PHILIPS

DATA
HANDBOOK

PHILIPS ELECTRONIC COMPONENTS
AND MATERIALS DIVISION

ELECTRON TUBES

PART 6 JUNE 1969

Photomultiplier tubes

Devices for Nuclear Equipment

ELECTRON TUBES

Part 6 **June 1969**

Photomultiplier tubes

Scintillators

Photoscintillators

Radiation counter tubes

Semiconductor radiation detectors

Neutron generator tubes

Associated accessories

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 (5 parts)	RED
COMPONENTS AND MATERIALS (5 parts)	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued annually; 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. 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. If you need confirmation that the published data about any of our products are the latest available, may we ask that you contact our representative. He is at your service and will be glad to answer your inquiries.

7Z2 9287

ELECTRON TUBES (BLUE SERIES)

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

Part 1 — **December 1968**

Transmitting tubes (Tetrodes, Pentodes)
Associated accessories

Part 2 — **February 1969**

Tubes for microwave equipment

Part 3 — **March 1969**

Special Quality tubes
Miscellaneous devices

Part 4 — **April 1969**

Receiving tubes

Part 5 — **May 1969**

Cathode-ray tubes
Photo tubes
Camera tubes
Photoconductive devices
Associated accessories

Part 6 — **June 1969**

Photomultiplier tubes
Scintillators
Photoscintillators
Radiation counter tubes
Semiconductor radiation detectors
Neutron generator tubes

Part 7 — **July 1969**

Voltage stabilizing and reference tubes
Counter, selector, and indicator tubes
Trigger tubes
Switching diodes
Thyratrons
Ignitrons
Industrial rectifying tubes
High-voltage rectifying tubes

Part 9 — **December 1968**

Transmitting tubes (Triodes)
Tubes for R.F. heating (Triodes)
Associated accessories

Part 8

T.V. Picture tubes — will be issued in August 1969

7Z2 9297

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

Part 1 **September 1968**

General section
Signal diodes
Variable capacitance diodes
Voltage regulator diodes
Rectifier diodes
Thyristors
Rectifier stacks
Accessories and heatsinks

Part 2 **October 1968**

General section
Germanium transistors
Photo devices
Accessories and heatsinks

Part 3-4 **November 1968**

General section
Silicon transistors
Accessories and heatsinks

Part 5 **January 1969**

General section
Digital integrated circuits
Linear integrated circuits

7Z2 9289

COMPONENTS AND MATERIALS (GREEN SERIES)

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

Part 1 Circuit Blocks, Input/Output Devices **September 1968**

Circuit blocks:
- 100 kHz Series
- 1-Series
- 10-Series
- 20-Series
- 40-Series
- Norbits (60-Series)

Circuit blocks for ferrite core memory drive
Input/output devices
Accessories for circuit blocks:
- Power supplies
- Mounting chassis [1])
- Printed-wiring boards [2])

Part 2 Resistors, Capacitors **November 1968**

Fixed resistors
Variable resistors
Non-linear resistors
Ceramic capacitors
Polycarbonate, paper, mica, polystyrene capacitors
Electrolytic capacitors
Variable capacitors

Part 3 Radio, Audio, Television **January 1969**

FM tuners
Coils and resonators
Audio and mains transformers
Loudspeakers
Electronic organ assemblies
Television tuners
Components for black and white television
Components for colour television
Deflection assemblies for camera tubes

Part 4 Magnetic Materials, White Ceramics **March 1969**

Ferrites for radio, audio and television
Ferroxcube potcores
Microchokes
Ferroxcube transformer cores
Piezoxide
Insulating and dielectric materials
Permanent magnet materials

Part 5 Memory Products, Magnetic Heads, Quartz Crystals, Microwave Devices, Variable Transformers, Electro-mechanical Components **June 1969**

Ferrite memory cores
Matrix planes, matrix stacks
Complete memories
Magnetic heads
Quartz crystal units, crystal filters
Isolators, circulators
Variable mains transformers
Electro-mechanical components

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[1]) As from June, 1969, this subsection forms part of Part 5, section Electro-mechanical components.

[2]) See also Part 5, section Electro-mechanical components

7Z2 9296

Photomultiplier tubes

LIST OF SYMBOLS

Photocathode	k
Secondary emission electrode (dynode) No.n	S_n
Anode	a
Accelerating electrode	acc
Luminous cathode sensitivity	N_k
Luminous anode sensitivity	N_a
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 photo-emissive 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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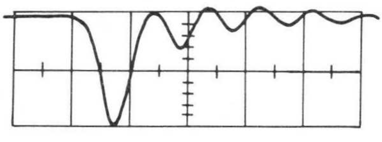


Fig. 1.4.1.a

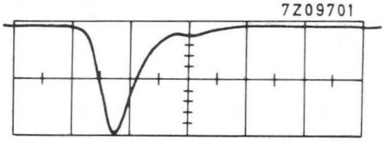


Fig. 1.4.1.b

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 tri-alkali 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-alkali semi-transparent photocathode on a polished Pyrex 7740 window. This photocathode has a high quantum efficiency in the blue region and a low parasitic emission.

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 light flux, 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 light flux is measured by a thermocouple.

2.4 Cathode quantum efficiency

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

$$\eta = N_{kr} \cdot y(\lambda_x) \cdot (\frac{12.4}{\lambda_x})$$

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

$y(\lambda_x)$ = the relative spectral response in % at λ_x

λ_x = wavelength in Å

In the case where λ_x = wavelength of maximum response (published value), $\lambda_x = 100$.
For other wavelengths see relative spectral response curves.
Lines of constant quantum efficiency are shown in Fig. 7.

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.
The anode sensitivity (N_a) is related to the gain (G) and the cathode sensitivity (N_k) by the formula

$$N_a = G \cdot N_k .$$

Since the gain is so high (> 10^6), it is not possible to measure both the anode and the cathode currents under the same conditions. The anode current is normally below 1 mA, so the cathode current is a few tenths of a nano amp.
Since the cathode current, dynode currents and anode current are practically proportional to the incident luminous flux, the following method can be used to get over this difficulty:
First the photomultiplier is connected as a diode, and the cathode is illuminated so strongly that it gives a cathode current of about 0.1 μA. This current is measured, and then the luminous flux falling on the photocathode is reduced to a fraction ($1/a_1$) of its original value by means of, e.g., a neutral filter of known transmittance. Next the appropriate voltage is applied to the photomultiplier, and the anode current measured. The gain is then given by

$$G = \frac{I_a}{a_1 \cdot I_k}$$

The attenuation factor a_1 can also be measured, with the aid of the tube, as the ratio of the currents flowing to one dynode after and before the reduction of the luminous flux. If the gain is very high it is advisable to measure it in a number of steps: e.g., from the cathode to the p^{th} dynode and from the p^{th} dynode to the anode.

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_{a_0}).
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.A 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 determining these characteristics. Even if the transparent, conductive supporting layer is applied with great care the cathode resistance will be of the order of some hundreds of kilo-ohms. The voltage between the cathode and the first dynode must therefore be chosen higher than the voltage between successive dynodes if the current is to be saturating throughout the working range.

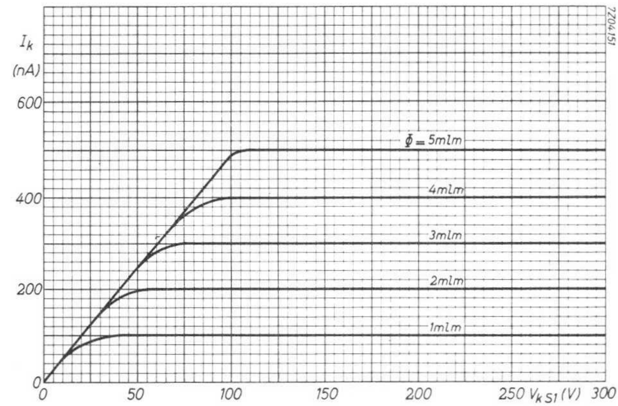


Fig.A The cathode current as a function of the voltage between the photocathode and the first dynode at various values of the luminous flux.

The saturation current of the dynodes, on the other hand, is always reached under normal operating conditions even at the highest permissible luminous flux, so there is no need to take any special measures about them.

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 incident light usually illuminates the entire photocathode.

2.8.3 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 counting rate is to be high or a continuous luminous flux is to be measured 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 of the two voltages with respect to earth, the common terminal may be earthed.

3.2 The voltage divider of a photomultiplier tube must be so designed that it does not cause any troublesome changes in the dynode voltages when the tube starts operating. To this end the divider current I_{bl} (current flowing through the voltage divider) must be large compared to the anode current. If this condition is not fulfilled the dynode voltages, especially in the last stages, will be found to decrease exessively when the tube starts to operate. This effect is more noticeable as the dynode currents (and hence the anode current) are larger.

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

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

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.
The capacitors should be chosen according to the following relationship:

$$C_n \approx \delta\, C_{n-1}$$
$$C_{n-1} \approx \delta\, C_{n-2} \text{ etc.}$$

where C_n = capacitor across resistor feeding last dynode
C_{n-1} = capacitor across resistor feeding last dynode but one etc.

The exact calculation of the capacitively stabilized voltage divider is extremely tedious, because of the large number of parameters involved. However, with the aid of some approximations it can be shown that the relative variation of the gain is approximately:

$$\frac{\Delta G}{G} = \frac{\tau \cdot I_{a\,max}}{I_{b\ell}} \cdot \frac{e^{t/\tau} - e^{-t/RC_n}}{\tau - RC_n}$$

where τ = time constant of the scintillator
$I_{a\,max}$ = peak value of the anode current
RC_n = time constant of the last stage of the voltage divider.

It follows that a peak value of the anode current of 1 mA causes a relative variation of the gain of less than 1% when the time constant RC_n is greater than 100 τ and the current in the voltage divider is at least 1 mA. The voltage fluctuations occurring in this arrangement are small but of long duration, so that when the count rate is high the fluctuations due to successive pulses may be partially superimposed, resulting in an error which is a function of the count rate. In the example just given, the duration of each fluctuation would be approximately 470 τ and if overlapping does not occur, the count rate could not exceed $1/470\tau$ p.p.s. For a time constant of 1 μs this corresponds to a rate of approximately 2200 p.p.s.

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.

These tubes are tested according to the test conditions for space vehicles like "Véronique", "Bélier", "Centaure", "Dragon", "Rubis", 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.

These tubes are tested according to the test conditions for experiments like "Diamant".

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 1000 c/s.
- 40 minutes for measurement at a count rate of 10.000 c/s.
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 drift 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:

$$D_T = \frac{\sum_{i=1}^{n} \overline{P} - P_i}{n} \frac{100}{\overline{P}} \ (\%)$$

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 drift is given by:

$$D_{cr} = \frac{\sum_{1=n+1}^{n+4} P_i - P_n}{4} \frac{100}{P_n} \ (\%)$$

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_T and $D_{cr} \leq 1\%$.

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 outside 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

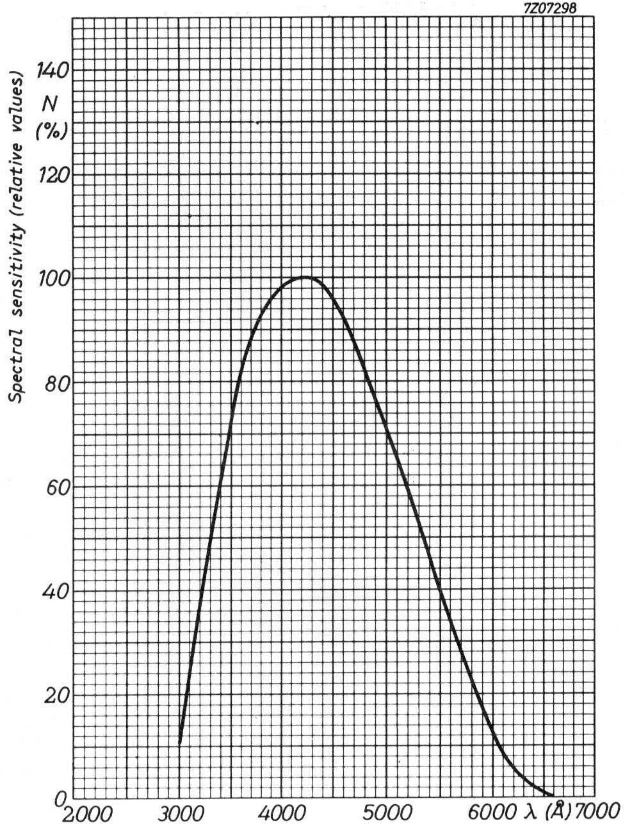
$S_{cr} \leq 1\%$

Available types: XP1101/08, 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).

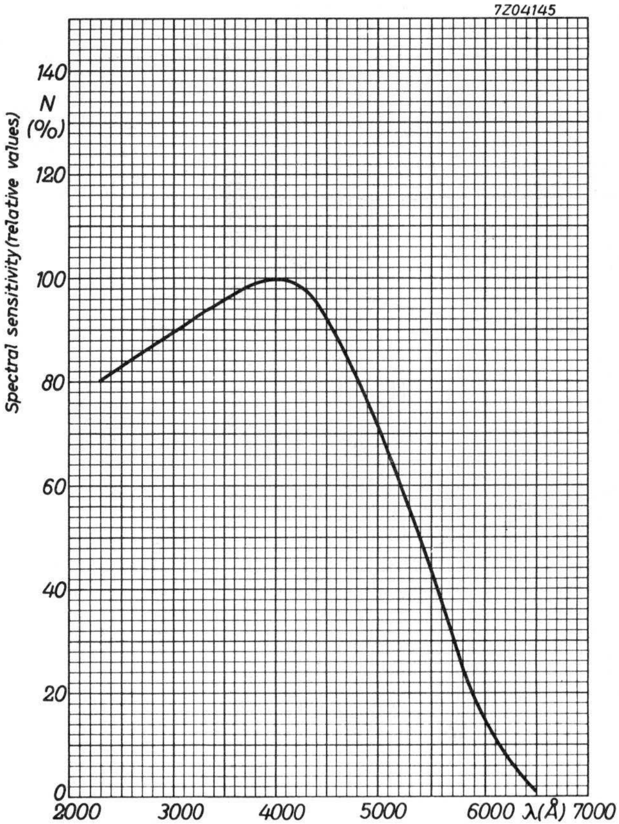
Available types: XP1001 (Sp selection of type XP1000)
XP1031 (Sp selection of type XP1030)
54AVP/Sp, 56AVP/Sp, 150AVP/Sp and 153AVP (Sp-selection of type 53AVP).

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



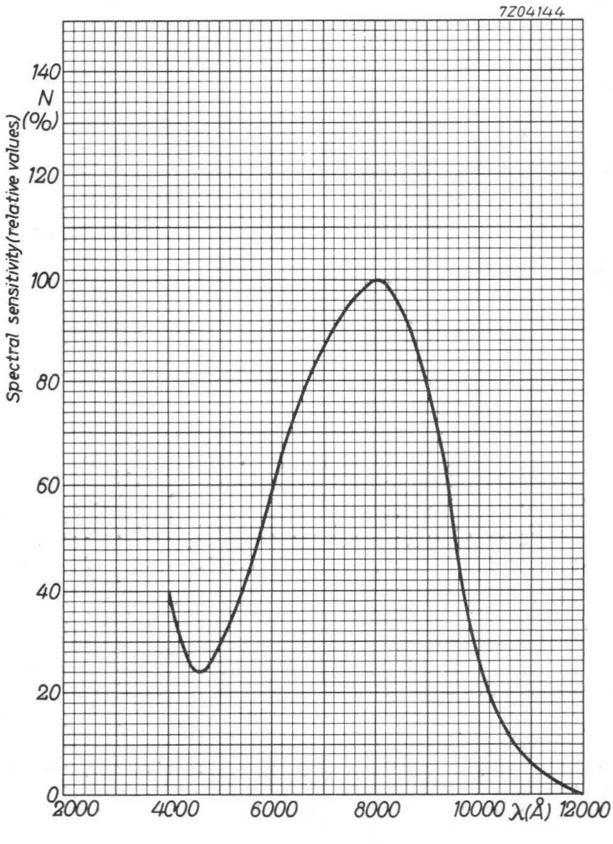
Spectral response curve type A (S11)

Fig. 1



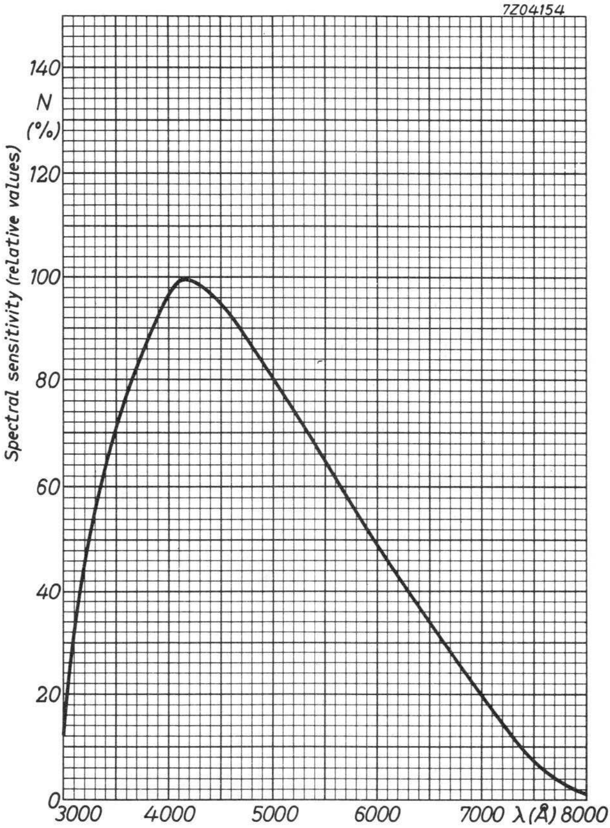
Spectral response curve type U (S13)

Fig. 2



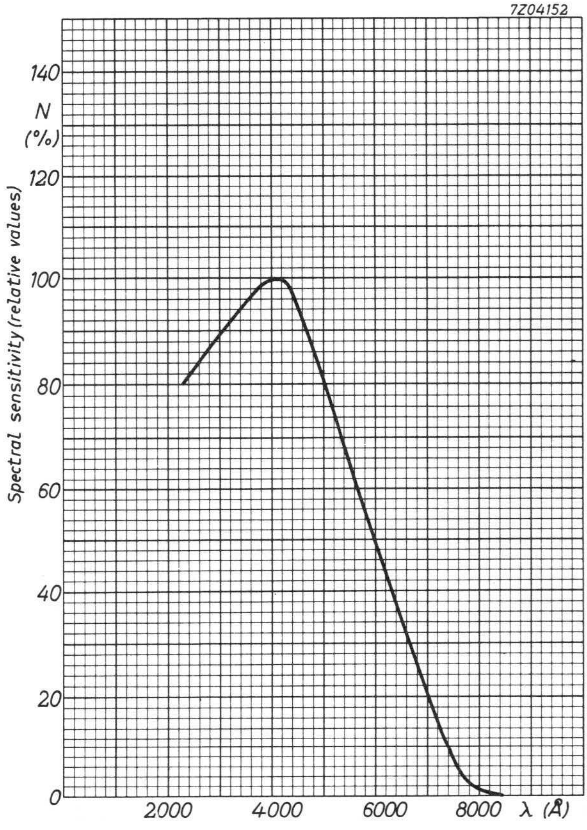
Spectral response curve type C (S1)

Fig.3



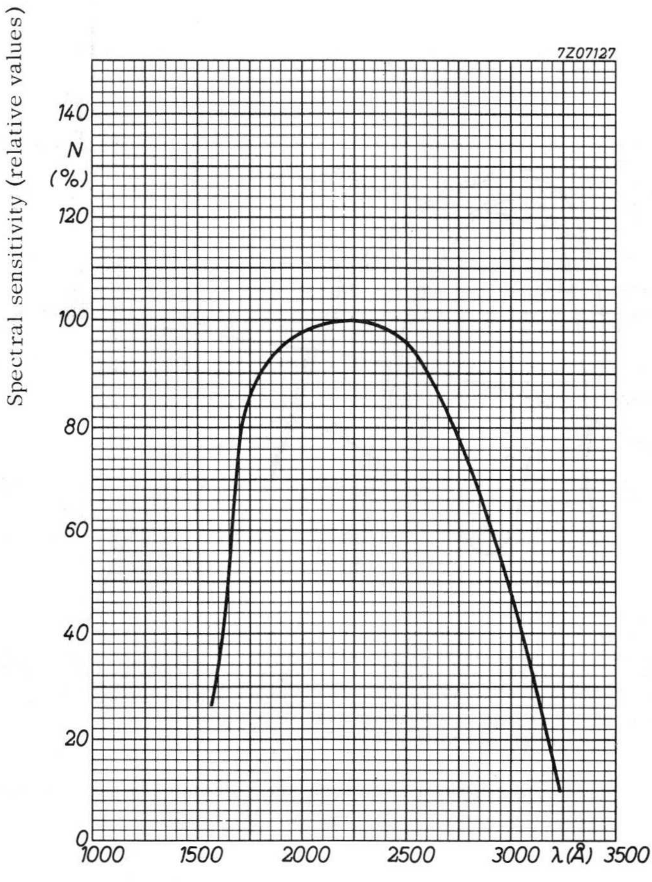
Spectral response curve type T (S20)

Fig.4



Spectral response curve type TU

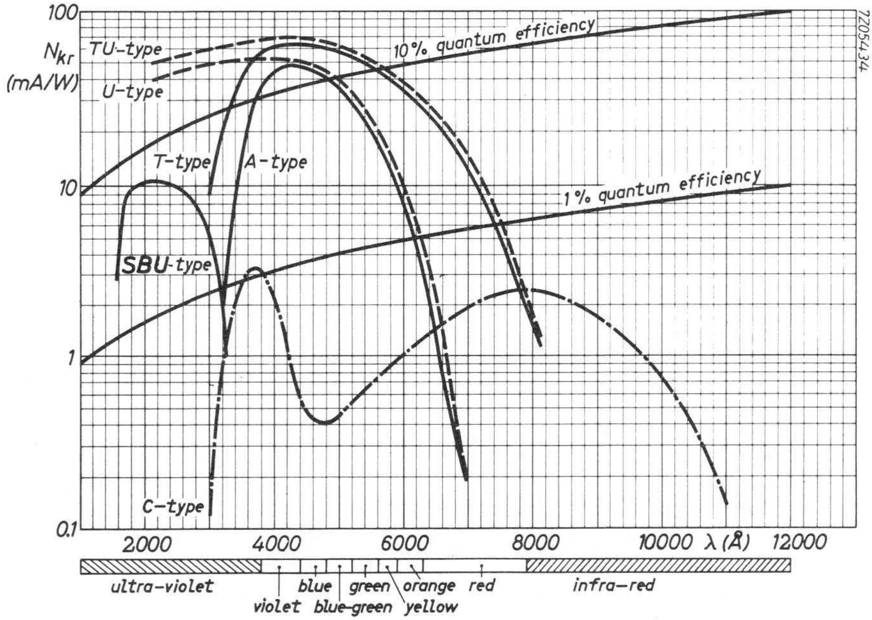
Fig. 5



Spectral response curve type SBU

Fig. 6

Comparison of the various spectral response curves



For the typical sensitivity of each type see relevant characteristics

Fig.7

RATING SYSTEM

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

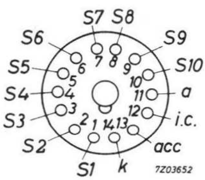
The tube is intended for use in applications such as scintillation counting of alpha, beta, gamma, neutron radiation and X-rays and different kinds of optical instruments.

