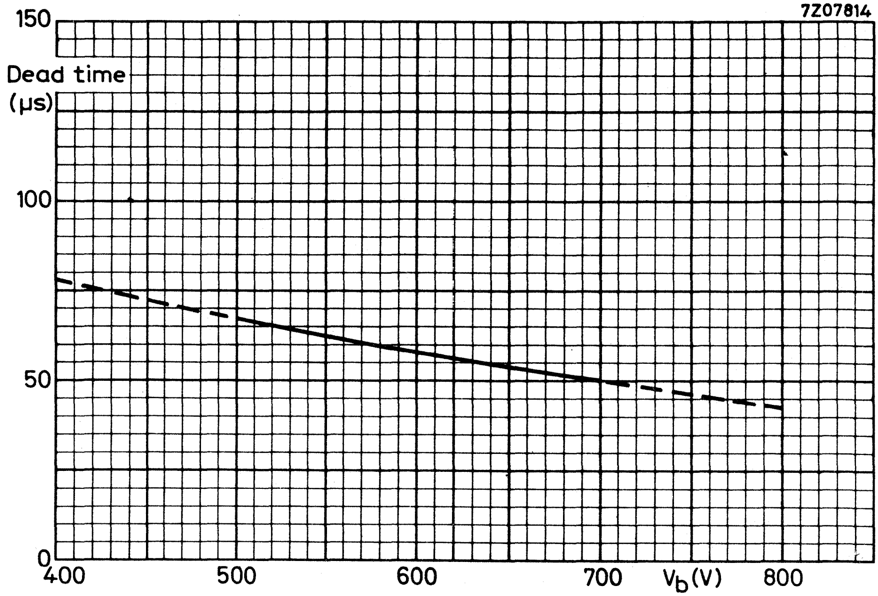
[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V.



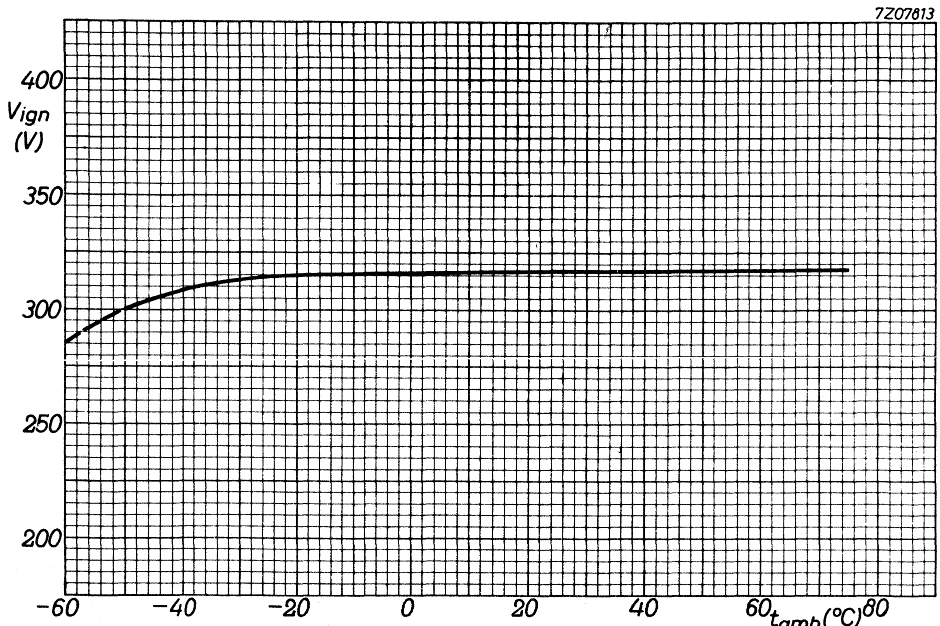
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

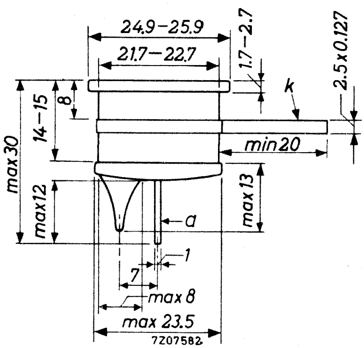
ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube.

QUICK REFERENCE DATA				
Window thickness	1,5	to	2,0	mg/cm^2
Window diameter			19,8	mm
Operating voltage	500	to	700	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



WINDOW

Thickness	1,5	to	2,0	mg/cm^2
Effective diameter			19,8	mm
Material			mica	

CATHODE

Thickness	1,2	mm
Effective length	13	mm
Material	28 % Cr, 72 % Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 1 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of Fig.1.

Starting voltage	V_{ign}	≤	350	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to	700	V
Plateau slope	S_{pl}	≤	0,09	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	≤	8	counts/min
Dead time at V_b = 600 V	τ	≤	65	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2,2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	max.	+75	°C
		min.	-50	°C
for continuous operation	t_{amb}	max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 4300 c/s — 5×10^{10} counts

MEASURING CIRCUIT

R_1 = 4,7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

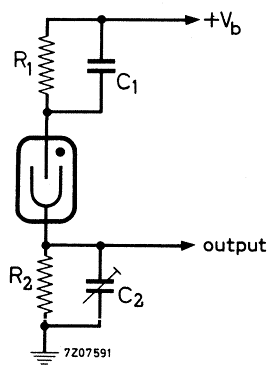
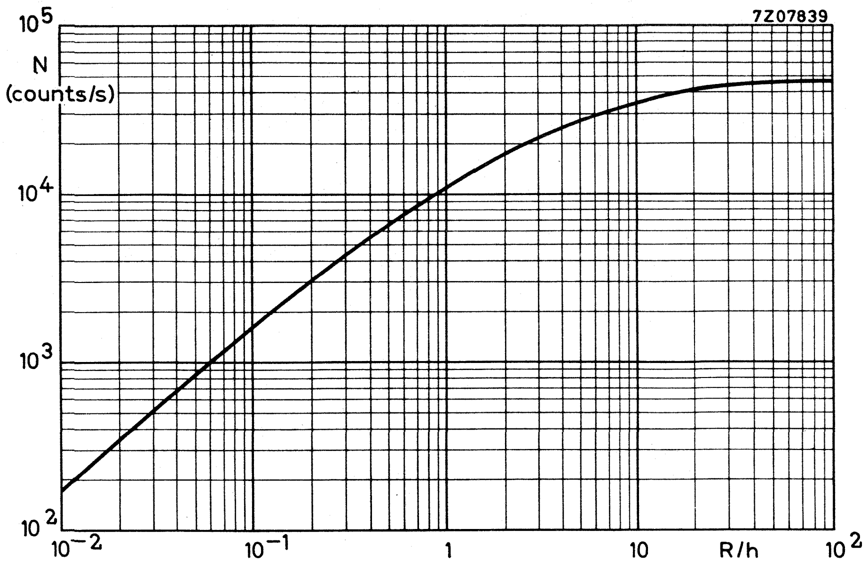


Fig. 1

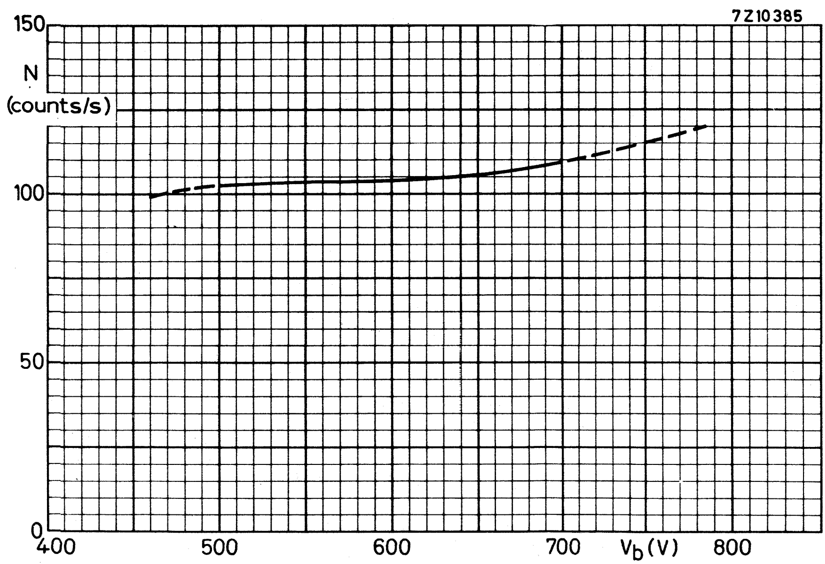
REMARK

In order to prevent leakage the tube should be kept dry and clean.

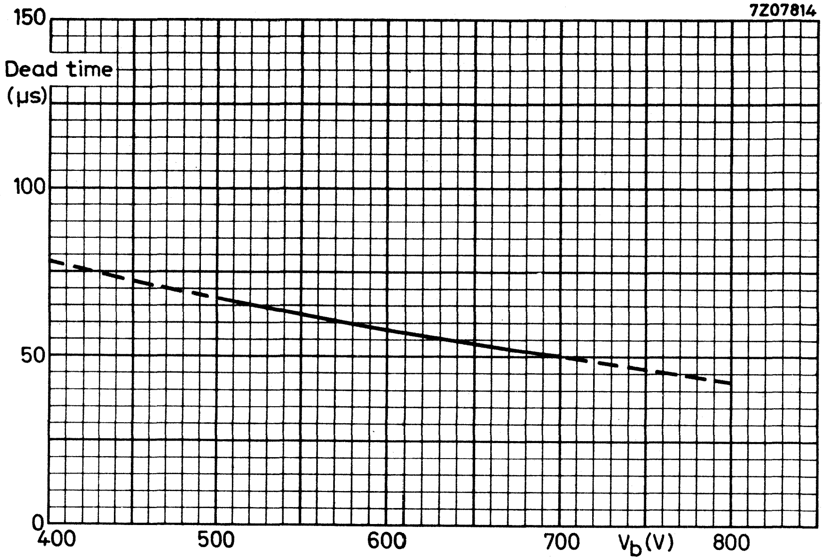


Count rate as function of dose rate

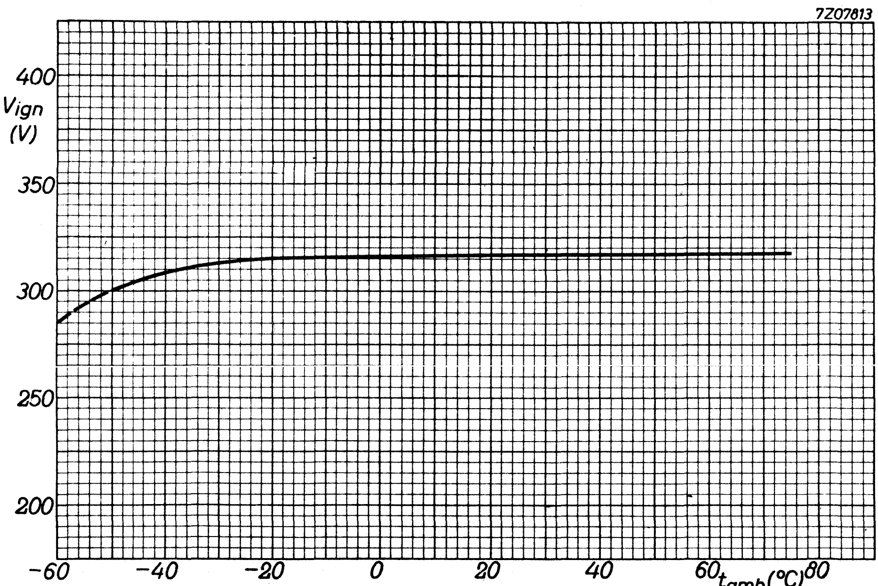
(measured with ^{60}Co)



Plateau curve



Dead time curve



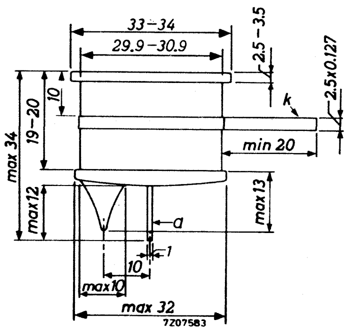
Starting voltage as function of ambient temperature

BETA RADIATION COUNTER TUBE

End window halogen quenched β radiation counter tube for low level measurements in combination with a guard counter (e.g. type 18518)

QUICK REFERENCE DATA		
Window thickness	10	mg/cm^2
Window diameter	27.8	mm
Operating voltage	500 to 750	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	10	mg/cm^2
Effective diameter	27.8	mm
Material	CrFe	

CATHODE

Thickness	1.3	mm
Effective length	18	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.3	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig. 1

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau [1]		
Plateau	V_{pl}		500 to 750	V
Plateau slope	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600V	N_o	max.	9	counts/min.
Background in anticoincidence circuit with guard counter 18518, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_a	max.	1.3	counts/min.
Dead time at V_b = 600 V	τ	max.	70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 3200 c/s	5.10^{10}	counts

MEASURING CIRCUIT

R = 10 MΩ

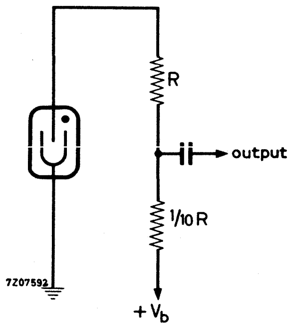


Fig. 1

[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V.

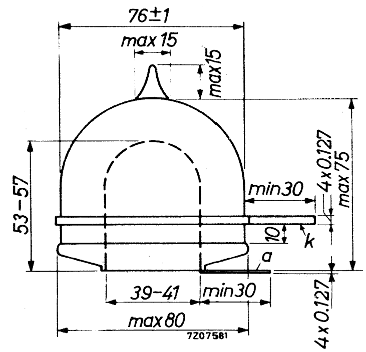
COSMIC RAY GUARD COUNTER TUBE

Halogen quenched cosmic ray guard counter tube for low background measurements in combination with β counter (e.g. type 18515 or 18536) in an anticoincidence circuit. It can also be used in combination with a gas-flow counter.

QUICK REFERENCE DATA		
Hollow anode diameter	40	mm
Operating voltage	800 to 1200	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE AND ANODE

Thickness	1 mm
Material	28% Cr, 72% Fe

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	8 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	650	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau (at 50 counts/ s)	V_{pl}	800 to 1200		V
Plateau slope (at 50 counts/ s)	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 1000V	N_o	max.	70	counts/min.
Dead time (at 50 counts/ s)	τ	max.	1	ms

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	10	MΩ
Anode voltage	V_a	max.	1200	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 1300 c/s — 5.10^{10} counts

MEASURING CIRCUIT

For use as guard counter tube in anticoincidence circuits in combination with 18515 or 18536: recommended circuit see fig.2.

R = 10 MΩ

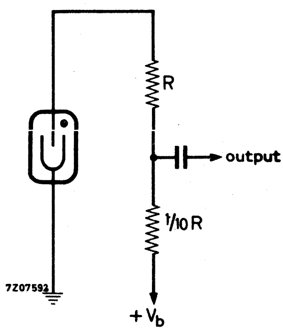


Fig.1

R_1 = 10 MΩ

R_2 = 10 MΩ

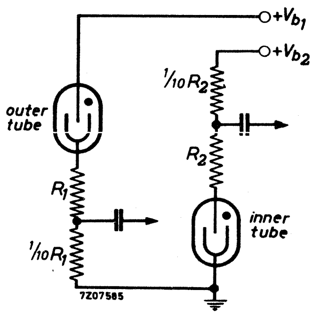
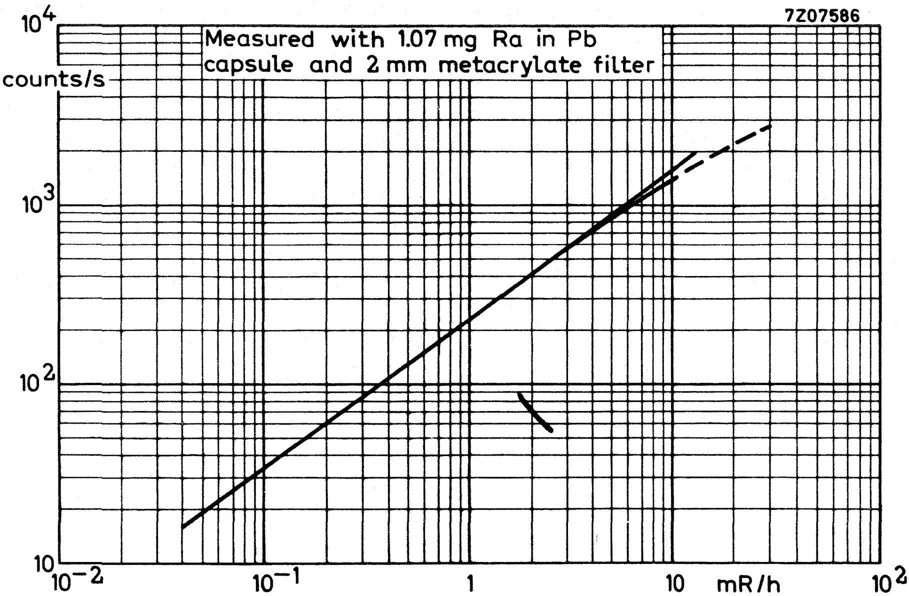
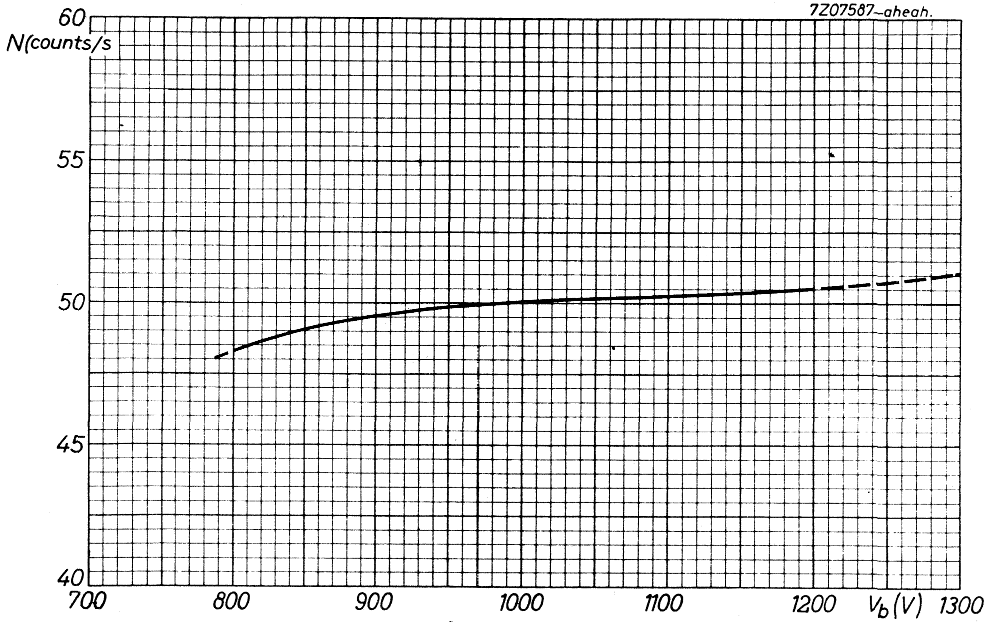


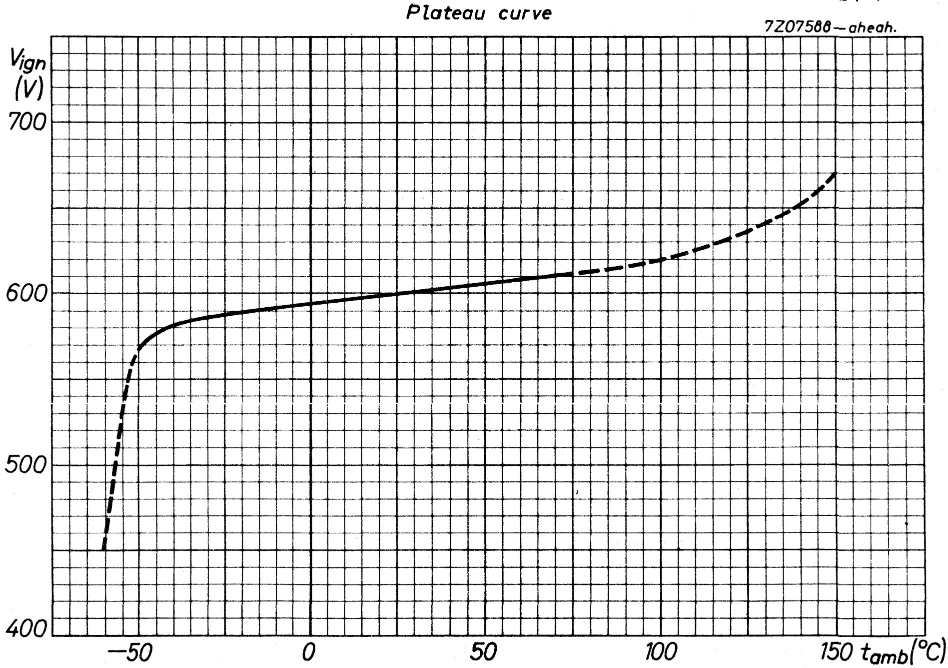
Fig.2



Count rate as function of dose rate



Plateau curve



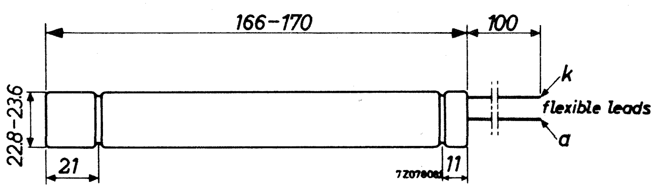
Starting voltage as function of temperature

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube.

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	5.10^{-4} to 2.10^{-1}	R/h
Operating voltage	375 to 475	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	0.7 mm
Effective length	140 mm
Material	27% Cr, 73% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	4.5 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C). Measured in circuit of fig.1.

Starting voltage	V_{ign}	max.	360	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	375 to 475		V
Plateau slope	S_{pl}	max.	0.15	%/V
Background, shielded with 50 mm Pb, at V_b = 450 V	N_o		40	counts/min.
Dead time at V_b = 450 V	τ	max.	220	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	475	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C 5.10^{10} counts

MEASURING CIRCUIT

R = 2.7 MΩ

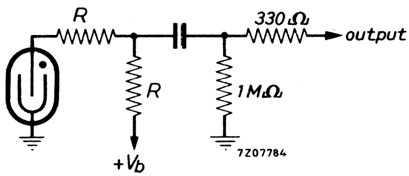
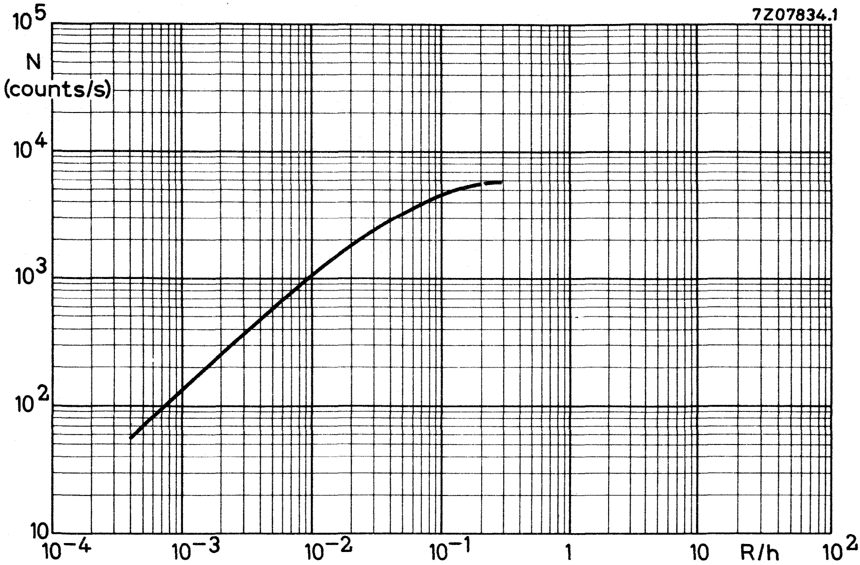
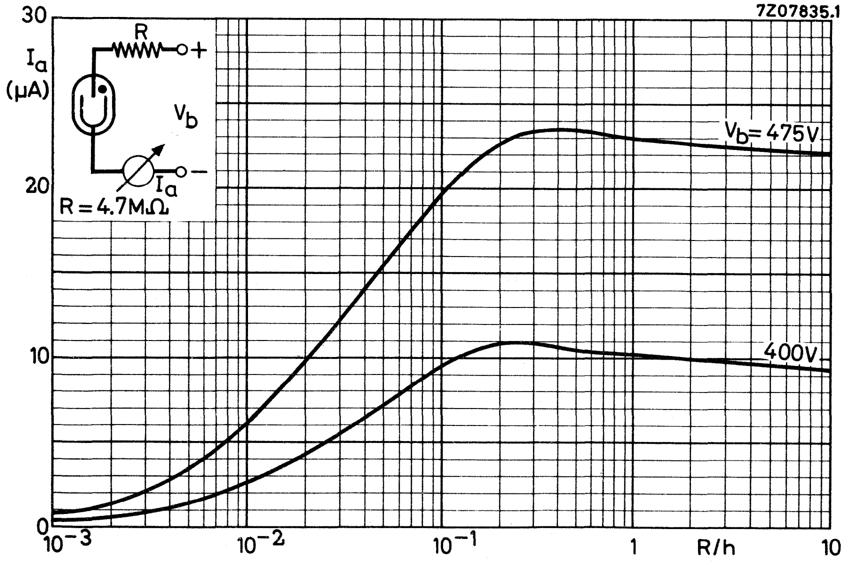


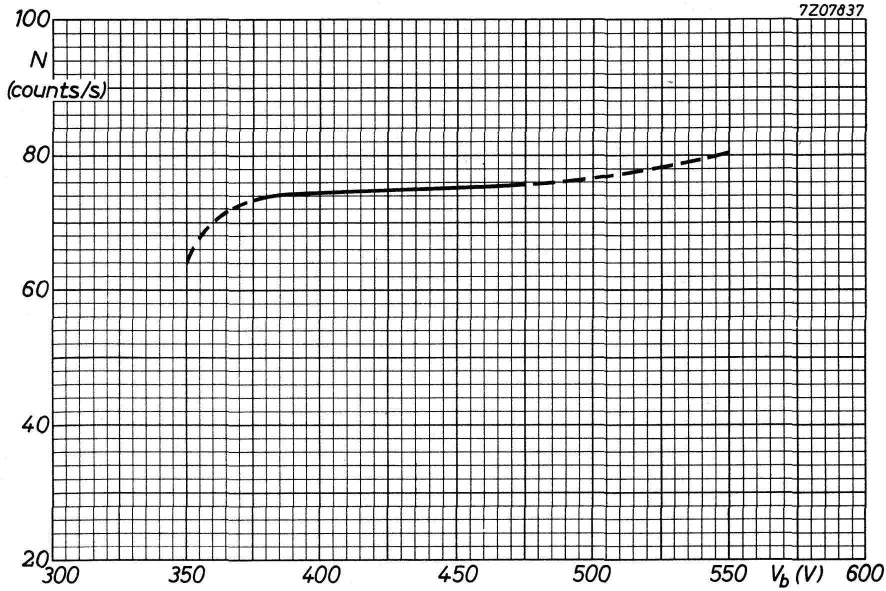
Fig.1



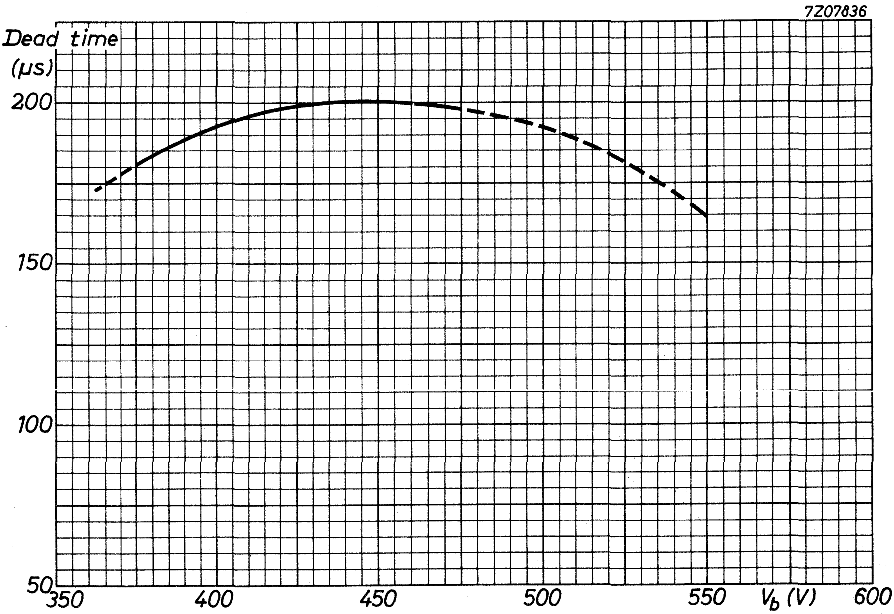
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



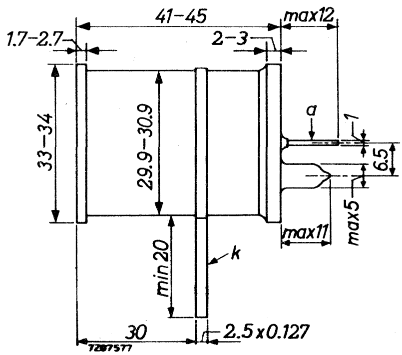
Dead time curve

ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched α, β, and γ radiation counter tube.

QUICK REFERENCE DATA		
Window thickness	1,5 to 2,0	mg/cm^2
Window diameter	27,8	mm
Operating voltage	450 to 700	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



Cathode connector
0.127 mm thick

WINDOW

Thickness	1,5 to 2,0	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1,3	mm
Effective length	37	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	3,5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	≤	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 700		V
Plateau slope	S_{pl}	≤	0,035	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 575 V	N_o	≤	25	counts/min.
Dead time at V_b = 575 V	$\bar{\tau}$	≤	190	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2,2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation	t_{amb}	max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 2200 c/s — 5×10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

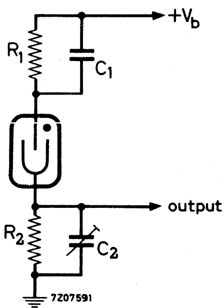
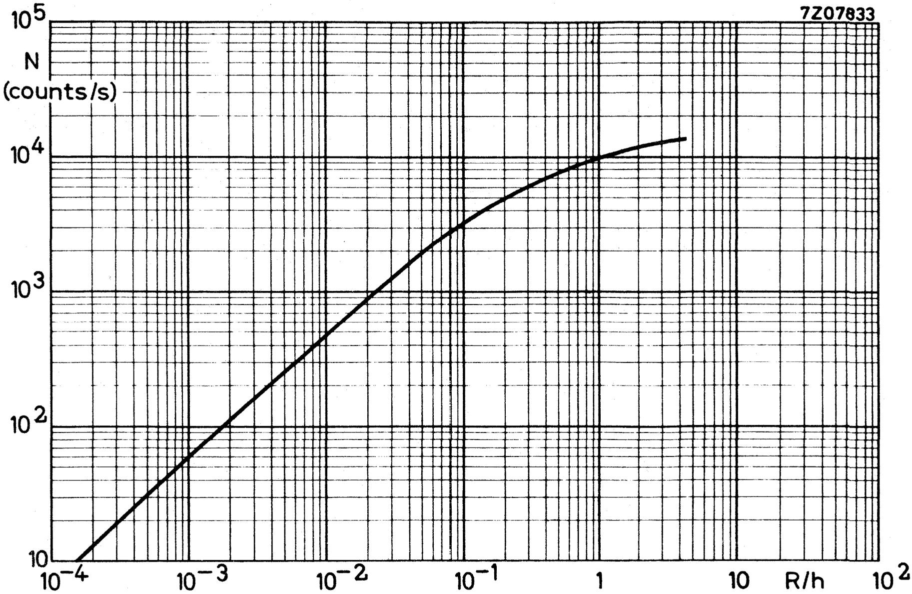
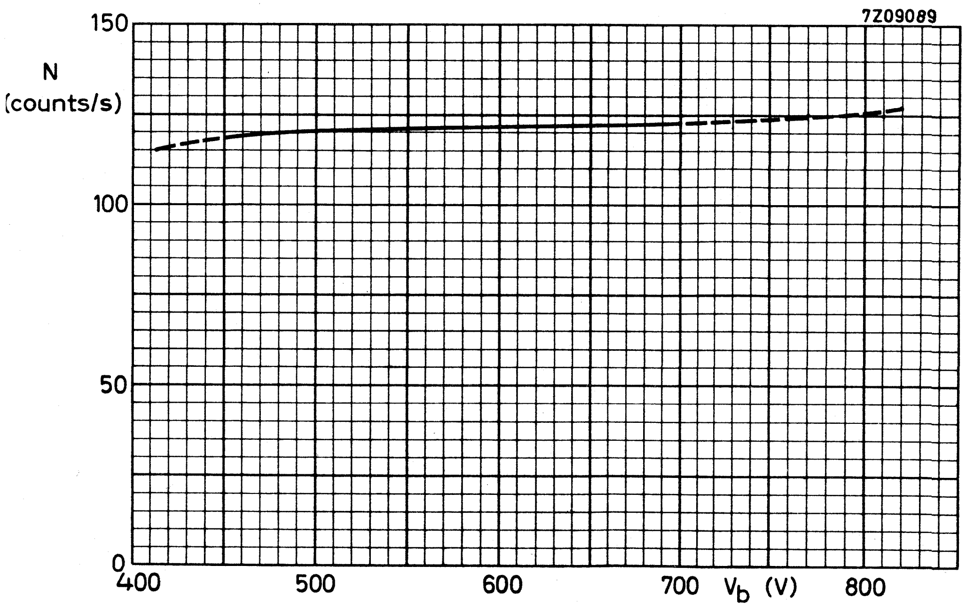


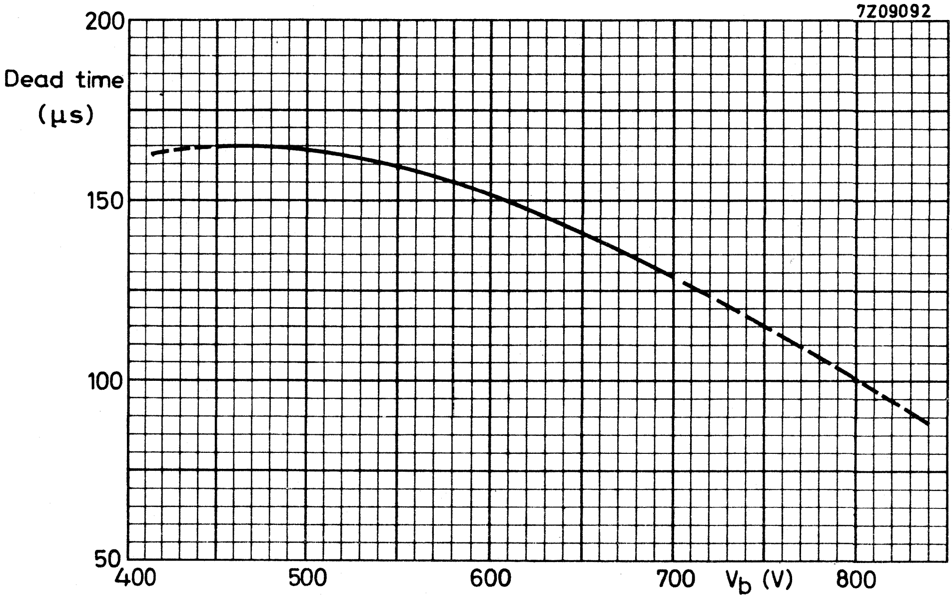
Fig.1



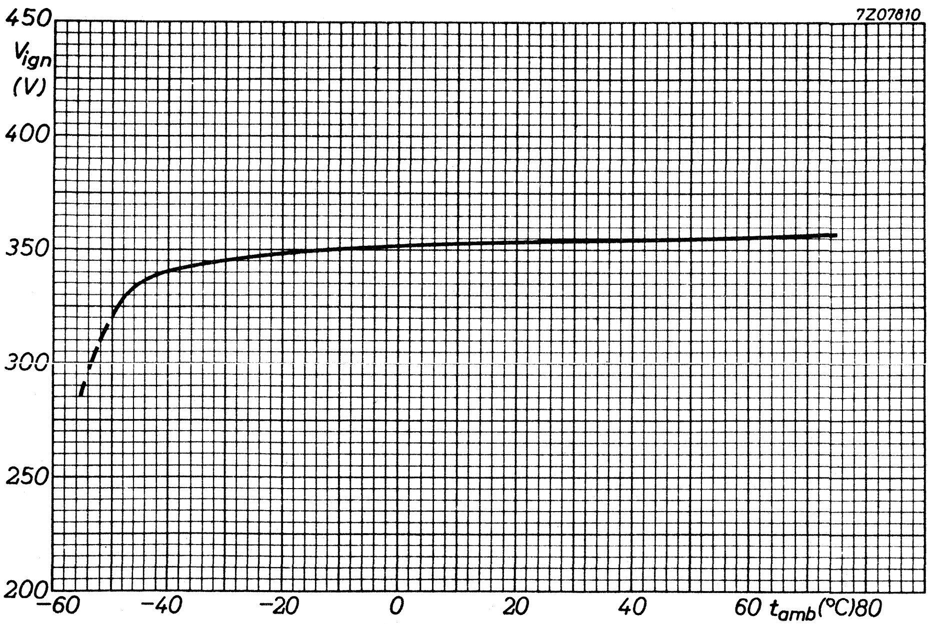
Count rate as function of dose rate (side response)
(measured with ^{60}Co)



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

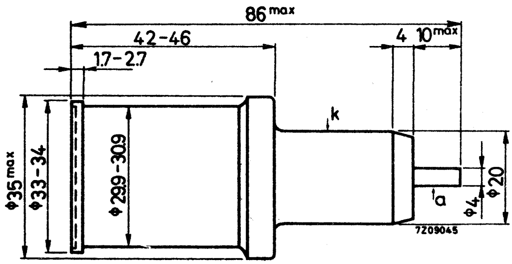
ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched α, β and γ radiation counter tube with a DIN base.