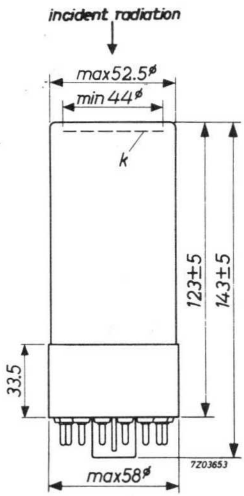
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm

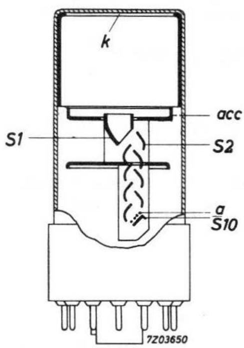
DIMENSIONS AND CONNECTIONS

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 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	$C_{a/S10}$	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)

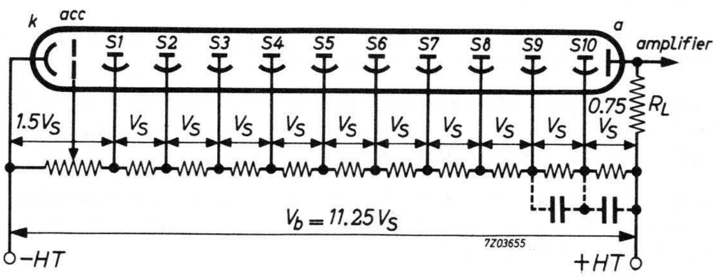
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1500 V [1]	4.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [1]	12.10^{-9}	s
Transit time difference between the the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9}	s
Total transit time at V_b = 1500 V [1]	40.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

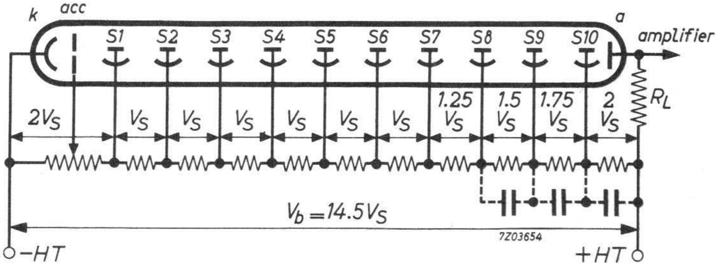


Voltage divider type A

[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.

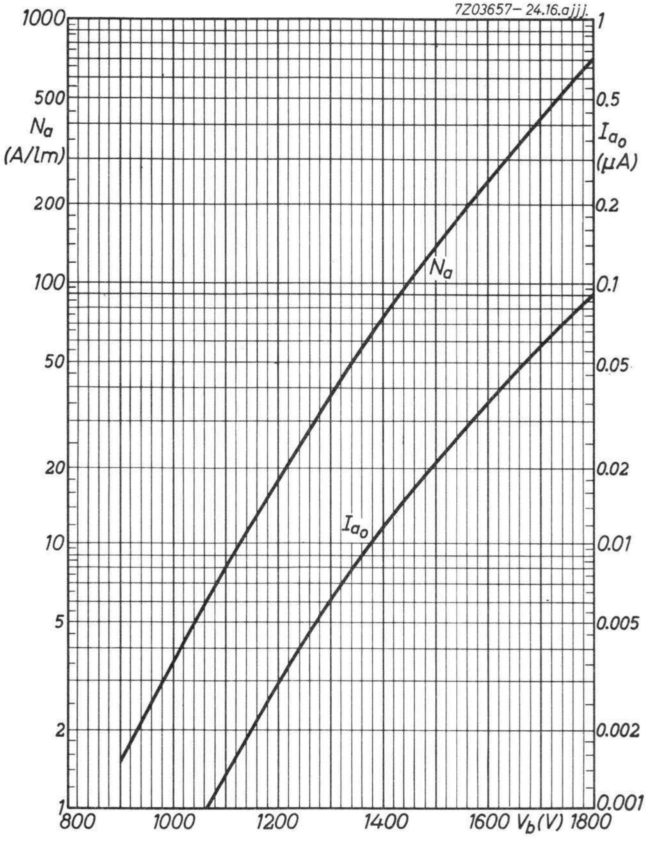
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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.


7Z03657- 24.16.ajjj.
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
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}
800
1000
1200
1400
1600
V_b(V)
1800

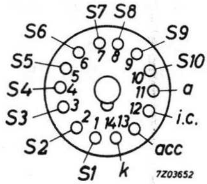
10 STAGE PHOTOMULTIPLIER TUBE

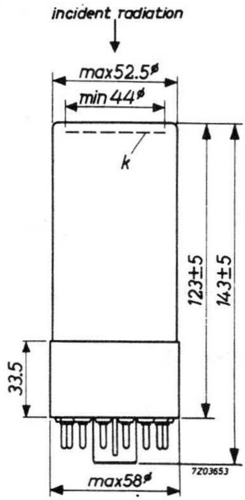
The tube is intended for use in applications such as gamma-ray spectrometry.

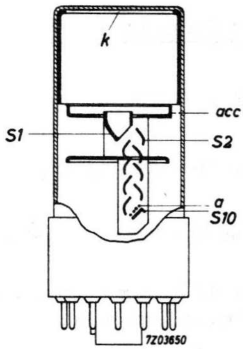
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm
Energy resolution for ^{137}Cs (0.661 MeV) [4])	8.5	%

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 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.	700	A/lm
		min.	400	A/lm
Anode dark current at N_a = 100 A/lm [3]	I_{a_0}	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)

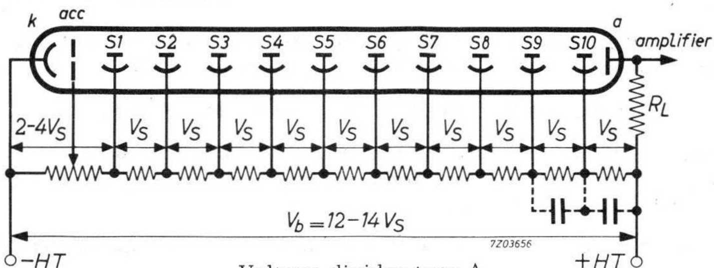
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100 mA
Anode pulse rise time at V_b = 1500 V [1]	4.10^{-9} s
Anode pulse width at half height at V_b = 1500 V [1]	12.10^{-9} s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9} s
Total transit time at V_b = 1500 V [1]	40.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

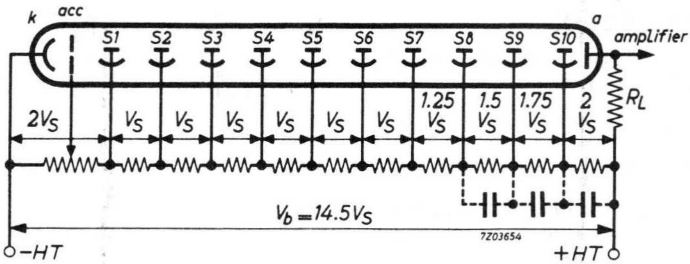
k = cathode		S_n = dynode No.n	
acc = accelerating electrode		a = anode	

---

[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

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.

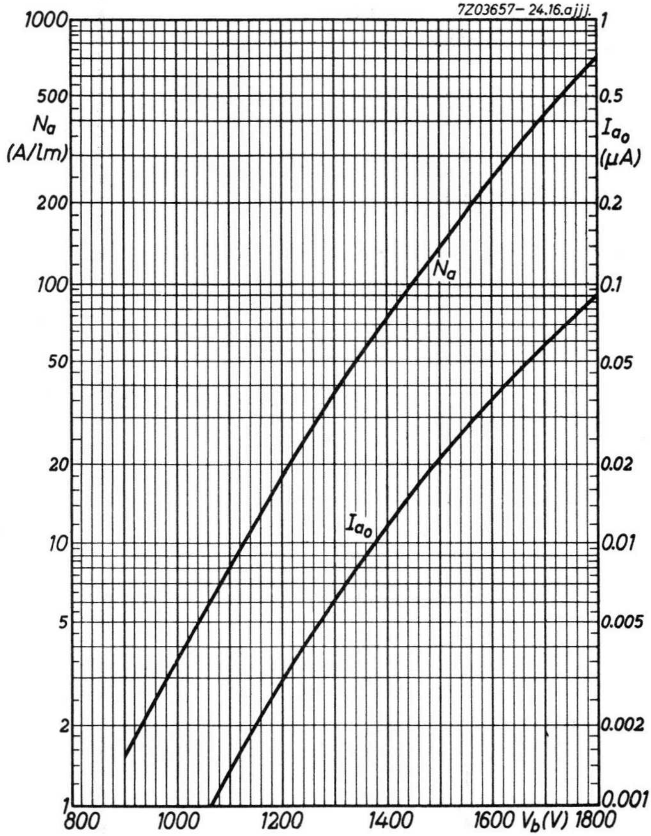
The best results in γ-ray spectrometry will be achieved with a voltage of 4-times "V_S" between the cathode and the first dynode; however, the limiting values must not be exceeded. At a high tension of about 1100 V the tube will work most favourably.

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
Na
(A/lm)
200
100
50
20
10
5
2
1
1
0.5
Iao
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
Na
Iao
800
1000
1200
1400
1600 Vb(V) 1800

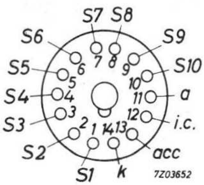
10 STAGE PHOTOMULTIPLIER TUBE

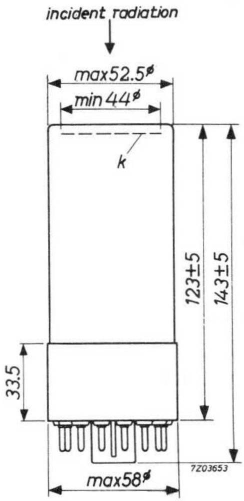
The tube is intended for use in laser technics, working in the orange and green range and for photometry where a high sensitivity in the whole visible region is required.

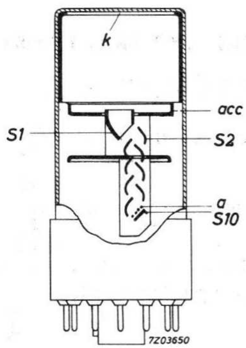
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

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	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)

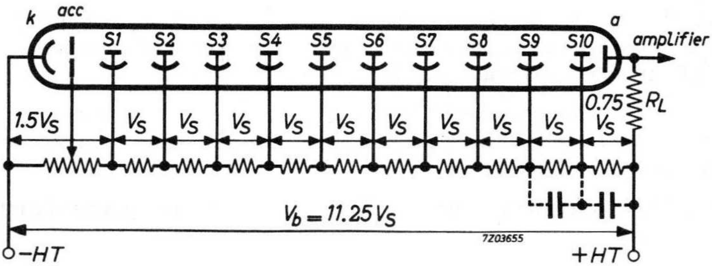
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100 mA
Anode pulse rise time at V_b = 1500 V [1]	4.10^{-9} s
Anode pulse width at half height at V_b = 1500 V [1]	12.10^{-9} s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9} s
Total transit time at V_b = 1500 V [1]	40.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

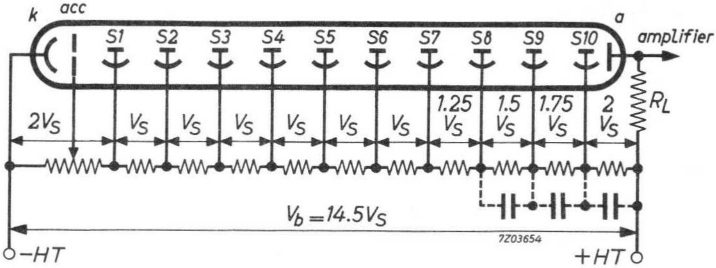


Voltage divider type A

[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.

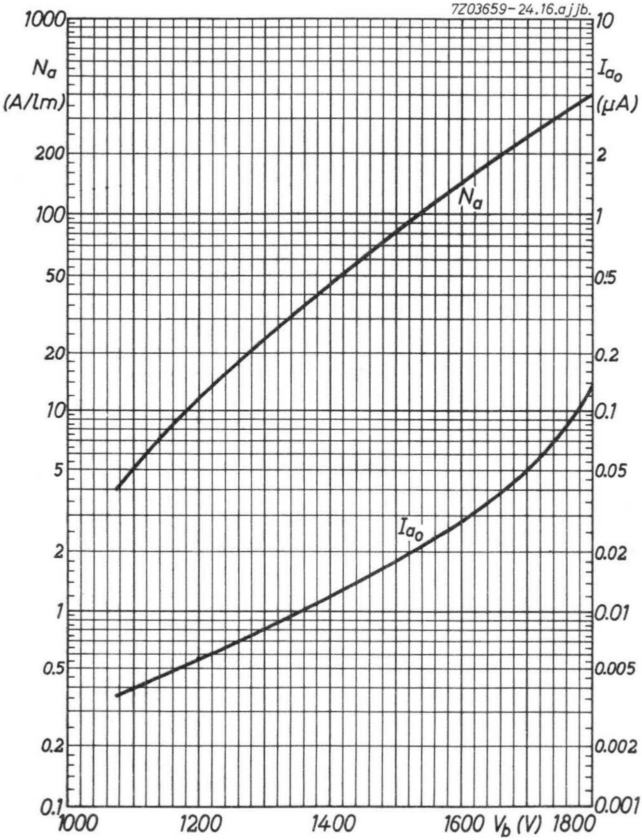
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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.


7Z03659-24.16.ajjb.
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

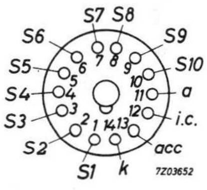
The tube is intended for use in laser technics, and photometry where a high sensitivity in the whole visible and ultraviolet region is required.

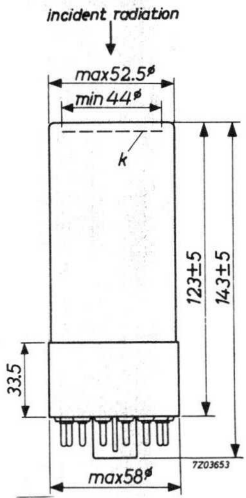
QUICK REFERENCE DATA		
Spectral response	type	TU (extended S20)
Window material	quartz	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

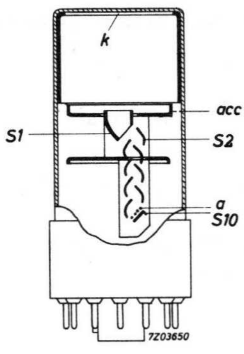
DIMENSIONS AND CONNECTIONS

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 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	$C_{a/S10}$	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. 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)

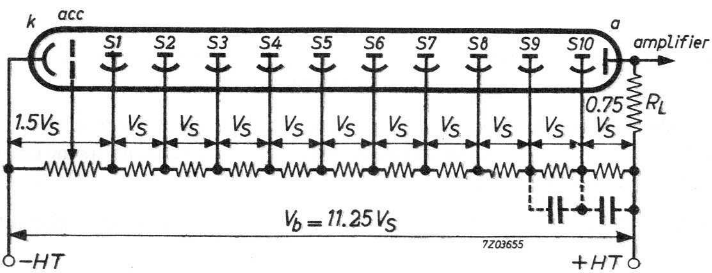
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		4.10^{-9}	s
Anode pulse width at height at V_b = 1500 V [1]		12.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4.10^{-9}	s
Total transit time at V_b = 1500 V [1]		40.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

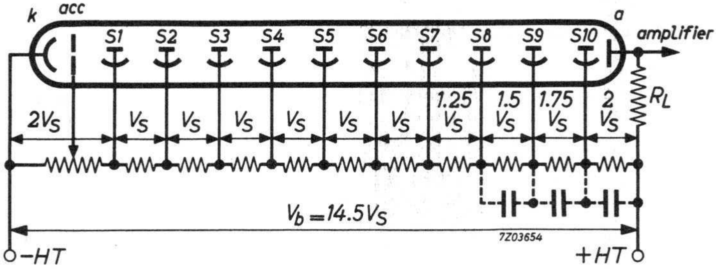


Voltage divider type A

[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.

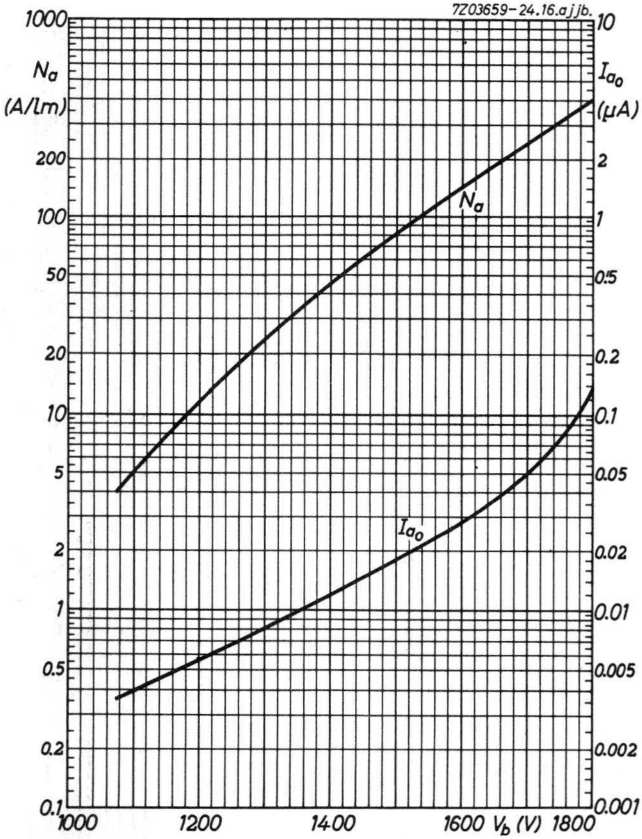
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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
N_a
I_{a_0}
1000
1200
1400
1600 V_b (V) 1800

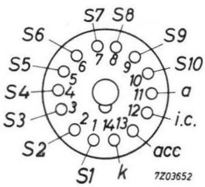
10 STAGE PHOTOMULTIPLIER TUBE

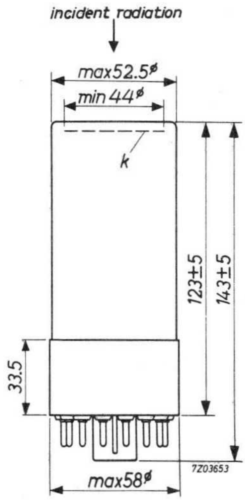
The tube is intended for use in optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

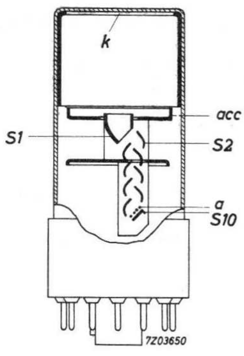
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	700	A/lm

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	$C_{a/S_{10}}$		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)

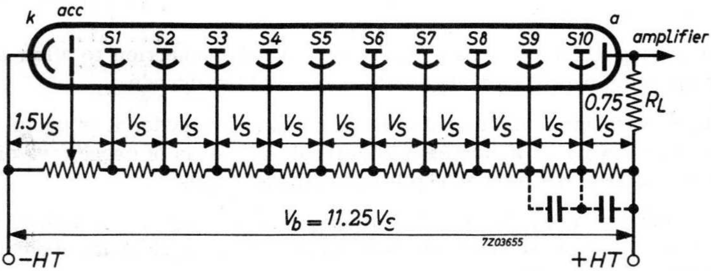
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1500 V [1]	4.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [1]	12.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9}	s
Total transit time at V_b = 1500 V [1]	40.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

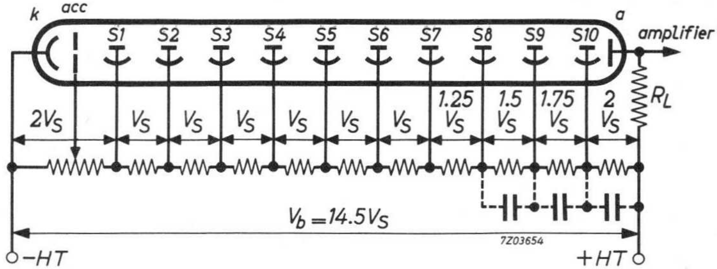


Voltage divider type A

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
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.

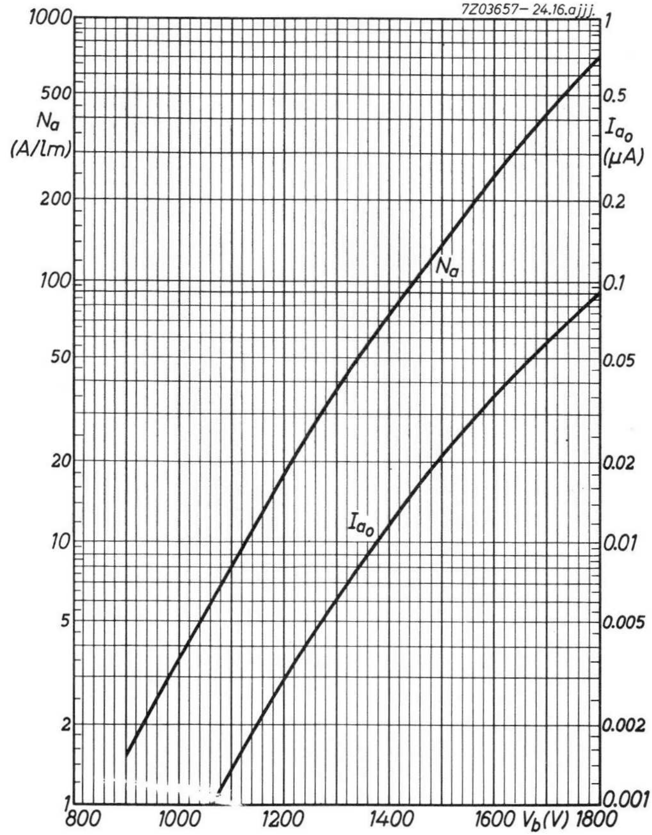
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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 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
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}

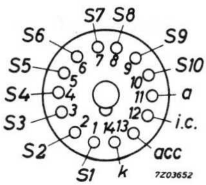
10 STAGE PHOTOMULTIPLIER TUBE

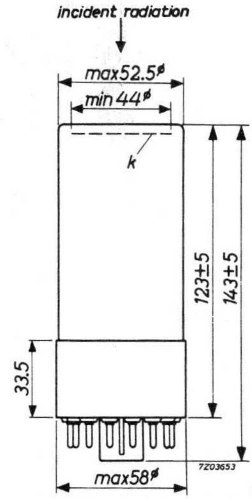
The tube is intended for use in applications such as infra-red telecommunication and ranging and in optical instruments operating in the far red and near infra-red region.

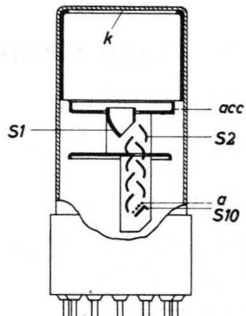
QUICK REFERENCE DATA		
Spectral response	type C (S1)	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	100	A/lm

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)

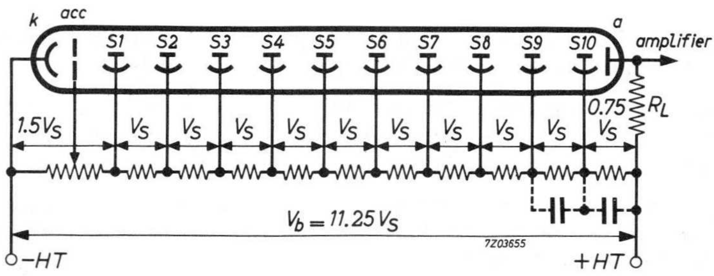
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 10	mA
Anode pulse rise time at V_b = 1500 V [1]	4.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [1]	12.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9}	s
Total transit time at V_b = 1500 V [1]	40.10^{-9}	s

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. 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



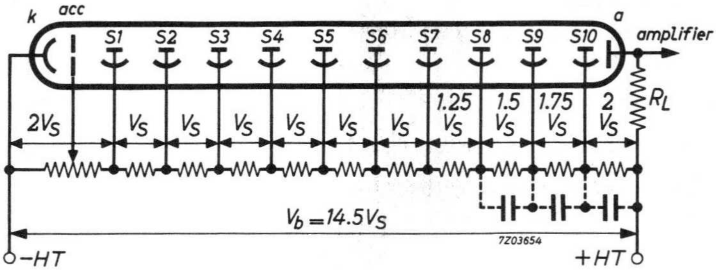
Voltage divider type A

---

[1]) For an 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.

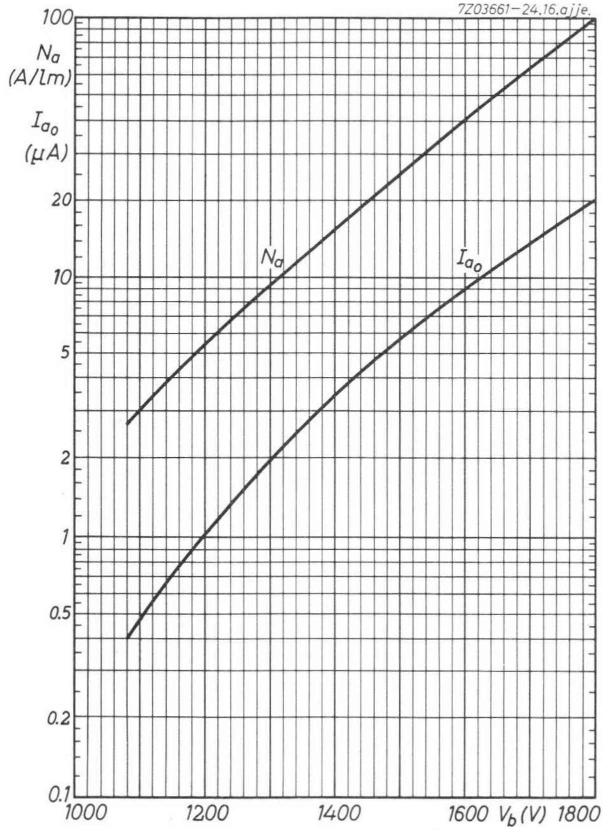
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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

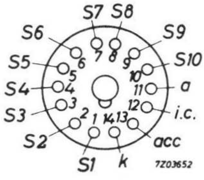
The tube is intended for use in applications such as scintillation counting and measurement of low luminous fluxed.

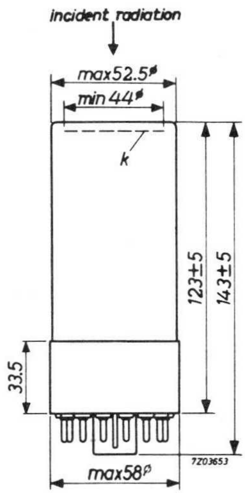
QUICK REFERENCE DATA		
Spectral response	bialkali type D	
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	250	A/lm

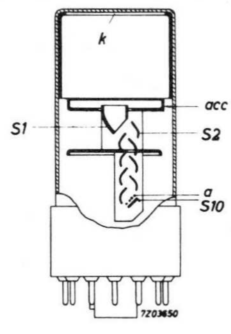
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-pin (Jedec B14-38)







ACCESSORIES

Socket	type FE1001
Mu-metal shield	type 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_{a_o}	av.	0.020	μA
		max.	0.050	μA
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.

TYPICAL CHARACTERISTICS (continued)

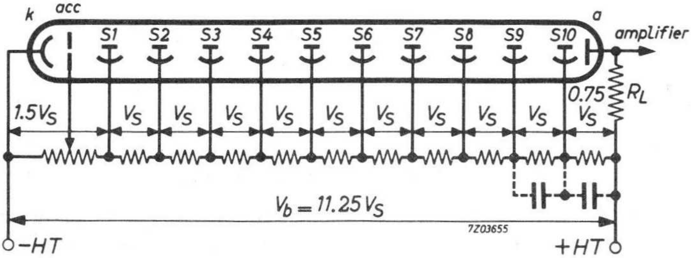
With voltage divider B

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.	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

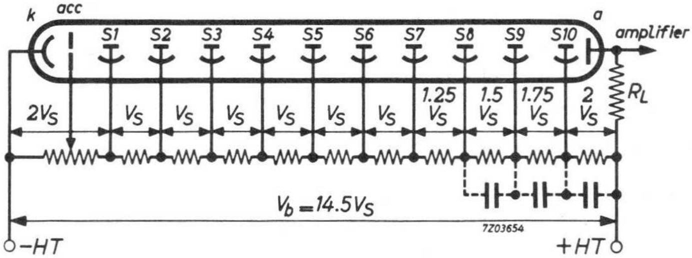


Voltage divider type A

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

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.

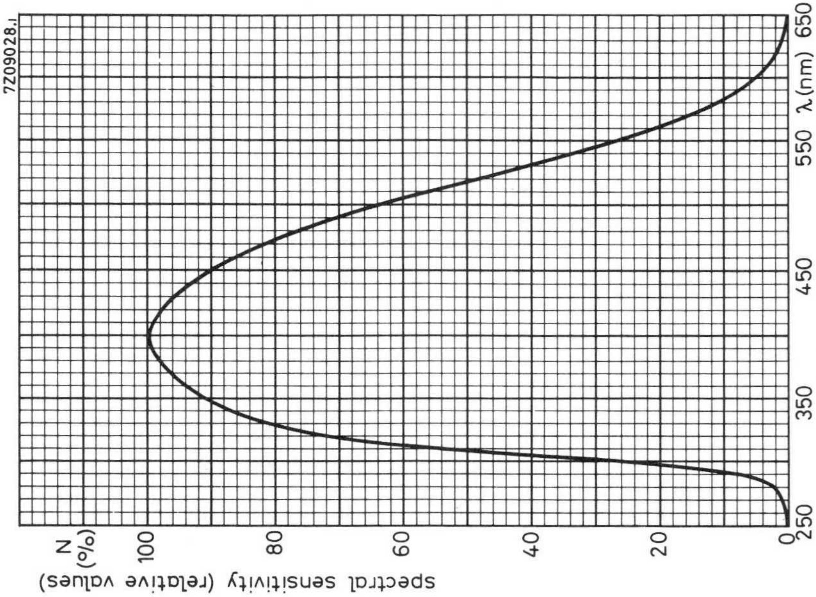
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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.



spectral response curve type D

Fig. 5

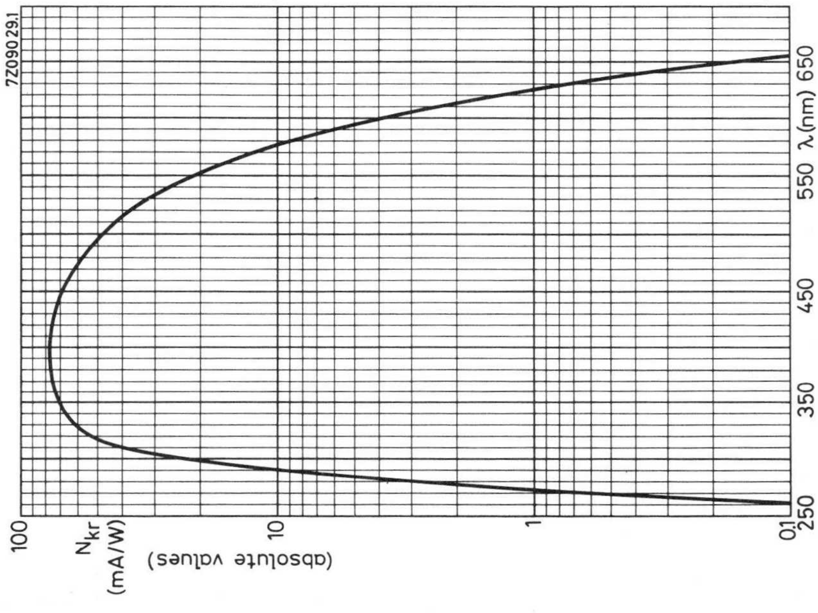


Fig. 6

10 STAGE PHOTOMULTIPLIER TUBE

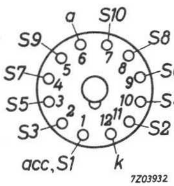
This low noise tube is intended for use in applications such as X- and γ-ray spectrometry.

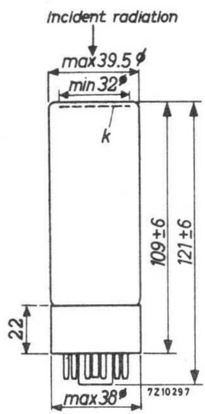
QUICK REFERENCE DATA			
Spectral response		type	A (S11)
Useful diameter of the photocathode		32	mm
Anode sensitivity (at 1800 V)		700	A/lm
Plateau length (Mn, K_α line 5.9 keV)	min.	70	V
Plateau slope	max.	0.08	%/V
Background in middle of plateau		10	Hz

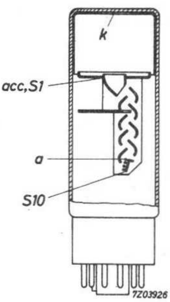
DIMENSIONS AND CONNECTIONS

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 A (S11)	
Wavelength at maximum response		4200 ± 300	Å
Luminous sensitivity [2]	N_k	av. 80 min. 70	μA/lm 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. 700 min. 400	A/lm A/lm
Anode dark current at N_a = 60 A/lm [3]	I_{a_o}	av. 0.010 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)

Plateau length (Mn, K line 5.9 KeV) 1)	min.	70	V
Plateau slope 1)	max.	0.08	%/V
Background in middle of plateau 1)	av. max.	10 50	Hz Hz
Total voltage in middle of plateau		1100	V
Energy resolution for Cu, K (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)		4.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		3.10^{-9}	s
Total transit time at V_b = 1500 V		36.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

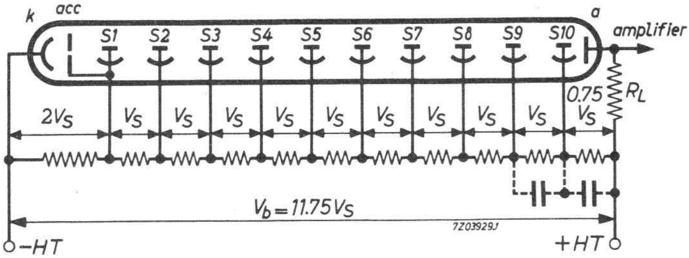
Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynode	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode 3)	$V_{a/S_{10}}$	max. min.	300 80	V V

1) Measured with a 32 mm x 1 mm NaI(Tl) crystal, at a counting rate of about 2500 Hz 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).

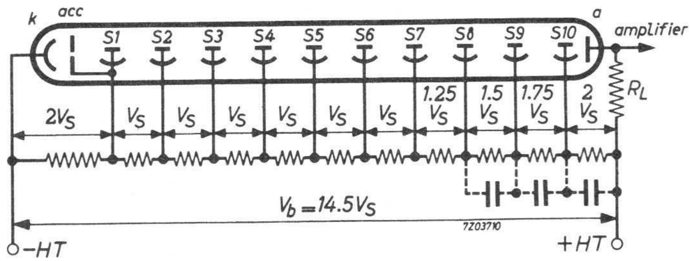
2) For an infinitely short light pulse, fully illuminating the photocathode.

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

OPERATIONAL CONSIDERATIONS

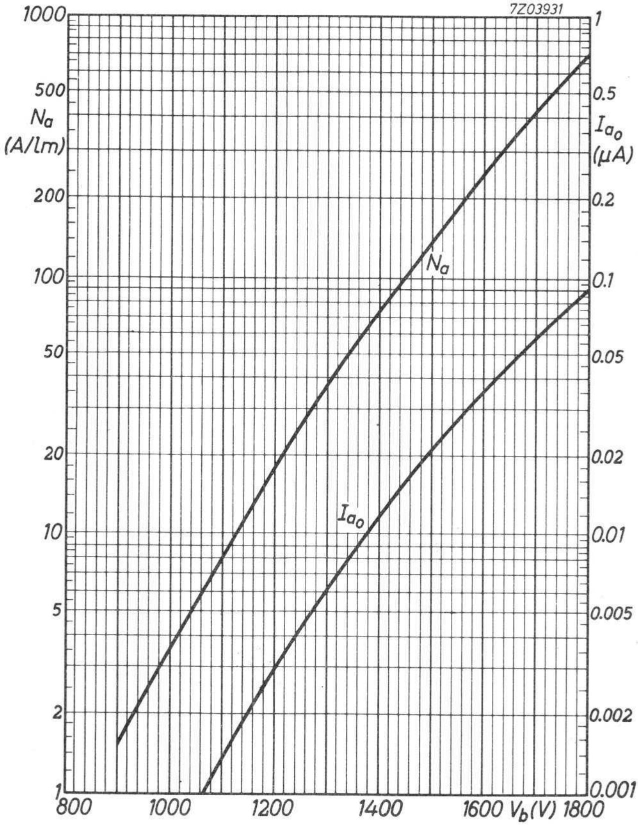
To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

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

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
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
1
0.5
I_{a_0}
(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_0}

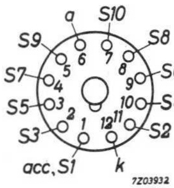
10 STAGE PHOTOMULTIPLIER TUBE

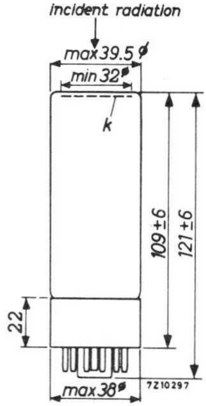
The tube is intended for scintillation counting and optical measurements under severe operating conditions. Its rugged construction makes it particularly suitable for application under severe operating conditions.

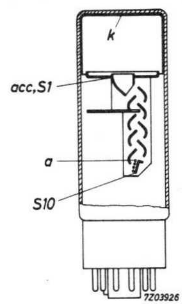
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

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 diameter		32 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	$C_{a/S10}$	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.	0.010 0.050	μA μA
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]			4.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [2]			8.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V			3.10^{-9}	s
Total transit time at V_b = 1500 V [2]			36.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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

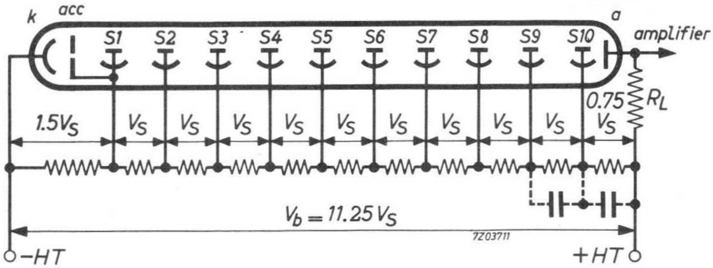
---

1) At an ambient temperature of 25 °C.

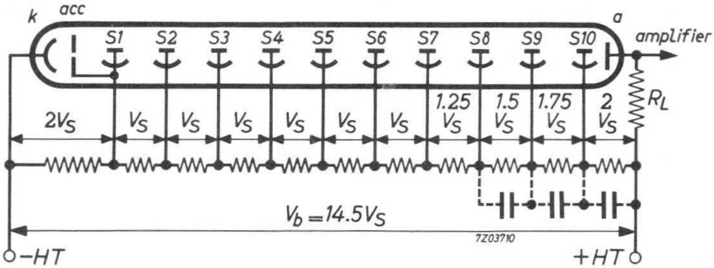
2) For an infinitely short light pulse, fully illuminating the photocathode.

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	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.