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	27.8	mm
Operating voltage	450 to 700	V
Anode resistor, mounted in the base	10	MΩ

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base matched to socket DIN44421



WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1.3	mm
Effective length	37	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	3.5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig. 1

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}		450 to 700	V
Plateau slope	S_{pl}		0.035	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 575 V	N_o	max.	25	counts/min.
Dead time at V_b = 575 V	τ	max.	190	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY at t_{amb} = 25 °C, count rate 2200 c/s 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

$R_1C_{stray} = R_2C_2$

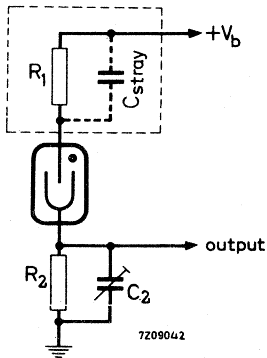


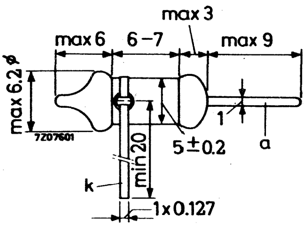
Fig. 1

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched radiation counter tube for the measurement of γ and high energy β (> 0.5 Me V) radiation.

QUICK REFERENCE DATA		
Range ($^{60}Co\,\gamma$ radiation)	10^{-2} to 2.10^{3}	R/h
Operating voltage	500 to 600	V

DIMENSIONS AND CONNECTIONS — Dimensions in mm



CATHODE

Thickness	80 to 100	mg/cm^2
Effective length	8	mm
Material	28% Cr, 72% Fe	

FILLING — He, Ne, halogen

CAPACITANCE

Anode to cathode	C_{ak}	0.7	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}		500 to 600	V
Plateau slope	S_{pl}	max.	0.3	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 550V	N_o	max.	1	count/min.
Dead time at V_b = 550 V	τ	max.	11	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	−40	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 3200 c/s	10^{10}	counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 47 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

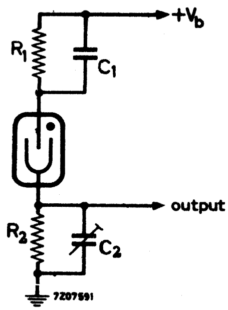
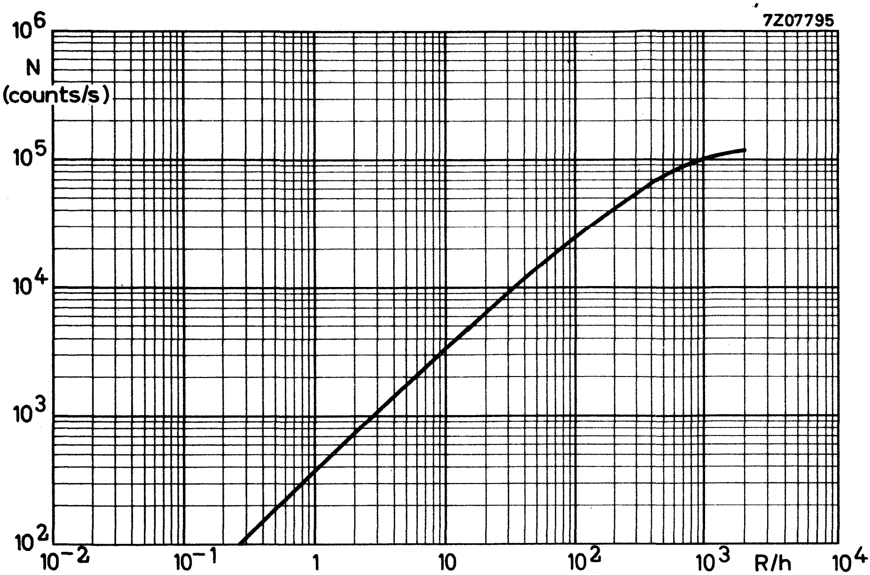
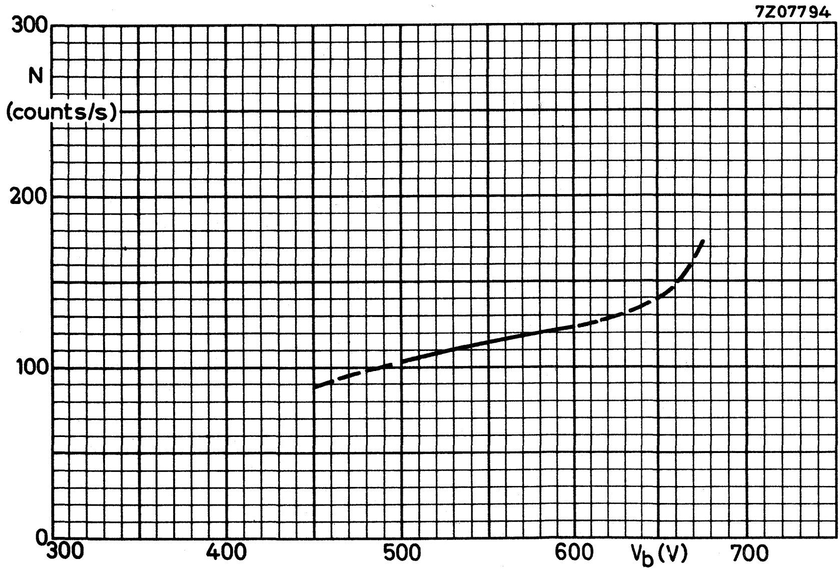


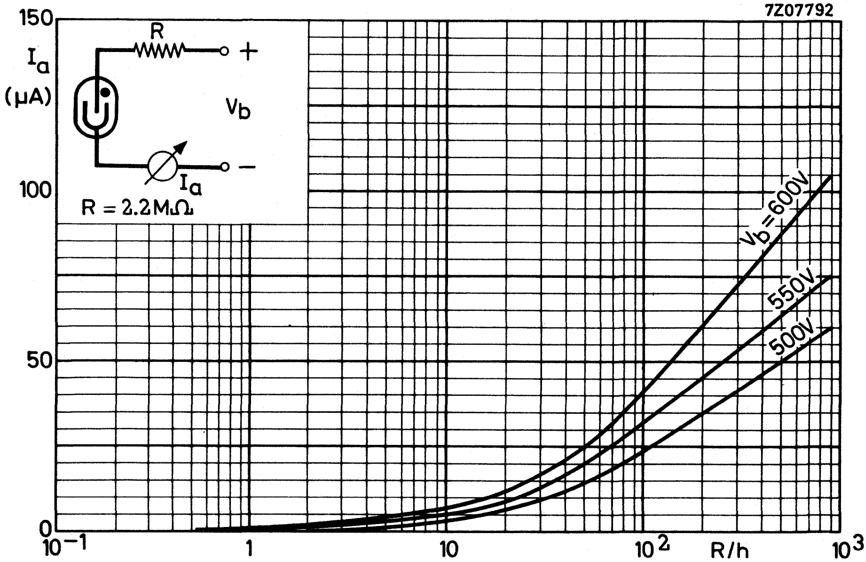
Fig.1



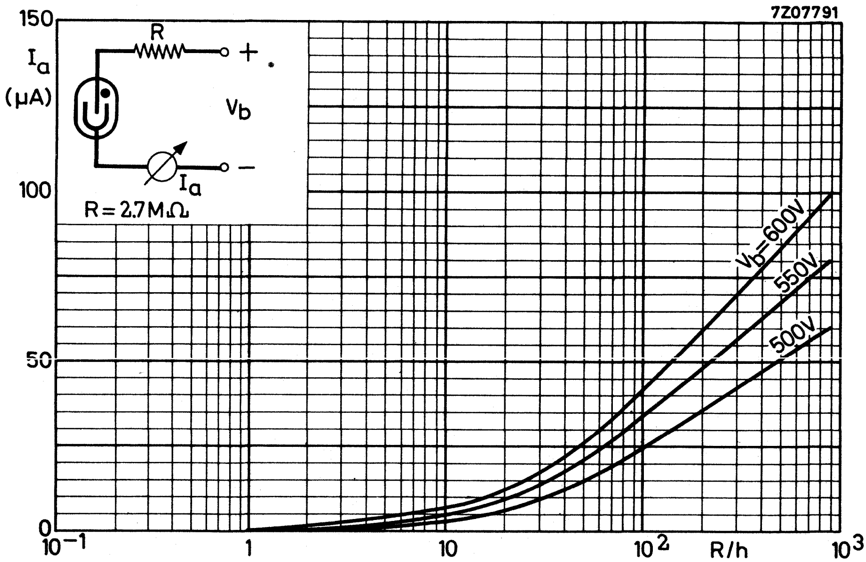
Count rate as function of dose rate



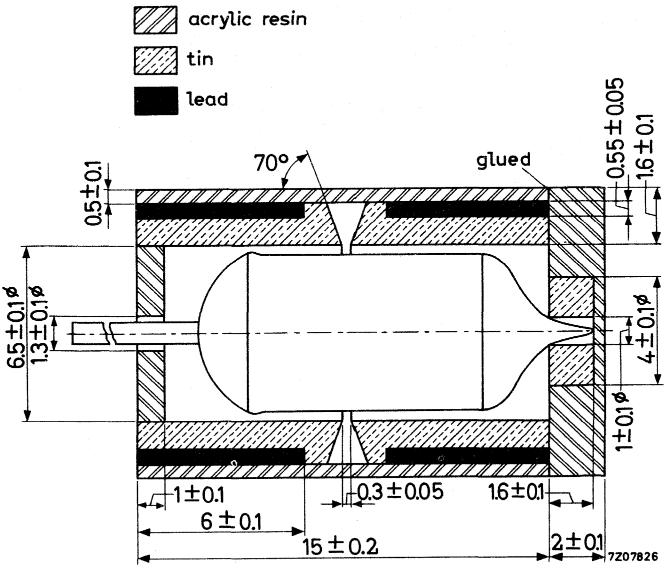
Plateau curve

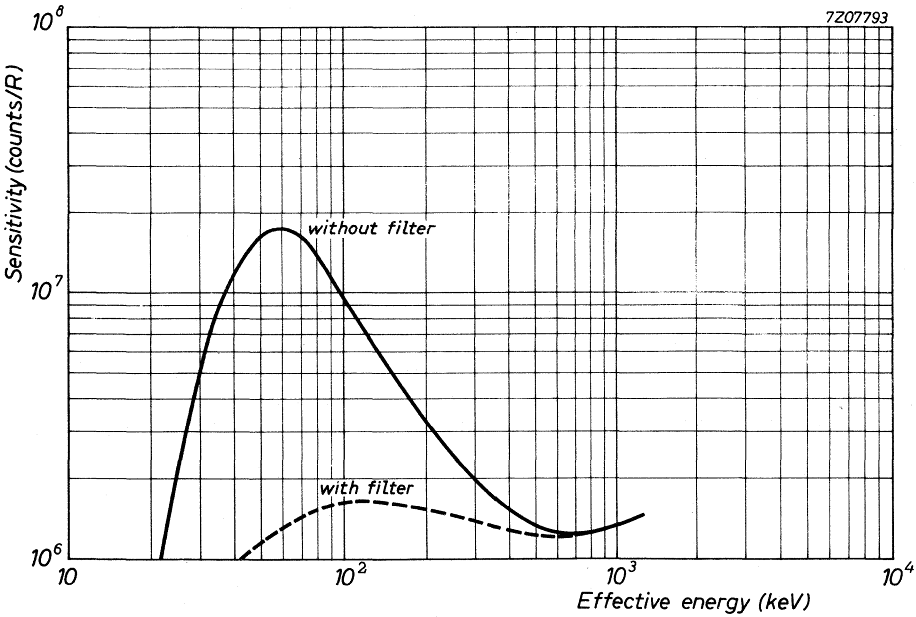


Current as function of dose rate



Current as function of dose rate





Energy response curve (side response)

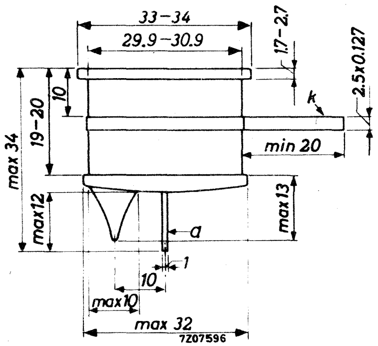
ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube, for low level measurements in combination with a guard counter (e.g. type 18518)

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	27.8	mm
Operating voltage	500 to 750	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1.3	mm
Effective length	18	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.4	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau [1]		
Plateau	V_{pl}	500 to 750		V
Plateau slope	S_{pl}	max.	0.07	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	max.	9	counts/min.
Background in anticoincidence circuit with guard counter 18518, shielded with 100mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	max.	2	counts/min.
Dead time at V_b = 600 V	τ	max.	60	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+30	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 3200 c/s — 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

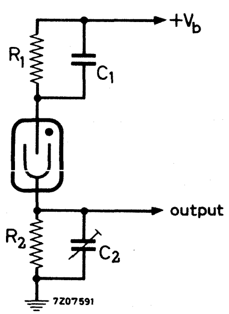
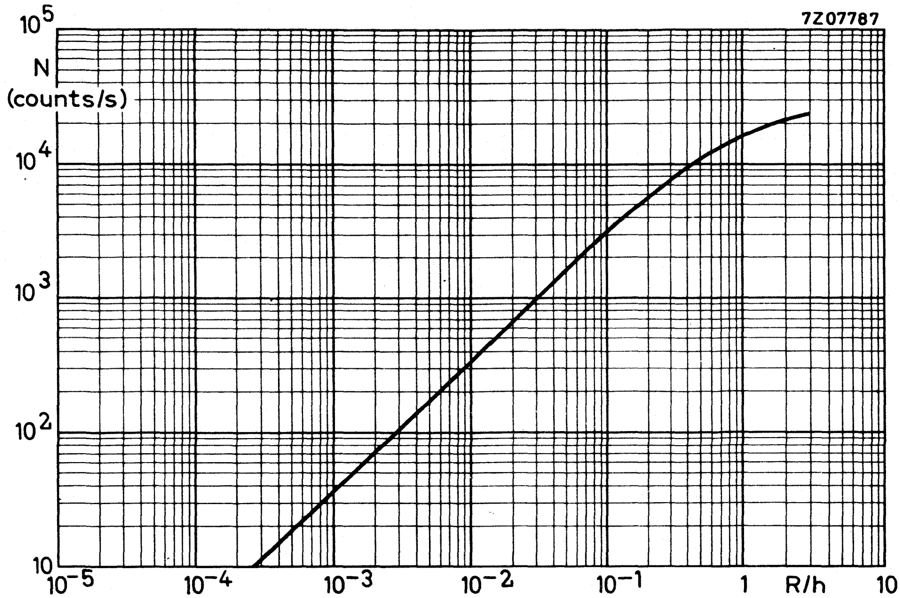
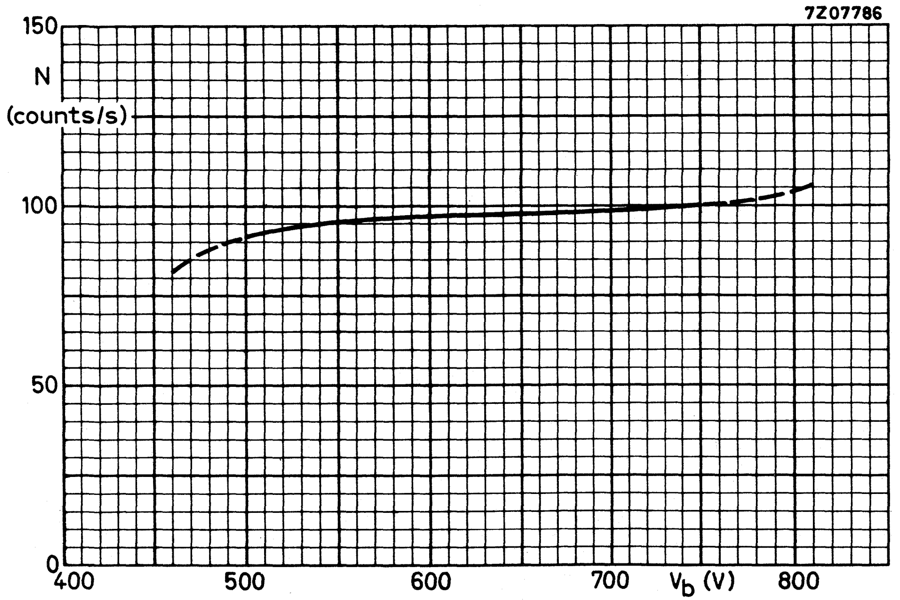


Fig.1

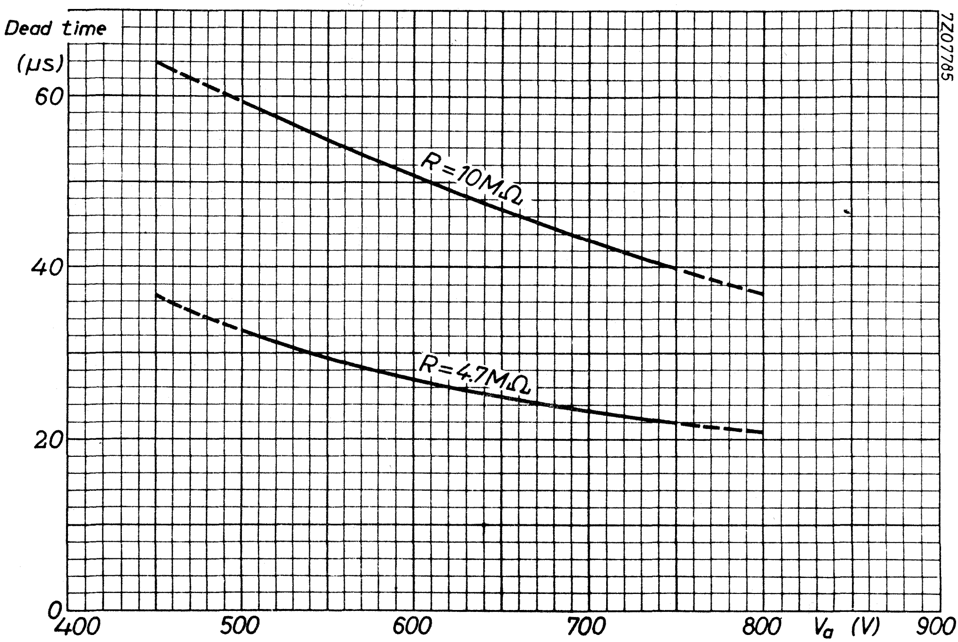
[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V



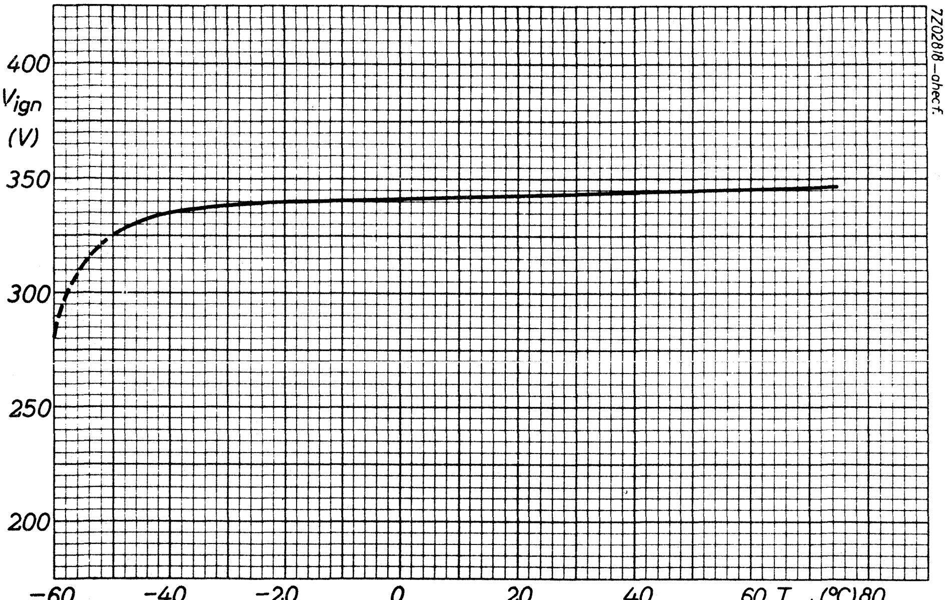
Count rate as function of dose rate



Plateau curve



Dead time curve



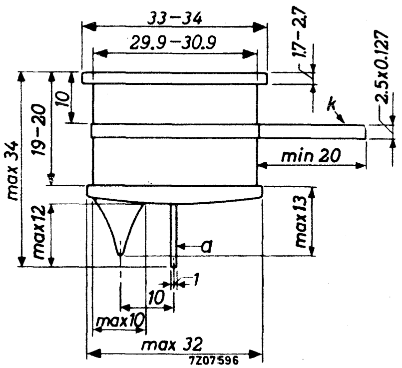
Starting voltage as function of ambient temperature

ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube for low level measurements.

QUICK REFERENCE DATA		
Window thickness	1,5 to 2,0	mg/cm^2
Window diameter	27,8	mm
Operating voltage	500 to 750	V

DIMENSIONS AND CONNECTIONS — Dimensions in mm



WINDOW

Thickness	1,5 to 2,0	mg/cm^2
Effective diameter	27,8	mm
Material	mica	

CATHODE

Thickness	1,3	mm
Effective length	18	mm
Material	28 % Cr, 72 % Fe	

FILLING — Ne, A, halogen

CAPACITANCE

Anode to cathode — C_{ak} 1,4 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of Fig. 1.

Starting voltage	V_{ign}	≤	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to	750	V
Plateau slope	S_{pl}	≤	0.07	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside, at V_b = 600 V	N_o	≤	12	counts/min
Dead time at V_b = 600 V	τ	≤	60	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4,7	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	max.	+75	°C
		min.	-50	°C
for continuous operation	t_{amb}	max.	30	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 3200 c/s 5×10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

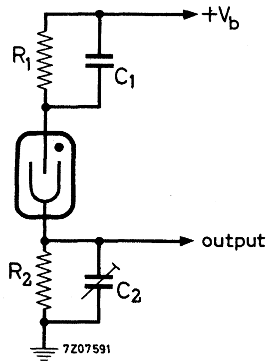
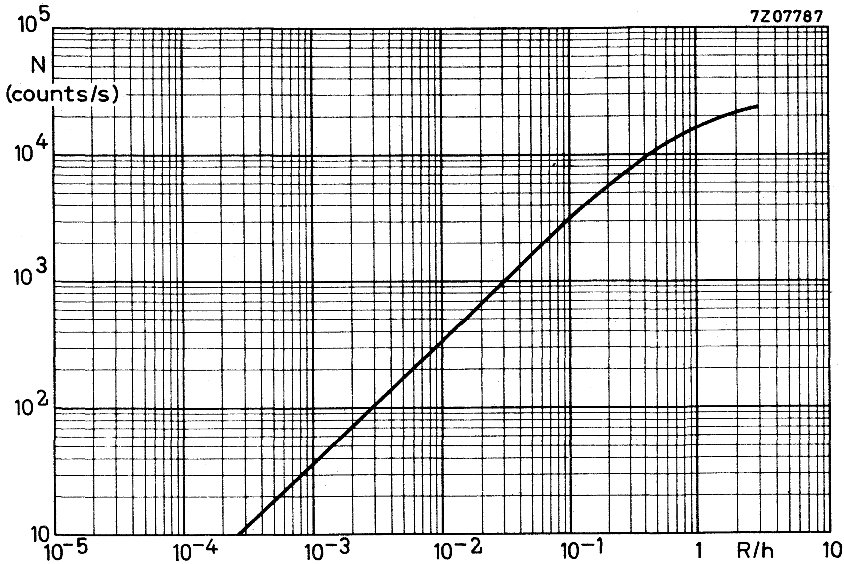
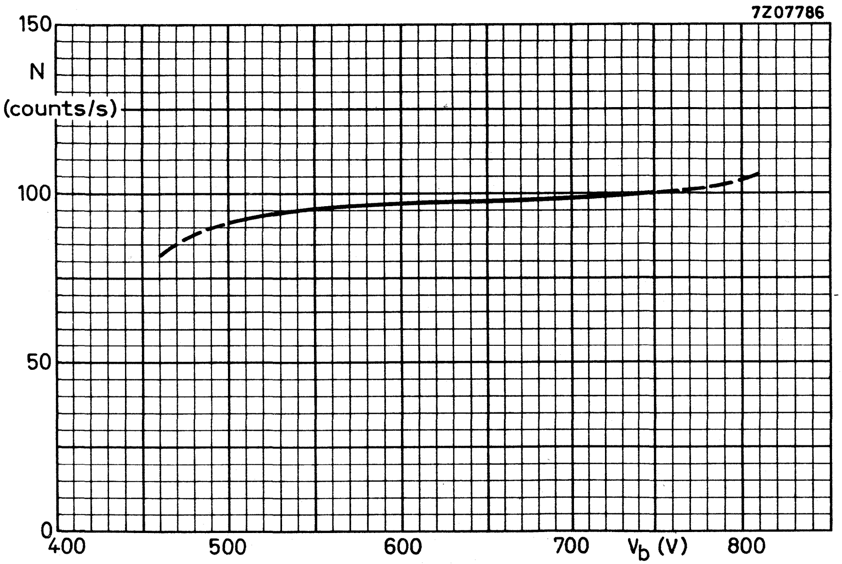


Fig. 1

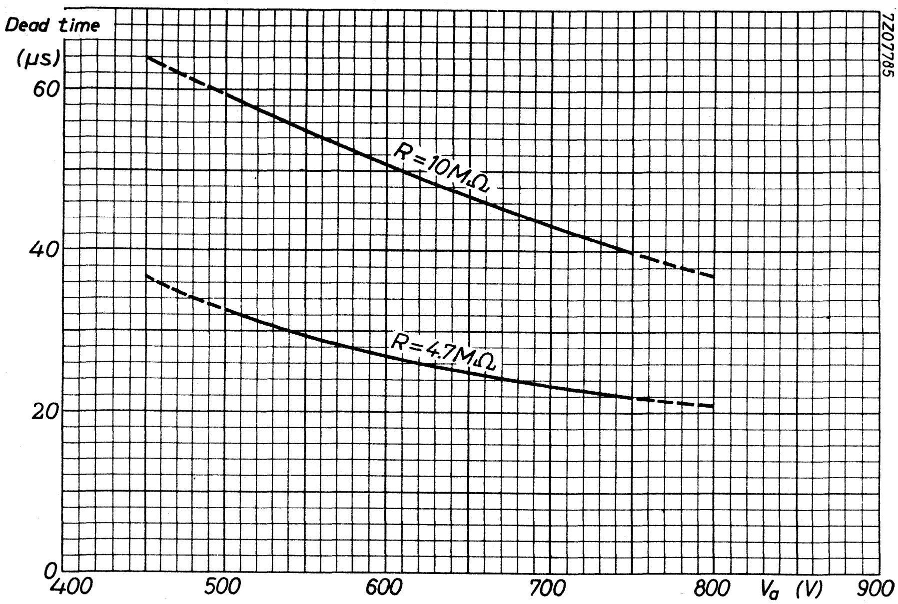


Count rate as function of dose rate

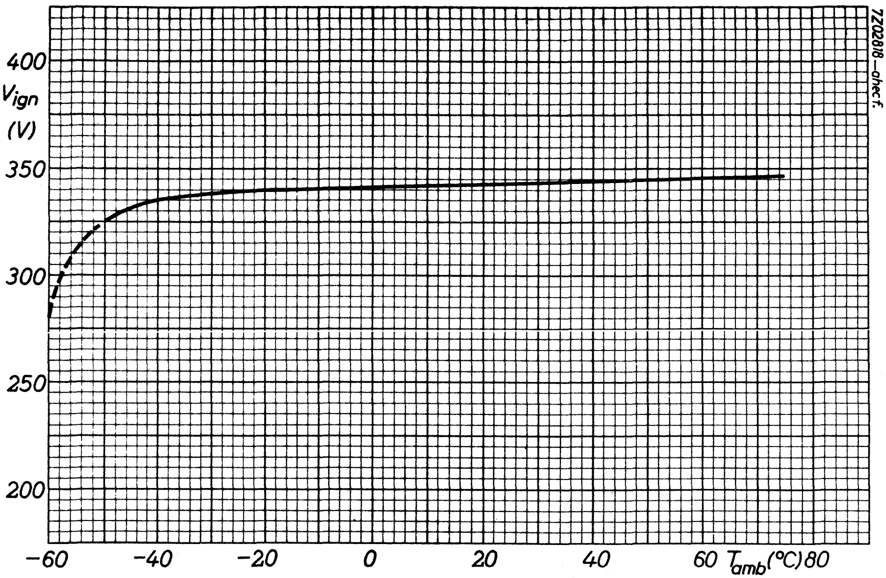
(measured with ^{60}Co)



Plateau curve



Dead time curve



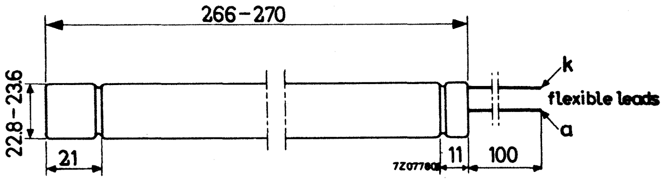
Starting voltage as function of ambient temperature

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-4} to 10^{-1}	R/h
Operating voltage	380 to 480	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	525	mg/cm^2
Effective length	240	mm
Material	27% Cr, 73% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	10	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C). Measured in circuit of fig.1.