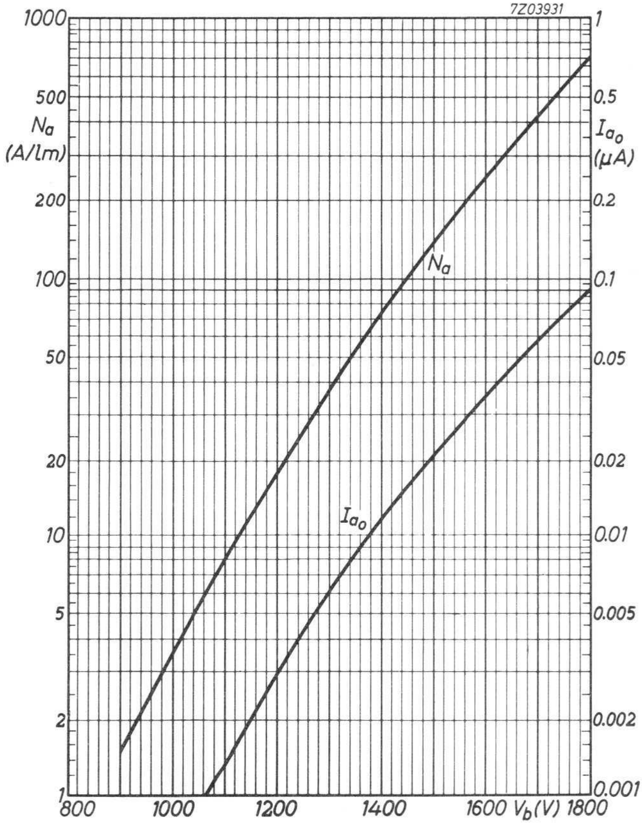
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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
1000
500
N_a
(A/lm)
200
100
50
20
10
5
2
1
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}
800
1000
1200
1400
1600 V_b(V) 1800

10 STAGE PHOTOMULTIPLIER TUBE

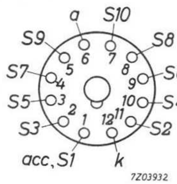
The tube is intended for scintillation counting and optical measurements under severe operating conditions. Its rugged construction makes it particularly suitable for application under severe operating conditions

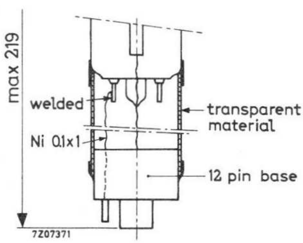
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

DIMENSIONS AND CONNECTIONS

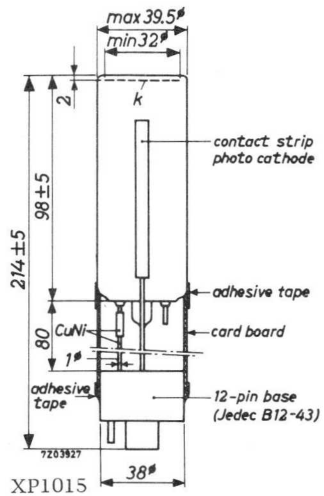
Dimensions in mm

Base: 12-pin (Jedec B12-43)

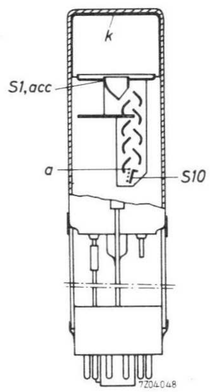




XP1015C



XP1015



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.	0.010 0.050	μA μA
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]			4.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [2]			8.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V			3.10^{-9}	s
Total transit time at V_b = 1500 V [2]			36.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

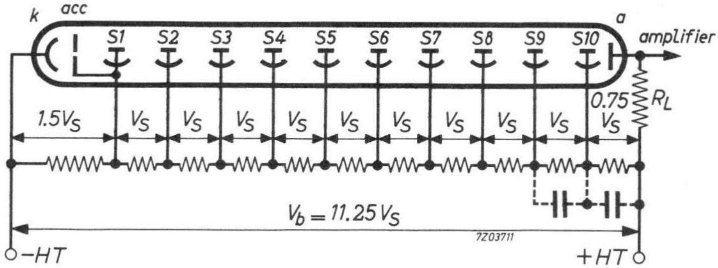
Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. min.	500 120	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	300 80	V V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max. min.	300 80	V V

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

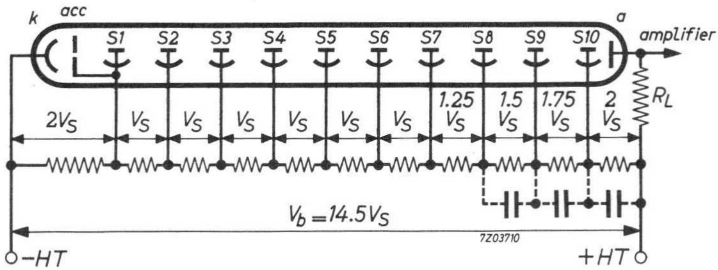
[2]) For an infinitely short light pulse, fully illumunating the photocathode.

[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.

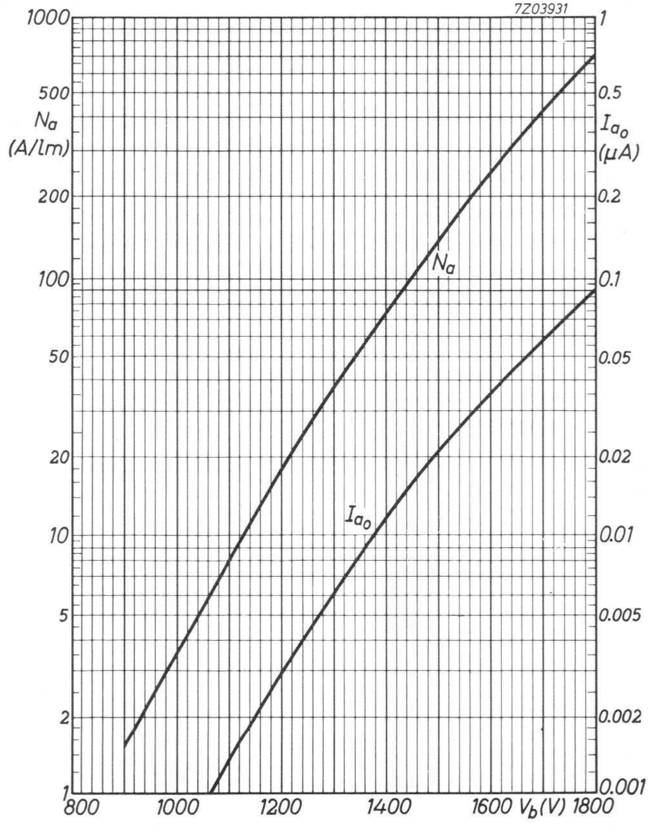
Different kinds of voltage dividers are possible. A circuit of type A results in the highest gain of the tube at a given total voltage; a circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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
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
1800
V_b (V)

10 STAGE PHOTOMULTIPLIER TUBE

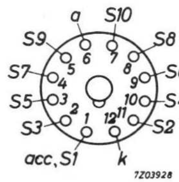
The tube is intended for use in laser technics working in the orange, yellow and green range and in photometric applications. Its rugged construction makes it particularly suitable for application under severe operating conditions.

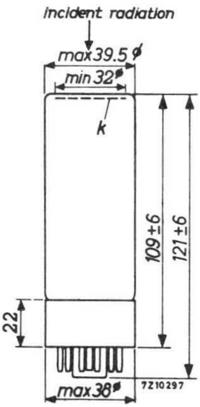
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	400	A/lm

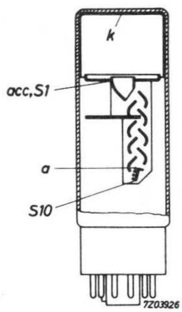
DIMENSIONS AND CONNECTIONS

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		av.	13	mA/W
		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.	3	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)

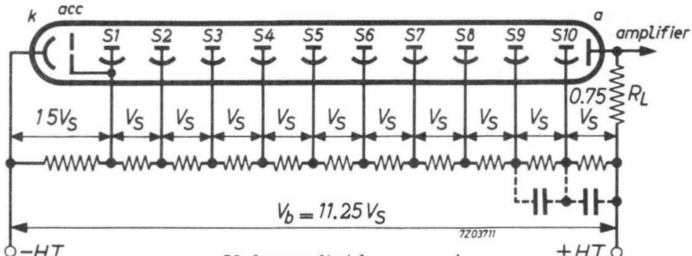
Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	mA
Voltage between cathode and first dynode	Vk/S_1	max.	500	V
		min.	120	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	300	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	300	V
		min.	80	V

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

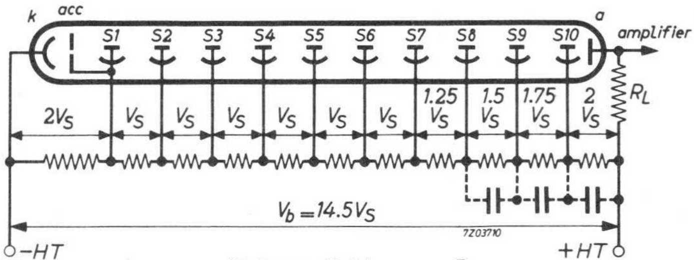
[2] For an infinitely short light pulse, fully illuminating the photocathode.

[3] 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 outputwith better timecharacteristics, but thetotal 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.

12 STAGE PHOTOMULTIPLIER TUBE

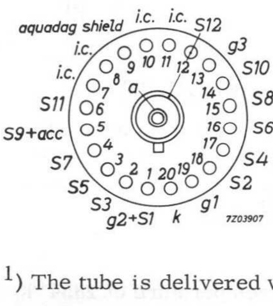
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, "time-of-flight" measurements, Cerenkov counters).

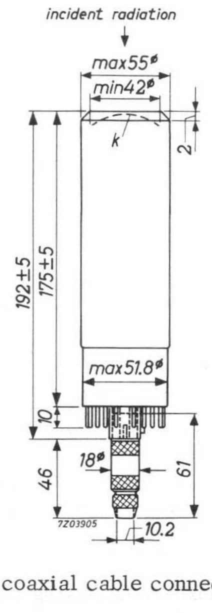
QUICK REFERENCE DATA			
Spectral response		type A (S11)	
Useful diameter of the photocathode		42	mm
Gain (at 2500 V)		10^8	
Anode pulse rise time	<	1.8	ns
Coaxial outlet		100	Ω
Linearity		up to 300	mA

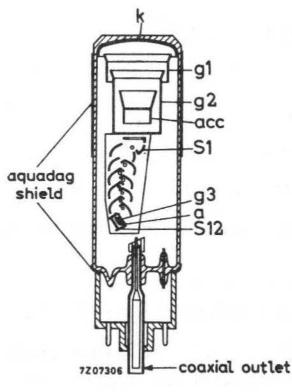
DIMENSIONS AND CONNECTIONS

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 min. 45	μA/lm 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]	$< 1,8.10^{-9}$	s
Anode pulse width at half height at V_b = 2500 V [2]	$3,2.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	$0,2.10^{-9}$	s
Total transit time at 2500 V [2]	28.10^{-9}	s
Maximum peak current	0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V [2]	$< 1,8.10^{-9}$	s
Anode pulse width at half height at V_b = 2500 V [2]	$2,7.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	$0,2.10^{-9}$	s
Total transit time at V_b = 2500 V [2]	28.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage [3]	V_b	max.	3000	V
Continuous anode current	I_a	max.	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

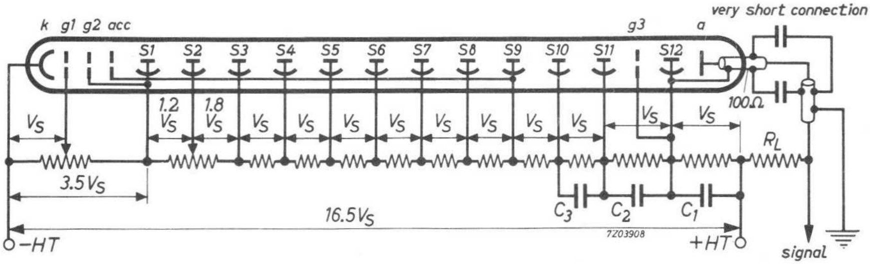
[1] At an ambient temperature of 25 °C.

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

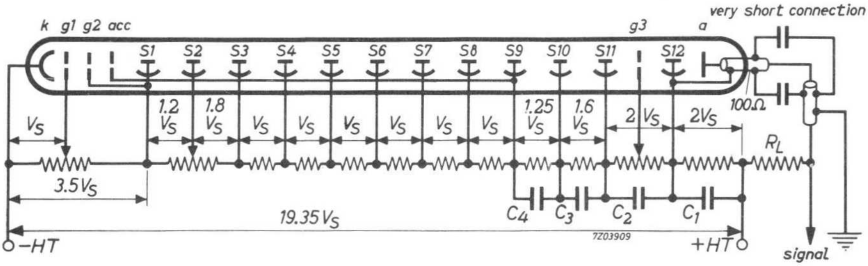
[3] Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.

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

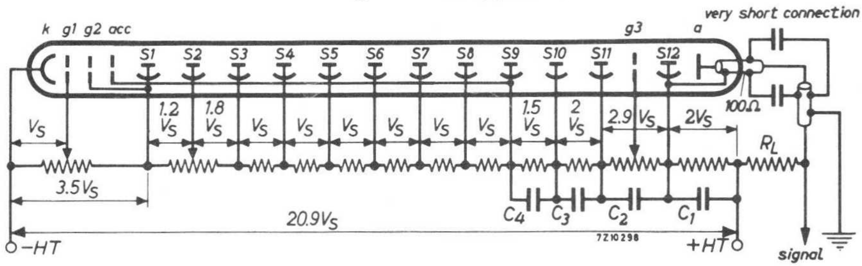
RECOMMENDED CIRCUITS



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.

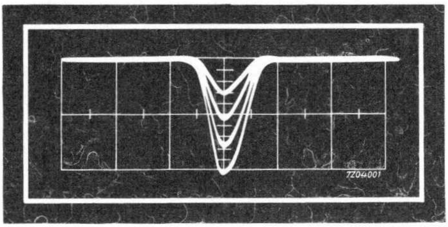


Fig.1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

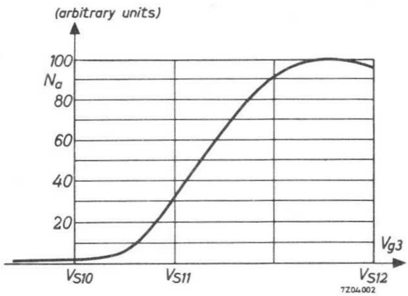
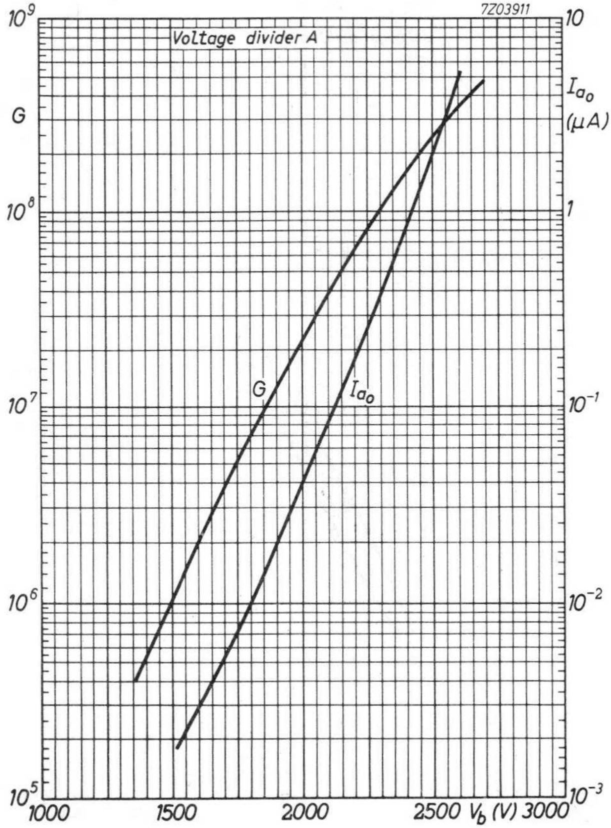


Fig.2 Anode sensitivity as a function of shadow grid potential

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.

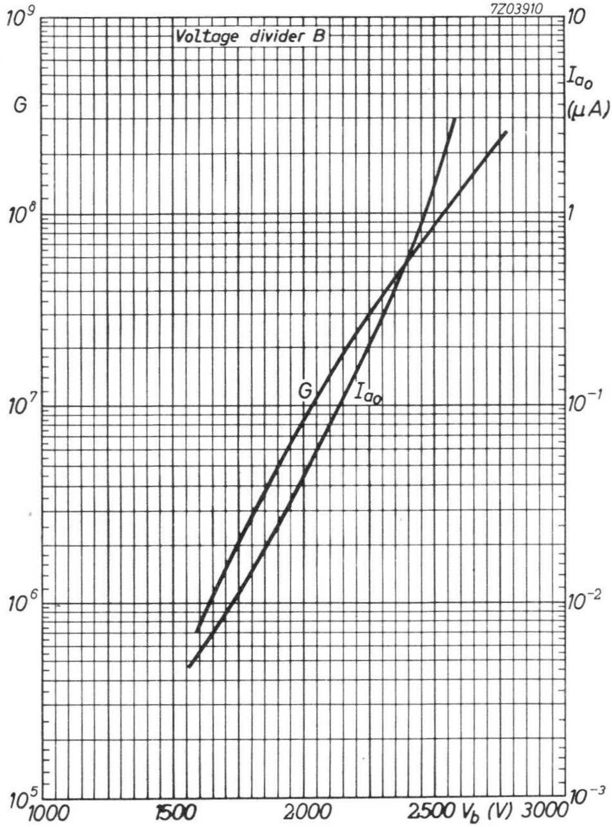
It should be noted that at equal high tensions the gain of the tube is smaller for voltage divider type B than for one according to type A. (See figures 3 and 4.)

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



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

Fig. 3



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

Fig.4

12 STAGE PHOTOMULTIPLIER TUBE

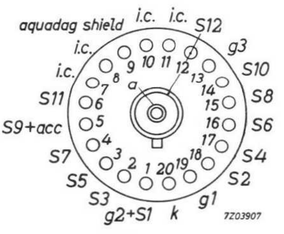
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, "time-of-flight" measurements, Cerenkov counters).

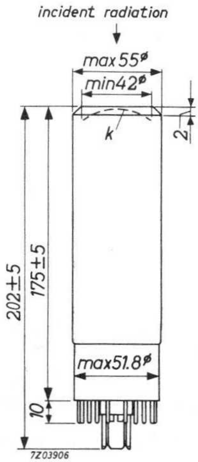
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	< 1.8	ns
Coaxial outlet	50	Ω
Linearity	up to 300	mA

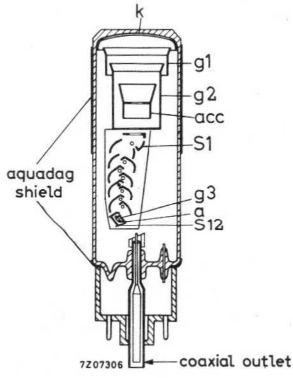
DIMENSIONS AND CONNECTIONS

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.	2500	V
		max.	3000	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)	$< 1,8.10^{-9}$	s
Anode pulse width at half height at V_b = 2500 V 2)	$3,2.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	$0,2.10^{-9}$	s
Total transit time at V_b = 2500 V 2)	28.10^{-9}	s
Maximum peak currents	0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)	$< 1,8.10^{-9}$	s
Anode pulse width at half height at V_b = 2500 V 2)	$2,7.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	$0,2.10^{-9}$	s
Total transit time at V_b = 2500 V 2)	28.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	3000	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	600	V
		min.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{12}}$	max.	500	V
		min.	80	V

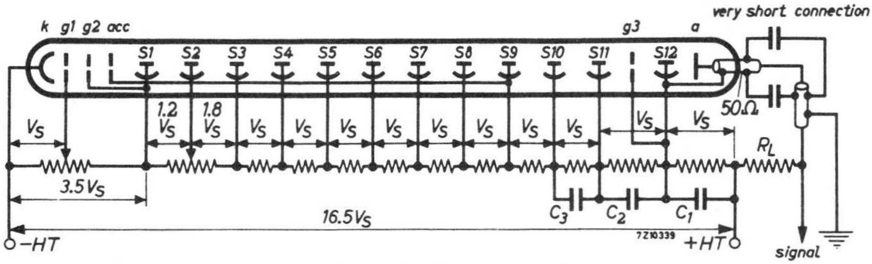
1) At an ambient temperature of 25 °C.

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

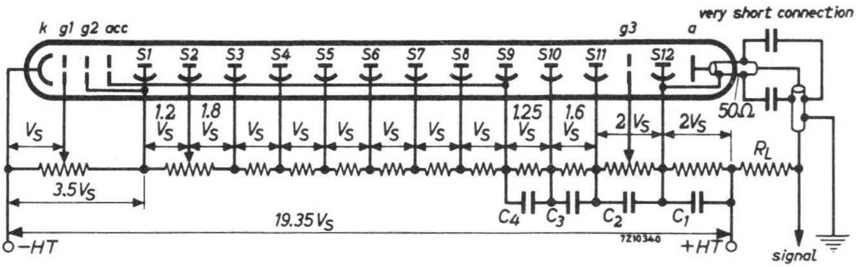
3) Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.

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

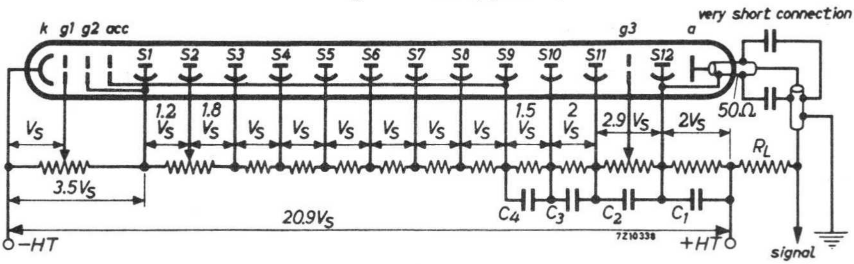
→ RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode 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.

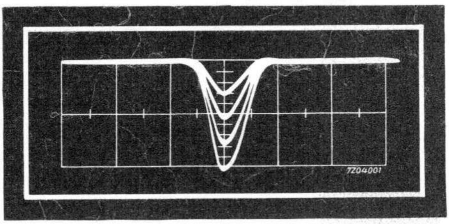


Fig.1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

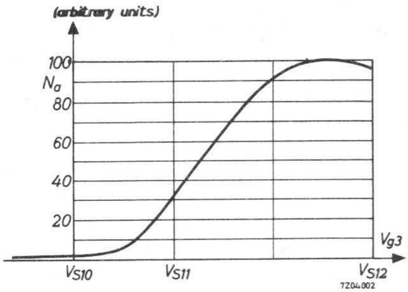


Fig.2 Anode sensitivity as a function of shadow grid potential

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.

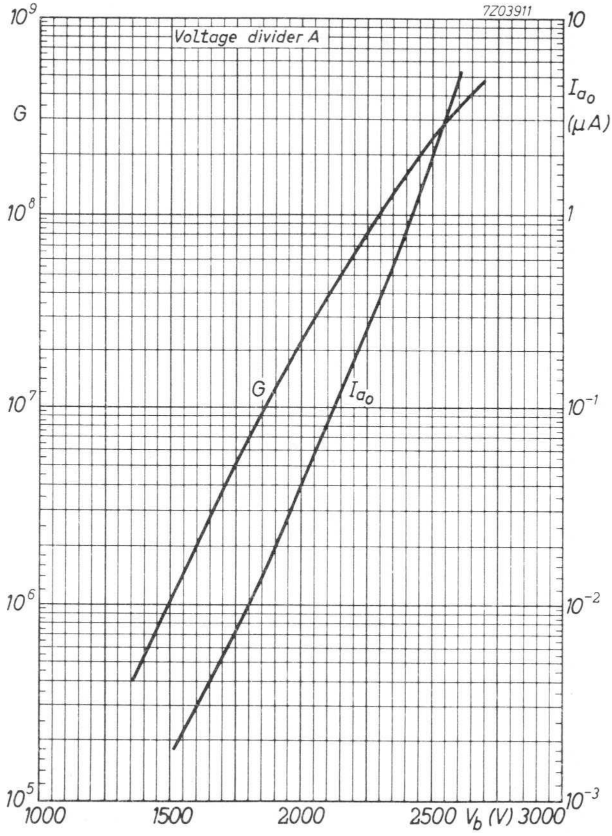

7Z03911
Voltage divider A
10^9
G
10^8
10^7
10^6
10^5
10
I_{a_0}
(μA)
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
1000
1500
2000
2500 V_b (V) 3000

Fig. 3

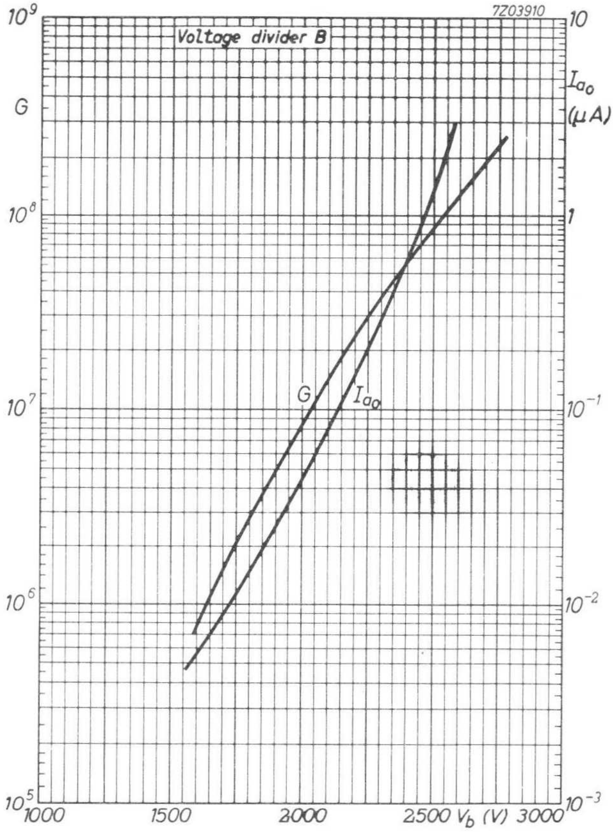

7Z03910
Voltage divider B
G
I_{a_0} (μA)
10^9
10^8
10^7
10^6
10^5
10
1
10^{-1}
10^{-2}
10^{-3}
G
I_{a_0}
1000
1500
2000
2500
V_b (V)
3000

Fig. 4

12 STAGE PHOTOMULTIPLIER TUBE

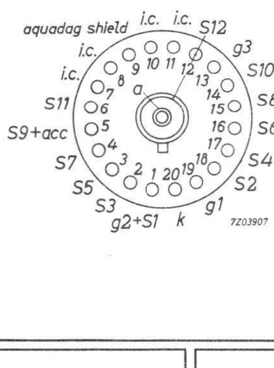
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the ultraviolet region.

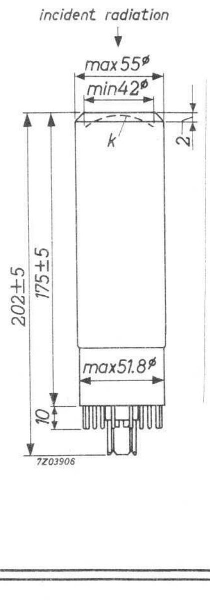
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	< 1.8	ns
Coaxial outlet	50	Ω
Linearity	up to 300	mA

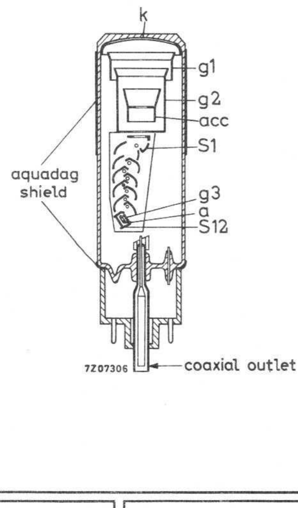
DIMENSIONS AND CONNECTIONS

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	μA/lm
		min. 45	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

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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.

[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.	3000	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)	$< 1,8.10^{-9}$	s
Anode pulse width at half height at $V_b = 2500$ V 2)	$3,2.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V	$0,2.10^{-9}$	s
Total transit time at $V_b = 2500$ V 2)	28.10^{-9}	s
Maximum peak currents	0.5 to 1	A

With voltage divider B'

Anode pulse rise time at $V_b = 2500$ V 2)	$< 1,8.10^{-9}$	s
Anode pulse width at half height at $V_b = 2500$ V 2)	$2,7.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at $V_b = 2500$ V	$0,2.10^{-9}$	s
Total transit time at $V_b = 2500$ V 2)	28.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	3000	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	600	V
		min.	300	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode 4)	$V_{a/S_{12}}$	max.	500	V
		min.	80	V

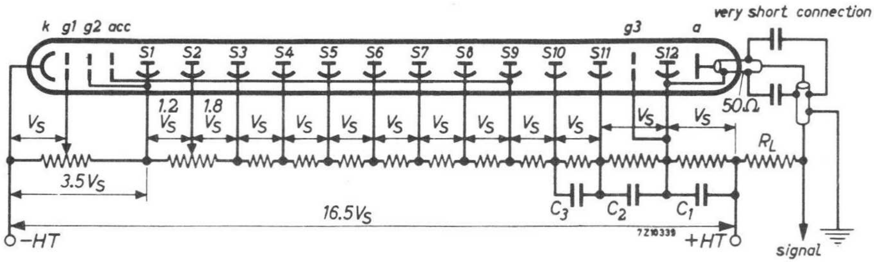
1) At an ambient temperature of 25 °C

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

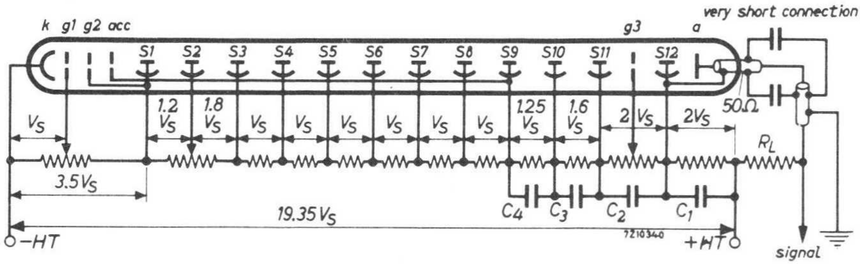
3) Or the voltage at which the tube circuited in the voltage-divider A has a gain of about 10^9, whichever is lowest.

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

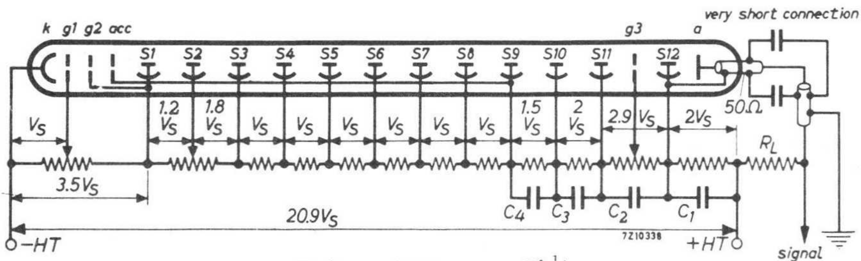
→ RECOMMENDED CIRCUITS



Voltage divider type A [1])



Voltage divider type B [1])



Voltage divider type B' [1])

k = cathode
g_1 = focusing electrode 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.

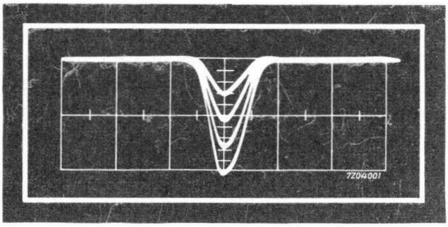


Fig. 1 Photograph of anode pulses
abscissa - 5 nanoseconds per major division
ordinate - 10 volts per major division

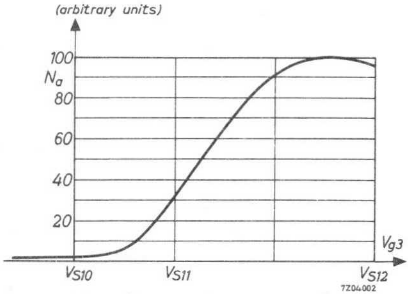


Fig. 2 Anode sensitivity as a function of shadow grid potential

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.

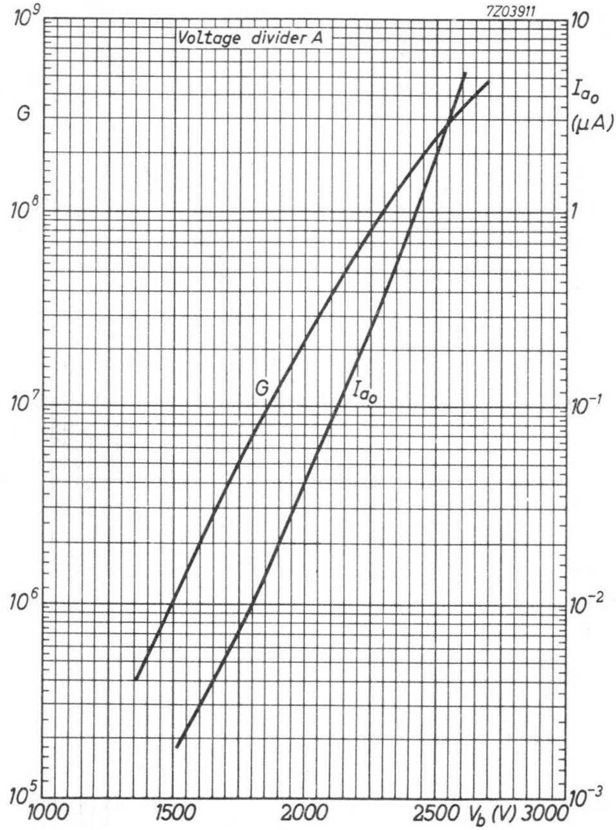
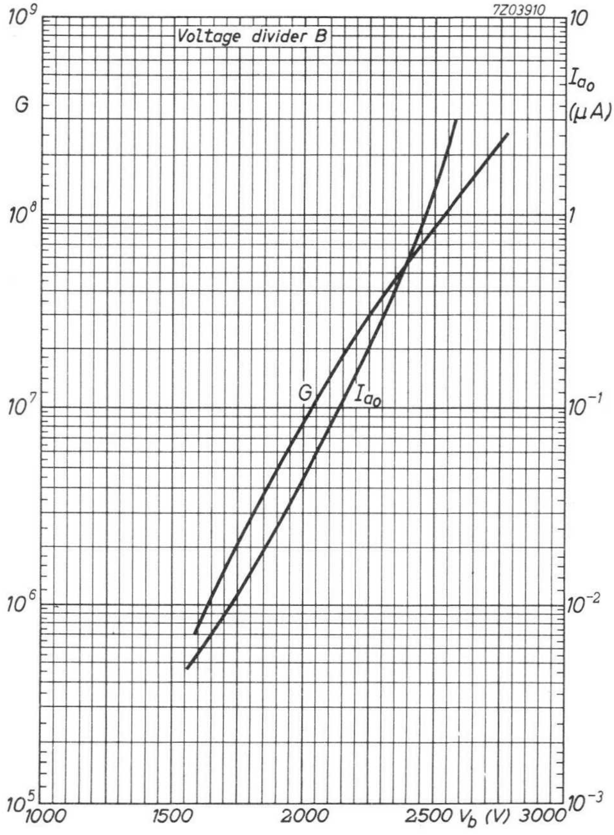

7Z03911
Voltage divider A
10^9
10^8
10^7
10^6
10^5
G
10
1
10^{-1}
10^{-2}
10^{-3}
I_{a_0} (μA)
G
I_{a_0}
1000
1500
2000
2500 V_b (V) 3000

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}
1000
1500
2000
2500
3000
V_b (V)

Fig. 4

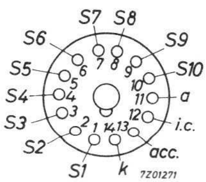
10 STAGE PHOTOMULTIPLIER TUBE

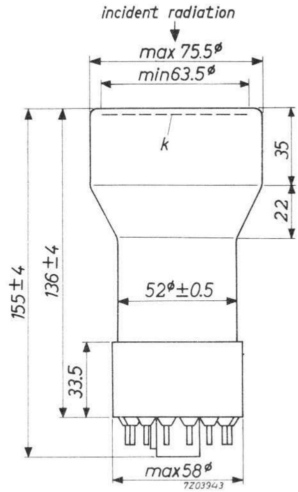
The tube is intended for use in applications such as scintillation counting in nuclear research together with large size crystals, plastic or liquid scintillators and in optical equipment in which a photomultiplier with a photosensitive area larger than usual is required.

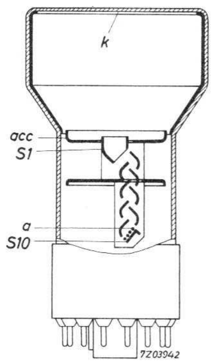
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm

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]	7.10^{-9}	s
Anode pulse width at half height at V_b = 1400 V [1]	15.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V	7.10^{-9}	s
Total transit time at V_b = 1400 V [1]	60.10^{-9}	s

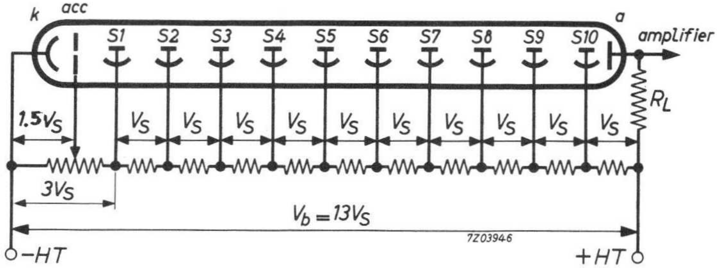
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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

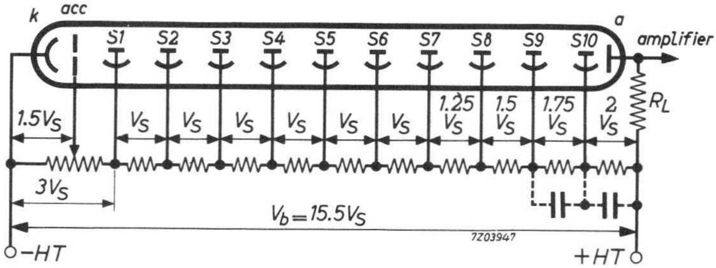
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[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
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.

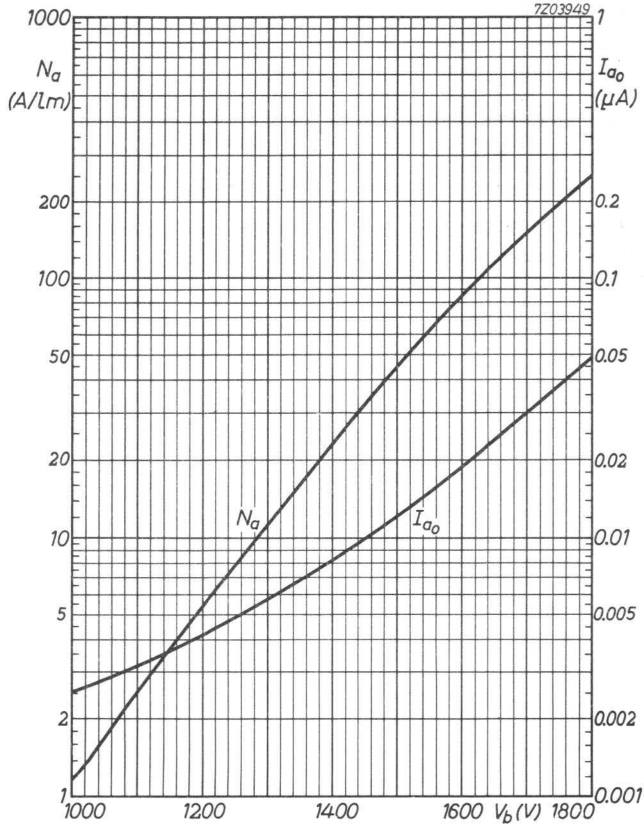
A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

The accelerating electrode has a 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
200
100
50
20
10
5
2
1
N_a
(A/lm)
1
I_{a_0}
(μA)
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}

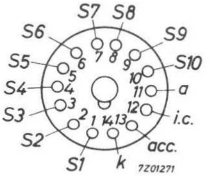
10 STAGE PHOTOMULTIPLIER TUBE

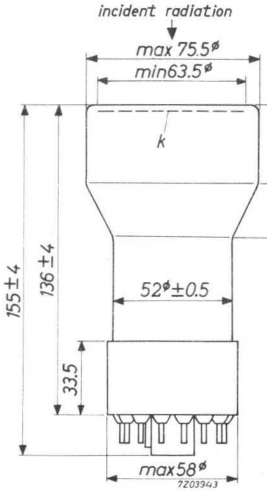
The tube is intended for use in applications such as gamma-ray spectrometry and gamma scintillation cameras.

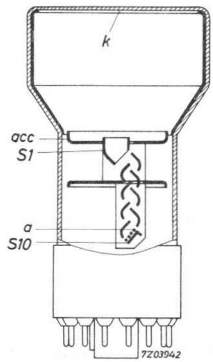
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm
Energy resolution for ^{137}Cs(0.661 MeV)	8.5	%

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_0}	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

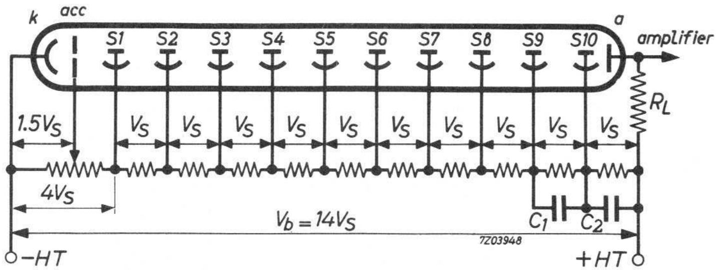
Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1400 V 4)		7.10^{-9}	s
Anode pulse width at halfheight at V_b = 1400 V 4)		15.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V		7.10^{-9}	s
Total transit time at V_b = 1400 V 4)		60.10^{-9}	s

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

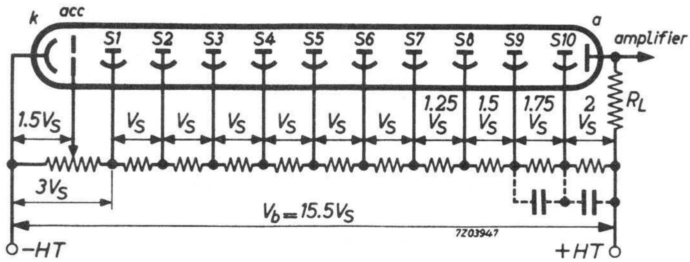
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	1	mA
Voltage between cathode and first dynode	$V_{k/S1}$	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 [6]	$V_{a/S10}$	max.	300	V
		min.	80	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

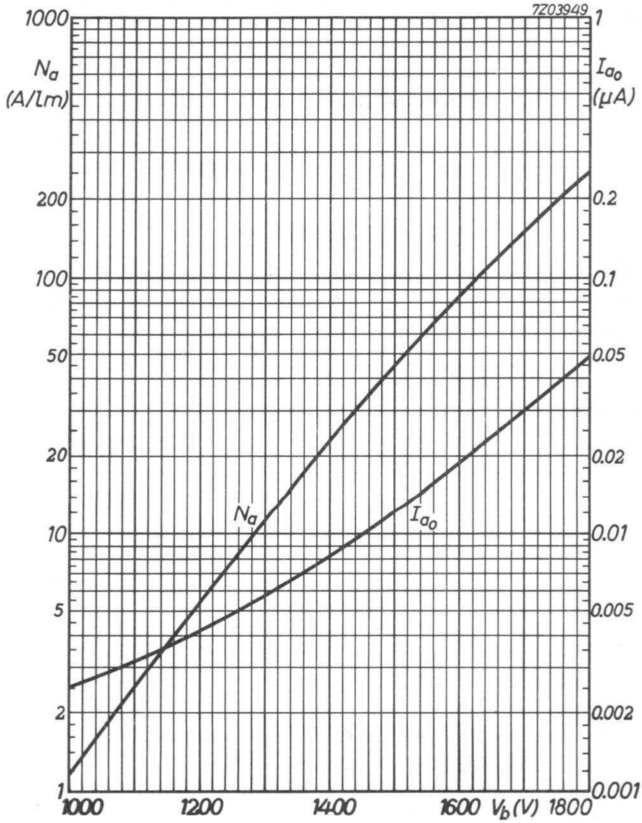
To achieve a stability of about 1% the ratio of the current through the voltage-divider bridge to that through the heaviest loaded stage of the tube should be approx. 100.