Starting voltage	V_{ign}	max.	360	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	380 to 480		V
Plateau slope	S_{pl}	max.	0.10	%/V
Background, shielded with 50 mm Pb and 6 mm Al, at V_b = 420 V	N_o	max.	75	counts/min.
Dead time at V_b = 420 V	τ	max.	200	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.7	MΩ
Anode voltage	V_a	max.	480	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C 5.10^{10} counts

MEASURING CIRCUIT

R = 2.7 MΩ

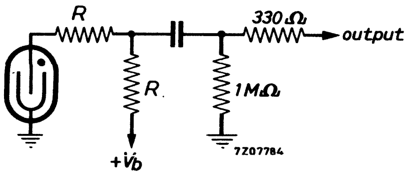
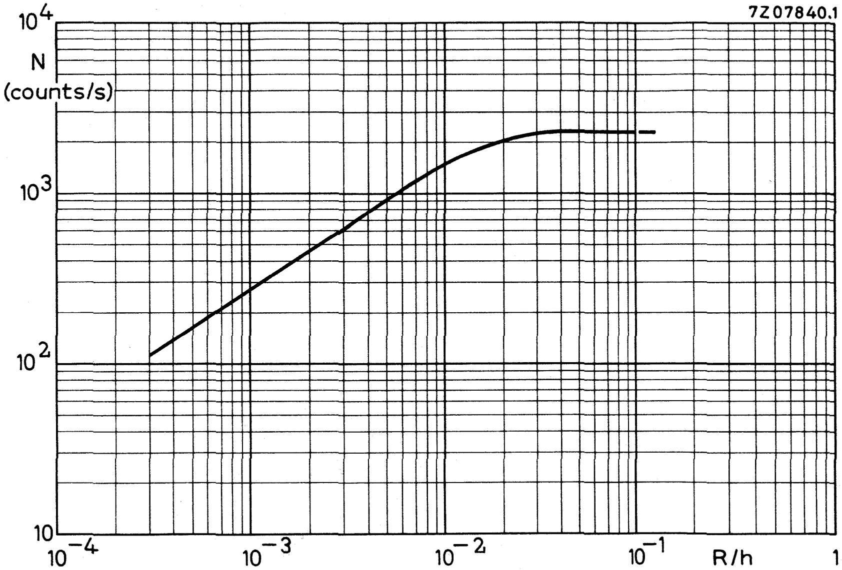
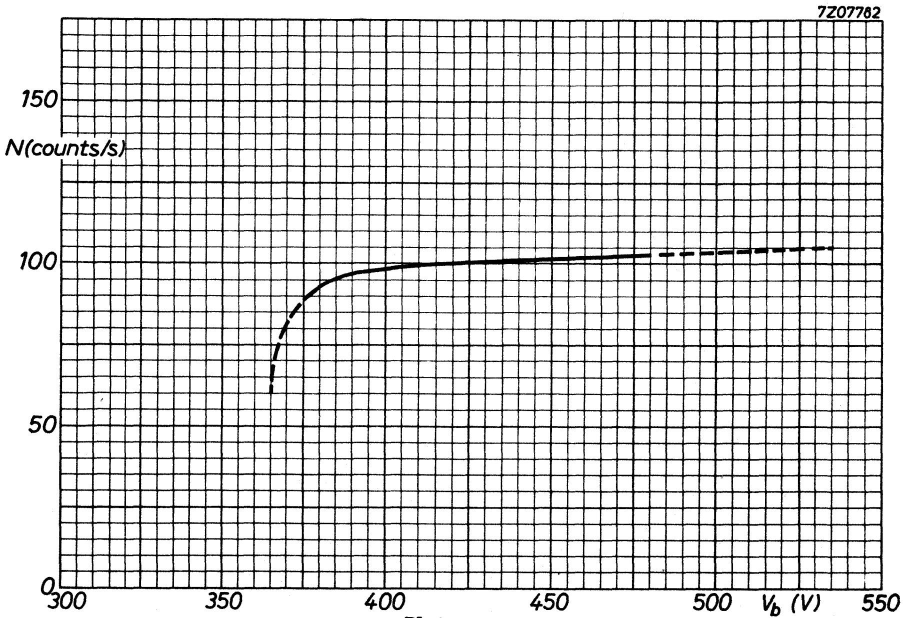


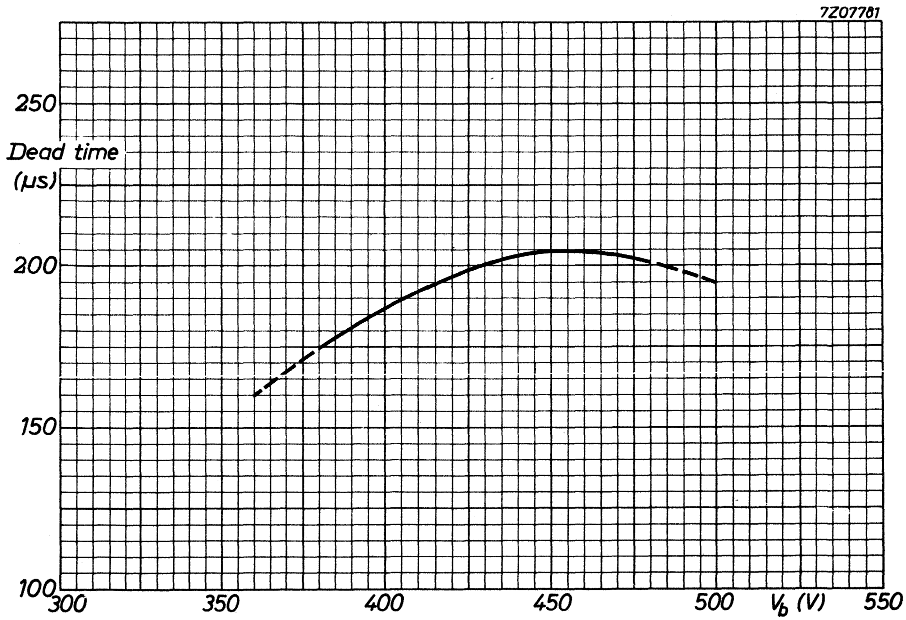
Fig.1



Count rate as function of dose rate



Plateau curve



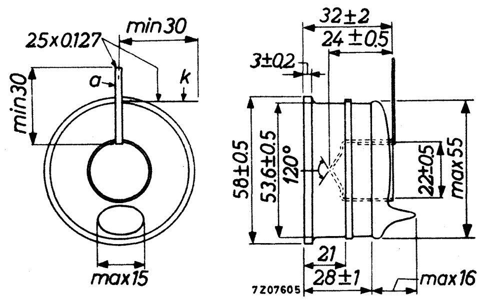
Dead time curve

BETA RADIATION COUNTER TUBE

End window halogen quenched β radiation counter tube.

QUICK REFERENCE DATA		
Window thickness	3.5 to 4	mg/cm^2
Window diameter	51	mm
Operating voltage	700 to 1100	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	3.5 to 4	mg/cm^2
Effective diameter	51	mm
Material	mica	

CATHODE

Thickness	1.25	mm
Effective length	25	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	5	pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	700 to 1100		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 900 V	N_o	max.	30	counts/min.
Dead time at V_b = 900 V	τ	max.	45	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	3.9	MΩ
Anode voltage	V_a	max.	1100	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 2500 c/s 5.10^{10} counts

MEASURING CIRCUIT

R = 4.7 MΩ

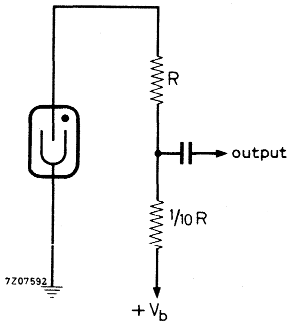
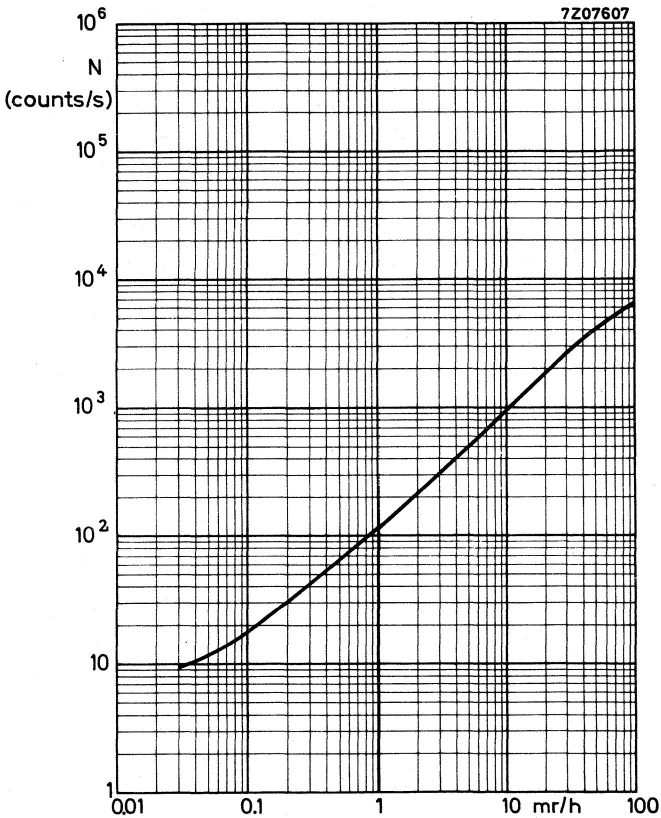
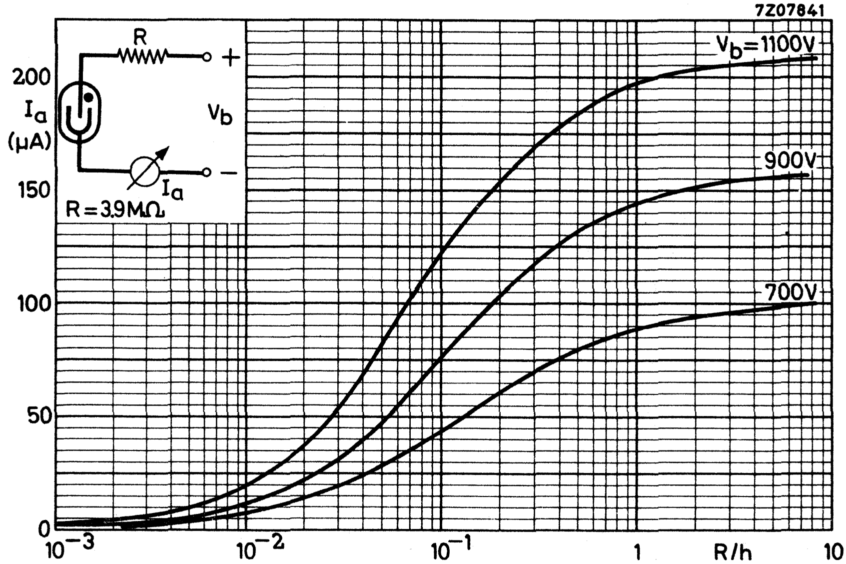


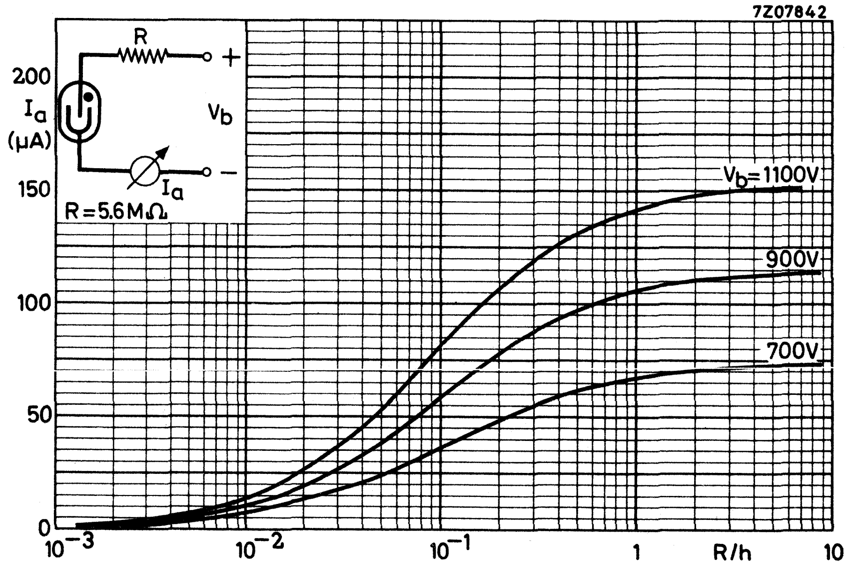
Fig.1



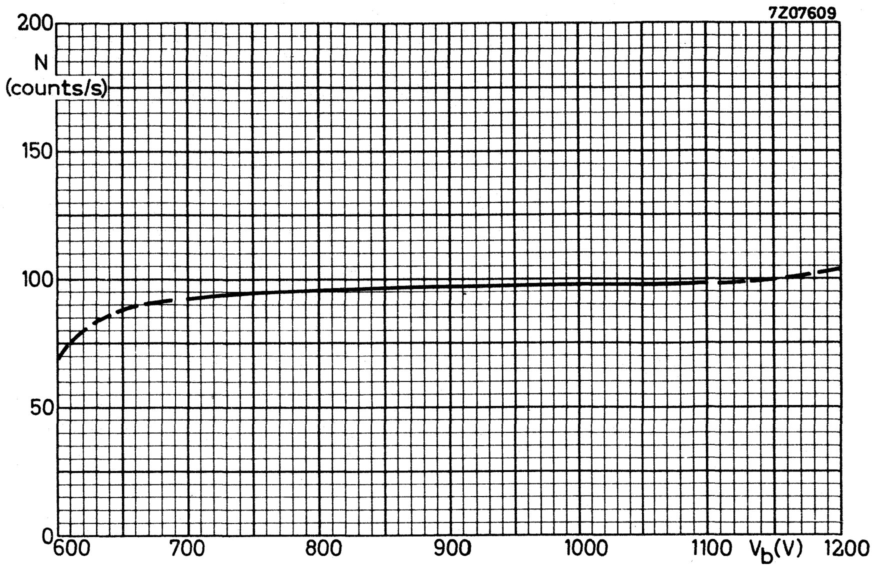
Count rate as function of dose rate



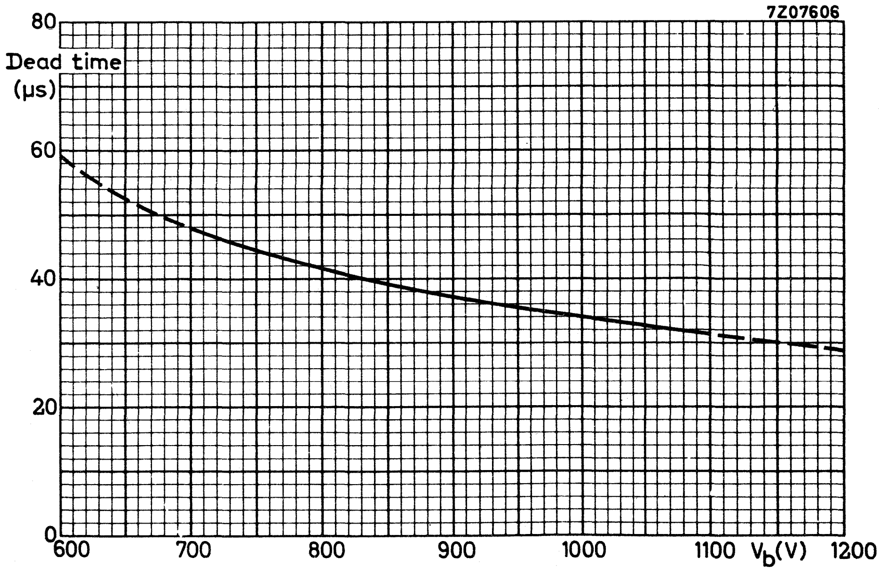
Current as function of dose rate



Current as function of dose rate



Plateau curve



Dead time curve

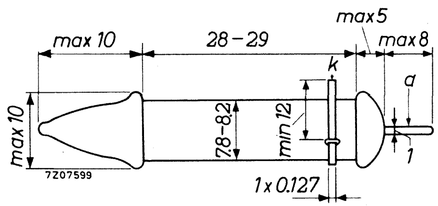
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (>0.25 MeV) and γ radiation counter tube.

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-3} to 10^{2}	R/h
Cathode wall thickness	32 to 40	mg/cm^2
Operating voltage	500 to 650	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	32 to 40	mg/cm^2
Effective length	28	mm
Material	28%Cr, 72%Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 1.1 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	380	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to 650		V
Plateau slope	S_{pl}	max.	0.08	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 575 V	N_o	max.	12	counts/min.
Dead time at V_b = 600 V	τ	max.	45	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	650	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 800 c/s 5.10^{10} counts

MEASURING CIRCUITS

R_1 = 4.7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

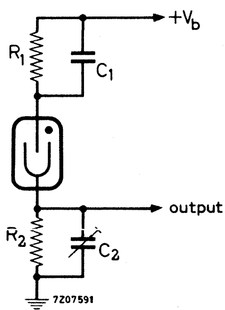
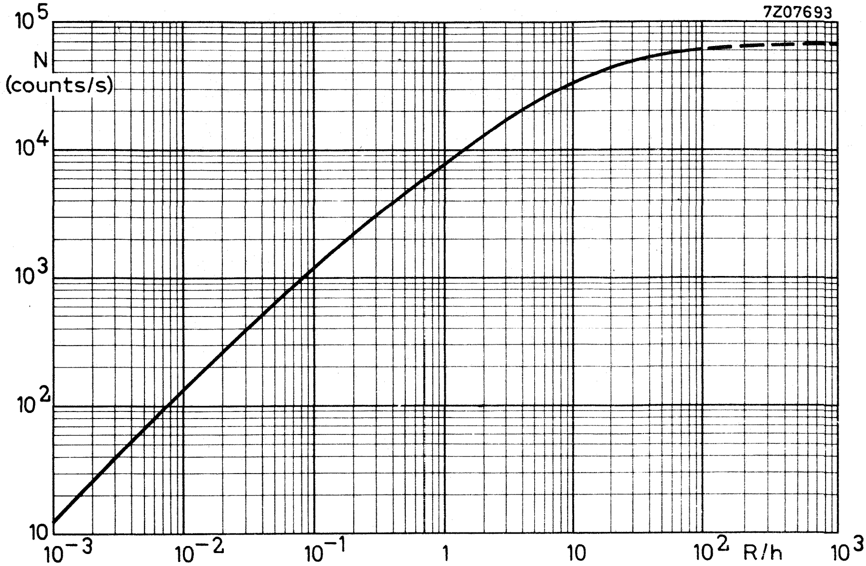
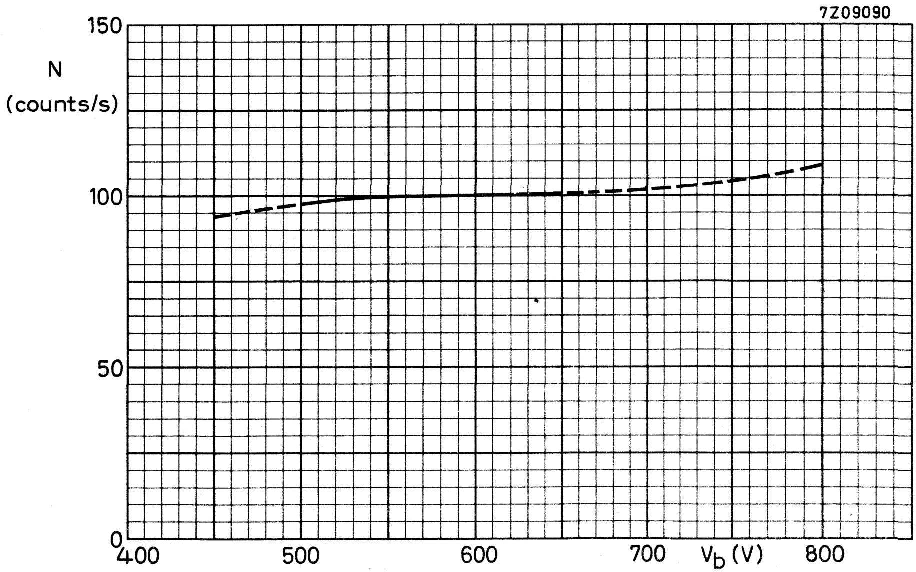


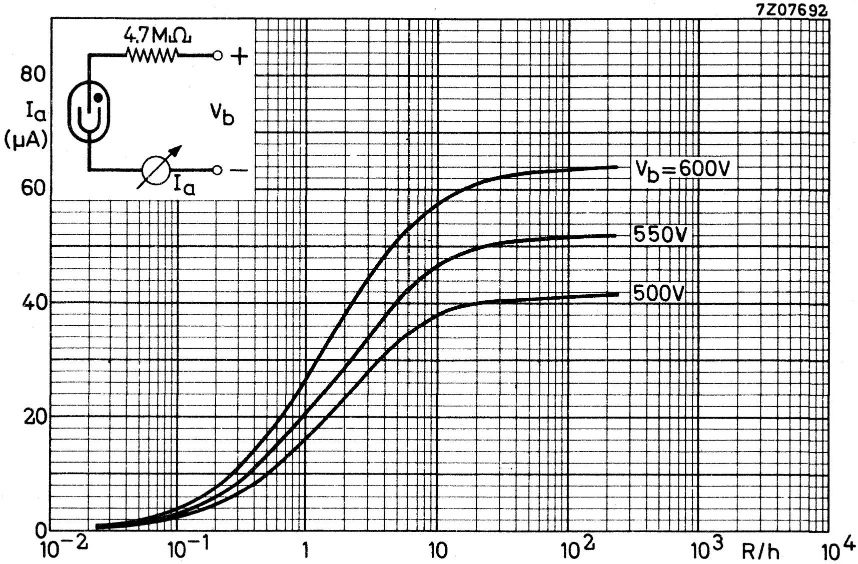
Fig.1



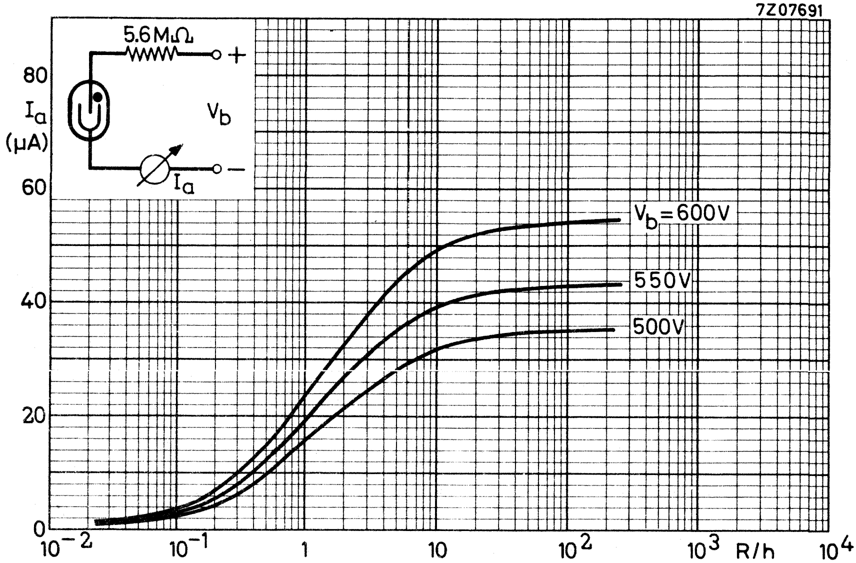
Count rate as function of dose rate



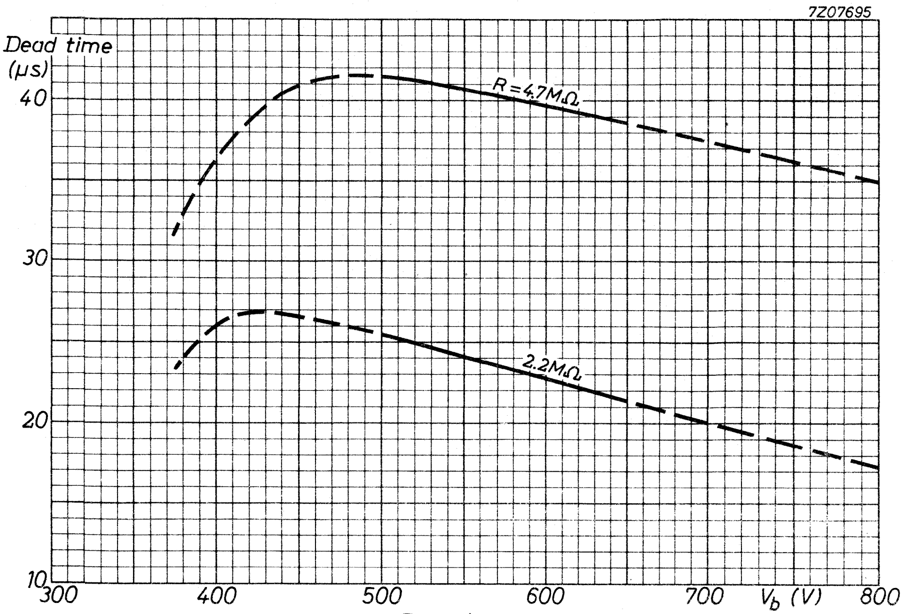
Plateau curve



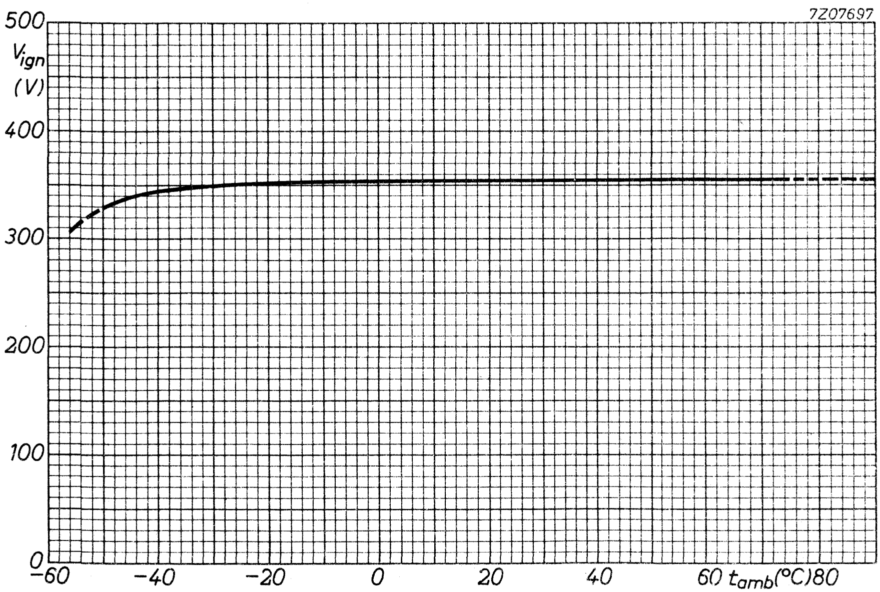
Current as function of dose rate



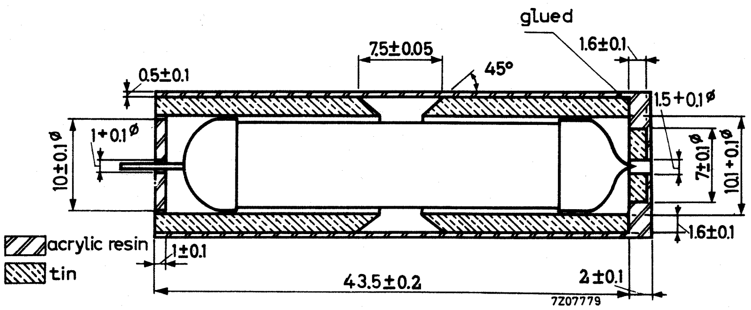
Current as function of dose rate

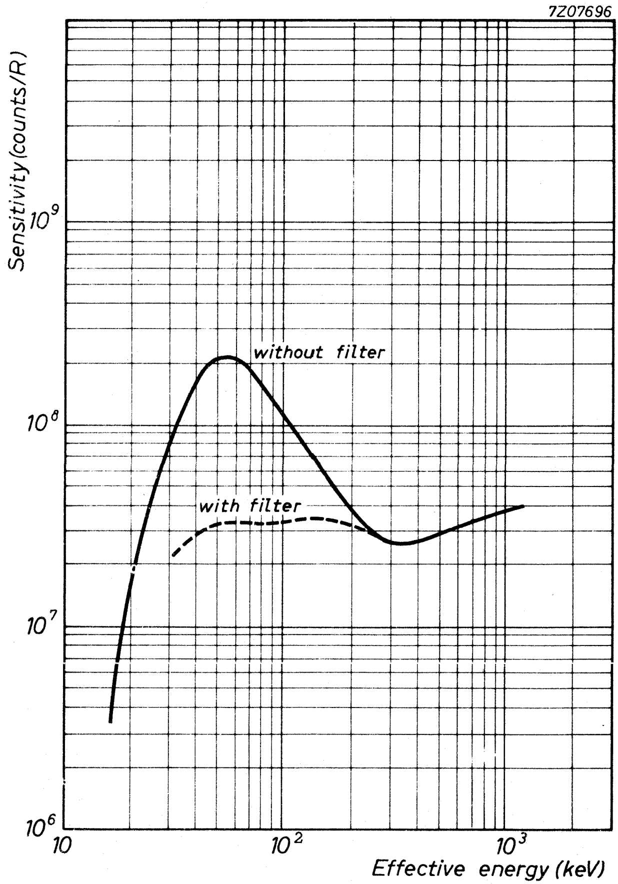


Dead time curve



Starting voltage as function of ambient temperature





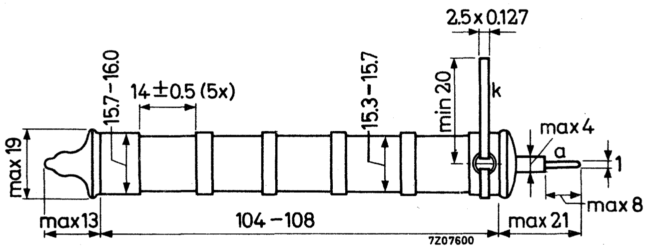
Energy response curve (side response)

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (>0.3 MeV) and γ radiation counter tube.

QUICK REFERENCE DATA		
Range ($^{60}Co\,\gamma$ radiation)	10^{-3} to 10	R/h
Cathode wall thickness between the strengthening rings	40 to 60	mg/cm^2
Operating voltage	450 to 800	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Construction	cylindrical wall with strengthening rings
Thickness between the strengthening rings	40 to 60 mg/cm^2
Total effective length	75 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig. 1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 800		V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 625 V	N_o	max.	30	counts/min.
Dead time at V_b = 600 V	τ	max.	70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	1	MΩ
Anode voltage	V_a	max.	800	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 600 c/s 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

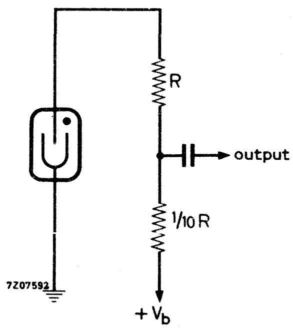


Fig. 1

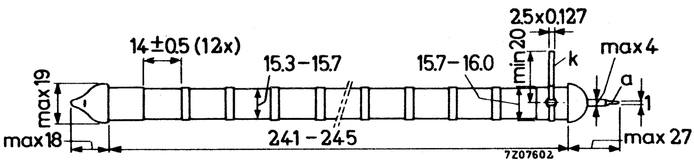
OBSOLESCENT TYPE

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (>0.3 MeV) and γ radiation counter tube

QUICK REFERENCE DATA	
Range (^{60}Co γ radiation)	10^{-4} to 1 R/h
Cathode wall thickness between the strengthening rings	40 to 60 mg/cm^2
Operating voltage	450 to 800 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Construction: cylindrical wall with strengthening rings

Thickness between the strengthering rings: 40 to 60 mg/cm^2

Total effective length between the strengthening rings: 185 mm

Material: 28% Cr, 72% Fe

FILLING: Ne, A, halogen

CAPACITANCE

Anode to cathode: C_{ak} 10 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 800		V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al, at V_b = 625 V	N_o	max.	60	counts/min.
Dead time at V_b = 600 V	τ	max.	100	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	800	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 600 c/s 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

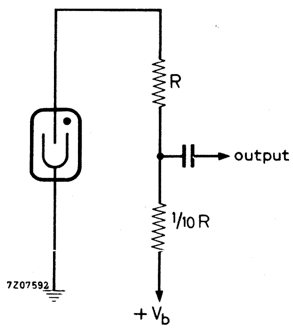
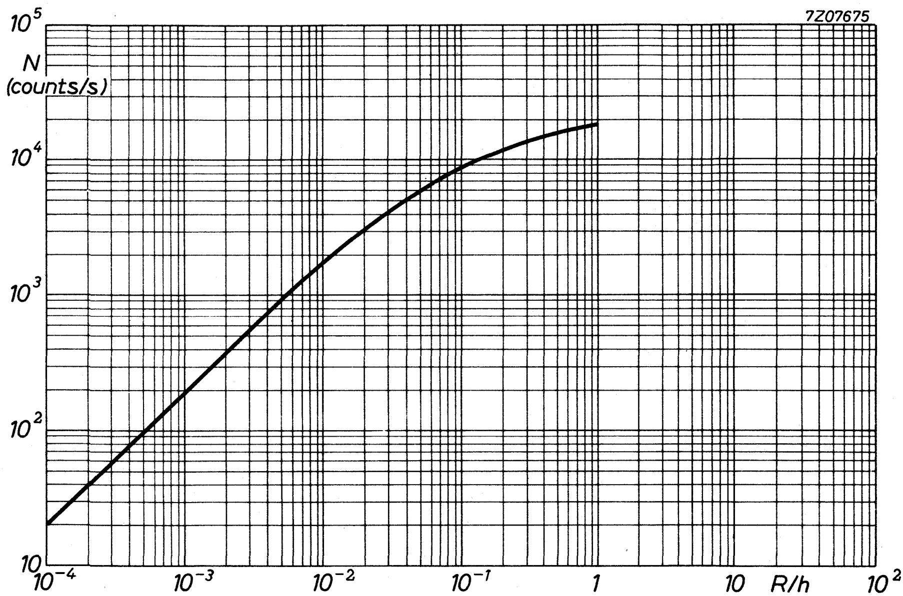
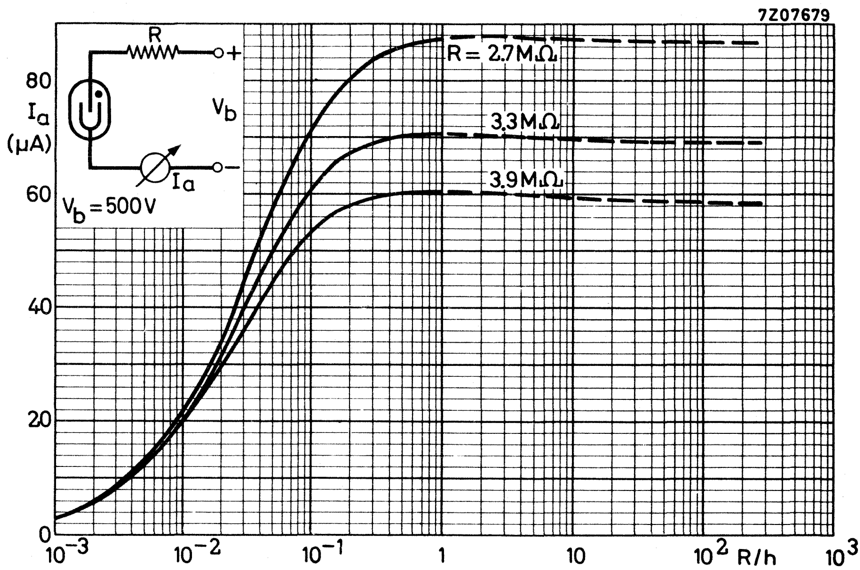


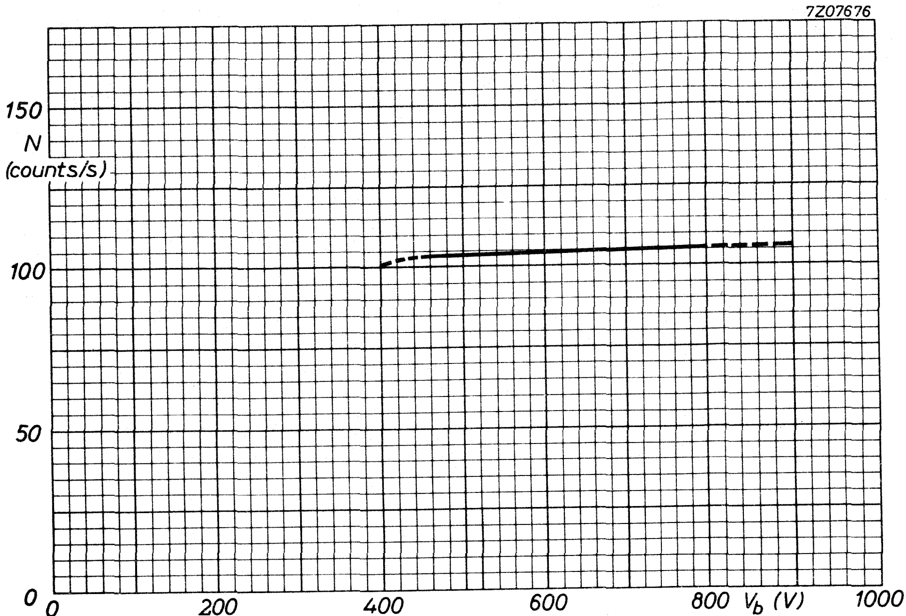
Fig.1



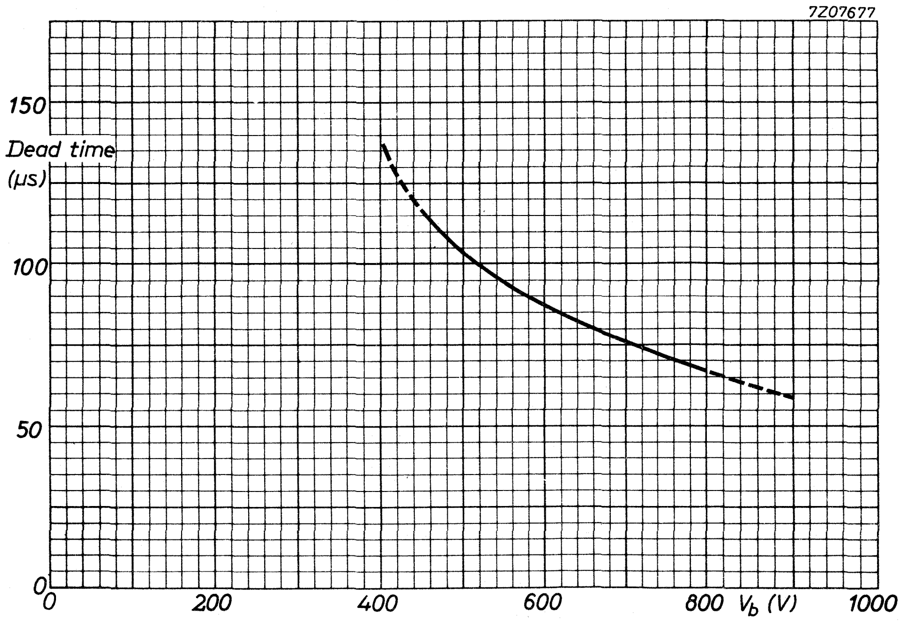
Count rate as function of dose rate



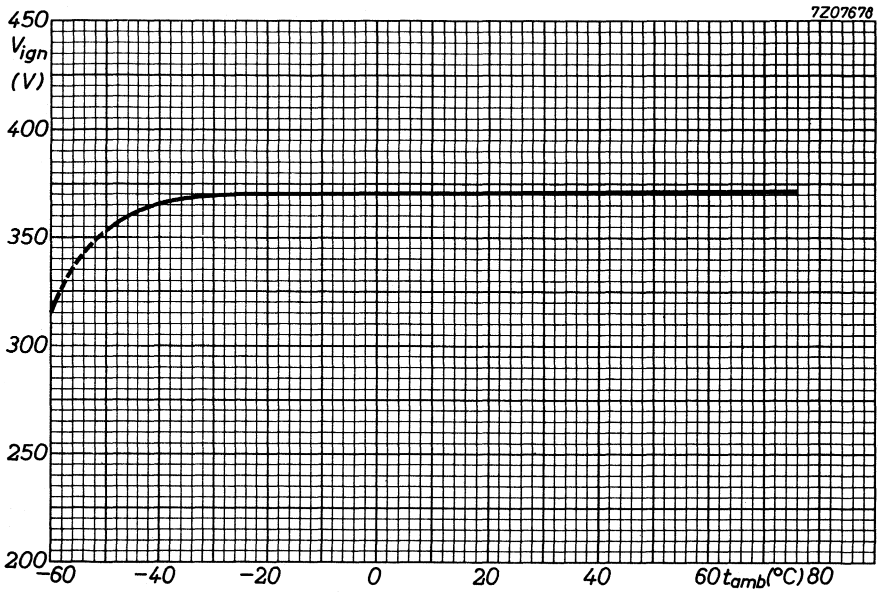
Current as function of dose rate



Plateau curve



Dead time curve



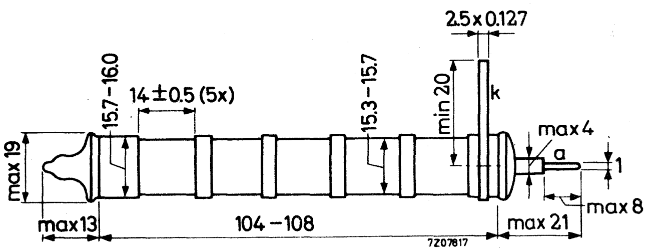
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (> 0.3 MeV) and γ radiation counter tube suitable for use in damp and/or saline atmosphere.

QUICK REFERENCE DATA		
Range (^{60}Co γ radiation)	10^{-3} to 10	R/h
Cathode wall thickness between the strengthening rings	40 to 60	mg/cm^2
Operating voltage	450 to 800	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Construction	cylindrical wall with strengthening rings
Thickness between the strengthening rings	40 to 60 mg/cm^2
Total effective length	75 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1.

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}		450 to 800	V
Plateau slope	S_{pl}	max.	0.02	%/V
Background shielded with 50 mm Pb and 3 mm Al, at V_b = 625 V	N_o	max.	30	counts/min.
Dead time at V_b = 600 V	τ	max.	70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	1	MΩ
Anode voltage	V_a	max.	800	V
Ambient temperature	t_{amb}	min.	−50	°C
		max.	+75	°C
for continuous operation		max.	+50	°C

LIFE EXPECTANCY

Life expectancy at t_{amb} = 25 °C, count rate 600 c/s 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

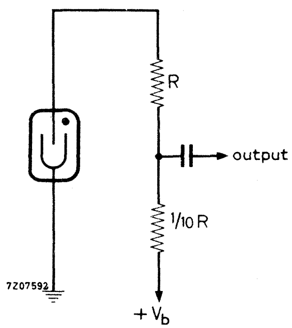
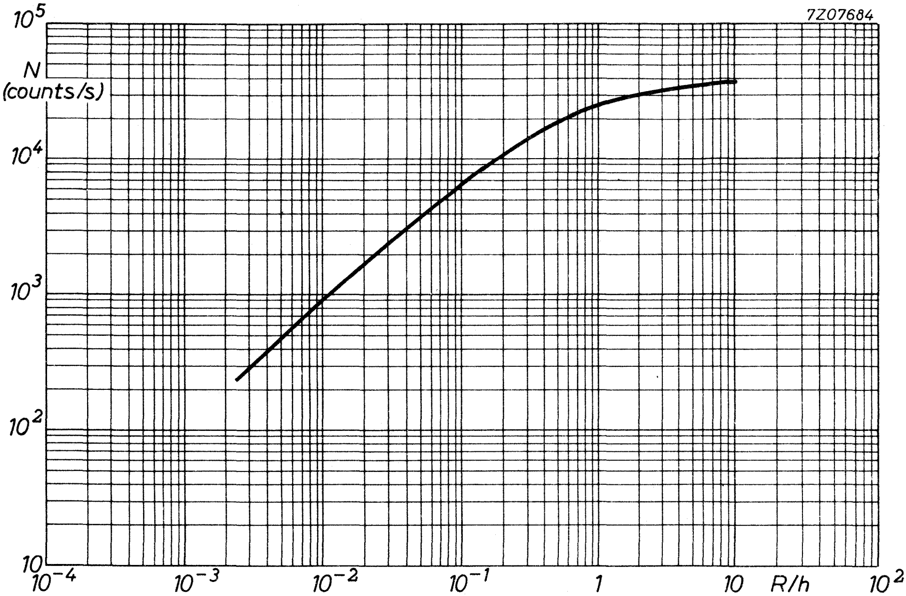


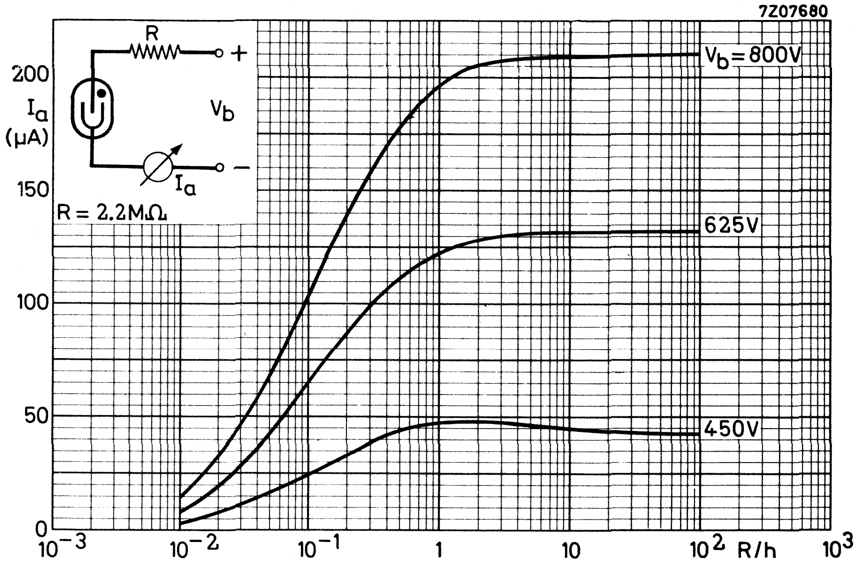
Fig. 1

REMARK

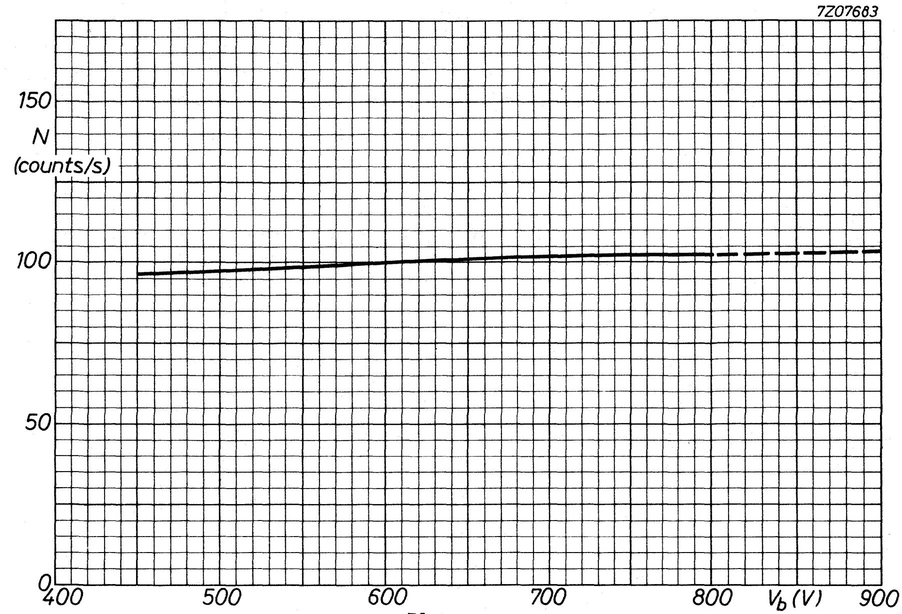
The cathode is covered with a corrosion resistive coating of lacquer, fulfilling the conditions of salt spray testing according to ASTM B117-49T and PNX41-002.



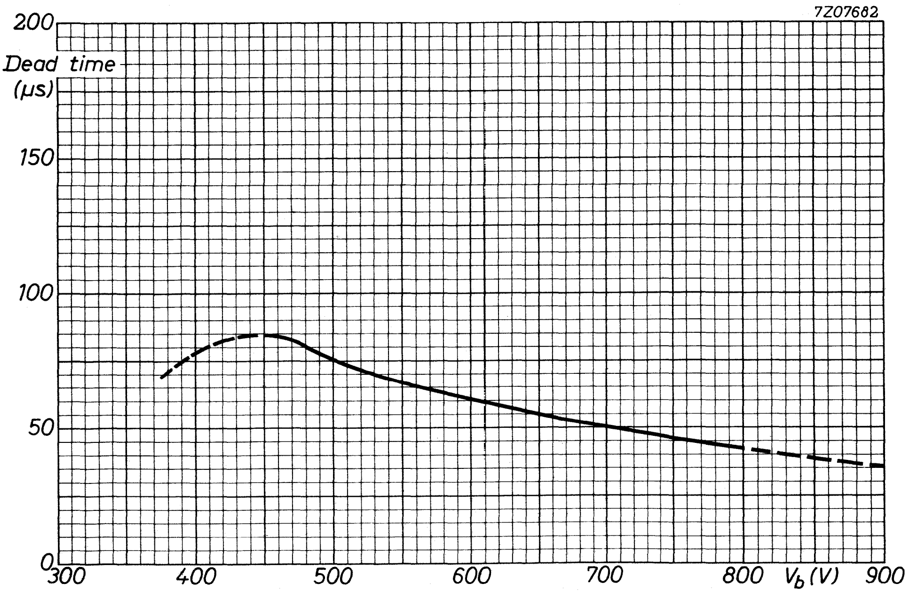
Count rate as function of dose rate



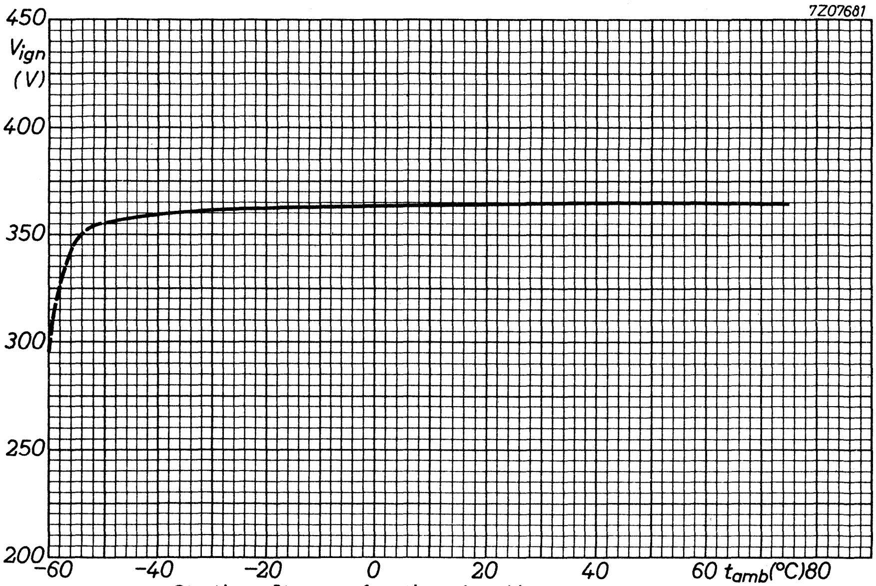
Current as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

Semiconductor radiation detectors

SEMICONDUCTOR RADIATION DETECTORS
SURVEY OF TYPES

Lithium drifted germanium detectors	
<u>Coaxial</u>	
Ture coaxial (double open-ended)	APY21 to APY27
Coaxial, closed ended	APY41 to APY49
Well type	APY56 to APY59
<u>Planar</u>	
Standard	APY16 to APY19
Thin window	APY30, APY31 APY36 to APY38
Lithium drifted silicon detectors	BPX10 to BPX14 BPX56, BPX57
Silicon surface barrier detectors	
<u>Partially depleted</u>	
Circular	BPY51 to BPY57
Annular	BPY58, BPY59
<u>Totally depleted</u>	
Circular	BPY81 to BPY87
Annular	BPY88, BPY89
<u>Chequer-board</u>	BPY75-300
Diffused silicon detectors	BPY20 to BPY24
Pre-amplifiers	56050-01 56054-01 to 56057-01 56059
Cryostats	CRY201 to CRY204

For full information on semiconductor radiation detectors and accessories please ask for "Product Survey Semiconductor Radiation Detectors"

Neutron generator tubes

LIST OF SYMBOLS

Electrodes

a	anode
coll	collector
f	filament or filamentary cathode, heater
g	grid
k	cathode
t	target

The electrodes of multiple-unit tubes, in which the units are dissimilar, are distinguished by the following indices:

IG	ionization gange
IS	ion source
PR	pressure regulator

Voltages

V	symbol for voltage, followed by indices denoting the relevant electrode, reference electrode, and unit, if necessary [1].
V_b	supply voltage
V_p	peak value of a voltage

Currents

I	symbol for current, followed by indices denoting the relevant electrode, and unit, if necessary.

Miscellaneous

n	neutron output
p	pressure
g	flow-rate
s	sensitivity
t	temperature; t_{amb} = ambient temperature
T	time (period): T_{av} = averaging time
δ	duty factor
W	dissipation

1) Voltages between electrodes are denoted as V./--, in which/-- indicates the reference electrode. /-- may be omitted if no confusion can arise.
Example:
$V_{kIS/t}$ = voltage between the cathode of the ion source and the target; target reference.

NEUTRON GENERATOR TUBE

Sealed-off neutron generator tube for continuous operation.

DESCRIPTION

The 18600R is a compact and sturdy sealed-off accelerating tube generating over 10^8 14 MeV neutrons per second on the basis of the ^3H (d,n) ^4He reaction. It is a mono-energetic continuous neutron source, operating at a target voltage of - 125 kV w.r.t. earth. The incorporated Penning ion-source operates at the same pressure as the accelerating system.

The gas filling is a mixture of deuterium and tritium, the pressure of which is controlled by a pressure regulator.

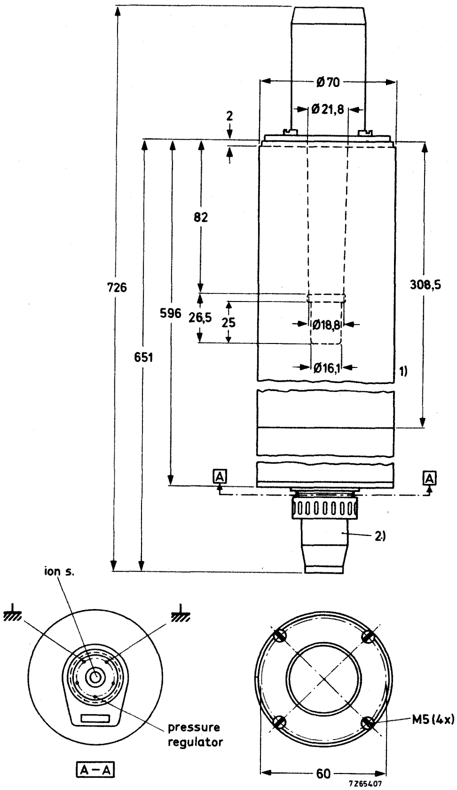
The beam of accelerated deuterium and tritium ions strikes and replenishes the titanium-tritium target. Hence the tube life is not limited by the tritium content of the target, resulting in a tube life expectancy of more than 1000 hours under "Typical operating conditions".

APPLICATIONS

1. Soil studies, e.g. for road and airport construction.
2. Ground water measurements for irrigation or drainage projects.
3. Moisture control of foundry sand.
4. Fast reactor control.
5. Sub-critical reactor research.
6. Fundamental nuclear research.
7. Education.

MECHANICAL DATA AND CONNECTIONS

Dimensions in mm



Weights

		Tube	HT cable	
Net weight	approx.	5	14	kg
Shipping weight	approx.	12	15	kg

Mounting position : any

---

1) The location of the target is indicated by a groove in the tube envelope.

2) LT 6-pin female connector type number 56008.

Accessories

a) Supplied with tube

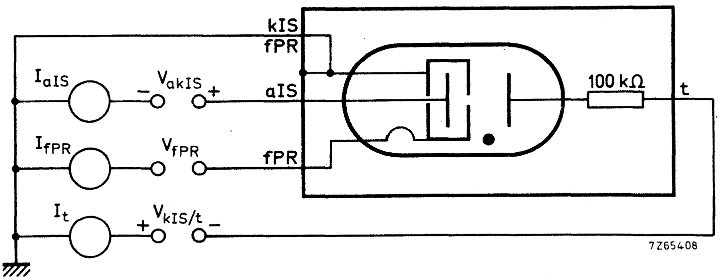
Tube of silicon grease DC 4	type number 56007
Low tension 6-pin female connector	type number 56008

b) Optimal at extra cost

High tension cable, length 15 m	type number 56038

CHARACTERISTICS

Neutron energy (DT reaction)	approx.	14	MeV
Neutron output at an accelerating voltage = 125 kV, target current = 100 μA	n	$> 10^8$	n/s
Neutron output = f(accelerating voltage)	see page 5		
Target current = f(accelerating voltage)	see page 6		
Capacitance target to envelope		40	pF



TYPICAL OPERATING CONDITIONS

The voltages are measured on the tube terminals.

Neutron output	n	$> 10^8$	n/s
Accelerating voltage, d.c.	$V_{kIS/t}$	125	kV
Target current, d.c.	I_t	100	μA
Ion-source voltage, d.c.	V_{akIS}	2	kV
Ion-source current, d.c.	I_{aIS}	0,3	mA
Filament current of pressure regulator	I_{fPR}	3,5	A
Ambient temperature	t_{amb}	25	°C

LIMITING VALUES (Absolute max. rating system)

Accelerating voltage	$V_{kIS/t}$	max.	130	kV [1]
Target current	I_t	max.	125	μA
Target dissipation	W_t	max.	12,5	W
Ion-source voltage	V_{akIS}	max.	2,5	kV
		min.	1,5	kV
Ion-source current	I_{aIS}	max.	0,6	mA
Filament voltage of pressure regulator	V_{fPR}	max.	3	V
Filament current of pressure regulator	I_{fPR}	max.	5	A
Ambient temperature	t_{amb}	max.	+70	°C
		min.	-5	°C

LIFE EXPECTANCY

The life expectancy of the tube is over 1000 hours under "Typical operating conditions".

WARNING

The tube contains 9,5 curie of titanium bound tritium. During and after use appropriate measures against neutron and secondary gamma radiation must be taken.

OPERATIONAL CONSIDERATIONS

For satisfactory operation of the tube the recommendations given in the "Instructions for first operation" packed with the tube should be carefully observed.

For operation under non-typical conditions, please contact the manufacturer.

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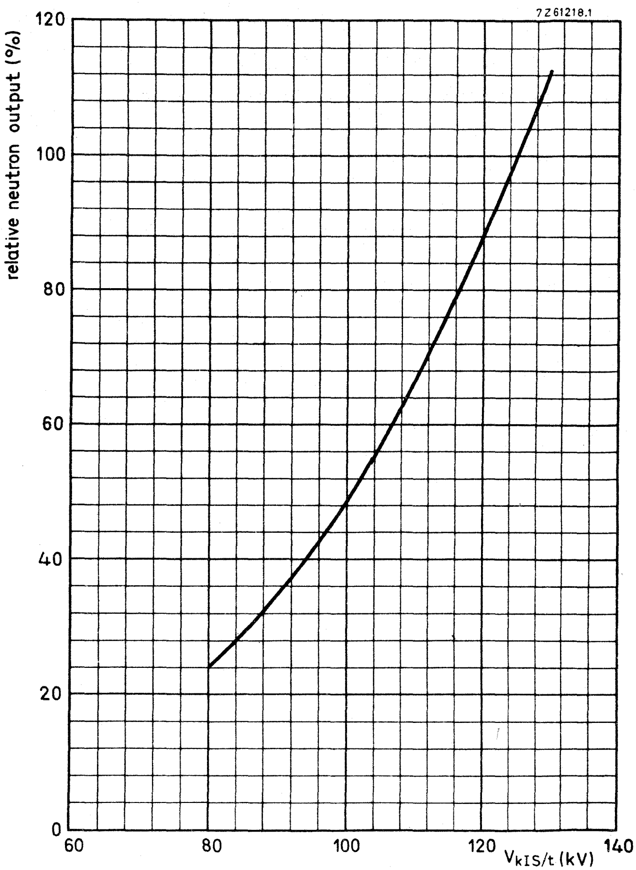
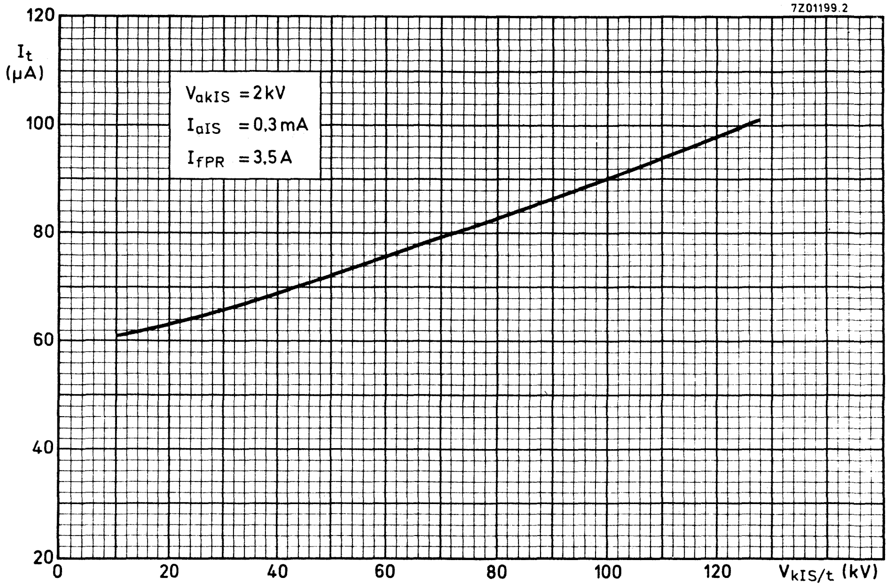
[1]) Breakdown in the HT supply equipment should be avoided, since the resulting oscillations in the secondary L-C circuit may lead to destruction of the tube. In order to protect the tube it is recommended to use a current limiting resistor of 3 MΩ in the target supply line.



Relative neutron output as a function of the accelerating voltage.

V_{akIS} = 2 kV
I_{aIS} = 0,3 mA
I_{fPR} = 3,5 A



Target current as a function of the accelerating voltage.

NEUTRON GENERATOR TUBE

Sealed-off neutron generator tube for continuous and pulsed operation.

DESCRIPTION

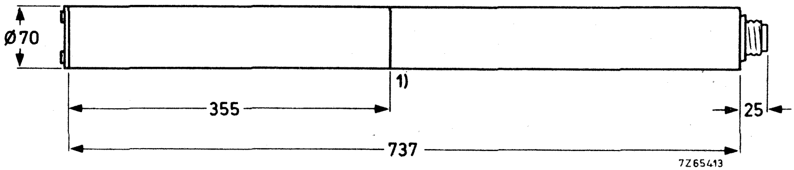
The 18601 is a sturdy and compact sealed-off accelerating tube generating 14 MeV neutrons on the basis of the ^{3}H (d,n) ^{4}He reaction.
It is a mono-energetic neutron source producing over 10^{8} neutrons per second in continuous operation and, in pulsed operation, up to 2×10^{11} neutrons per second during the pulse.
The incorporated Penning ion-source operates at the same pressure as the accelerating system.
The gas filling is a mixture of deuterium and tritium, the pressure of which is controlled by a pressure regulator and measured by a built-in ionization gauge.
The beam of accelerated deuterium and tritium ions strikes and replenishes the titanium-tritium target. Hence the tube life is not limited by the tritium content of the target, resulting in a tube life expectancy of more than 1000 hours under "Typical operating conditions".

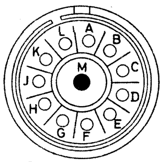
APPLICATION

1. Soil studies, e.g. for road and airport construction.
2. Ground water measurements for irrigation or drainage projects.
3. Moisture control of foundry sand.
4. Fast reactor control.
5. Subcritical reactor research.
6. Fundamental nuclear research.
7. Education.

MECHANICAL DATA AND CONNECTIONS

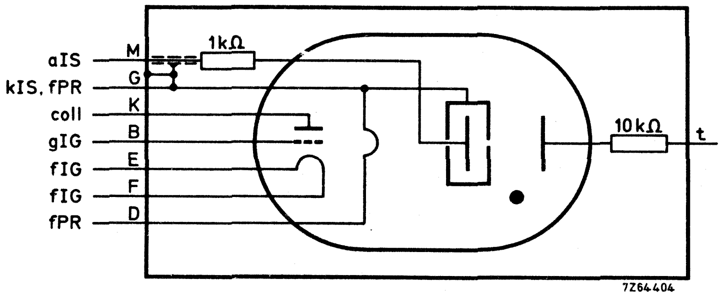
Dimensions in mm





plug connections

7Z07454



Mounting position — any

Weights

Net weight	approx. 6 kg
Shipping weight	approx. 12,5 kg

Accessories

a) Supplied with tube:

Tube of silicon grease DC4	type number 56007
Low tension 12-pin female connector	type number 56012

b) Optional at extra cost:

High tension cable, length 15 m	type number 56038
Supply cable (without connectors) for ion source, ionization gauge, and pressure regulator (length optional)	type number 56014

CHARACTERISTICS

Neutron energy (DT reaction)	approx.	14	MeV
Neutron output at an accelerating voltage = 125 kV, target current = 100 μA Continuous and average during pulsed operation	n	> 10^8	n/s
during pulse max. output		> 10^{11}	n/s
Pulse duration at an output of 10^{11} n/s T_{imb}		5 to 1000	μs
Neutron output = f (accelerating voltage)		see page 5	
Maximum duty factor = f (gas pressure)		see page 6	
Peak neutron output = (gas pressure)		see page 7	
Peak ion source current = f (gas pressure)		see page 8	
Peak target current = f (gas pressure)		see page 9	
Gas pressure = f (pressure regulator current)		see page 10	
Build-up time of ion source current pulse = f (gas pressure)		see page 11	

TYPICAL OPERATING CONDITIONS

		Continuous operation	Pulsed operation	
Neutron output	n	2 x 10^8	2 x 10^{11}	n/s
Pulse duration	T_{imp}	-	5 to 1000	μs
Accelerating voltage	$V_{kIS/t}$	125	125	kV
Target current	I_t	100	mean value 100	μA
Ion-source supply voltage	V_{bakIS}	2	1,6	kV
Ion-source current	I_{aIS}	10^{-4}	peak value 1	A
Filament current of pressure regulator	I_{fPR}	≈ 3	≈ 3,6	A
Gas pressure	p	6 x 10^{-5} (≈ 8 x 10^{-3})	8 x 10^{-3} (≈ 1)	torr N/m^2
Ambient temperature	t_{amb}	25	25	°C
Ionization gauge				
Emission current	I_{IG}	10		μA
Grid to filament voltage	V_{gfIG}	150		V
Filament voltage	V_{fIG}	≈ 2		V

LIMITING VALUES (Absolute max. rating system)

Accelerating voltage	$V_{kIS/t}$	max.	130	kV
Accelerating voltage, during continuous operation	$V_{kIS/t}$	min.	30	kV
during pulsed operation		min.	80	kV
Target dissiaption, during continuous operation	W_t	max.	12,5	W
during pulse operation (T_{av} = max. 5 s and δ = 0,5)		max.	15	W
Target current, during continuous operation	I_t	max.	100	μA
during pulse, peak value	I_{tp}	max.	300	mA
average value	I_t	max.	100	μA
during pulsed operation (T_{av} = max. 5 s and δ = 0,5)	I_t	max.	120	μA
Ion source supply voltage	$V_{b_{akIS}}$	max.	3	kV
Filament current of regulator	I_{fPR}	max.	6	A
Gas pressure	p	max.	10^{-2} (1,333)	torr N/m^2
Ambient temperature	t_{amb}	max.	+70	°C
		min.	-5	°C

LIFE EXPECTANCY

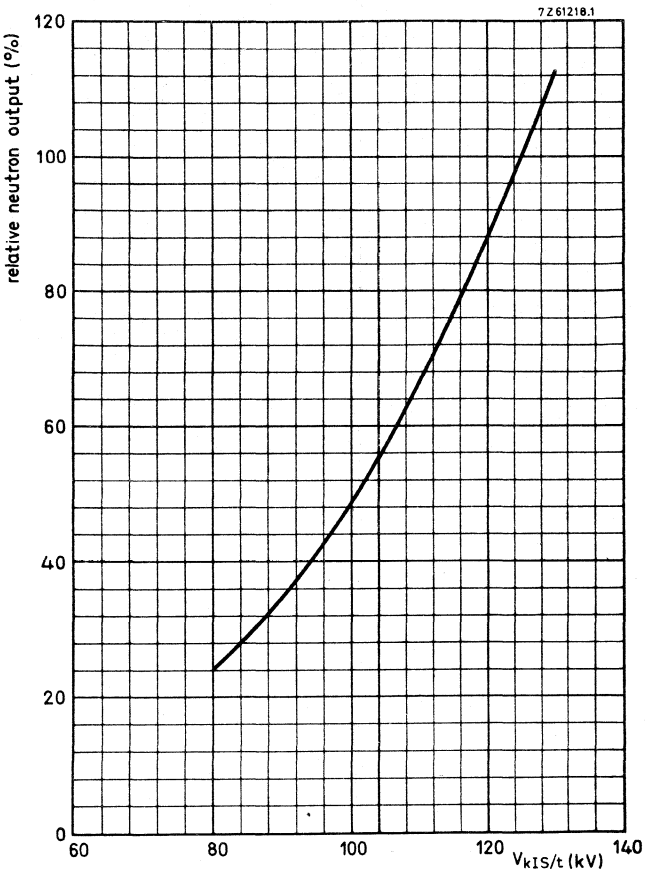
The life expectancy of the tube is > 1000 hours under "Typical operating conditions".