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.



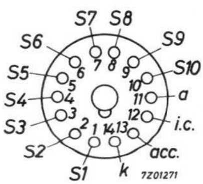
10 STAGE PHOTOMULTIPLIER TUBE

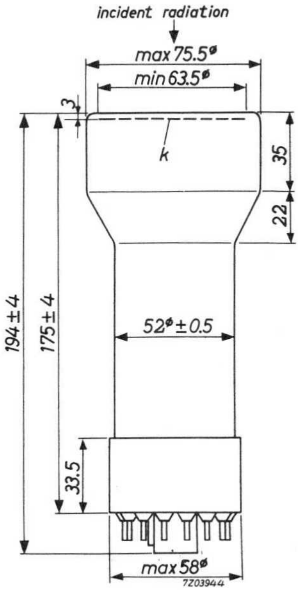
The tube is intended for use in applications which require a good sensitivity in the ultraviolet region, combined with a photosensitive area larger than usual.

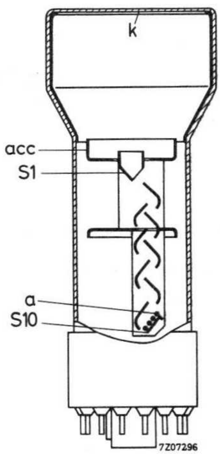
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	63.5	mm
Anode sensitivity (at 1800 V)	250	A/lm

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	$C_{a/S_{10}}$	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)

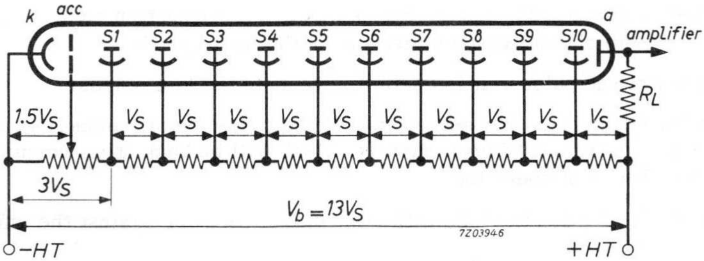
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100 mA
Anode pulse rise time at V_b = 1400 V [1]	7.10^{-9} s
Anode pulse width at half height at V_b = 1400 V [1]	15.10^{-9} s
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V	7.10^{-9} s
Total transit time at V_b = 1400 V [1]	60.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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

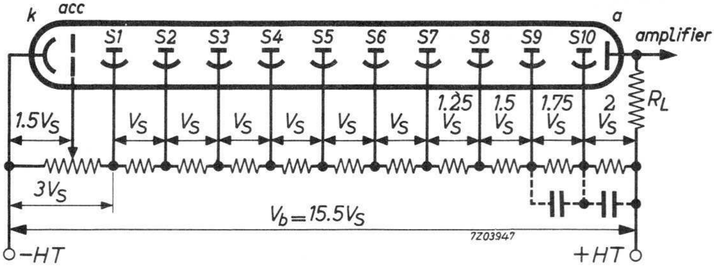


Voltage divider type A

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

[2]) When 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.

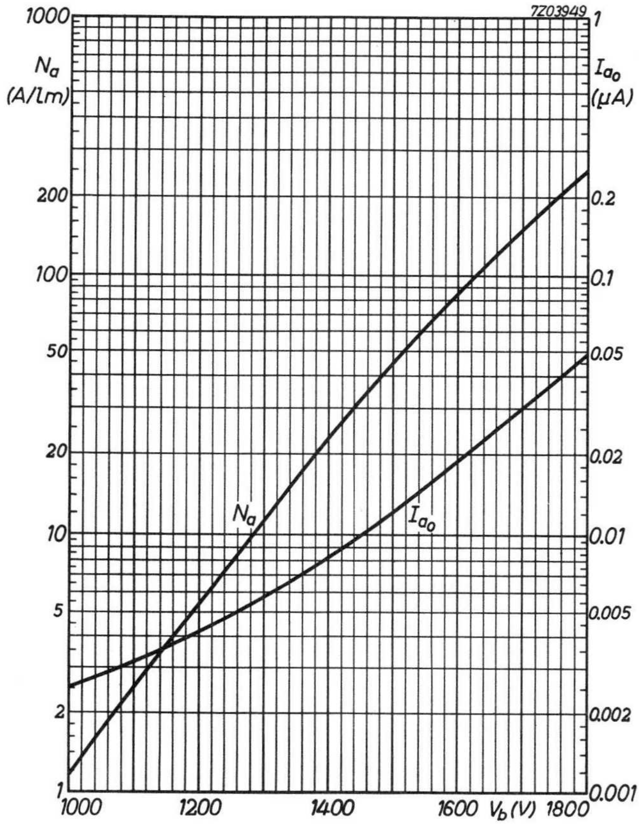
A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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_{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

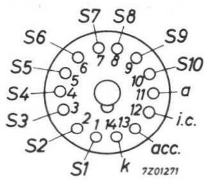
10 STAGE PHOTOMULTIPLIER TUBE

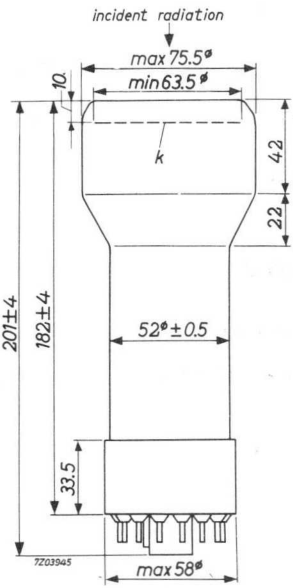
The tube is intended for geophysical measurements in which the thick quartz window serves as a medium for Cerenkov radiation caused by cosmic-rays.

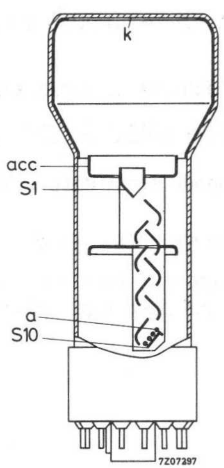
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	63.5	mm
Window thickness (quartz)	10	mm
Anode sensitivity (at 1800 V)	250	A/lm

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_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)

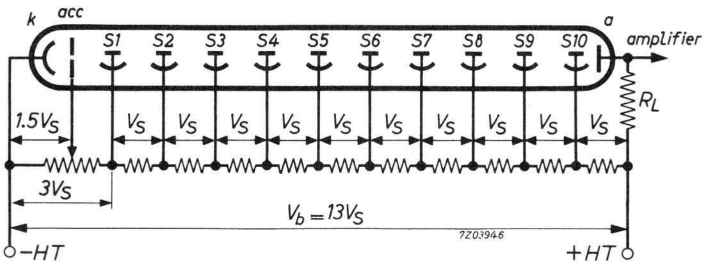
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100 mA
Anode pulse rise time at V_b = 1400 V [1]	7.10^{-9} s
Anode pulse width at half height at V_b = 1400 V [1]	15.10^{-9} s
Transit time difference between the centre of the photocathode and the edge at V_b = 1400 V	7.10^{-9} s
Total transit time at V_b = 1400 V [1]	60.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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

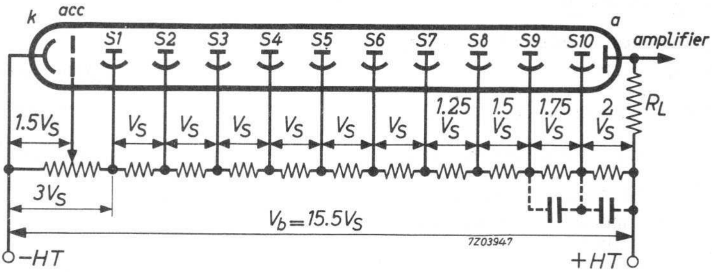


Voltage divider type A

[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.

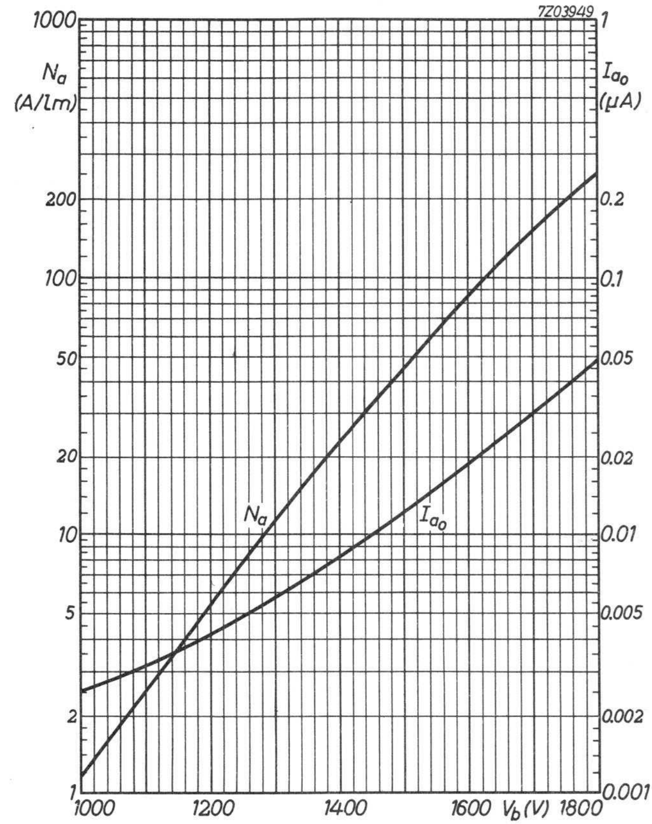
A circuit of type A results in the highest gain of the tube at a given total voltage. A circuit of type B gives a higher current output with better time characteristics, but the total gain is less at the same total voltage.

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.


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

10 STAGE PHOTOMULTIPLIER TUBE

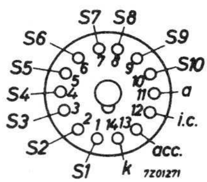
The tube is intended for use in applications such as scintillation counting and measurement of low luminous fluxes.

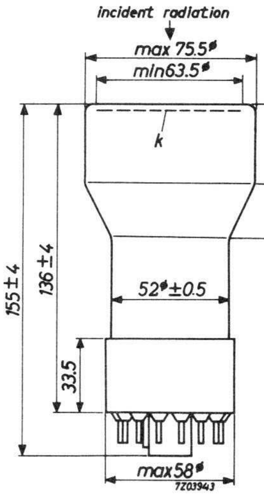
QUICK REFERENCE DATA			
Spectral response	bialkali	type	D
Useful diameter of the photocathode		63.5	mm
Anode sensitivity (at 1800 V)		250	A/lm

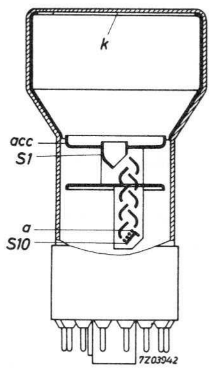
DIMENSIONS AND CONNECTIONS

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, flet 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
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.

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

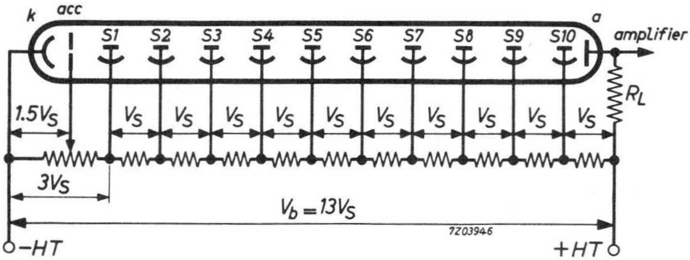
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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

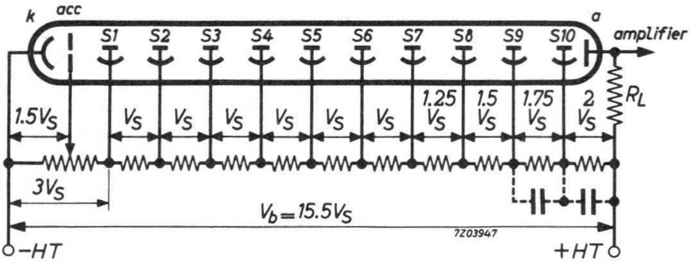
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[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

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.

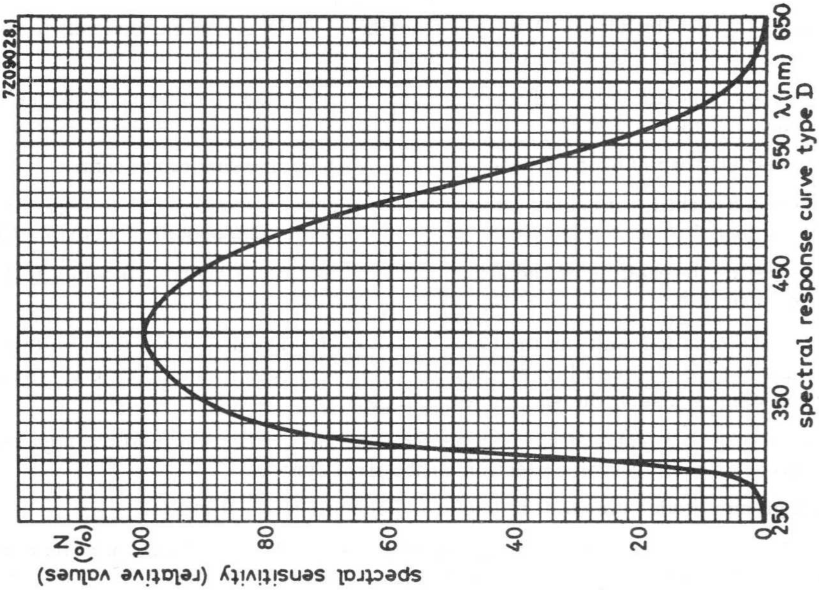
A circuit of type A results in the highest gain of the tube at a given total voltage.
A circuit of type B gives a higher current output with better time characteristics,but the total gain is less at the same total voltage.

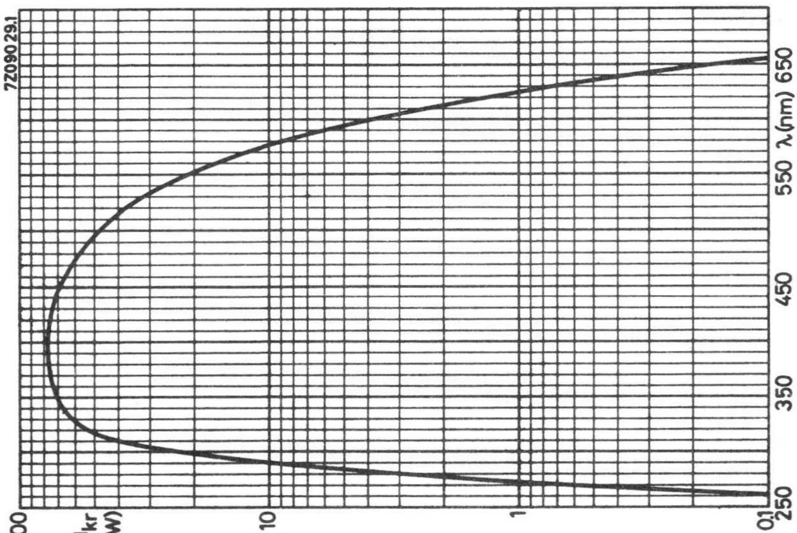
The accelerating electrode has a seperate external connection to allow adjustment for optimum photoelectron collection on the first dynode.

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.


7Z09028.1
spectral sensitivity (relative values)
N
(%)
100
80
60
40
20
0
250
350
450
550
650
λ(nm)
spectral response curve type D


7Z09029.1
(absolute values)
N_{kr}
(mA/W)
100
10
1
0.1
250
350
450
550
650
λ(nm)

14 STAGE PHOTOMULTIPLIER TUBE

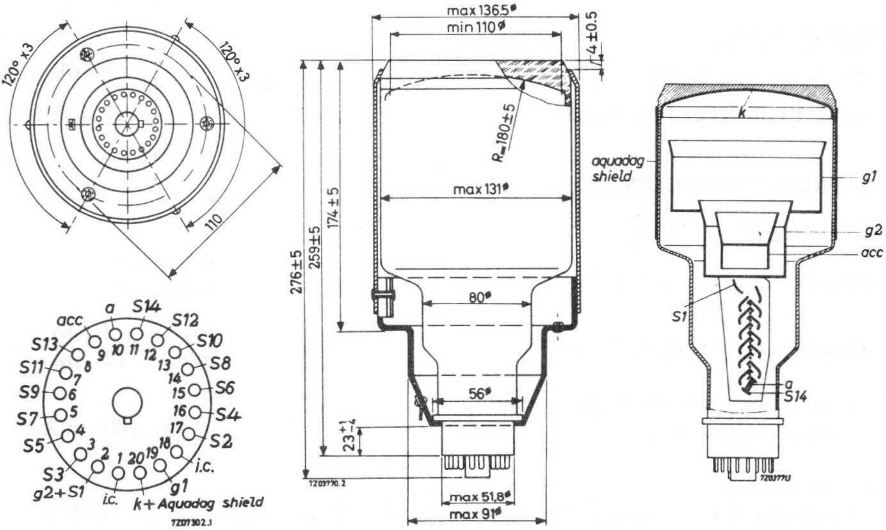
The tube is intended for use in nuclear-physics applications where a high degree of time definition is required (fast coincidences, Cerenkov counters).

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 min. 45	μA/lm 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 max. 3000	V V
Anode dark current at $G = 10^8$ [4]	I_{a_o}	av. 2 max. 12	μA 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]		2.10^{-9}	s
Anode pulse width at half height at V_b = 2800 V [1]		3.10^{-9}	s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V		10^{-9}	s
Total transit time at V_b = 2800 V [1]		46.10^{-9}	s
Maximum peak currents		0.5 to 1	s

With voltage divider B 1

Anode pulse rise time at V_b = 2800 V [1]	2.10^{-9}	s
Anode pulse width at half height at V_b = 2800 V [1]	3.10^{-9}	s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	10^{-9}	s
Transit time spread	10^{-9}	s
Total transit time at V_b = 2800 V [1]	43.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

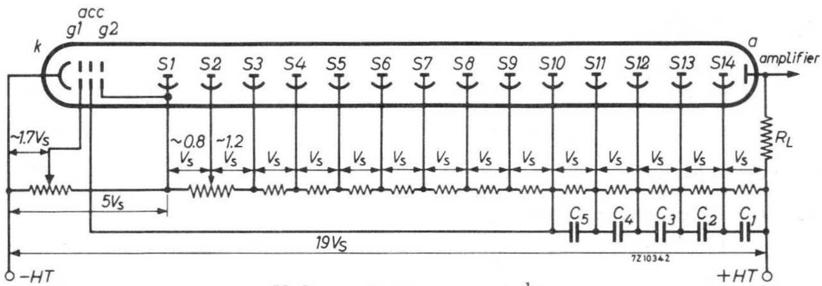
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max. min.	800 250	V V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	1400 to	1800	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
Voltage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

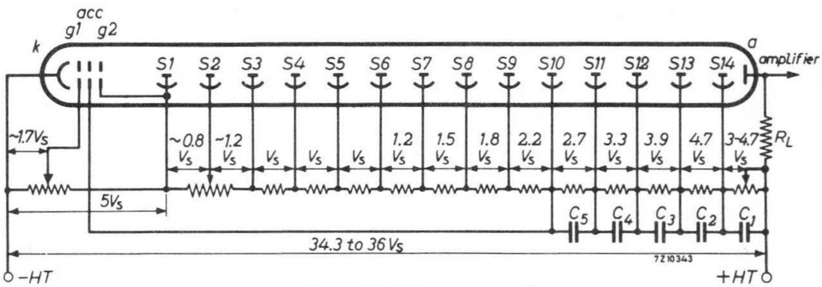
[2]) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

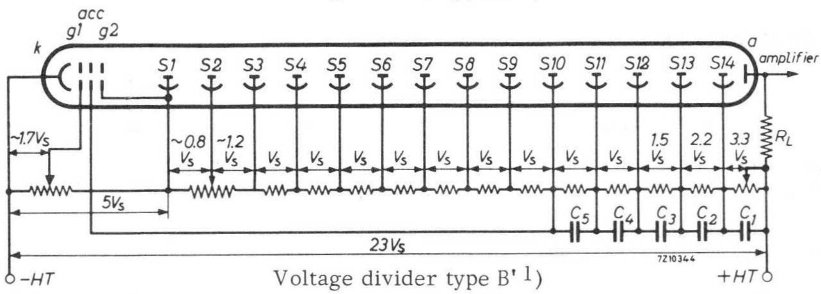
RECOMMENDED CIRCUITS



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 thrøugh 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-accelerating voltage of about 1500 V (to be connected to the tenth or a subsequent 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.