WARNING

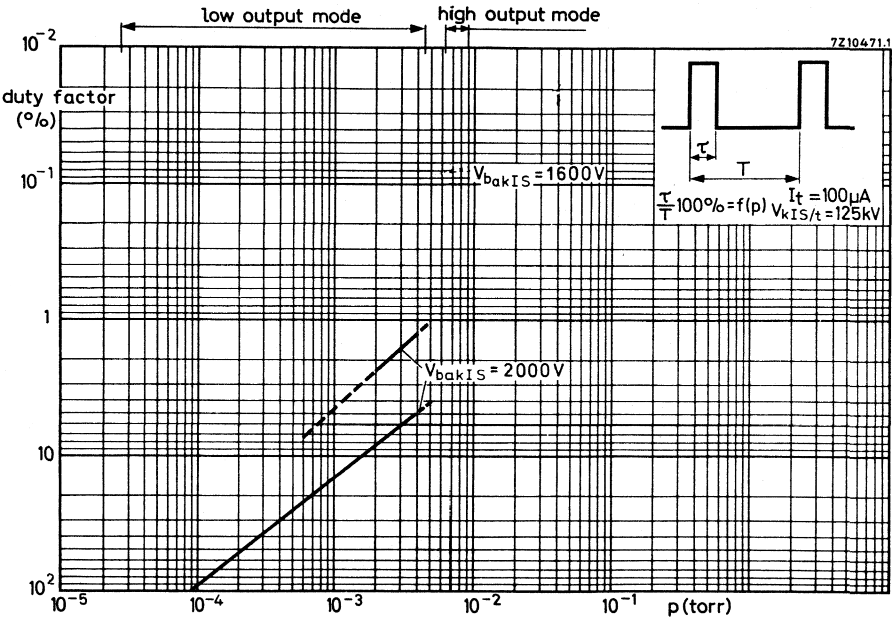
The tube contains 9,5 curie of the titanium bound tritium. During and after use appropriate measures against neutron and secondary gamma radiation must be taken.

OPERATIONAL CONSIDERATIONS

For satisfactory operation of the tube recommendations given in the "Instructions for operation" packed with the tube should be carefully observed.



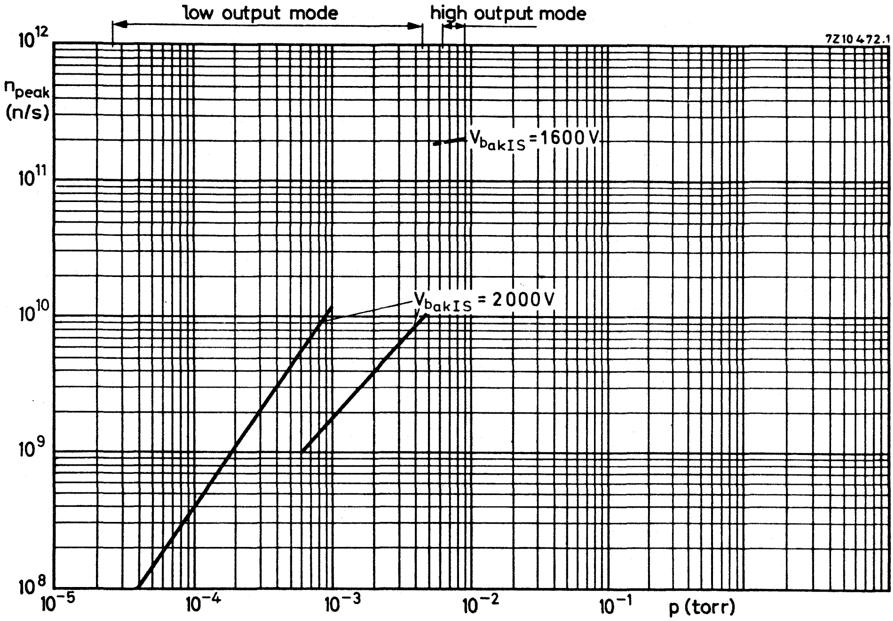
Neutron output = f (accelerating voltage)



Minimum duty factor as a function of gaspressure (p)

NOTE

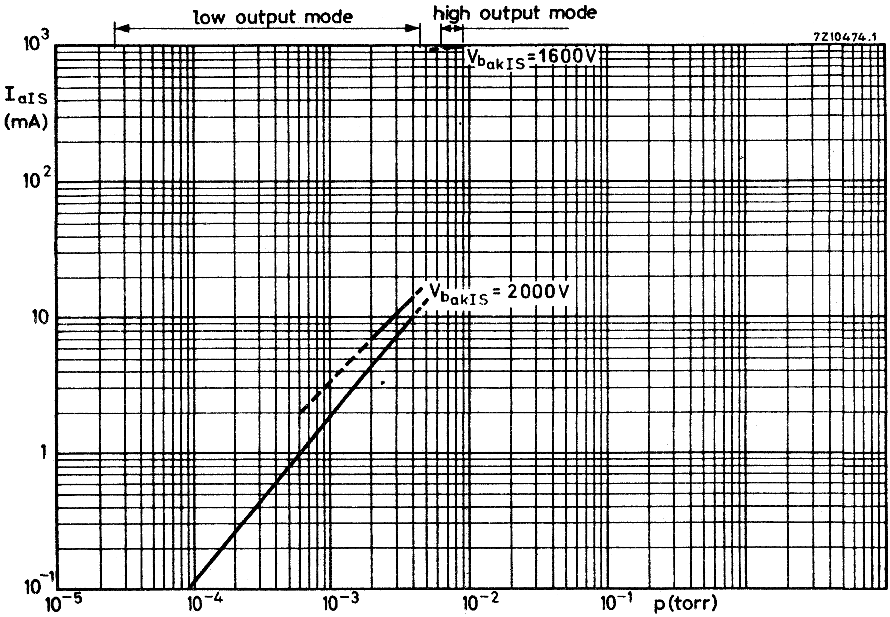
- In the dashed ranges the ion source produces different types of discharge resulting in a variation in neutron output per pulse.



Peak neutron output (n_{peak}) as a function of gaspressure (p)
$V_{kIS/t}$ = 125 kV

NOTES

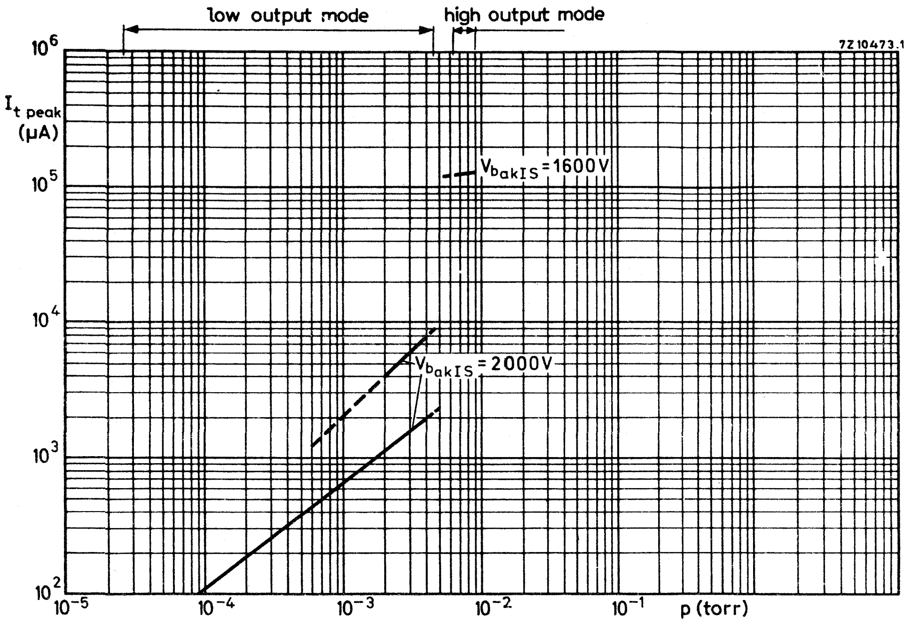
- It is not permitted to operate the tube at a gas pressure higher than that given for each of the performance ranges in order to avoid exceeding the maximum **target** dissipation.
- In the dashed ranges the ion source produces different types of discharge resulting in a variation in neutron output per pulse.



Peak ion source current (I_{ISpeak}) as a function of gaspressure (p)

NOTE

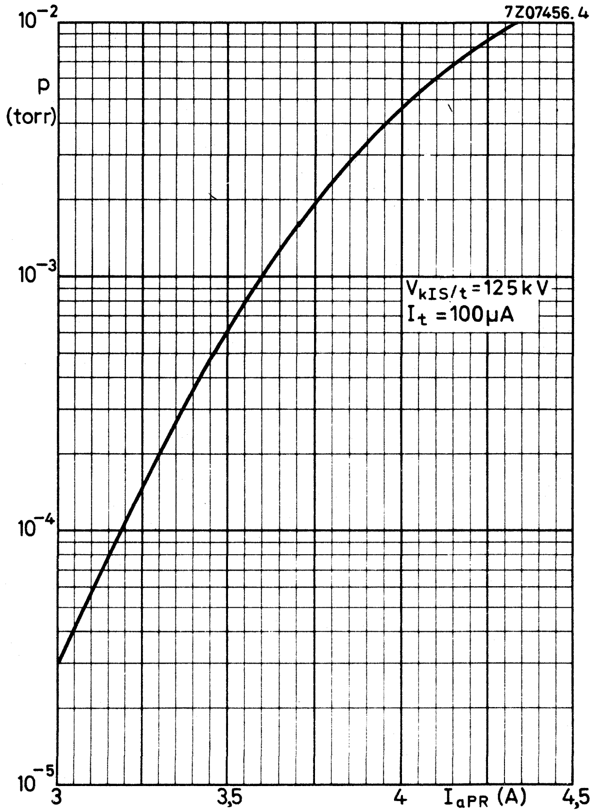
- In the dashed ranges the ion source produces different types of discharge resulting in a variation in neutron output per pulse.



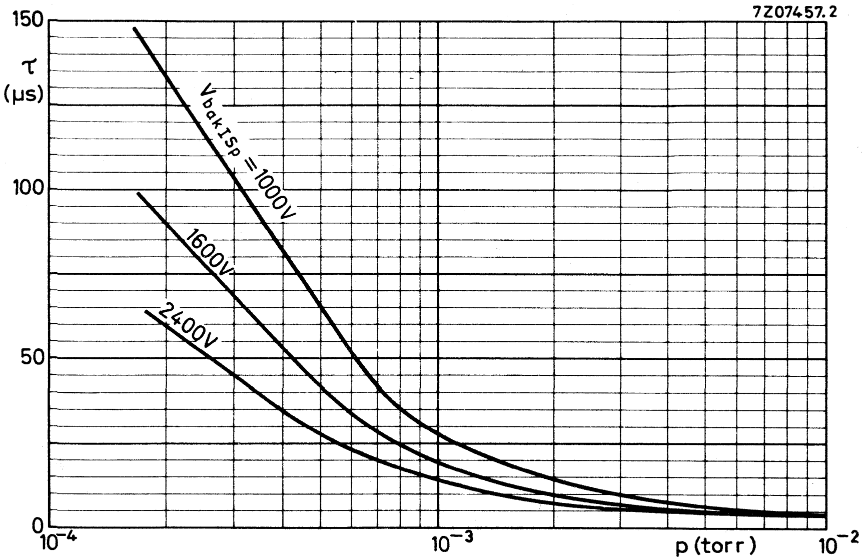
Peak target current ($I_{t\ peak}$) as a function of gaspressure (p)

NOTE

- In the dashed ranges the ion source produces different types of discharge resulting in a variation in neutron output per pulse.



Gas pressure (p) as a function of pressure regulator current (I_{PR})



Build-up time (τ) of ion source current pulse as a function of gas pressure (p)

NEUTRON GENERATOR TUBE

Sealed-off neutron generator tube for continuous operation.

DESCRIPTION

The 18602 is a sturdy and compact sealed-off accelerating tube, generating over 2×10^{10} 14 MeV neutrons per second on the basis of $^{3}H(d,n)^{4}He$ reaction. It is a mono-energetic continuous neutron source.
A high useful neutron flux is obtained because of the good accessibility of the water-cooled grounded target.
The Penning ion source operates at the same pressure as the accelerating system, at a positive potential of 150 kV with respect to the target. By keeping the accelerating electrode at a negative potential with respect to the target, it acts as a trap for secondary electrons formed at the target, preventing them from reaching the ion source.

By replenishing the tritium content of the titanium-tritium target the tube life may extend to over 1000 neutron generating hours. The pressure of the deuterium-tritium gas filling is controlled by a pressure regulator and measured by means of the built-in ionization gauge.

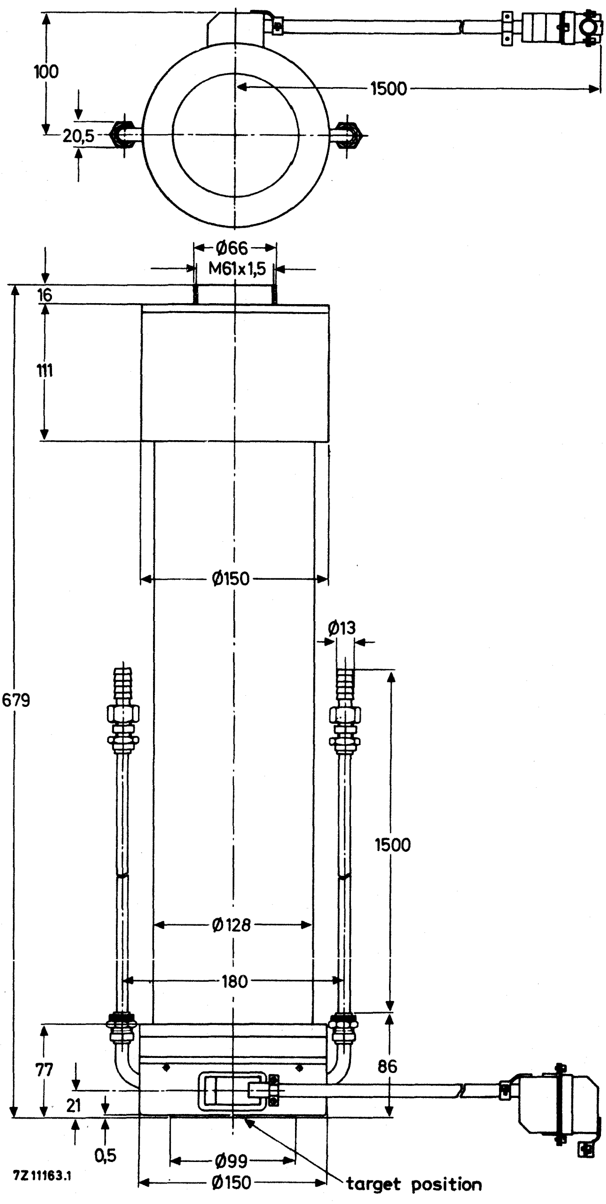
By automatically stabilizing the target current - by means of an electronic circuit controlling the gas pressure regulator - the tube can be operated continuously, unattended.

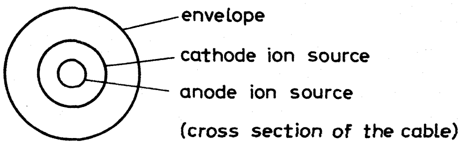
APPLICATION

1. Activation analysis.
2. Radio biology.
3. Radio chemistry.
4. Neutron radiography.
5. Neutron dosimetry.
6. Investigation of neutron collimation.
7. Investigation of shielding.
8. Radiation damage studies.
9. Isotope production.
10. Fast reactor control.
11. Nuclear physics research.
12. Solid state physics.
13. Education.
14. Nuclear safeguards.

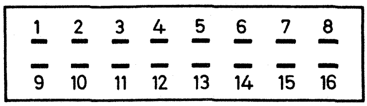
MECHANICAL DATA AND CONNECTIONS

Dimensions in mm



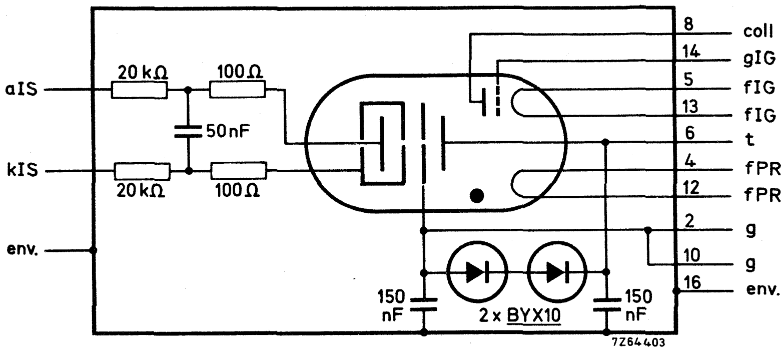


high voltage cable connection



Amphenol plug no. 26-4401-16p

7Z10956



Mounting position : vertical
For other mounting positions please contact the manufacturer.

Weights

Net weight	approx. 14,5 kg
Shipping weight	approx. 29 kg

Accessories

a) Supplied with the tube

Low tension cable with connectors and loose socket for pressure regulator and ionization gauge	type number 56015
Cooling water tubes with couplings (two supplied with each 18602)	type number 56016
Silicon rubber sleeve for high tension cable	type number 56017 [1])

b) optional at extra cost

High tension cable, length 5 m, with connectors	type number 56036
High tension socket to be built into the high tension supply unit	type number 56018
Socket for low tension cable 56018	type number 56023
Plug for low tension socket 56023	type number 56024
Strap wrench for tightening high tension connectors	type number 56013 [1]
Allen wrench 2 mm for installing high tension cable	type number 56034 [1]

1) Standard accessories with high tension cable 56036.

CHARACTERISTICS

Neutron energy (DT-reaction)	approx.	14	MeV
Neutron output at an accelerating voltage = 150 kV, target current = 1,5 mA	typical	3×10^{10}	n/s
Neutron output = f(accelerating voltage)	see page	8	
Neutron output = f(target current)	see page	9	
Typical ion source characteristics	see page	10	
Suppressor current = f(target current)	see page	11	

TYPICAL OPERATION

Neutron output	n	3×10^{10}	n/s
Accelerating voltage	$V_{kIS/t}$	150	kV
Target current	I_t	1,5	mA
Ion source supply voltage	V_{bakIS}	5	kV
Ion source current	I_{aIS}	6	mA
Gas pressure	p	$\approx 1,6 \times 10^{-3}$	torr abs.
Suppressor voltage	V_{tg}	500	V
Suppressor current	I_g	160	μA
Filament current of pressure regulator	I_{fPR}	≈ 4	A
Ambient temperature	t_{amb}	25	°C
Cooling water flow	q	6 to 8	l/min
Ionization gauge			
Emission current	I_{em}	100	μA
Grid to filament voltage	V_{gf}	180	V
Filament voltage	V_f	≈ 2	V
Sensitivity (collector current)	s	≈ 0,5	$\mu A/10^{-3}$ torr abs

LIMITING VALUES (Absolute max. rating system)

Accelerating voltage	$V_{kIS/t}$	max.	160	kV
Target dissipation	W_t	max.	225	W
Ion source supply voltage	V_{bakIS}	max.	8	kV
Ion source current	I_{aIS}	max.	8	mA
Filament current of pressure regulator	I_{fPR}	max.	8	A
Filament voltage of pressure regulator	V_{fPR}	max.	2	V
Suppressor voltage	V_{tg}	max.	800	V
		min.	450	V
Gas pressure	p	max.	3×10^{-3}	torr abs.
			(0, 133	N/m^2)
Ambient temperature	t_{amb}	max.	70	^oC
		min.	-5	^oC
Pressure at cooling water inlet	p	max.	2	at abs.
			$(2,03 \times 10^5$	N/m^2)
Inlet temperature of cooling water	t_i	max.	25	^oC
Permissible lenght of high tension cable	l	max.	8	m
Total high tension cable capacitance	C	max.	1500	pF

LIFE EXPECTANCY

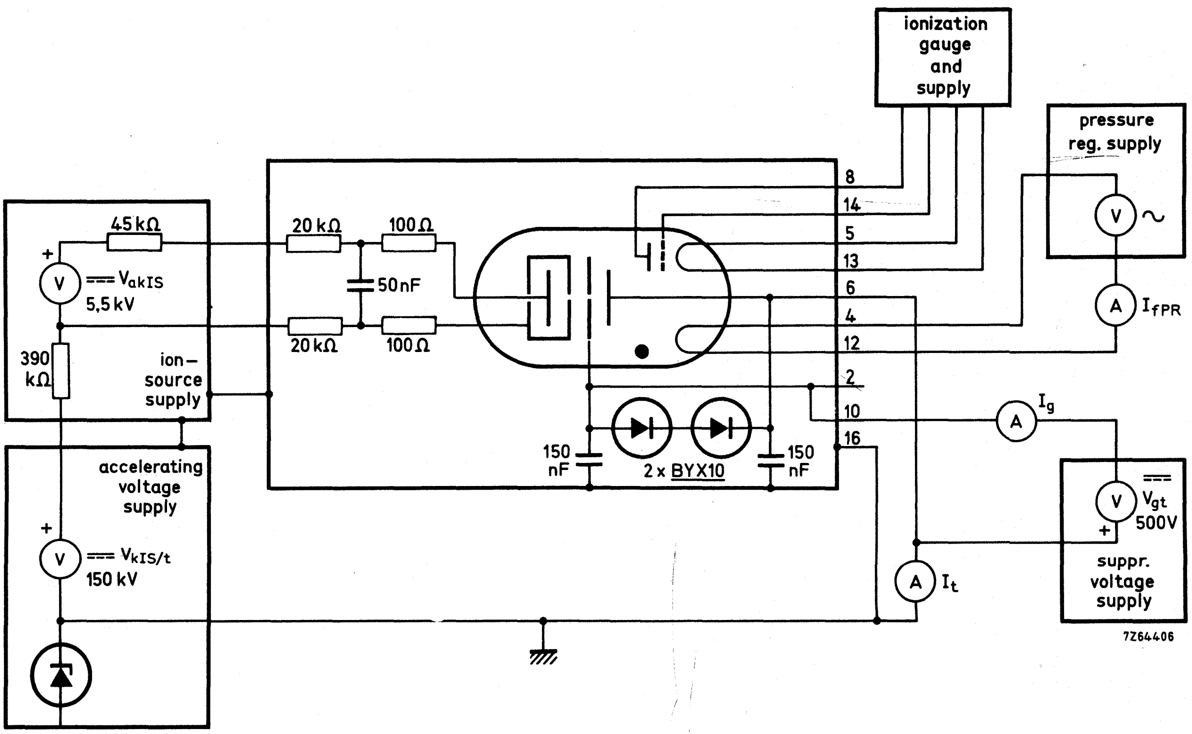
The life expectancy of the tube is over 1000 hours under "Typical operating conditions".

WARNING.

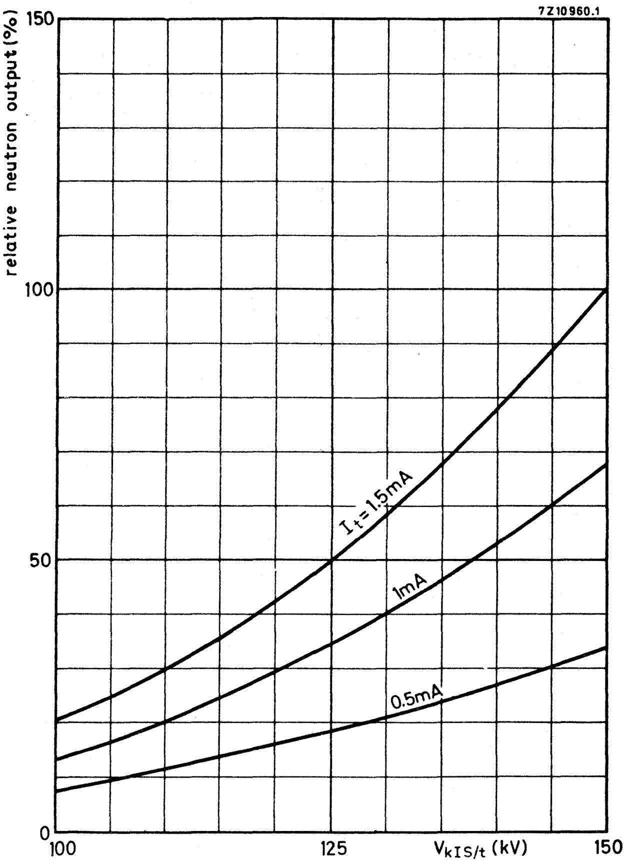
The tube contains 20 curie of titanium-bound tritium. During and after use appropriate measures against neutron and secondary beta and gamma radiation must be taken.

OPERATIONAL CONSIDERATIONS

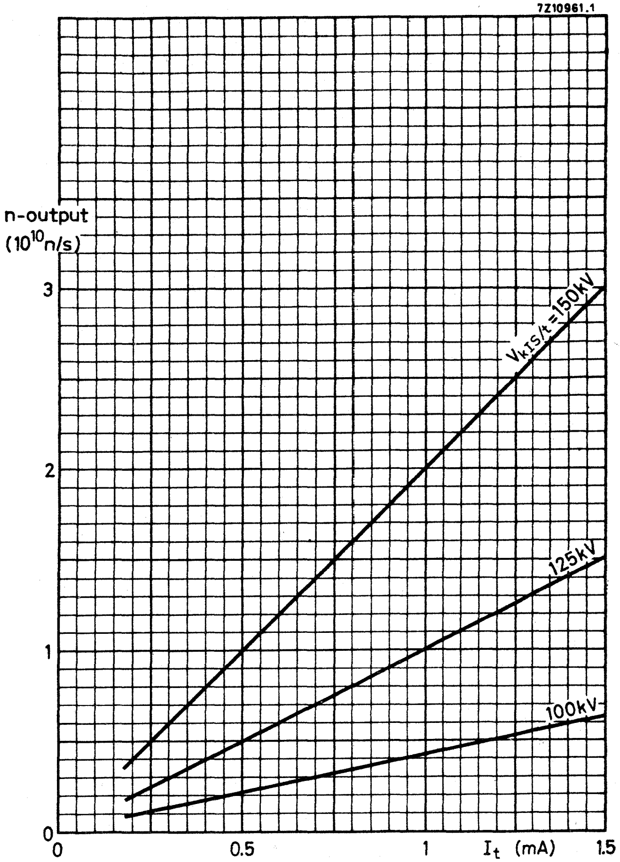
For satisfactory operation of the tube the recommendations given in the "Instructions for use" packed with the tube should be carefully observed.



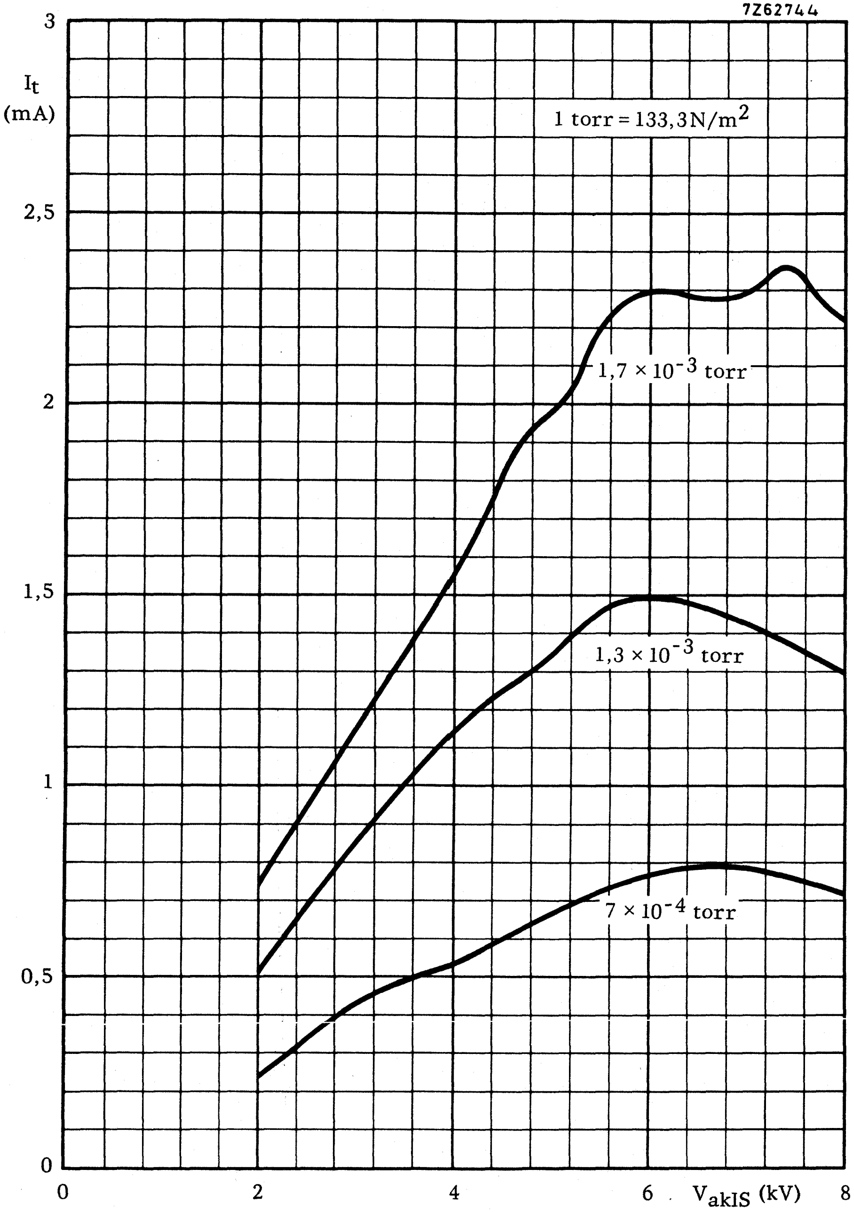
Circuit diagram of the tube and its associated power supplies.



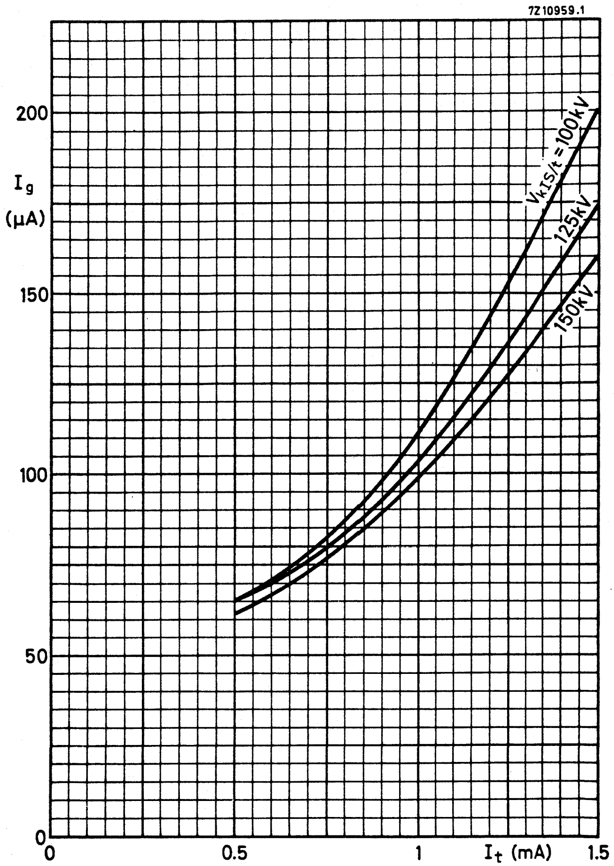
Relative neutron output as a function of accelerating voltage $V_{kIS/t}$ with target current I_t as parameter.



Neutron output as a function of target current I_t with accelerating voltage $V_{kIS/t}$ as parameter.



Typical ion source characteristics.



Suppressor current I_g as a function of target current I_t with accelerating voltage $V_{kIS/t}$ as parameter.

NEUTRON GENERATOR TUBE

Sealed-off neutron generator tube for continuous and pulsed operation at high temperatures.

DESCRIPTION

The 18603 is a mono-energetic continuous or pulsating neutron source, generating over 10^8 14 MeV neutrons per second in continuous operation, and, in pulsed operation, up to 7×10^9 neutrons per second during the pulse.

It is a sealed-off accelerating tube suitable for use at ambient temperatures up to 125 ^{o}C, and its working principle is based on the ^3H (d,n) ^4He reaction.

The incorporated Penning ion-source operates at the same pressure as the accelerating system.

The gas filling is a mixture of deuterium and tritium, the pressure of which is controlled by a pressure regulator.

The beam of accelerated deuterium and tritium ions strikes and replenishes the titanium-tritium target. Hence the tube life is not limited by the tritium content of the target, resulting in a tube life expectancy of more than 500 hours under "Typical operating conditions".

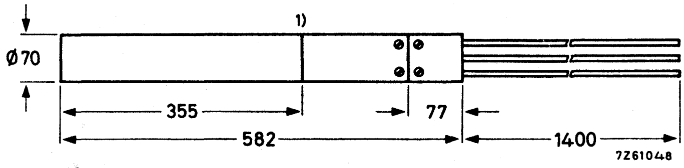
APPLICATION

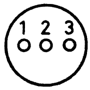
1. Bore hole logging for mineral prospecting.
2. Soil studies e.g. for road and airport construction.
3. Ground water measurements for irrigation or drainage projects.
4. Moisture control of foundry sand.
5. Sub-critical reactor research.
6. Radio chemistry.
7. Fundamental nuclear research.
8. Education.

Data based on pre-production tubes.

MECHANICAL DATA AND CONNECTIONS

Dimensions in mm





1 = Pressure regulator

2 = Earth

3 = Ion source

Detailed information on high tension connectors is available on request.

Mounting position:	any

Weights

Net weight	approx.	5,4	kg
Shipping weight	approx.	12,5	kg

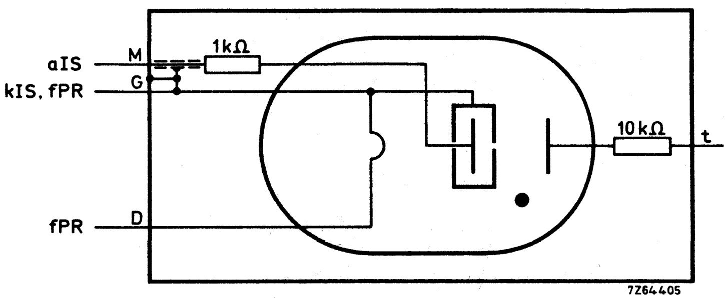
Accessory

Tube of silicon grease DC 4 ; supplied with tube — type number 56007

[1]) The location of the target is indicated by a groove in the tube envelope.

CHARACTERISTICS

Neutron energy (DT reaction)	approx.	14	MeV
Neutron output at an accelerating voltage = 125 kV, target current = 100 μA			
continuous (and average during pulsed operation)	n	> 10^8	n/s
max. output during pulse	n	> 5×10^9	n/s
Pulse duration at an output of 10^{10} n/s	T_{imp}	5 to 1000	μs
Neutron output = f(accelerating voltage)	see page 5		



TYPICAL OPERATING CONDITIONS

		continuous operation	pulsed operation	
Neutron output				
continuous or average	n	2×10^8	2×10^8	n/s
during pulse	n	-	7×10^9	n/s
Pulse duration	T_{imp}	-	5 to 1000	μs
Duty factor	δ	-	3	%
Accelerating voltage	$V_{kIS/t}$	125	125	kV
Target current	I_t	100	mean value 60	μA
Ion-source supply voltage	$V_{b_{akIS}}$	2	2	kV
Ion-source current	I_{aIS}	0,1	peak value 10	mA
Filament current of pressure regulator	I_{fPR}	3	4	A
Ambient temperature	t_{amb}	25	25	°C

LIMITING VALUES (Absolute max. rating system)

Accelerating voltage	$V_{kIS/t}$	max.	130	kV
Accelerating voltage, during continuous operation	$V_{kIS/t}$	min.	30	kV
during pulsed operation		min.	80	kV
Target dissipation, continuous	W_t	max.	12,5	W
Target dissipation (T_{av} = max. 5 s and δ = 0,5)	W_t	max.	15	W
Target current, during continuous operation	I_t	max.	100	μA
during pulse, peak value	I_{t_p}	max.	2	mA
during pulse, average value (T_{av} = max. 5 s)	I_t	max.	100	μA
Ion-source supply voltage	$V_{b_{akIS}}$	max.	3	kV
Filament voltage of pressure regulator	V_{fPR}	max.	3	V
Filament current of pressure regulator	I_{fPR}	max.	6	A
Ambient temperature	t_{amb}	max.	+125	°C
		min.	-5	°C

LIFE EXPECTANCY

The life expectancy of the tube is over 500 hours under "Typical operating conditions"

WARNING

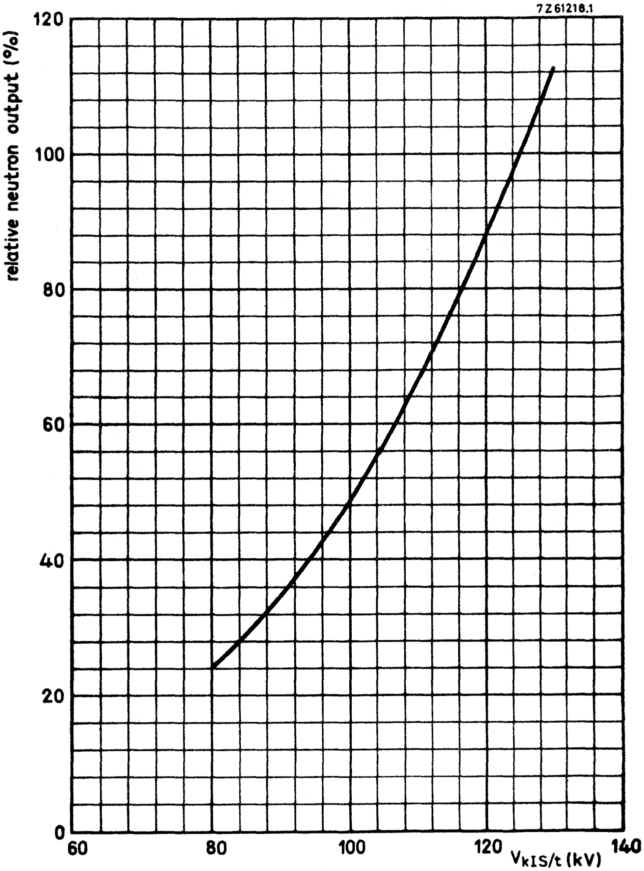
The tube contains 9,5 curie of titanium bound tritium. During and after use appropriate measures against neutron and secondary gamma radiation must be taken.

OPERATIONAL CONSIDERATIONS

For satisfactory operation of the tube the recommendations given in the "Instructions for operation" packed with the tube should be carefully observed.

The high tension connector should be so fastened that expansion and contraction due to temperature changes will be compensated.

Effective heat transfer from the tube to its environment should be ensured in order not to exceed the limiting value.



Neutron output as a function
of the accelerating voltage.

Photo diodes

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 Photo tubes are photo-electric devices of the emissive type, as distinct from the barrier-layer and photo-conductive cells. They may be divided into two groups:

1. High-vacuum photo tubes,
2. Gas-filled photo tubes

Each of these groups can be subdivided into red sensitive and blue sensitive photo tubes; the spectral response depending upon the photocathode material. For the blue sensitive photo tubes the "A" type of cathode is used (caesium-antimony).
For the red sensitive photo tubes the "C" type of cathode is used (caesium-oxidised silver).
Spectral response curves for each type of cathode are given at the end of these recommendations.

2. OPERATING CHARACTERISTICS

For a vacuum photo tube, the anode current for a fixed quantity of light, is reasonably constant at anode voltages above a certain low value known as the "saturation voltage".
The gas-filled photo tube contains a quantity of inert gas, the ionising potential of which is generally somewhat higher than the saturation voltage of an equivalent vacuum photo tube so that the anode current is substantially constant between the saturation voltage and the voltage at which ionisation commences. Above this voltage range, ionisation increases, resulting in a progressive increase in anode current.
Since a gas-filled photo tube operates at a higher voltage than the ionising potential it will have a greater sensitivity than a similar vacuum photo tube.
Within the operating ranges of both groups of photo tubes the anode current is directly proportional to the quantity of light incident on the cathode surface.

2.1 Luminous sensitivity. The response of a photo tube to light falling on its cathode is termed its luminous sensitivity; this is expressed in micro-amperes per lumen.
The sensitivity of all types is dependent upon the colour temperature of the light source and in some cases upon the portion of the cathode that is illuminated.

The sensitivity of gas-filled photo tubes moreover is dependent upon the anode voltage; the sensitivity of vacuum photo tubes in the "saturation region" in which region the tube mainly operates, is practically independent of the anode voltage.
Unless otherwise stated, the values given in the data sheets have been obtained by illuminating the total useful cathode area with an incandescent lamp having a colour temperature of 2700 ^{o}K.
The values given for sensitivity on the data sheets are the initial values for average photo tubes. The ratio between the maximum and minimum initial sensitivity of photo tubes of a given type will not exceed 3 to 1.

2.2 Dark current. This is the current which flows between photocathode and anode when the photo tube is in total darkness. The tube is in total darkness when no radiation within the spectral sensitivity curve of the photocathode is present. This current is caused mainly by electrical leakage and thermionic emission from the photocathode and will therefore increase with temperature and voltage.

2.3 Frequency response. The sensitivity of a vacuum photo tube is constant for frequencies of light modulation up to those generally met in practice. Only at very high frequencies, at which transit time limitations occur, the sensitivity becomes dependent upon the frequency.
The sensitivity of gas-filled photo tubes, however, decreases with the frequency. At a frequency of 15000 Hz this decrease is about 3 dB, as is shown in the accompanying 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 on the published data sheets.
It must be considered, however, that even in case the ambient temperature in the immediate vicinity of the photo tube 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. OPERATIONAL NOTES

Stability during life. Where a gas-filled photo tube is continuously operated at its maximum rated voltage its sensitivity may fall by as much as 50%, during 500 hours.
Vacuum photo tubes on the other hand are inherently more stable.

The stability of both types of photo tubes 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 in the case of gas-filled photo tubes reduction of the anode voltage will improve the stability.

Also in the inoperative periods photo tubes must not be exposed to strong radiation such as direct sunlight.

A loss of sensitivity of both vacuum and gas-filled photo tubes during operation will be wholly or partially restored during the inoperative periods.

Prevention of glow discharge. Gas-filled photo tubes 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 photo tube and even can result in rapid destruction of the photocathode. If accidental over-running can be expected the anode resistance should have a value of at least 0.1 MΩ.
Where it is necessary to use the maximum operating voltage a stabilized supply is recommended.

5. MOUNTING

If no restrictions are made on the individual published data sheets photo tubes may be mounted in any position.

6. STORAGE

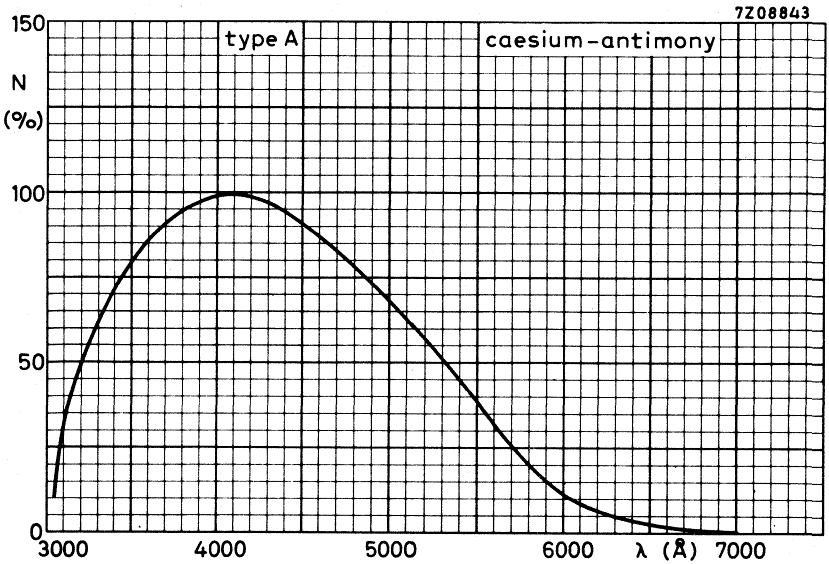
It is necessary that phototubes be always stored in the dark.

7. LIMITING VALUES

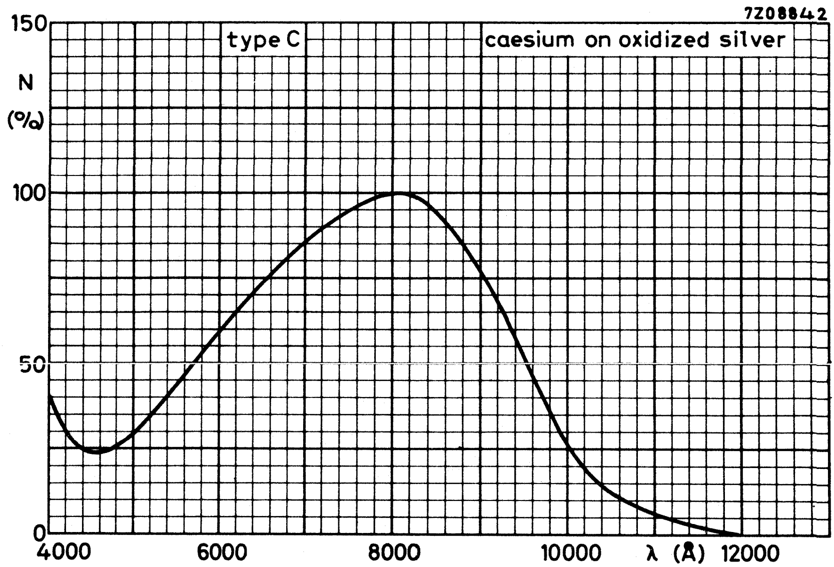
The limiting values of photo tubes are given in the absolute max. rating system.

8. OUTLINE DIMENSIONS

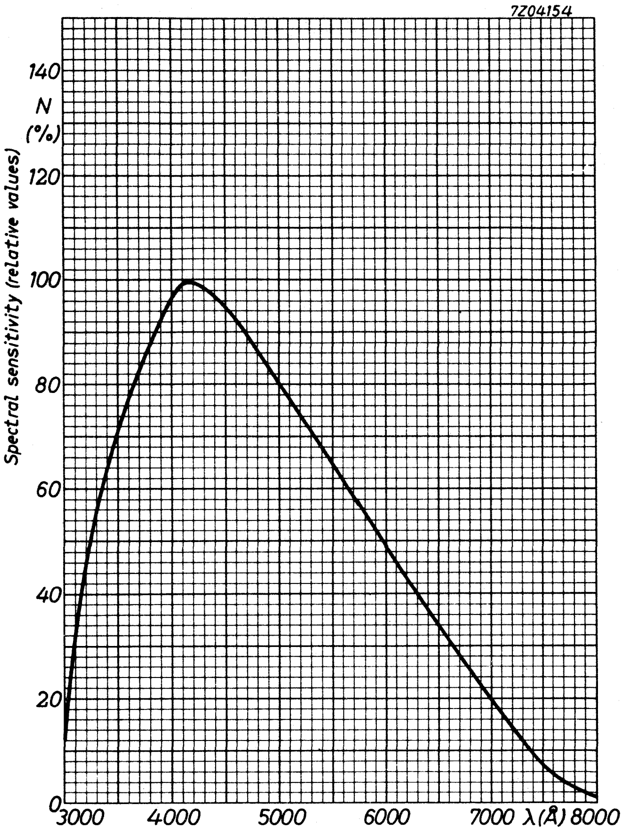
The outline dimensions are given in mm.



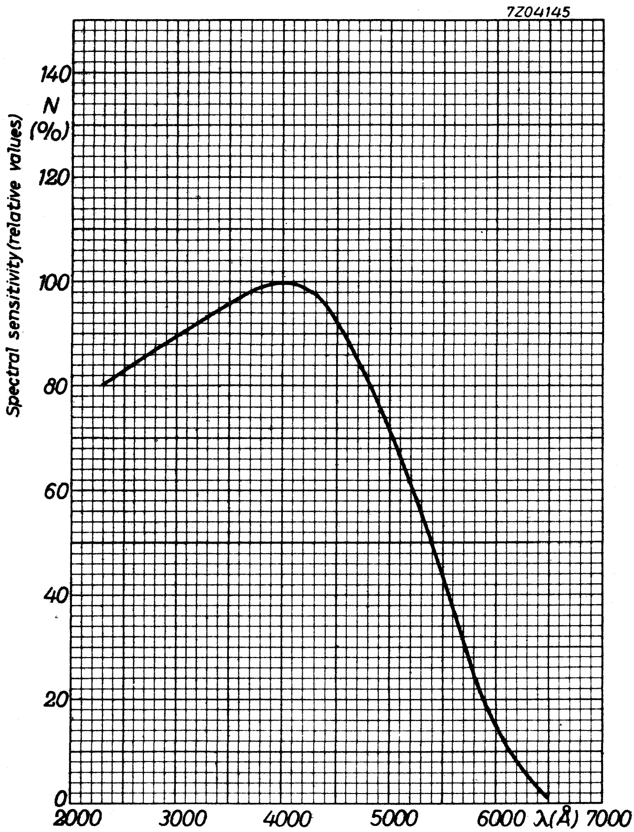
Reletive spectral response curve type A



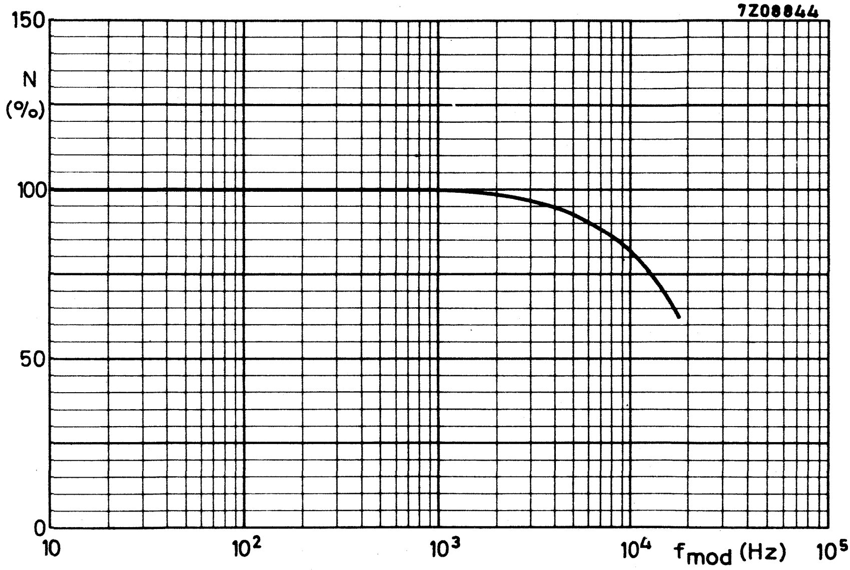
Relative spectral response curve type C



Spectral response curve type T (S20).



Spectral response curve type U



Frequency response curve (see also 2.3)

PHOTO TUBE

Fast phototube.

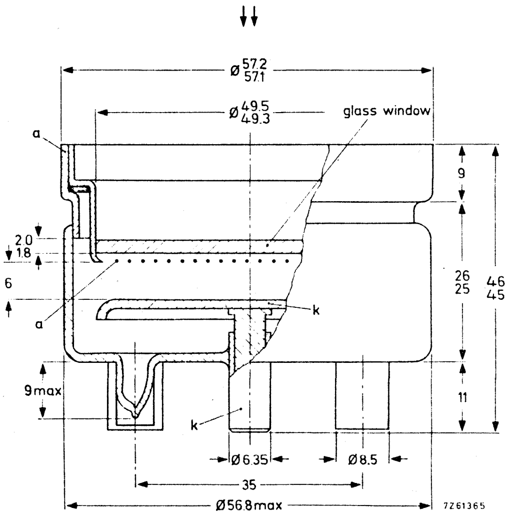
The AVHC41 is intended for use in applications with relatively high illumination and high peak current.

QUICK REFERENCE DATA				
Cathode current, peak	I_k	max.	50	A
Sensitivity	N		50×10^{-6}	A/lm
Rise time	T_r	max.	0.4	ns
Spectral response			type S4	
Outline dimensions			57.2 x 56.8	mm

MECHANICAL DATA Dimensions in mm

Socket: SC110

Mounting position: any



Data based on pre-production tubes

Faceplate	plane parallel glass			
Photocathode				
Description	head-on, opaque on metal plate flat surface			
Cathode material		Sb-Cs		
Useful diameter			40	mm
Spectral response curve		type S4		
Wavelength at max. response			400	nm
Luminous sensitivity at a c.t. of 2854 K	N	av.	50×10^{-6}	A/lm
		min.	20×10^{-6}	A/lm
Radiant sensitivity at 400 nm		av.	50	mA/W

TYPICAL CHARACTERISTICS[1] See measuring circuit

Dark current at V_a = 2.5 kV	I_{k_o}	max.	10×10^{-9}	A
Linearity within 10% at V_b = 2.5 kV		up to I_{k_p} =	6	A
Rise time	T_r	max.	0.4	ns

[1]) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109 and with socket SC110

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	2.5	kV
Cathode current, peak	I_{kp}	max.	50	A

MEASURING CIRCUIT

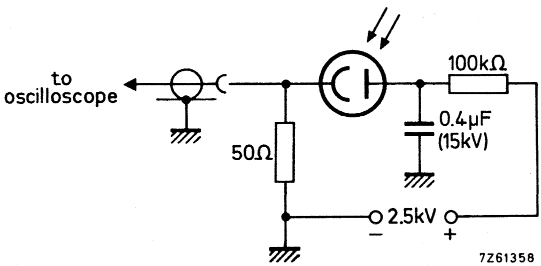


PHOTO TUBE

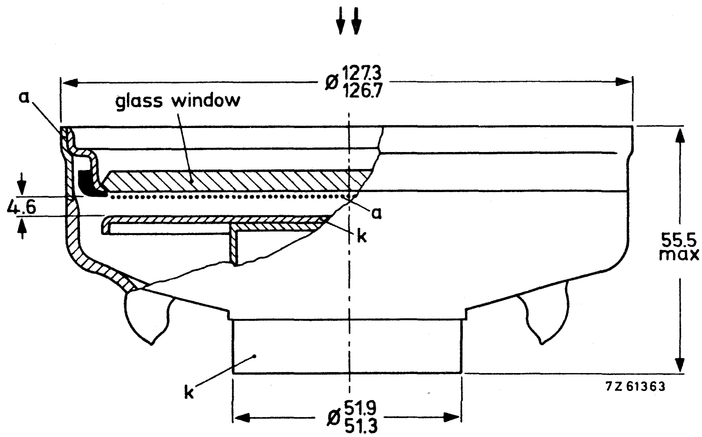
Fast phototube.

The AVHC201 is intended for use in applications with relatively high illumination and high peak current.

QUICK REFERENCE DATA				
Cathode current, peak	I_{kp}	max.	100	A
Sensitivity	N		50×10^{-6}	A/lm
Rise time	T_r	max.	1	ns
Spectral response			type S4	
Outline dimensions			127.3 x 55.5	mm

MECHANICAL DATA Dimensions in mm

Mounting position: any



Data based on pre-production tubes

Faceplate	plane parallel glass			
Photocathode				
Description	head-on, opaque on metal plate flat surface			
Cathode material		Cs-Sb		
Useful diameter			108	mm
Spectral response curve		type S4		
Wavelength at max. response			400	nm
Luminous sensitivity at a c.t. of 2854 K	N	av.	50×10^{-6}	A/lm
		min.	20×10^{-6}	A/lm
Radiant sensitivity at 400 nm			25	mA/W

TYPICAL CHARACTERISTICS' See measuring circuit

Dark current at V_a = 2.5 kV	I_{k_o}	max.	10.10^{-9}	A
Linearity within 10% at V_b = 2.5 kV		up to I_{kp} =	30	A
Rise time	T_r	max.	1	ns [1])

1) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	2.5	kV
Cathode current, peak	I_{kp}	max.	100	A

MEASURING CIRCUIT

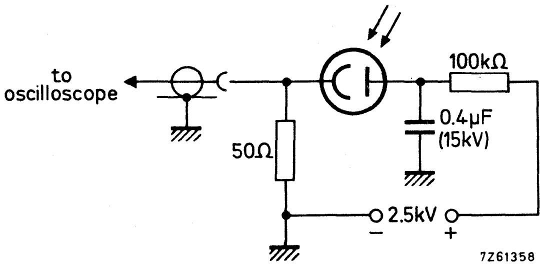


PHOTO TUBE

Fast phototube.

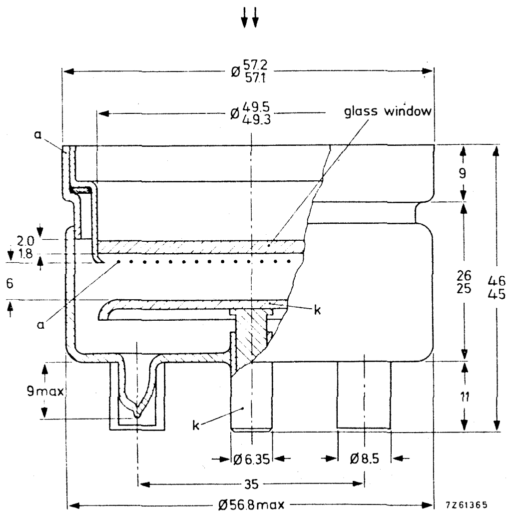
The TVHC40 is intended for use in applications with high peak current e.g. with LASERS.

QUICK REFERENCE DATA				
Cathode current, peak	I_{kp}	max.	50	A
Sensitivity	N		150×10^{-6}	A/lm
Rise time	T_r	max.	0.4	ns
Spectral response			type T(S20)	
Outline dimensions			57.2 x 46	mm

MECHANICAL DATA Dimensions in mm

Socket: SC110

Mounting position: any



Data based on pre-production tubes

Faceplate		plane parallel glass		
Photocathode				
Description		head-on, opaque on metal plate flat surface		
Cathode material		$SbNaKCs$		
Useful diameter			40	mm
Spectral response curve		type T (S20)		
Wavelength at max. response			500	nm
Luminous sensitivity at a c.t. of 2854 K, t_{amb} = 60 °C	N	av.	150×10^{-6}	A/lm
Radiant sensitivity at 437 nm		av.	70	mA/W
at 698 nm		av.	5	mA/W

TYPICAL CHARACTERISTICS[1] See measuring circuit

Dark current at V_a = 2.5 kV	I_{k_o}	av.	0.15×10^{-9}	A
		max.	5×10^{-9}	A
Linearity within 10% at V_b = 2.5 kV		up to I_{k_p} =	5	A
Rise time	T_r	max.	0.4	ns

1) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109 and socket SC110.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	5	kV
Cathode current, peak	I_{kp}	max.	50	A
Ambient temperature, operating	t_{amb}	min.	−40	^oC
		max.	+60	^oC

MEASURING CIRCUIT

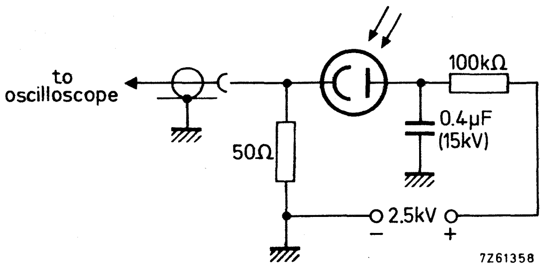


PHOTO TUBE

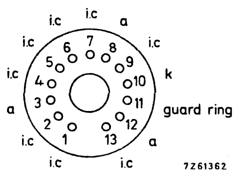
Fast phototube with low dark current due to a guard ring around the photocathode. The XA1000 is shock and vibration resistant and intended for use in mobile equipment.

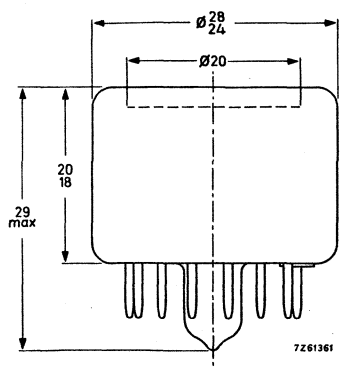
QUICK REFERENCE DATA				
Cathode current, mean	I_k	max.	300	nA
Cathode current, peak	I_{kp}	max.	2	mA
Sensitivity	N		60×10^{-6}	A/lm
Rise time	T_r	max.	1	ns
Spectral response		≈	type A	
Outline dimensions			29 x 28	mm

MECHANICAL DATA Dimensions in mm

Base: special 13 pin

Mounting: To obtain an extremely low dark current it is recommended to use a Teflon or ceramic socket, or to use a "floating" cathode connection (cathode contact spring loose in socket)
Mounting position: any





Data based on pre-production tubes

Faceplate		plane parallel glass		
Photocathode				
Description		semi transparent, head-on, flat surface		
Cathode material		Cs-Sb		
Useful diameter			20	mm
Spectral response curve	≈	type A (S11)		
Wavelength at max. response			440 ± 30	nm
Luminous sensitivity at a c.t. of 2854 K, t_{amb} = 60 °C	N	av.	60×10^{-6}	A/lm
		min.	40×10^{-6}	A/lm
Radiant sensitivity at 440 nm		av.	70	mA/W

TYPICAL CHARACTERISTICS' See measuring circuit

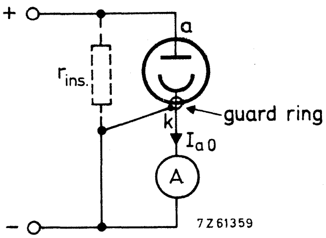
Saturation voltage for I_k = 1 nA	V_a	max.	8	V
Dark current at V_a = 4.5 V, t_{amb} = 60 °C	I_{ko}	max.	10^{-12}	A
Insulation resistance between anode and guard ring at V_a = 4.5 V, t_{amb} = 60 °C	r_{ins}	min.	10^{12}	Ω
Linearity at V_b = 700 V, T_{imp} = 1 μs		up to I_{kp} =	0.5	mA
Rise time at V_b = 700 V	T_r	max.	1	ns
F.W.H.M. ($I_{kp}/2$) at V_b = 700 V	T_{imp}	max.	1	ns [1])

[1]) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	700	V
Cathode current, mean	I_k	max.	300	nA
peak	I_{kp}	max.	2	mA
Ambient temperature, operating	t_{amb}	min.	−40	°C
		max.	+60	°C
, storage	t_{amb}	min.	−50	°C
		max.	+60	°C

MEASURING CIRCUIT



SHOCK AND VIBRATION RESISTANCE

The following test conditions are applied to assess the mechanical quality of the tube. These conditions are not intended to be used as normal operating conditions.

Shock
30 g_p, 11 ms, 3 shocks in the three positions of the tube.

Vibration
Variable frequency vibration, 10 to 55 Hz, frequency variation linear with time, amplitude $_{p-p}$ 1.5 mm, 10 to 15 minutes in each of the three positions of the tube.

Vibration
Variable frequency vibration, 10 to 55 Hz, frequency variation linear with time, amplitude 1.5 mm $_{p-p}$, 1 min per cycle, 120 cycles in each of the three positions of the tube.

PHOTO TUBE

Fast phototube with low dark current due to a guard ring around the photocathode.

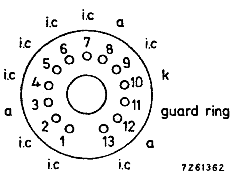
The XA1001 is intended for use in mobile equipment.

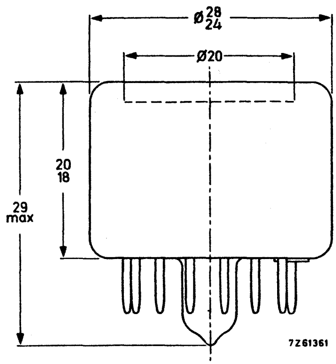
QUICK REFERENCE DATA				
Cathode current, mean	I_k	max.	300	nA
Cathode current, peak	I_{kp}	max.	2	mA
Sensitivity	N		60×10^{-6}	A/lm
Rise time	T_r	max.	1	ns
Spectral response		≈	type A	
Outline dimensions			29 x 28	mm

MECHANICAL DATA Dimensions in mm

Base: special 13 pin

Mounting: To obtain an extremely low dark current it is recommended to use a Teflon or ceramic socket, or to use a "floating" cathode connection (cathode contact spring loose in socket)
Mounting position: any.





Data based on pre-production tubes

Faceplate		plane parallel glass		
Photocathode				
Description		semi transparent, head-on, flat surface		
Cathode material		Cs-Sb		
Useful diameter			20	mm
Spectral response curve		≈ type A(S11)		
Wavelength at max. response			440 ± 30	nm
Luminous sensitivity at a c.t. of 2854 K, t_{amb} = 60 °C	N	av.	60×10^{-6}	A/lm
		min.	40×10^{-6}	A/lm
Radiant sensitivity at 440 nm		av.	70	mA/W

TYPICAL CHARACTERISTICS ' See measuring circuit

Saturation voltage for I_k = 1 nA	V_a	max.	8	V
Dark current at V_a = 4.5 V, t_{amb} = 60 °C	I_{k_o}	max.	10^{-12}	A
Linearity at V_b = 700 V, T_{imp} = 1 μs		up to I_{kp} =	0.5	mA
Rise time at V_b = 700 V	T_r	max.	1	ns
F.W.H.M. ($I_{kp}/2$) at V_b = 700 V	T_{imp}	max.	1	ns [1]

[1] Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	700	V
Cathode current, mean	I_k	max.	300	nA
peak	I_{kp}	max.	2	mA
Ambient temperature, operating	t_{amb}	min.	−40	°C
		max.	+60	°C
, storage	t_{amb}	min.	−50	°C
		max.	+70	°C

MEASURING CIRCUIT

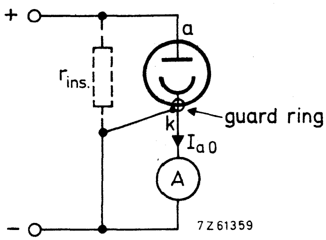


PHOTO TUBE

Fast phototube.

The XA1002 is intended for use in applications with relatively high illumination and high peak current.

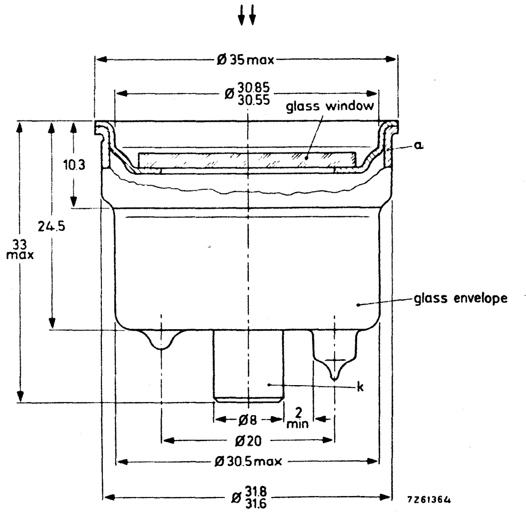
QUICK REFERENCE DATA				
Cathode current, peak	I_{kp}	max.	10	A
Sensitivity	N		30×10^{-6}	A/lm
Rise time	T_r		0.25	ns
Spectral response			type S4	
Outline dimensions			35 x 33	mm

MECHANICAL DATA

Dimensions in mm

Socket: 56041

Mounting position: any



Data based on pre-production tubes

Faceplate	plane parallel glass			
Photocathode				
Description	head-on, opaque on metal plate flat surface			
Cathode material		Cs-Sb		
Useful diameter			20	mm
Spectral response curve		type S4		
Wavelength at max. response			400	nm
Luminous sensitivity at a c.t. of 2854 K	N	av.	30×10^{-6}	A/lm
		min.	20×10^{-6}	A/lm
Radiant sensitivity at 400 nm		av.	35	mA/W

TYPICAL CHARACTERISTICS

Saturation voltage for I_k = 1 nA	V_a	max.		V
Dark current at V_a = 2.5 kV, t_{amb} = 25 °C	I_{ko}		$0.5.10^{-9}$	A
		max.	5.10^{-9}	A
Linearity at V_b = 4 kV		up to I_{kp} = 5 to 10		A 2)
Rise time	T_r	max.	0.25	ns 1)
Capacitance anode to cathode	C_{ak}		2	pF

1) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109 and with socket 56041.