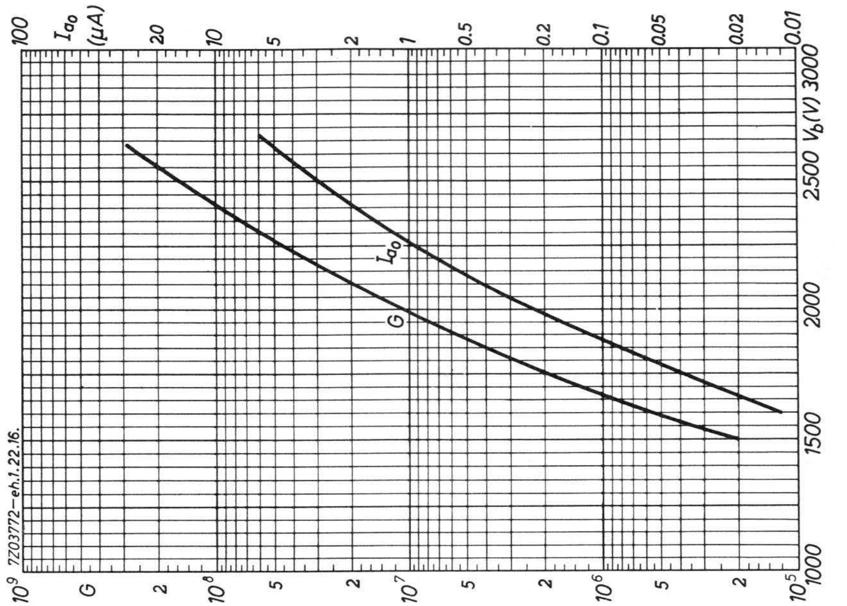

7Z03772-eh.1.22.16.
I_{ao} (μA)
100
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
G
10^9
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
I_{ao}
G
1000
1500
2000
2500
3000
V_b (V)

Fig. 1

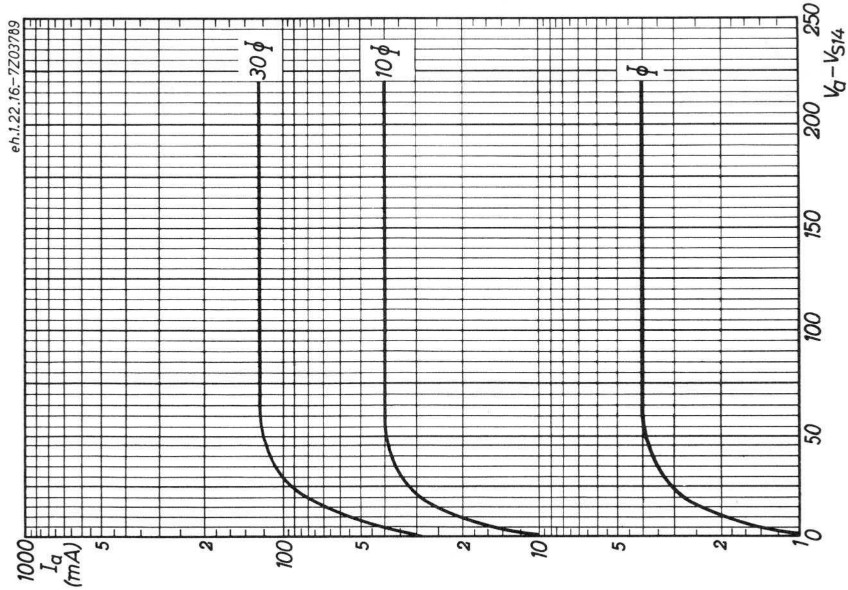

eh.1.22.16.-7Z03789
1000
I_a (mA)
5
2
100
5
2
10
5
2
1
30 Φ
10 Φ
Φ
0
50
100
150
200
250
$V_a - V_{S14}$

Fig. 2

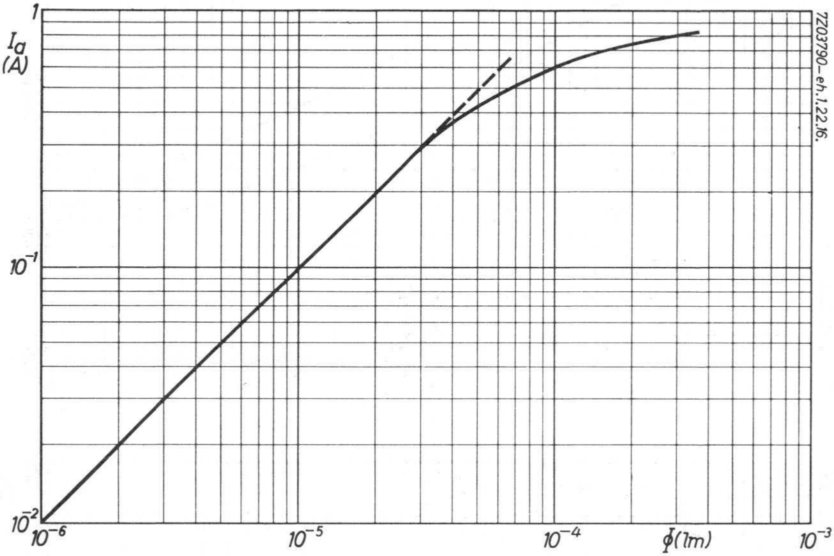


Fig. 3

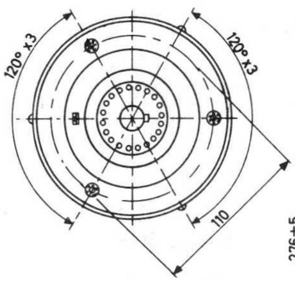
14 STAGE PHOTOMULTIPLIER TUBE

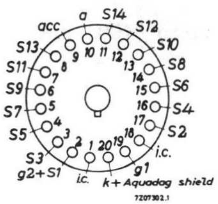
The tube is intended for use in nuclear-physics applications where very low luminous fluxes are to be measured and where a high degree of time definition is required.

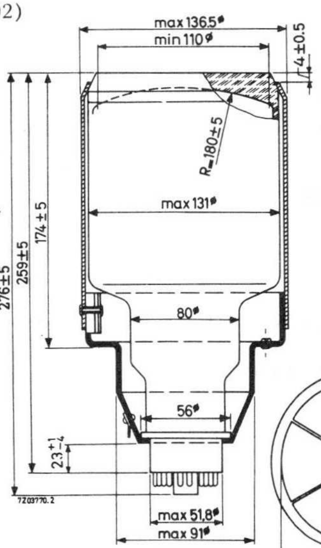
QUICK REFERENCE DATA		
Spectral response	bi-alkali type D	
Useful diameter of the photocathode	110	mm
Gain (at 2250 V)	10^8	
Anode pulse rise time	2	ns
Quantum efficiency (at 400 nm)	25	%

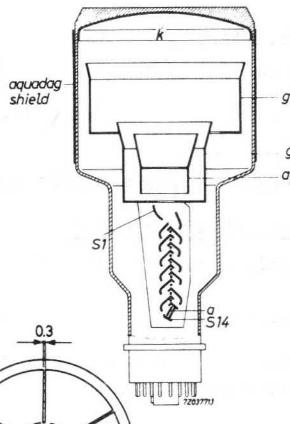
DIMENSIONS AND CONNECTIONS Dimensions in mm

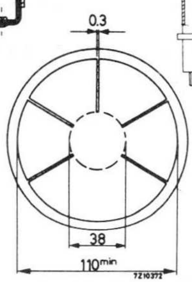
Base: 20-pin (Jedec B20-102)











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	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

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 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)

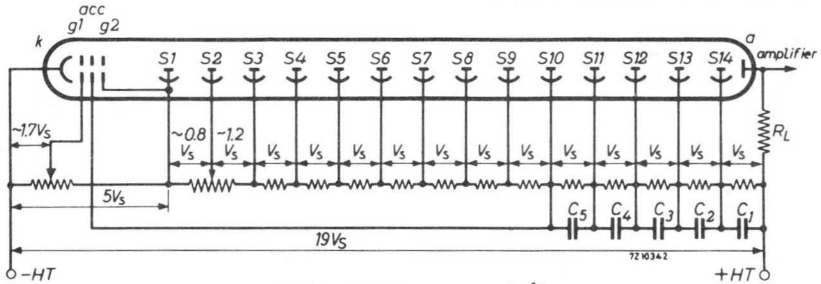
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	14 V_s to	18	V_s
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300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

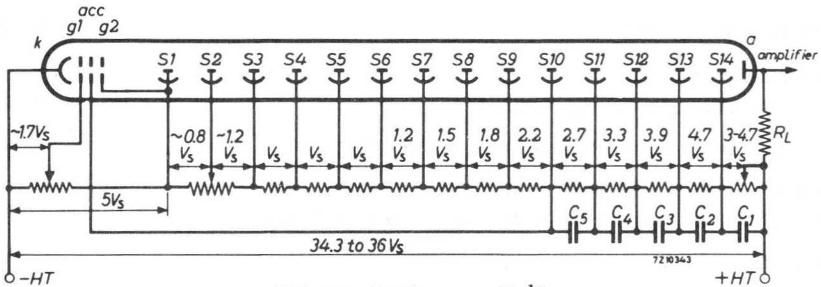
2) Or the voltage at which the tibe circuited in the voltage divider A has a gain of about $5x10^8$, whichever is lowest.

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

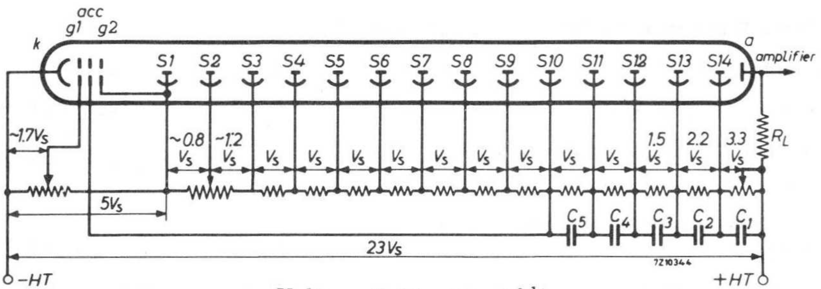
RECOMMENDED CIRCUITS



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 brought 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 C1 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 a plexiglass 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-accelerating 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 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.

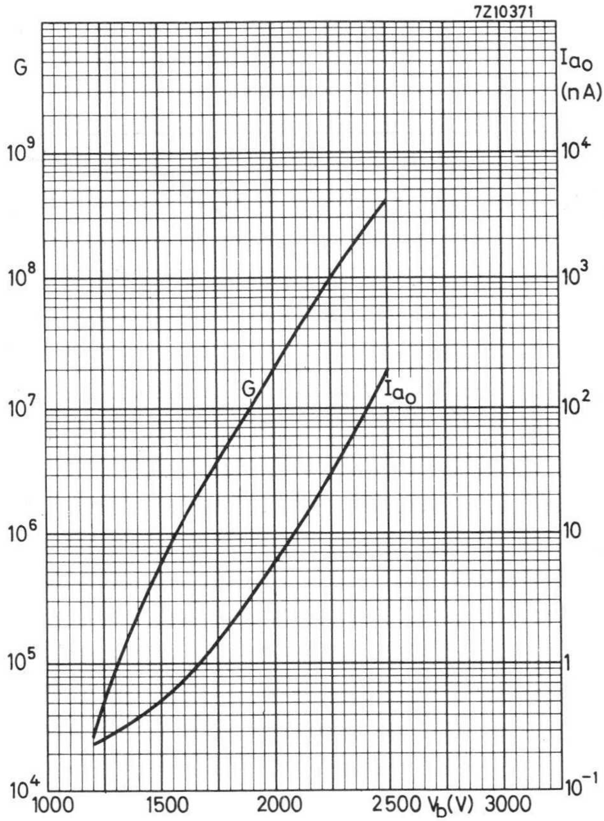

7Z10371
G
I_{a_0} (nA)
10^9
10^8
10^7
10^6
10^5
10^4
10^4
10^3
10^2
10
1
10^{-1}
G
I_{a_0}
1000
1500
2000
2500
V_b(V)
3000

fig.1

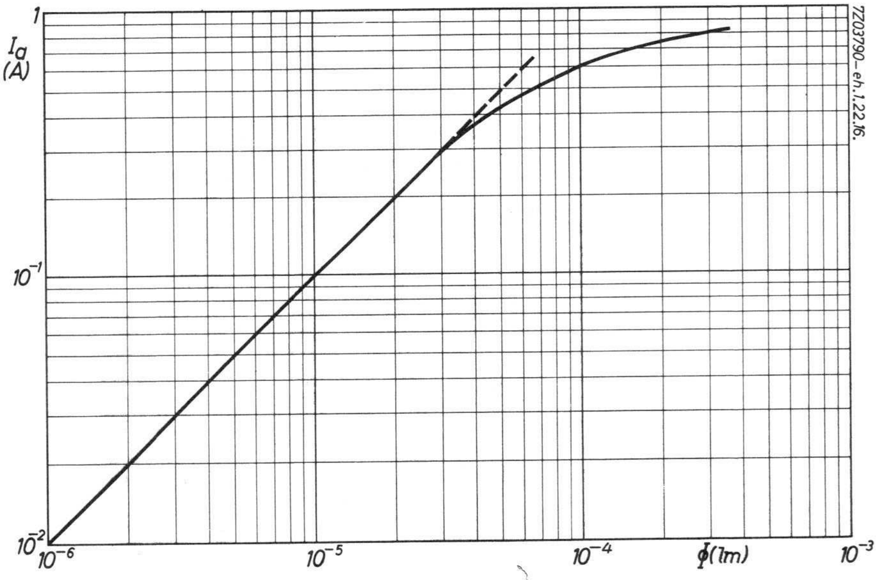


fig. 2

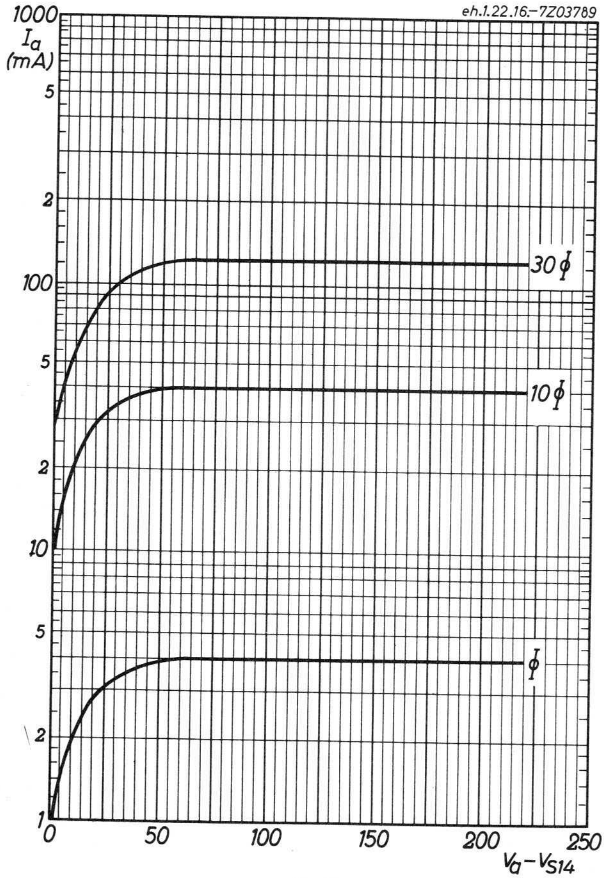
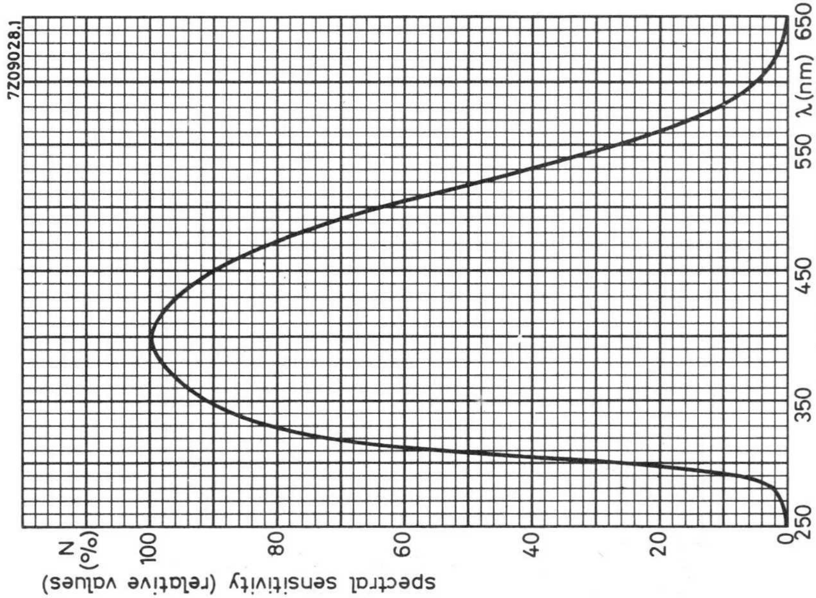

eh.1.22.16.-7Z03789
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 ɸ
10 ɸ
ɸ

fig. 3



spectral response curve type D

fig.4

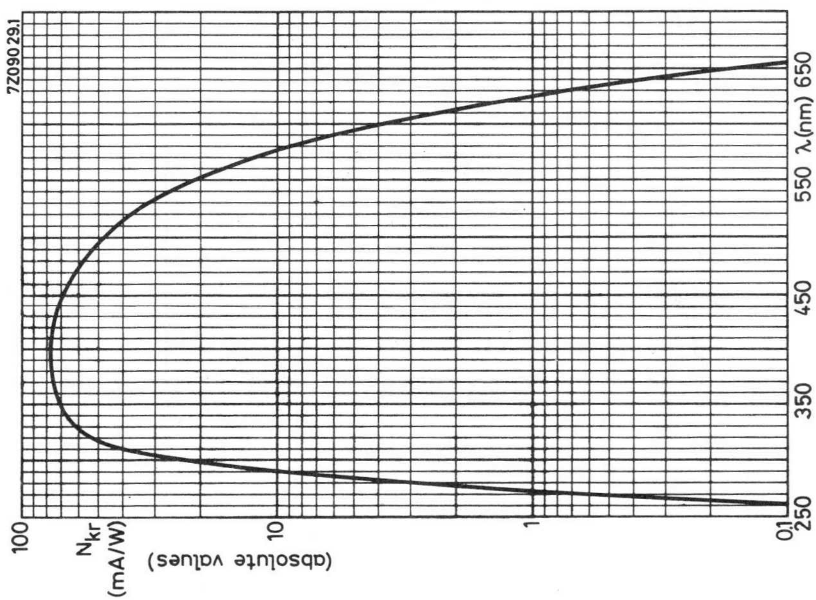


Fig. 5

10 STAGE PHOTOMULTIPLIER TUBE

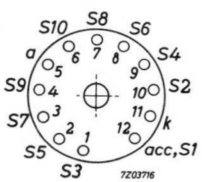
The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements with narrow light beams, in-microscope light transmission measurements, and computer punch-tape or punch-card reading etc.

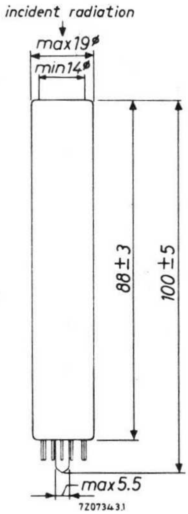
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

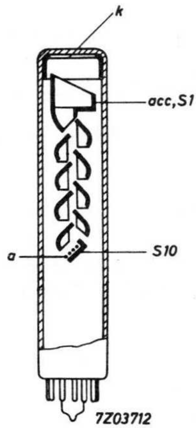
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type 56073
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		4200 ± 300 Å
Luminous sensitivity [2]	N_k	av. 65 μA/lm min. 35 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	$C_{a/S_{10}}$	1.5 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. 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

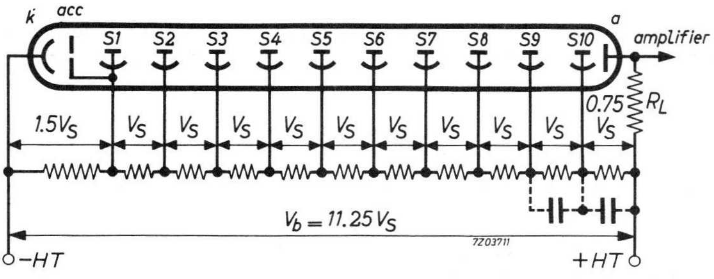
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	30	mA
Anode pulse rise time at V_b = 1800 V [1]		3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [1]		4.10^{-9}	s
Total transit time at V_b = 1800 V [1]		25.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	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]	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS

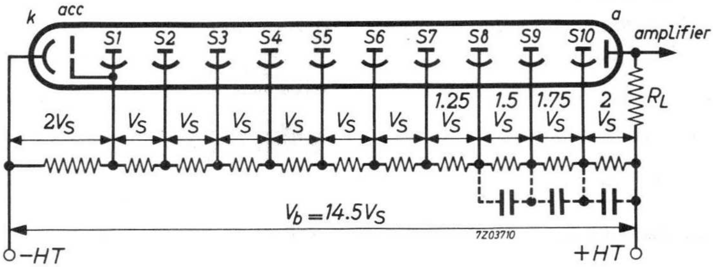


Voltage divider type A

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

[2]) 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.