2) With the tube mounted in the socket 56041 the linearity is maintained only if the charge of the anode current pulses does not exceed 10^{-6} As (1 μC).

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	4	kV
Cathode current, peak	I_{kp}	max.	10	A
Ambient temperature, operating	t_{amb}	min.	−40	°C
		max.	+60	°C

MEASURING CIRCUIT

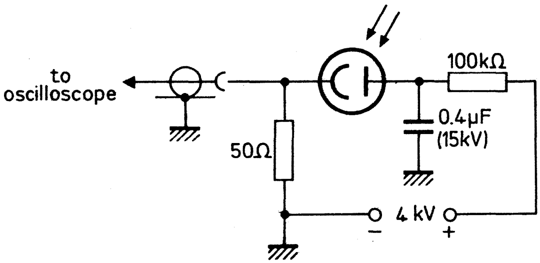


PHOTO TUBE

Fast phototube.

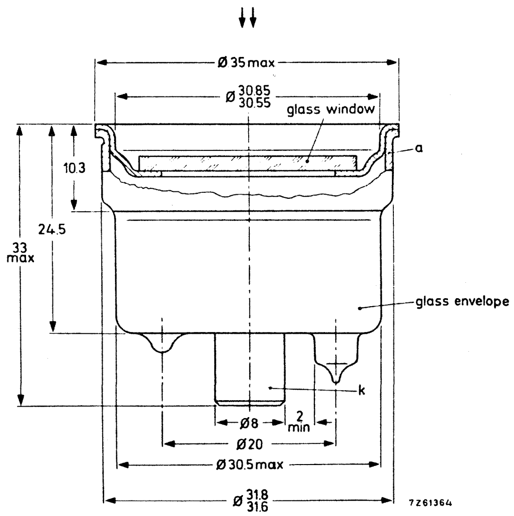
The XA1003 is intended for use in applications with relatively high illumination especially for use with LASERS.

QUICK REFERENCE DATA				
Cathode current, peak	I_k	max.	2	A
Sensitivity	N		20×10^{-6}	A/lm
Rise time	T_r	max.	0.2	ns
Spectral response			type S1	
Outline dimensions			35 x 33	mm

MECHANICAL DATA Dimensions in mm

Socket: 56041

Mounting position: any



Data based on pre-production tubes

Faceplate			plan parallel glass	
Photocathode				
Description			head-on, opaque on metal plate flat surface	
Cathode material			Cs-AgO	
Useful diameter			20	mm
Spectral response curve			type C (S1)	
Wavelength at max. response			800	nm
Luminous sensitivity at a c.t. of 2854 K	N	av.	20×10^{-6}	A/lm
		min.	15×10^{-6}	A/lm
Infra-red sensitivity		av.	2×10^{-6}	A/lm[2]
		min.	1.4×10^{-6}	A/lm[2]

TYPICAL CHARACTERISTICS See measuring circuit

Dark current at $V_a = 2.5$ kV	I_{k_o}	av.	5.10^{-9}	A
		max.	10.10^{-9}	A
Insulation resistance between anode and cathode	r_{ins}	min.	2.5×10^{11}	Ω
Linearity at $V_b = 2.5$ kV		up to I_{kp} =	0.8	A
Rise time	T_r	max.	0.2	ns [1]
Capacitance anode to cathode	C_{ak}		2	pF

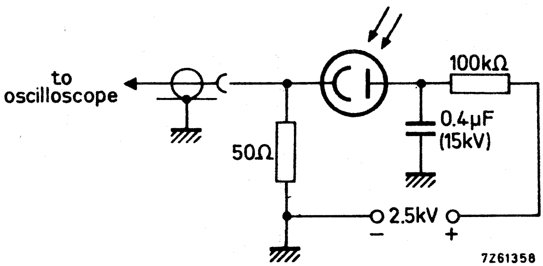
1) Measured with short light pulses (F.W.H.M. < 1 ns) with the pulsed-light source SL109 and with socket 56041.

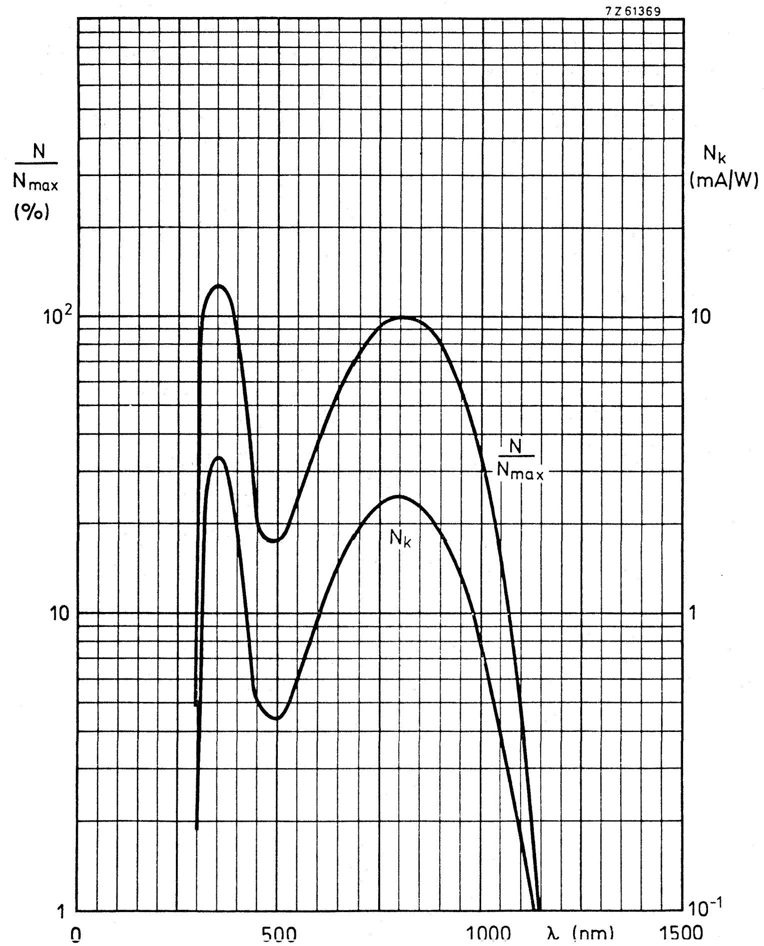
2) The lumen infra-red is defined as the luminous flux from a lumen "white" after passing a filter IR Corning CS94-2540 with a thickness of 2.61 mm.

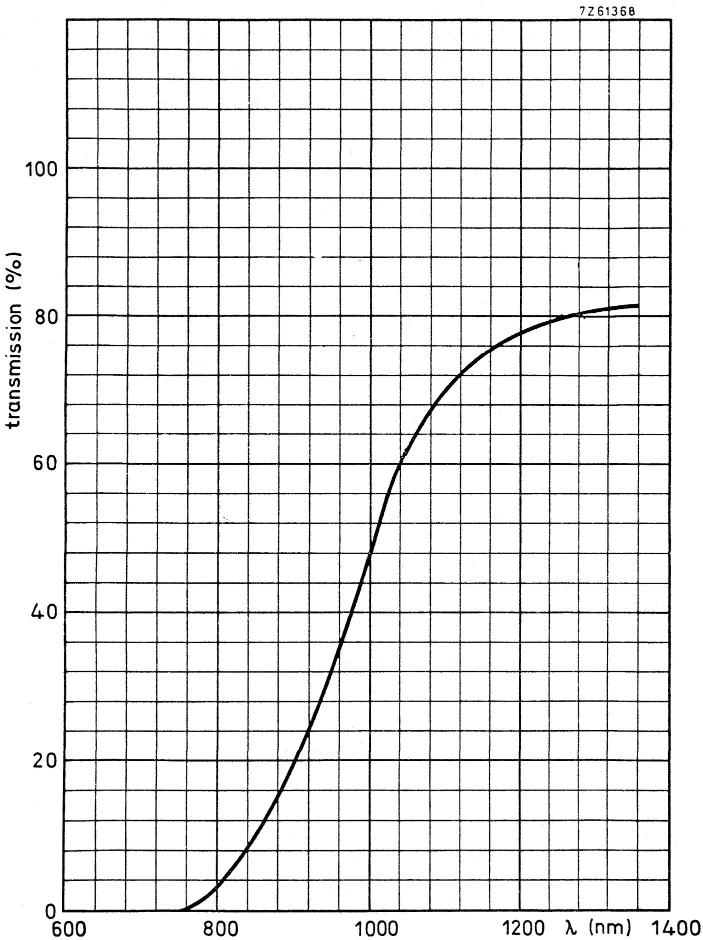
LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	4	kV
Cathode current, peak	I_{kp}	max.	2	A
Ambient temperature, operating	t_{amb}	min.	−40	°C
		max.	+60	°C

MEASURING CIRCUIT




7Z61369
N / Nmax (%)
Nk (mA/W)
10^2
10
1
10
1
10^-1
0
500
1000
λ (nm)
1500
N / Nmax
Nk



Transmission curve of the I.R. filter

Corning 2540 - CS94, thickness 2.61 mm

VACUUM PHOTOTUBE

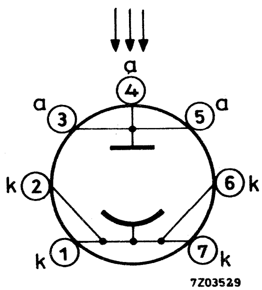
Vacuum phototube, particularly sensitive to daylight and to light radiation with a blue predominance.

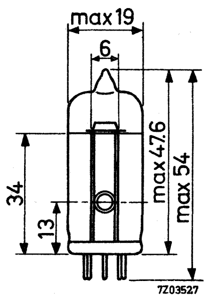
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	100	V
Luminous sensitivity	N		45	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA

Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 together

Photo cathode

Surface caesium antimony

Projected sensitive area 4 cm^2

ELECTRICAL DATA

Operating characteristics

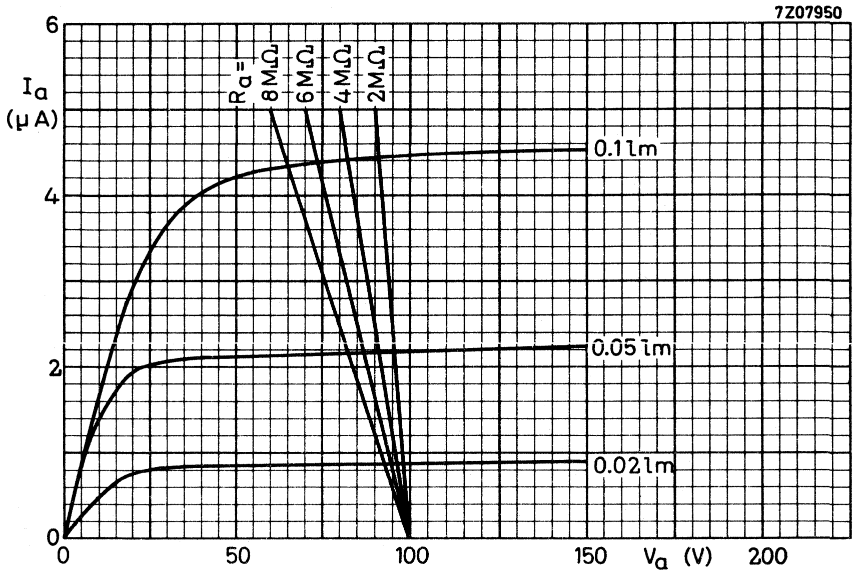
Anode supply voltage	V_b		100	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		45	μA/lumen
Dark current	I_{dark}	max.	0.05	μA

Capacitance

Anode to cathode	C_{ak}	0.7	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	100	V
Cathode current	I_k	max.	5	μA
Ambient temperature	t_{amb}	max.	70	°C



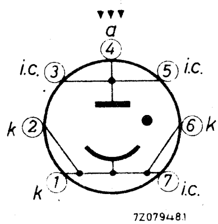
GAS FILLED PHOTOTUBE

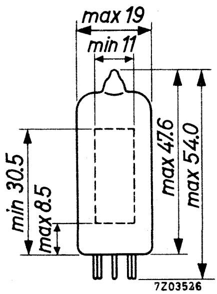
Gas filled phototube particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		125	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium on oxidized silver
Projected sensitive area	3.0 cm^2

ELECTRICAL DATA

Operating characteristics

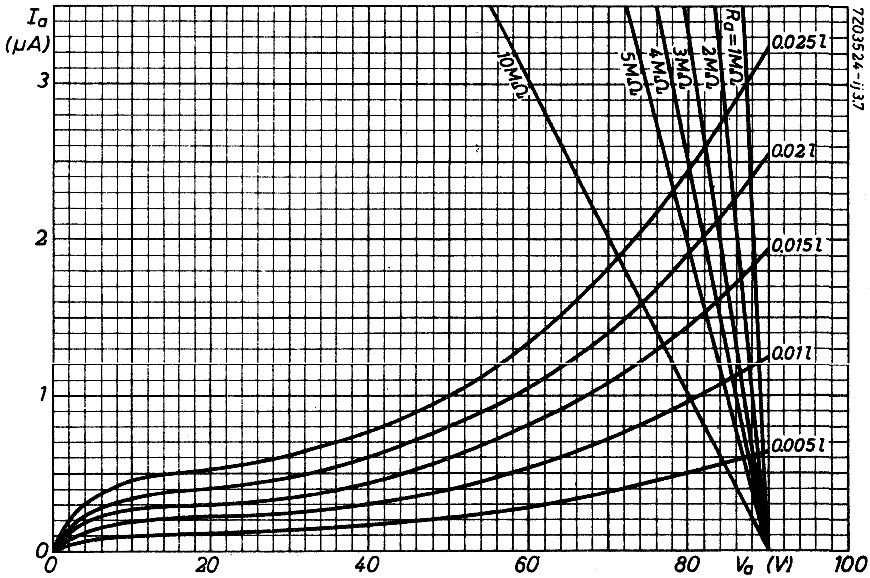
Anode supply voltage	V_b		90	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		125	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

Capacitance

Anode to cathode	C_{ak}		1.1	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	2.0	μA
Ambient temperature	t_{amb}	max.	100	°C



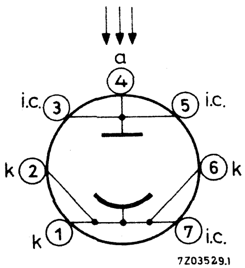
VACUUM PHOTOTUBE

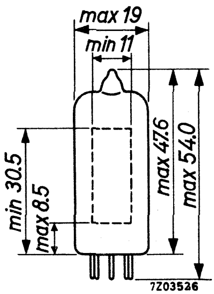
Vacuum phototube, particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	250	V
Luminous sensitivity	N		20	µA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photo cathode

Surface	Ceasium on oxidised silver
Projected sensitive area	3.0 cm^2

ELECTRICAL DATA

Operating characteristics

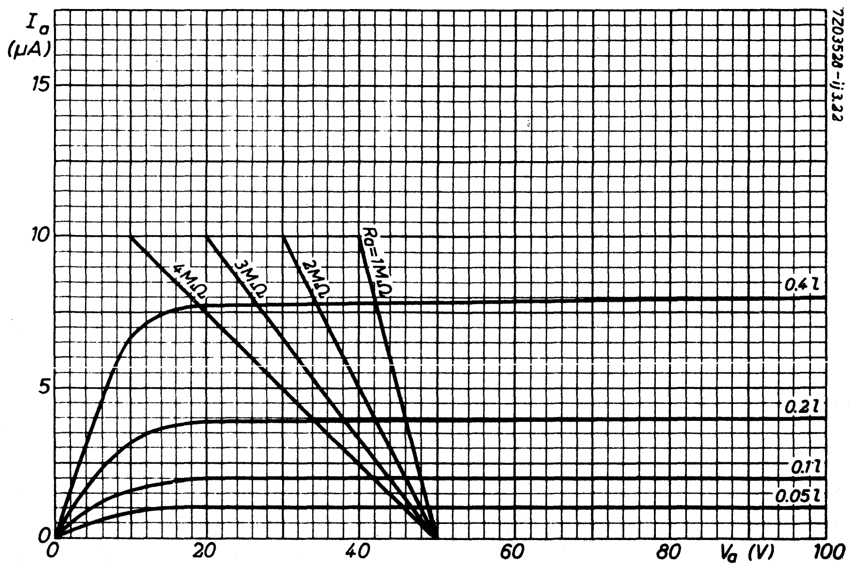
Anode supply voltage	V_b		50	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		20	μA/lumen
Dark current (at V_a = 100 V)	I_{dark}	max.	0.05	μA

Capacitance

Anode to cathode	C_{ak}	0.8	pF

LIMITING VALUES (Absolute max. rating system)

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



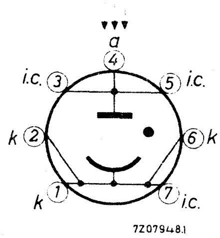
GAS FILLED PHOTOTUBE

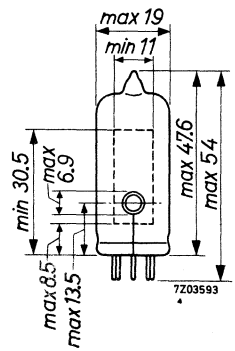
Gas-filled phototube particularly sensitive to daylight and to radiation having a blue predominance.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		130	µA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium antimony
Projected sensitive area	2.1 cm^2

ELECTRICAL DATA

Operating characteristics

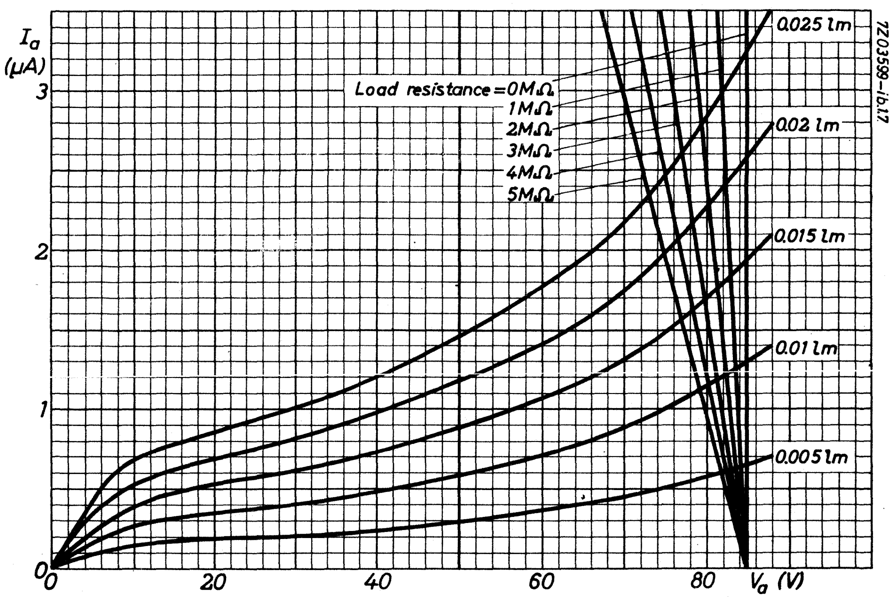
Anode supply voltage	V_b		85	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		130	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

Capacitance

Anode to cathode	C_{ak}	0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	0.0125	μA/mm2
Ambient temperature	t_{amb}	max.	70	°C



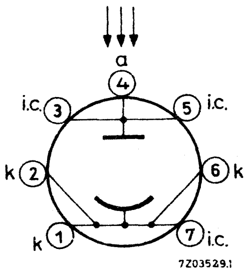
VACUUM PHOTOTUBE

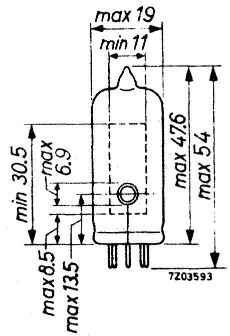
Vacuum phototube particularly sensitive to daylight and to light radiation with a blue predominance.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	100	V
Luminous sensitivity	N		45	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface caesium antimony

Projected sensitive area 2.1 cm^2

ELECTRICAL DATA

Operating characteristics

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

Capacitance

Anode to cathode	C_{ak}	0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	100	V
Cathode current	I_k	max.	0.025	$\mu A/mm^2$
Ambient temperature	t_{amb}	max.	70	°C

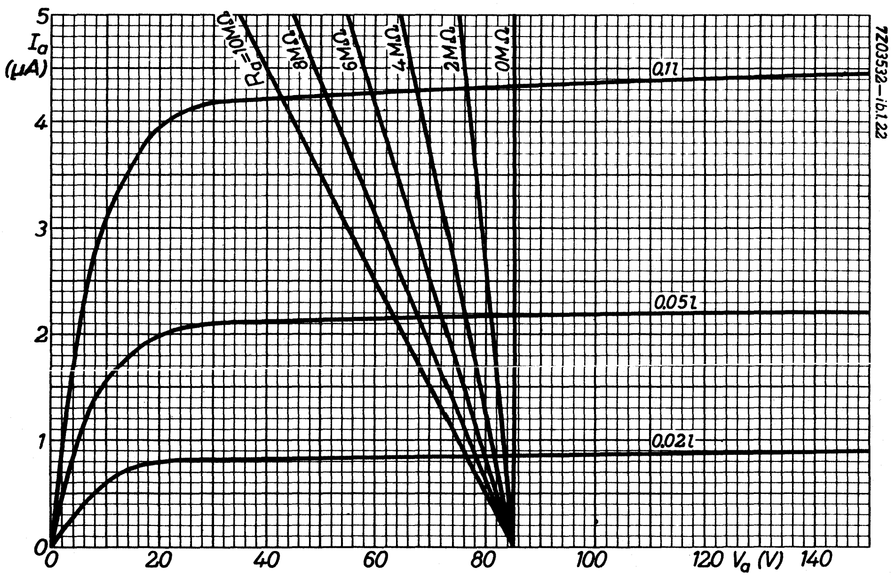
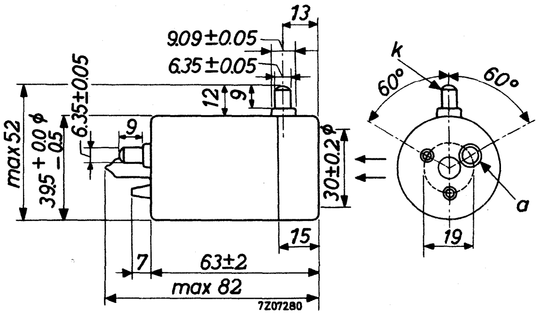


PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA			
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Average current	I	max. 50×10^{-9}	A
Peak current	I_p	max. 35×10^{-6}	A
Sensitivity	N	60×10^{-6}	A/lumen
Rise time		14	ns
Spectral response		type A	
Outline dimensions		max. 52 x 82	mm

MECHANICAL DATA Dimensions in mm



Mounting position: any

Photocathode

Cathode material	Caesium-antimony		

The cathode material has been deposed on the inner surface of the window. This window is optically plane and polished.
It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	30	mm
Spectral response	type A		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °C	typical	60×10^{-6}	A/lumen
	min.	35×10^{-6}	A/lumen

Each tube is marked with its sensitivity

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5 %.

CAPACITANCE

Anode to cathode	C_{ak}	13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen			< 6	$V_{D.C.}$
luminous flux 1 lumen			< 70	$V_{D.C.}$
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Dark current	I_{ao}	max.	10^{-12}	A
Linearity [1]			0.1	‰
Insulation resistance	r_{ins}	min.	10^{15}	Ω
Rise time	T_r		14	ns

[1] The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage		V_a	max.	100	$V_{D.C.}$
Cathode current per mm² of cathode area,	peak	I_{kp}	max.	50×10^{-9}	A/mm²
	average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm²
Cathode current,	peak [1]	I_{kp}	max.	35×10^{-6}	A
	average (T_{av} = 1 s)	I_k	max.	50×10^{-9}	A
Envelope temperature		t_{bulb}	min.	-90	°C
		t_{bulb}	max.	+60	°C

LIFE EXPECTANCY

With an average cathode current of 50×10^{-9} A, the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to -90 °C.

APPLICATION

The currents allowed through 150AV are so low that amplification will always be necessary. To maintain the precision of the signal coming from the phototube is often the main problem.

This problem may be divided into four parts:

1. Distortion due to capacitive shunting:

   The signal on the input of the amplifier is

$$v = \frac{i}{\sqrt{\frac{1}{R^2} + \omega^2 C^2}}$$

in which v = signal in V
i = current through phototube in A
R = part of series-resistance (in Ω) from which the signal is taken
ω = 2π X frequency of the signal in Hz
C = total capacitance of cathode of phototube + input-capacitance of amplifier + stray capacitance of wiring in F. The value of C will not easily be kept below 20 pF.

[1]) With the cathode uniformly illuminated.

If a certain distortion only is accepted the maximum frequency of the signal to be transferred will limit the value of the resistance from which the signal will be taken and by this limit the value of the signal on the input of the amplifier.

2. Noise:

The level of the signal on the input of the amplifier shall be above the noise level.
The 3 main sources of noise are:

a. Shot noise in the phototube which follows the formula:

$$I_{noise} = \sqrt{2ei \times B} \text{ in } A_{R.M.S.}$$

$$V_{noise} = R \times I_{noise}$$

in which e = 1.6×10^{-19} in As
i = the current through the phototube in A
B = the bandwidth in Hz
R = value of resistor from which signal is taken in Ω

b. Resistance noise of that part of the series-resistor from which the input signal for the amplifier is taken.
This part of the noise follows the formula:

$$V_{noise} = \sqrt{4 k T R B}$$

in which k = 1.35×10^{-23}
T = temperature in ^{o}K
R = value of resistor in Ω
B = bandwidth in Hz

c. Input-noise of the amplifier

In such cases where an electron tube is used in the input of the amplifier, the noise-voltage follows the formula

$$V_{noise} = \sqrt{\Sigma V^2_{eq} \Delta B}$$

The value of V_{eq} as a function of frequency is different for each type of tube, but for frequencies above 1000 Hz V_{eq} does not change much with the frequency allowing the formula to be reduced to

$$V_{noise} = V_{eq}\sqrt{B}$$

In that case V_{eq} can be approximated within a factor 2 to 3 by

$$V_{eq} = \frac{3 \times 10^{-9} \sqrt{I_a}}{S}$$

in which I_a is the anode current of the tube in A and S is the transconductance in A/V.

3. Input current of the amplifier

The input-current of the amplifier should be low compared with the signal current through the phototube.

4. Linearity of the amplifier

The amplifier should have a feedback so that the stability and the distortion of the signal is not impaired.

If the circumstances are such that the signal to noise ratio cannot be kept within acceptable limits - usually there where low incident illumination levels combine with high frequencies - use of this type of phototube should be abandoned in preference to photomultipliers where the distortion due to capacitive shunting and noise sources other than shot noise are of smaller relative importance.

Examples:

An example for a simple circuit which is useful for many purposes of static light measurements is shown in fig.1.

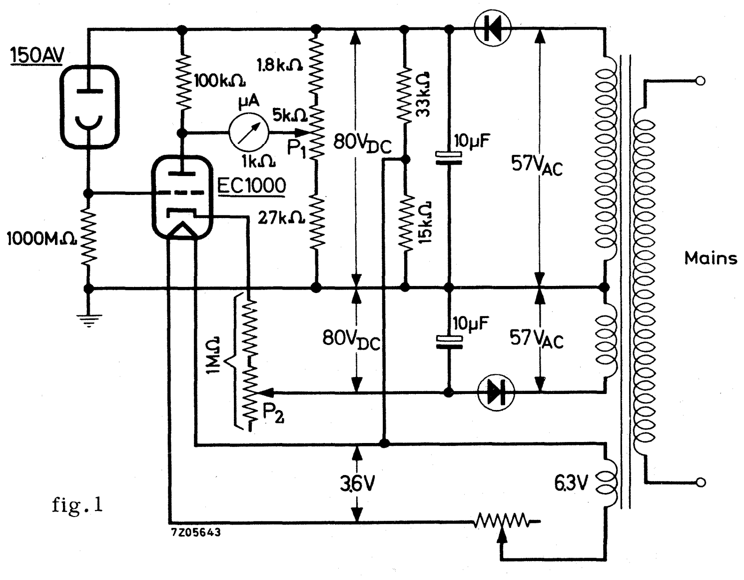


fig.1

In this circuit the μA meter with 50 μA f.s.d. may be calibrated in milli-lumen or - if the whole of the cathode is illuminated - in lux. Assuming that the pointer of the μA meter will not move with frequencies above 20 Hz, for calculation of the noise level frequencies below 20 Hz are of interest only.
For currents of 5×10^{-9} A through the phototube the signal on the input of the amplifier is of a level of 5 V, the shot noise on a level of 10^{-4} V, the resistance noise on a level of 10^{-5} V, the equivalent noise voltage on the input of EC1000 on a level of 10^{-6} V.

The feedback of this system is about 1000 times, so the accuracy is solely determined by the accuracy of the μA meter, all other sources being small.

Mains voltage variations of +10% and −15% are of no influence on the measuring result.

The circuit of Fig.1 is calibrated as follows:
Adjust P_2 so that the total cathode resistance of the EC1000 is $\frac{A \times R_1}{50 \times 1000}\ \Omega$

in which R_1 is the value of the series resistance of the 150AV and
A is the actual sensitivity in μA/lumen of the 150AV as marked on the tube.

Disconnect the connection between the phototube and the grid of the EC1000 and connect the grid of EC1000 to earth. Connect the circuit to the mains and adjust P_1 so that the μA meter indicates zero.

The circuit is now restored and has been calibrated for 0.02 mlumen per μA deflection of the μA meter.

For measurements of rapidly changing phenomena the series-resistor in Fig.1 of 150AV should be adapted for an acceptable signal to noise ratio and acceptable distortion while the μA meter should be replaced by a resistor shunted by the input of an oscilloscope.

Depending on the frequency further adaptations of the circuit may be necessary, e.g. further smoothing of the D.C. voltages and a D.C. heater supply for the EC1000.

For extremely rapid changes when all time constants of the circuit have to be reduced as far as possible a circuit as shown in fig.2 may be used on which laser light flashes can be recorded with a rise time of the signal on the oscilloscope of 20 ns.

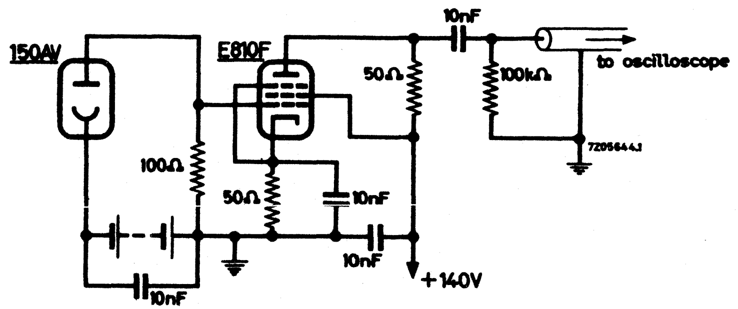


fig.2

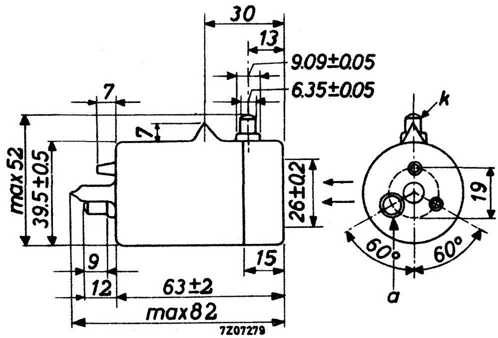
Remark P_1 and P_2 should be wirewound resistors.

PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision/photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA				
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Average current	I	max.	35×10^{-9}	A
Peak current	I_p	max.	25×10^{-6}	A
Sensitivity	N		20×10^{-6}	A/lumen
Rise time			14	ns
Spectral response			type C	
Outline dimensions		max.	52 x 82	mm

MECHANICAL DATA Dimensions in mm



Mounting position: any

Photocathode

Cathode material — Caesium on oxidized silver

The cathode material has been deposed on the inner surface of the window. This window is optically plane and polished.
It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	26	mm
Spectral response	type C		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °K	typical	20×10^{-6}	A/lumen
	min.	14×10^{-6}	A/lumen

Each tube is marked with its sensitivity.

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5%.

CAPACITANCE

Anode to cathode	C_{ak}		13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen			< 6	$V_{D.C.}$
luminous flux 1 lumen			< 70	$V_{D.C.}$
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Dark current	I_{a_o}	max.	10^{-9}	A
Linearity [1])			0.1	‰
Insulation resistance	r_{ins}	min.	10^{15}	Ω
Rise time	T_r		14	ns

[1]) The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm² of cathode area, peak	I_{kp}	max.	50×10^{-9}	A/mm²
average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm²
Cathode current, peak [1])	I_{kp}	max.	25×10^{-6}	A
average (T_{av} = 1 s)	I_k	max.	35×10^{-9}	A
Envelope temperature	t_{bulb}	min.	-90	°C
	t_{bulb}	max.	+60	°C

LIFE EXPECTANCY

With an average cathode current of 35×10^{-9} A, the sensitivity will not decrease more than 10 % of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to -90 °C.

APPLICATION

Please refer to data of 150AV.

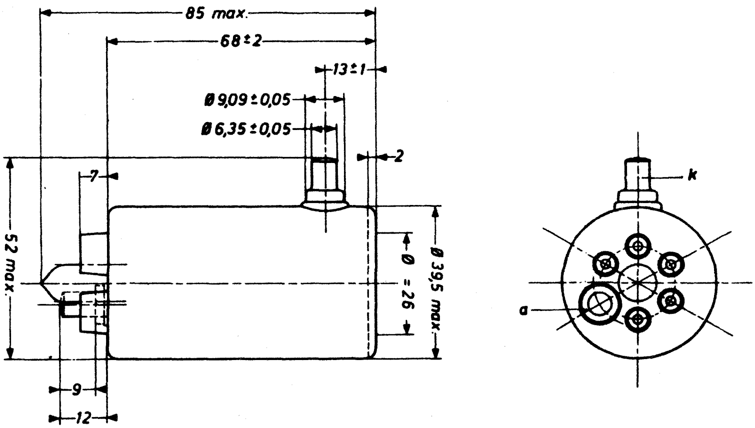
PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision photometry and for measurements of quickly changing light phenomena.

QUICK REFERENCE DATA			
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Average current	I_a	max. 35×10^{-9}	A
Peak current	I_p	max. 25×10^{-6}	A
Sensitivity	N	150×10^{-6}	A/lm
Rise time		14	ns
Spectral response		type T (S20)	
Outline dimensions		max. 52 x 85	mm

MECHANICAL DATA

Dimensions in mm



Mounting position: any

Photocathode

Cathode material		Caesium antimony	

The cathode material has been deposited on the inner surface of the B40 glass window, which is optically plane and polished.

Useful cathode area	dia	26	mm
Spectral response	type T	(S20)	
max. response at		420 ± 30	nm
Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2854 ± 5 K	typical	150	μA/lm
	min.	100	μA/lm
Sensitivity for monochromatie light, measured with a tungsten ribbon lamp having a c.t. of 2854 ± 5 K and a interference filter with maximum transmission at 698 ± 7 nm	typical	13	mA/W

CAPACITANCE

Anode to cathode	C_{ak}	13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lm		6	V
luminous flux 1 lm		70	V
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Dark current, $V_b = 90$ V, $t_{amb} = 25$ °C	I_{ao} typ.	1.5×10^{-12}	A
	max.	50×10^{-12}	A
Insulation resistance	r_{ins} min.	10^{15}	Ω
Rise time, $V_b = 90$ V	T_r	14	ns

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm^2 of cathode area, peak	I_{kp}	max.	50×10^{-9}	A/mm^2
average ($T_{av} = 1$ s)	I_k	max.	70×10^{-12}	A/mm^2
Cathode current, peak	I_{kp}	max.	25×10^{-6}	A [1] [2]
average ($T_{av} = 1$ s)	I_k	max.	35×10^{-9}	A [1] [2]
Envelope temperature	t_{bulb}	max.	60	°C [3]
	t_{bulb}	min.	−90	°C

REMARKS

The cathode should not be exposed to direct sunlight.

---

[1] The current is proportional to the luminous flux within measuring errors, provided that the anode voltage is higher than the saturation voltage.

[2] Cathode evenly illuminated

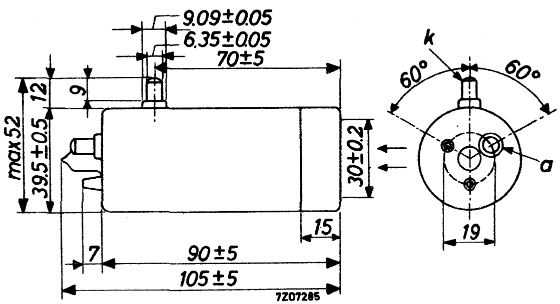
[3] During a few hours only

PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA				
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Average current	I	max.	50×10^{-9}	A
Peak current	I_p	max.	35×10^{-6}	A
Sensitivity	N		60×10^{-6}	A/lumen
Rise time			14	ns
Spectral response			type U	
Outline dimensions		max.	52 x 110	mm

MECHANICAL DATA Dimensions in mm



Mounting position: any

Photocathode

Cathode material	Caesium-antimony		

The cathode material has been deposed on the inner surface of the quartz window. This window is optically plane and polished.
It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	30	mm
Spectral response	type U		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °K	typical	60×10^{-6}	A/lumen
	min.	35×10^{-6}	A/lumen

Each tube is marked with its sensitivity.

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5 %.

CAPACITANCE

Anode to cathode	C_{ak}	13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen		< 6	$V_{D.C.}$
luminous flux 1 lumen		< 70	$V_{D.C.}$
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Dark current	I_{a_o}	max. 10^{-12}	A
Linearity [1]		0.1	‰
Insulation resistance	r_{ins}	min. 10^{15}	Ω
Rise time	T_r	14	ns

[1] The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm² of cathode area, peak	I_{kp}	max.	50×10^{-9}	A/mm²
average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm²
Cathode current, peak [1])	I_{kp}	max.	35×10^{-6}	A
average (T_{av} = 1 s)	I_k	max.	50×10^{-9}	A
Envelope temperature	t_{bulb}	min.	-90	°C
	t_{bulb}	max.	+60	°C

LIFE EXPECTANCY

With an average cathode current of 50×10^{-9} A, the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to -90 °C.

APPLICATION

Please refer to data of 150AV.

PHOTO TUBE

Top sensitive gas-filled phototube, sensitive to ultra-violet radiation, intended for use as an on-off device in flame failure circuits.

QUICK REFERENCE DATA			
Supply voltage	V_b	220	V_{RMS}

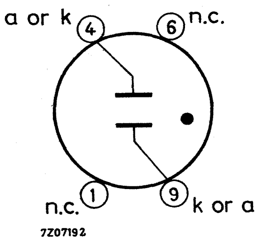
OPERATING PRINCIPLE

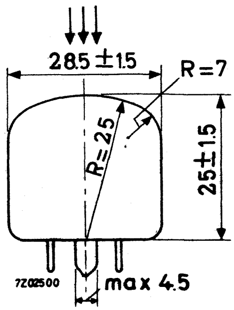
When photons of sufficient energy strike the cathode of the device electrons may be released. Provided the tube voltage is sufficiently high, these electrons may initiate a discharge. The probability that this will occur is dependent amongst other things on the value of the supply voltage and the ultra-violet radiation intensity.
The discharge will extinguish as soon as the instantaneous value of the tube voltage falls below the maintaining voltage.
It should be noted that ~~most~~ sources of visible light (e.g. the sun, fluorescent lamps) are at the same time sources of U.V. radiation.
Where the level of such radiation affects the reliable operation of the circuit, adequate shielding or filtering should be provided.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval 4 pins





The arrows show the required direction of incident radiation for highest sensitivity.
Mounting position: any

MOUNTING

A noval socket with a centre hole diameter of at least 5.4 mm should be used. Pins 1 and 6 should be connected to pins 9 and 4 respectively on the socket.

CHARACTERISTICS

Spectral response		0.2 to 0.29 μm (2000 to 2900 Å) See also page 7
Maintaining voltage	V_m	180 to 220 V

RECOMMENDED CIRCUITS

I. DIRECT RELAY CIRCUIT (t_{amb} = max. 70 °C)

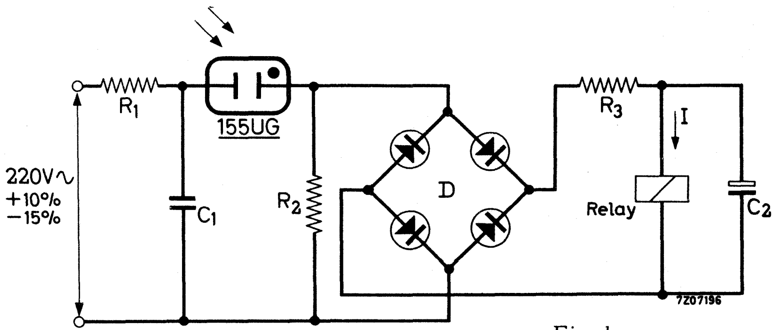


Fig.1

R_1	100 Ω ± 10 %
R_2	220 kΩ ± 10 %
R_3	270 Ω ± 10 %
D	4 diodes
C_1	12 nF ± 15 %
C_2	25 μF ± 15 %

Relay:

R		12 kΩ ± 10 %
I_{on}	<	3 mA
I_{off}		0.5 to 1.5 mA
W_{max}	>	1.2 W.

Notes

1. The filter R_1 C_1 reduces the effects of high voltage transients on the mains.
2. Incidental discharges of the tube will not activate the relay for any value of the mains voltage within the range 220 V + 10 % to −15 %.

Sensitivity

Under the worst probable conditions of supply voltage (190 V) component variation and characteristic variation of the tube during 10.000 hours, the tube will activate the relay when a "standard radiation source" (candle, see fig.4) is at a distance < 50 mm from the tube.

RECOMMENDED CIRCUITS (continued)

II. INDIRECT RELAY CIRCUITS (t_{amb} = max. 100 °C)

IIa

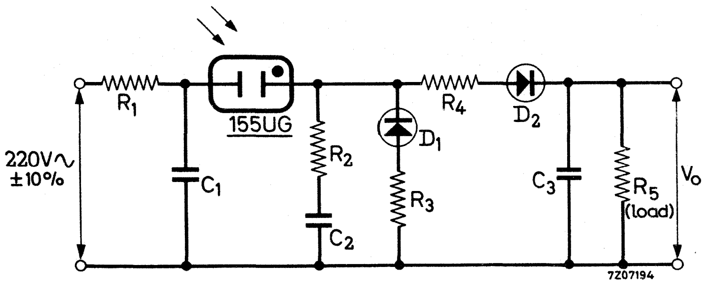


Fig.2

R_1	100 Ω ±10%	C_1	12 nF ±15%
R_2	100 Ω ±10%	C_2	12 nF ±15%
R_3	120 kΩ ±10%	C_3	2.2 μF ±15%
R_4	120 kΩ ±10%	D_1, D_2	diodes
R_5	470 kΩ ±10%		

Note

The filter R_1 C_1 reduces the effects of high voltage transients on the mains.

Sensitivity

The curve on page 8 shows the relationship between the output voltage V_o and the distance between the tube and the "standard radiation source" (see fig.4) under the worst probable conditions of supply voltage (198 V) and component variation for the least sensitive new tube.
After the first 10 000 hours of operation the sensitivity will have decreased, but will in all cases be better than indicated by the curve on page 8 provided the radiation source is doubled (two candles according to fig.4).

RECOMMENDED CIRCUITS (continued)

IIb

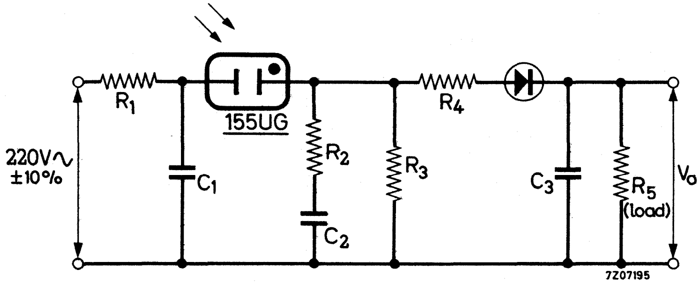


Fig.3

R_1	100 Ω ±10%	C_1	12 nF ±15%
R_2	100 Ω ±10%	C_2	12 nF ±15%
R_3	330 kΩ ±10%	C_3	2.2 μF ±15%
R_4	150 kΩ ±10%	D_1	diode
R_5	470 kΩ ±10%		

Note

The filter R_1 C_1 reduces the effects of high voltage transients on the mains.

Sensitivity

The curve on page 8 shows the relationship between the output voltage V_o and the distance between the tube and the "standard radiation source" (see fig.4) under the worst probable conditions of supply voltage (198 V) and component variation for the least sensitive new tube.
After the first 10 000 hours of operation the sensitivity will have decreased, but will in all cases be better than indicated by the curve on page 8 provided the radiation source is doubled (two candles according to fig.4).

LIMITING VALUES

Ambient temperature, operating	t_{amb}	min. −25	°C	
		max. 70	°C	when used in circuit fig.1
		max. 100	°C	when used in circuits fig.2 and 3
storage	t_{stg}	min. −50	°C	
		max. +50	°C	

Warning

Designers of flame failure detectors are strongly advised not to depart from the recommended circuits. Any such departure may result in an unsafe operating mode which is likely to cause an internal short in the tube before its rated useful life has expired.

Application notes

To ensure that the intensity of radiation incident on the built-in tube will be sufficient throughout its service life (10 000 hours in the case of a new tube) the following procedure should be observed:

For circuit fig.1

Place a "standard radiation source" at a distance of 50 mm from the tube and measure the average voltage across the relay.
In actual operation the same tube should be mounted at a distance from the flame such that the average voltage across the relay is at least equal to that obtained under irradiation from the "standard radiation source" at 50 mm.
Care should be taken that the value of the mains voltage is the same during both measurements.
The flame used during this measurement should be the minimum flame which has to be detected. No further readjustment of the distance between tube and flame will be necessary when the tube has to be replaced.

For circuits fig.2 and fig.3

The output power from the circuits in fig.2 and 3 is too low for direct tripping of a relay. For effective discrimination, the voltage on the input of the added amplifier must attain a certain threshold value when the U.V. energy emitted by the flame attains a certain critical intensity.
The implication is that steps must be taken to ensure that the output voltage V_O from the recommended circuit will remain above this threshold value throughout the life of the tube. This is done in the following way.
Read from the dotted curve on page 8 the distance d corresponding to the required minimum output voltage V_O.
Place two "standard radiation sources" at the distance d from the tube and connect the circuit output to a d.c. voltmeter with a high input resistance; observe the average output voltage V_O. (The mean value around which the needle swings.)
In actual operation the same tube should be mounted at a distance from the flame such that the average output voltage V_O is at least equal to that obtained under irradiation from the two "standard irradiation sources" at the distance d.

Care should be taken that the value of the mains voltage is the same during both measurements.
The flame used during this measurement should be the minimum flame which has to be detected.
No further readjustment of the distance between tube and flame is necessary when the tube has to be replaced.

Above procedures do of course not include allowance for dirt deposited on the tube during life.

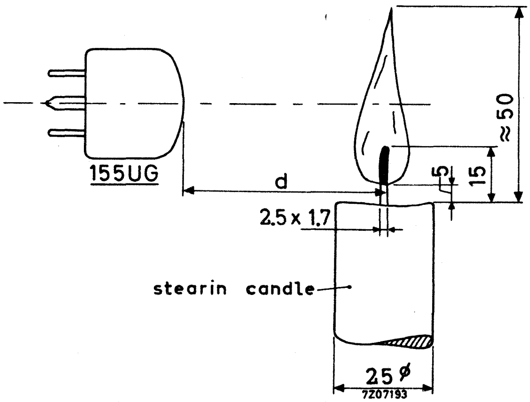
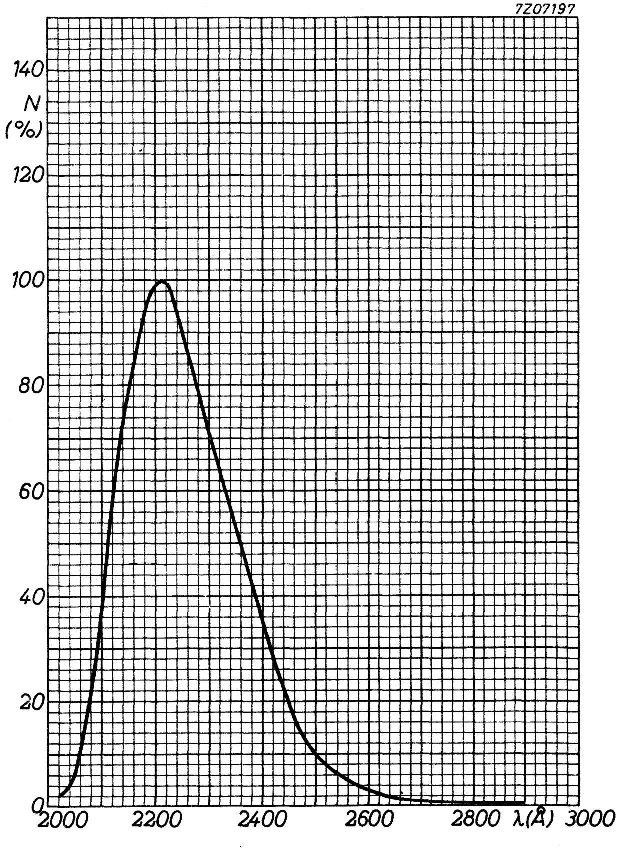
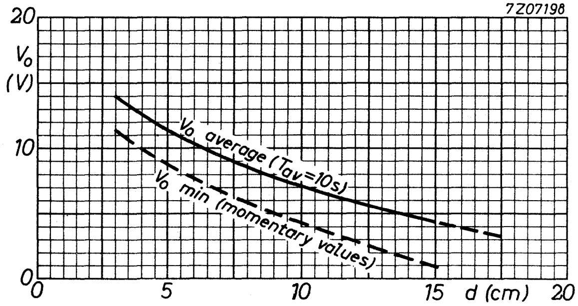


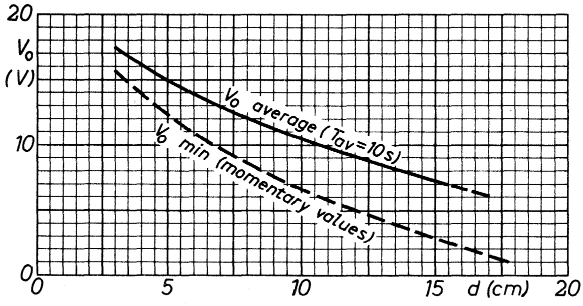
Fig.4

"Standard radiation source"


7Z07197
140
N
(%)
120
100
80
60
40
20
0
2000
2200
2400
2600
2800
λ(Å)
3000



The output voltage as a function of the distance between radiation source and the least sensitive tube in the circuit of fig.3.
The curve is valid at 0 hours when the tube is irradiated by one "standard radiation source" and at 10 000 hours when irradiated by two "standard radiation sources".



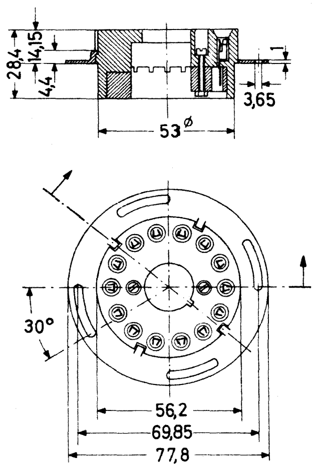
The output voltage as a function of the distance between radiation source and the least sensitive tube in the circuit of fig.2.
The curve is valid at 0 hours when the tube is irradiated by one "standard radiation source" and at 10 000 hours when irradiated by two "standard radiation sources".

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

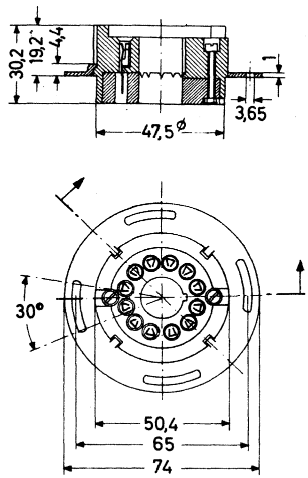


Maximum working voltage between two adjacent contacts		2600	V
Maximum working voltage between any contact and saddle		4500	V
Insulation resistance between two adjacent contacts (at V < 400 V)		$> 10^6$	MΩ
Insulation resistance between any contact and all other metal parts		$> 5 \times 10^4$	MΩ
Contact resistance		< 50	mΩ
Temperature	max.	60	°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

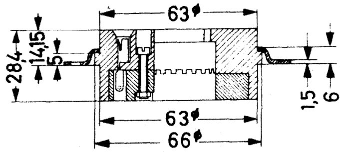


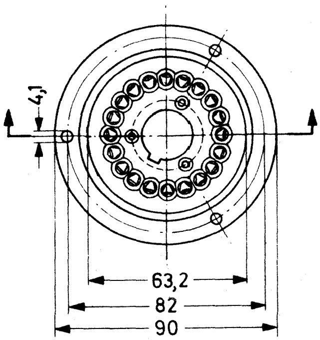
Maximum working voltage between two adjacent contacts		1800	V
Maximum working voltage between any contact and saddle		2800	V
Insulation resistance between two adjacent contacts (at V < 400 V)		$> 10^6$	MΩ
Insulation resistance between any contact and saddle		$> 5 \times 10^3$	MΩ
Contact resistance		< 50	mΩ
Temperature	max.	80	^oC
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



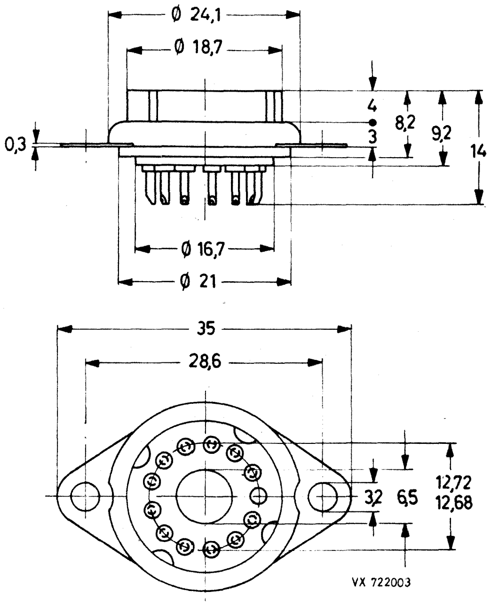


Maximum working voltage between two adjacent contacts		1850	V
Maximum working voltage between any contact and saddle		3200	V
Insulation resistance between two adjacent contacts		$>10^8$	MΩ
Contact resistance		<50	mΩ
Capacitance between two adjacent contacts		<2	pF
Temperature	max.	80	°C
Weight		170	g

SOCKET

Moulding with 12 gold-plated contacts

DIMENSIONS in mm



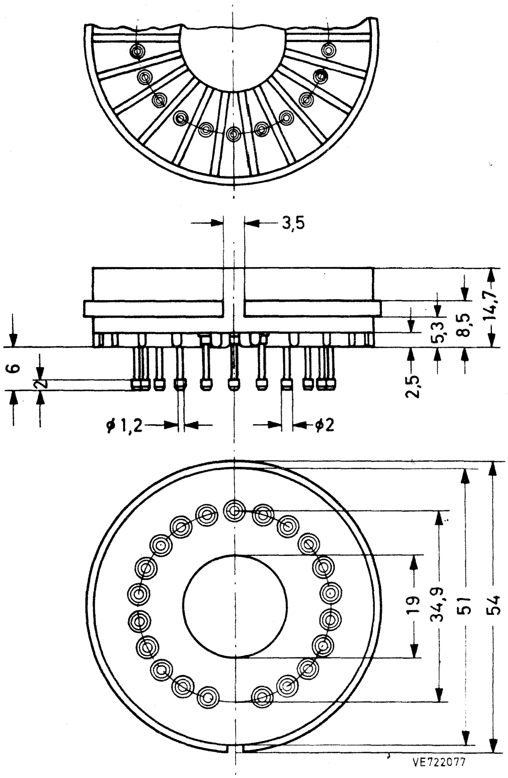
Maximum working voltage		2000	V
Insulation resistance		$> 5 \times 10^3$	MΩ
Contact resistance		10	mΩ
Capacitance, between two adjacent contacts		0, 8	pF
one contact to all		1, 3	pF
Temperature	max.	100	^oC
	min.	-55	^oC
Weight		6	g
Chassis hole		22, 5	mm dia

The use of flexible leads is strongly recommended.

SOCKET

Teflon* moulding with 21 gold-plated contacts.

DIMENSIONS in mm



* Registered Trade Mark

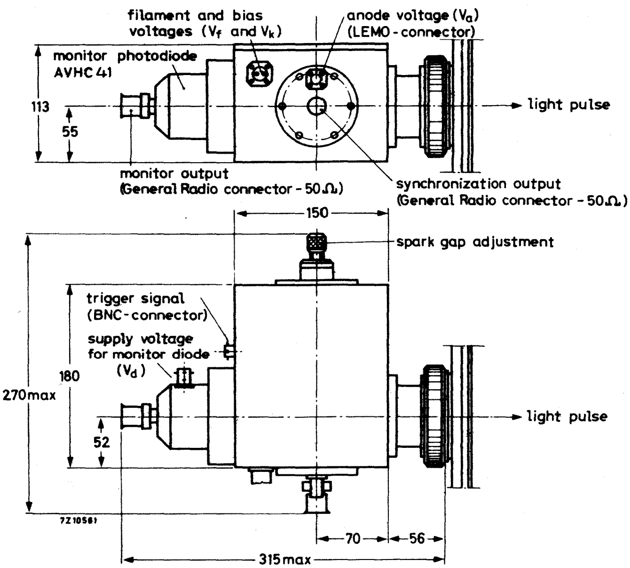
PULSED-LIGHT SOURCE

Pulsed-light source, intended for use in applications where a very short light pulse is needed, e.g., time response measurements of photoelectric devices. It comprises a pulsed-light unit with a monitor diode, and a power and pulse supply unit.

QUICK REFERENCE DATA		
Light pulse rise time	max. 0.5	ns
Light pulse width at half height	max. 0.9	ns
Pulse repetition frequency	0 to 150	p.p.s
Coaxial outlets, synchronization and monitor signals	50	Ω

DIMENSIONS AND CONNECTIONS Dimensions in mm

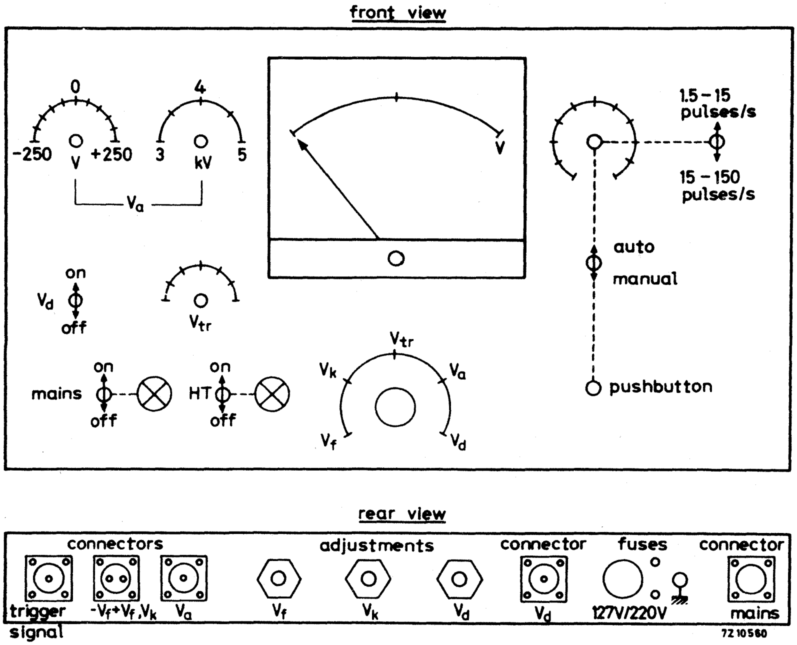
Pulsed-light unit



Data based on pre-production devices.

DIMENSIONS AND CONNECTIONS (continued)

Power and pulse supply unit



Designed to be used in 19 in racks.

CHARACTERISTICS

Light pulse rise time	τ_r	max.	0.5	ns
Light pulse width at half height	FWHM	max.	0.9	ns
Light pulse repetition frequency	from step by step to		150	p.p.s
Light pulse		See Fig. 1		
Electric pulse		See Fig. 2		

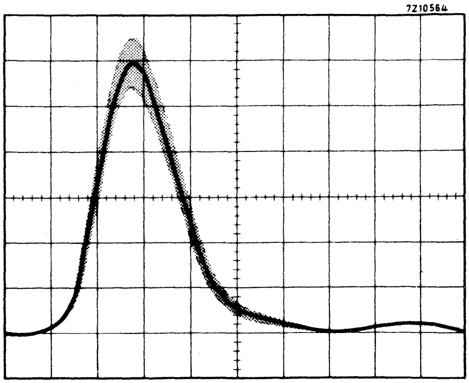


Fig. 1

Light pulse measured with monitor diode AVHC41

Abscissa: 0.5 ns/division
Ordinate: 70 mV/division

The rise time of the oscilloscope taken into account:

Rise time = 0.4 ns
FWHM = 0.85 ns

Pulse amplitude ≈ 420 mV across 50 Ω.

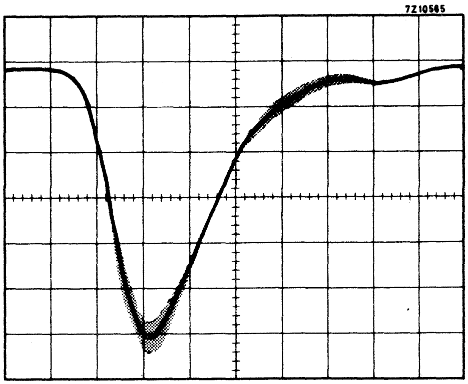


Fig. 2

Electric pulse from the synchronization output

Abscissa: 0.5 ns/division
Ordinate: 200 V/division

The rise time of the oscilloscope taken into account:

Rise time = 0.4 ns
FWHM = 1.2 ns

Pulse amplitude ≈ 1200 V across 50 Ω

OPERATIONAL CONSIDERATIONS

The light pulse characteristics given above are obtained by an optimum adjustment of the supply voltages and the distance between the spark-gap electrodes.

The light pulse is considered to be optimal when the fluctuations in amplitude are as small as possible. In this case the FWHM = 0.85 ns (see Fig. 1).
The electric pulse obtained from the synchronization output with these adjustments is given in Fig. 2. The FWHM is 1.2 ns with an amplitude of 1200 V.

Other adjustments of the spark-gap electrodes are possible:
- A slight decrease of the distance results in a light pulse with an FWHM of 0.75ns, but the fluctuations in amplitude increase considerably (see Fig. 3).
- A further decrease of the distance results in a very narrow electric pulse (FWHM < 1 ns) but the light pulse is unusable because the fluctuations in amplitude are too large.

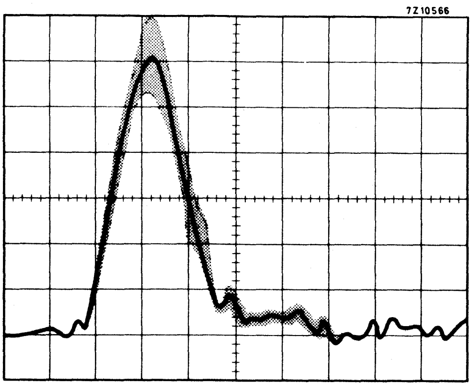


Fig. 3

Light pulse with adjustment giving a minimum FWHM

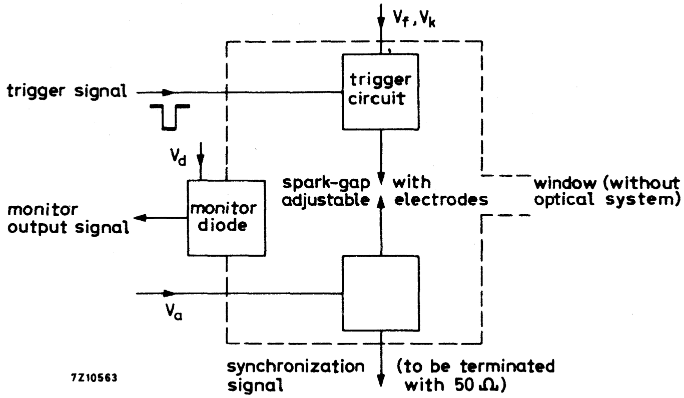
Abscissa: 0.5 ns/division
Ordinate: 50 mV/division
The rise time of the oscilloscope taken into account:
Rise time ≈ 0.4 ns
FWHM = 0.75 ns
Pulse amplitude 300 mV across 50 Ω

Measuring conditions

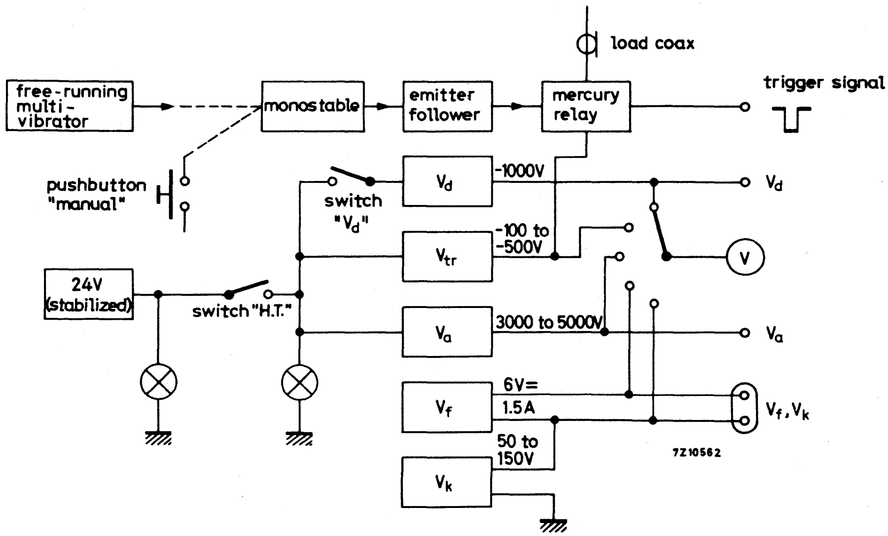
The oscillograms were obtained with:

Bias voltage	V_k	120	V
Trigger pulse amplitude		250	V
HT supply voltage	V_a	5000	V
Monitor diode voltage	V_d	1000	V
Rise time of the oscilloscope		0.35	ns

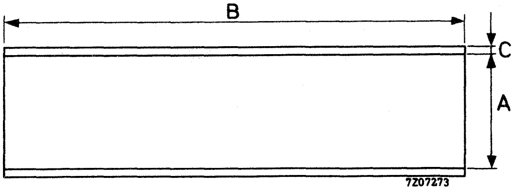
BLOCK DIAGRAM OF THE PULSED-LIGHT UNIT



BLOCK DIAGRAM OF THE POWER AND PULSE SUPPLY UNIT



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 OF TYPENUMBERS

Acc. = Accessories
C.E.M. = Channel electron multipliers
P.D. = Photo diodes
Ph.Sc. = Photoscintillators
Pm.T. = Photomultiplier tubes
Sc. = Scintillators
S.R.D. = Semiconductor radiation detectors

Acc. = Accessories
N. G. T. = Neutron generator tubes
P. D. = Photo diodes
Ph. Sc. = Photoscintillators
Pm. T. = Photomultiplier tubes
R. C. T. = Radiation counter tubes
S. R. D. = Semiconductor radiation detectors

Photomultiplier tubes

Channel electron multipliers

Scintillators

Photoscintillators

Radiation counter tubes

Semiconductor radiation detectors

Neutron generator tubes

Photo diodes

Associated accessories

Printed in The Netherlands

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