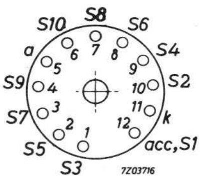
10 STAGE PHOTOMULTIPLIER TUBE

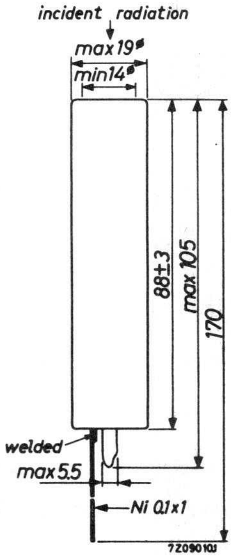
The tube is intended for use in applications such as scintillation counting under limited dimensional conditions, optical measurements with narrow light beams, in-microscope light transmission measurements, and computer punch-tape or punch-card reading etc.

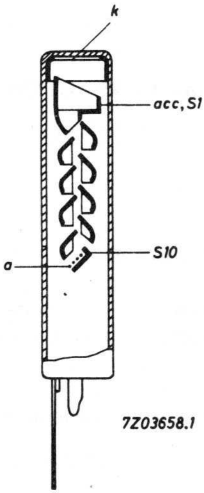
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12 isolated flexible leads







ACCESSORIES

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			4200 ± 300	Å
Luminous sensitivity 2)	N_k	av.	65	μA/lm
		min.	35	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	$C_{a/S_{10}}$	1.5	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.	0.02	μA
		max.	0.10	μA
Linearity between anode pulse amplitude and input light flux 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)

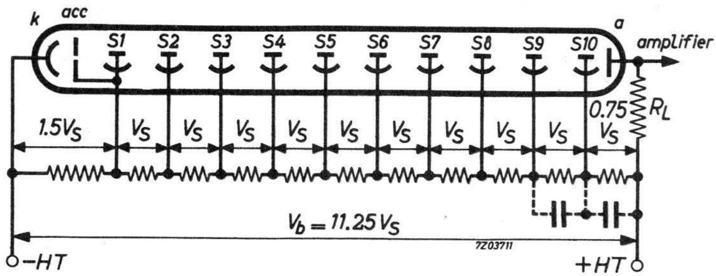
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 30	mA
Anode pulse rise time at V_b = 1800 V [1]	3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [1]	4.10^{-9}	s
Total transit time at V_b = 1800 V [1]	30.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	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]	$V_{a/S_{10}}$	max.	200	V
		min.	80	V

RECOMMENDED CIRCUITS



Voltage divider type A

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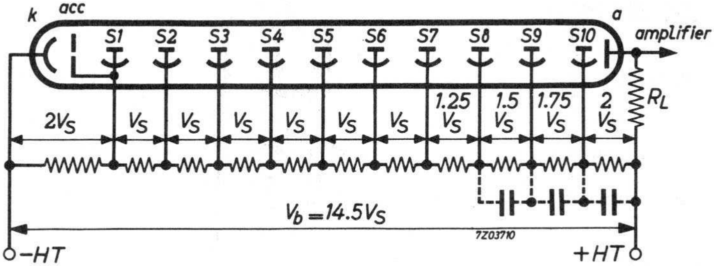
[1] For an infinitely short light pulse, fully illuminating the photocathode.

[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
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.

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.

6 STAGE PHOTOMULTIPLIER TUBE

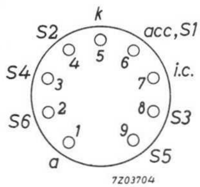
The tube is intended for use in optical applications, where space is very restricted and relatively high light fluxes are to be measured (10^{-5} to 10^{-3} lm).

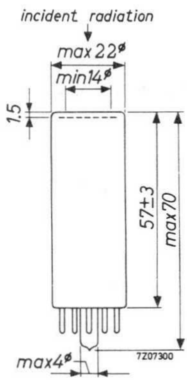
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1200 V)	0.9	A/lm

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. 0.010	µA
Linearity between anode pulse amplitude and input light pulse		up to 15	mA

With voltage divider B

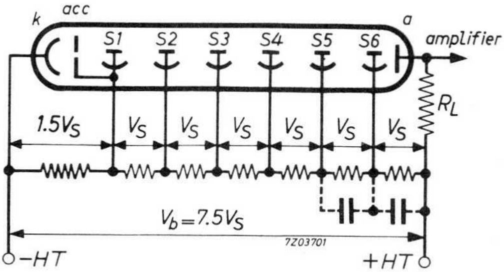
Linearity between anode pulse amplitude and input light pulse		up to 30	mA
Anode pulse rise tune at V_b = 1000 V 4)		3.10^{-9}	s
Anode pulse width at half height at V_b = 1000 V 4)		5.10^{-9}	s
Total transit time at V_b = 1000 V 4)		7.10^{-9}	s

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.

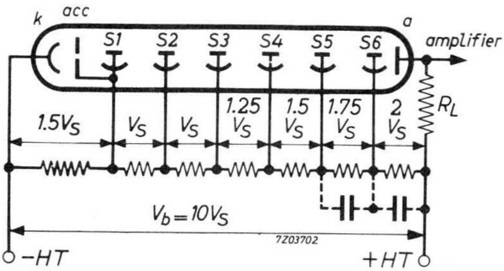
LIMITING VALUES (Absolute max. rating system)

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.

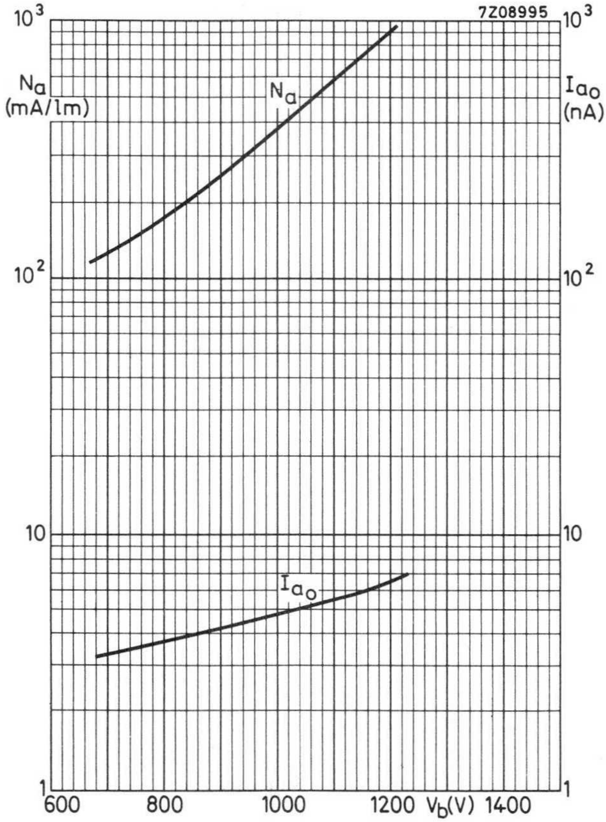
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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
10^2
10
1
N_a (mA/lm)
I_{a_0} (nA)
N_a
I_{a_0}
600
800
1000
1200
V_b(V)
1400

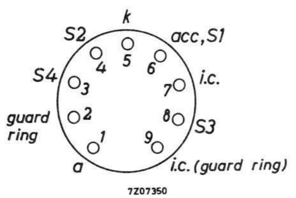
4 STAGE PHOTOMULTIPLIER TUBE

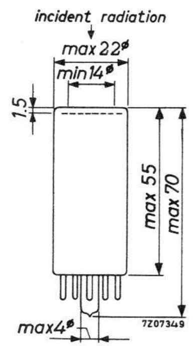
The tube is intended for use in optical applications, where space is very restricted and relatively high light fluxes are to be measured (10^{-4} to 10^{-1} lm).

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]	2.10^{-9}	s
Anode pulse width at half height at V_b = 850 V [4]	3.10^{-9}	s
Total transit time at V_b = 850 V [4]	11.10^{-9}	s

---

1) See spectral response curve in front of this section

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

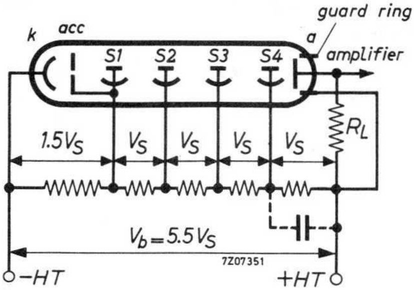
3) At an ambient temperature of 25 °C

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

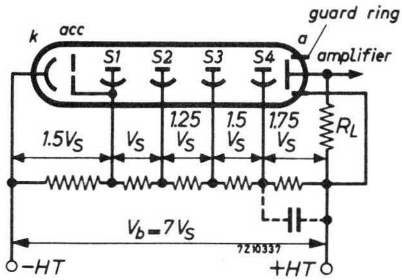
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	900	V
Continuous anode current	I_a	max.	0.1	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
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.

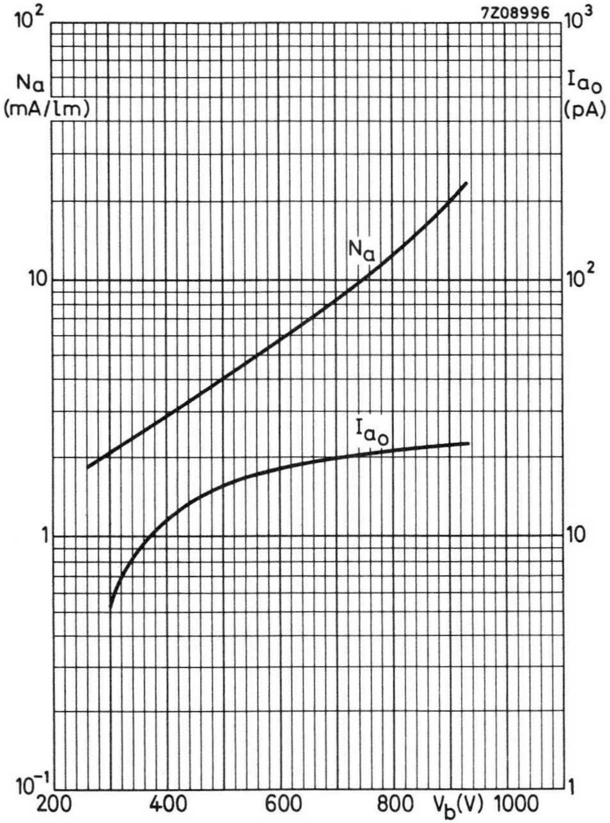
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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.



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

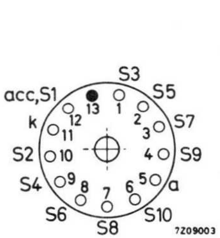
10 STAGE PHOTOMULTIPLIER TUBE

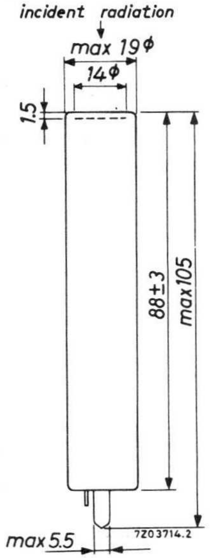
The tube is intended for use in applications such as scintillation counting and optical measurements under limited dimensional conditions. Its revolutionary rugged construction makes it particularly suitable for geophysical and astronomical missile experiments.

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

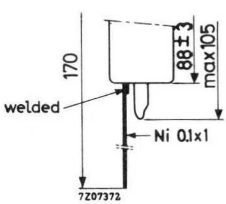
DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: XP1115A: 12-pin (glass)
XP1115B: 12 semi-flexible leads

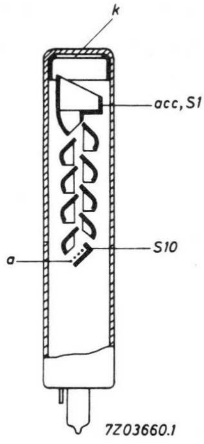




XP1115A



XP1115B



ACCESSORIES

Socket	type 56073
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			4200 ± 300	Å
Luminous sensitivity [2]	N_k	av.	65	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_aS_{10}	1.9	pF
Anode to all other electrodes	C_a	3.0	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.	250 30	A/lm A/lm
Anode dark current at N_a = 30 A/lm [1]	I_{a_o}	av. max.	0.02 0.10	μA 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 [2]			3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [2]			4.10^{-9}	s
Total transit time at V_b = 1800 V [2]			25.10^{-9}	s

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. min.	300 220	V V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max. min.	200 80	V V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max. min.	200 80	V V

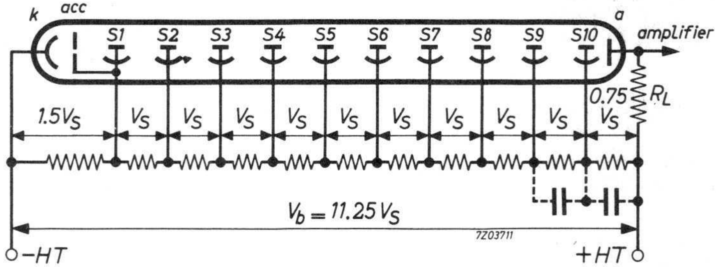
---

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

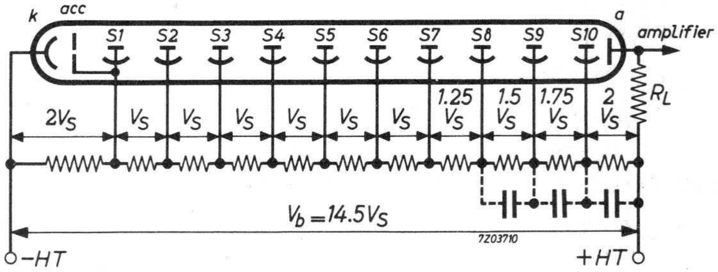
[2]) For an infinitely short light pulse, fully illuminating the photo cathode

[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.

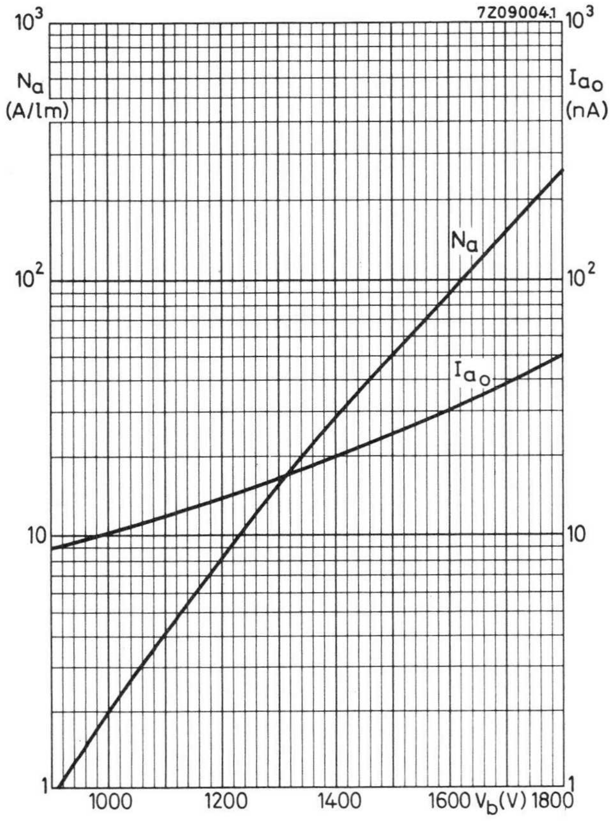
When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

OPERATIONAL CONSIDERATIONS (continued)

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.

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)
10^2
10
1
10^3
I_{ao}
(nA)
10^2
10
1
N_a
I_{ao}
1000
1200
1400
1600
V_b(V)
1800

10 STAGE PHOTOMULTIPLIER TUBE

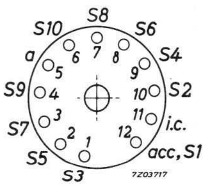
The tube is intended for use in applications such as infra-red telecommunication and ranging, under limited dimensional conditions. Its rugged construction makes it particularly suitable for industrial equipment.

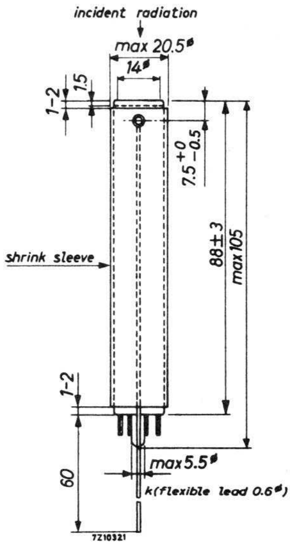
QUICK REFERENCE DATA		
Spectral response	type	C (S1)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	100	A/lm

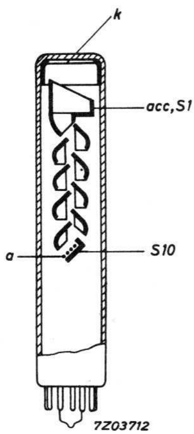
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type 56073
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.	25	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.	100	A/lm
		min.	20	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

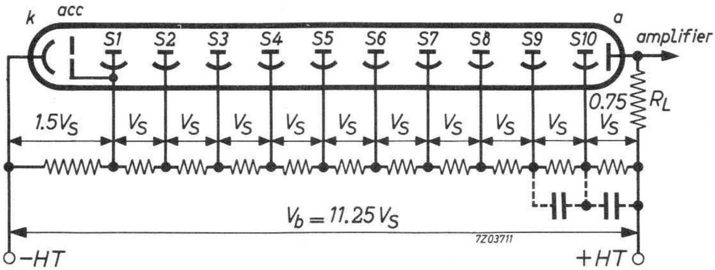
Linearity between anode pulse amplitude and input light pulse		up to	30	mA
Anode pulse rise time at V_b = 1800 V 4)			3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V 4)			4.10^{-9}	s
Total transit time at V_b = 1800 V 4)			25.10^{-9}	s

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

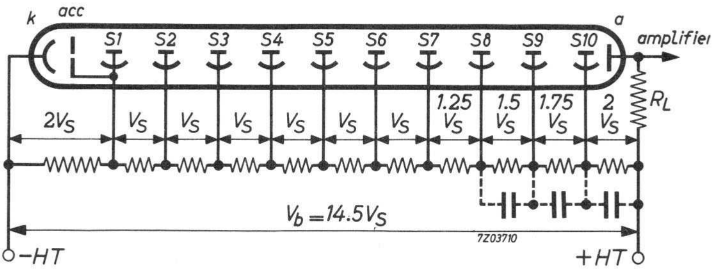
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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 [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.

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.

9 STAGE PHOTOMULTIPLIER TUBE

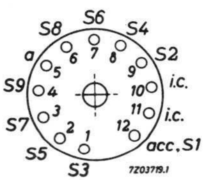
The tube is intended for use in laser-technics working in the orange, yellow and green range, under limited dimensional conditions. Its rugged construction makes it particularly suitable for industrial equipment.

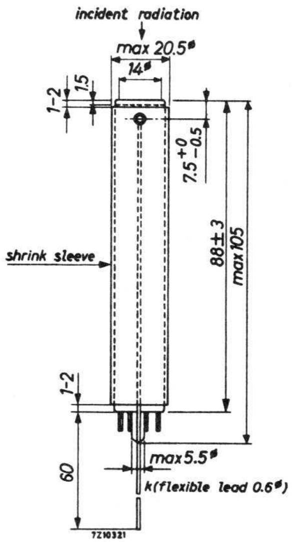
QUICK REFERENCE DATA		
Spectral response	type	T (S20)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	100	A/lm

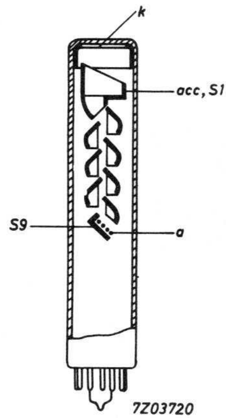
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type	56073
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.	0.01	µA
		max.	0.10	µA

→ With voltage divider B

Anode pulse rise time at V_b = 1800 V 4)	3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V 4)	4.10^{-9}	s
Total transit time at V_b = 1800 V 4)	20.10^{-9}	s

1) See spectral response curve in front of this section

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

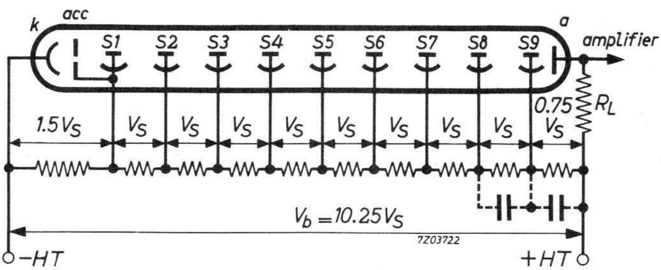
3) At an ambient temperature of 25 °C

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

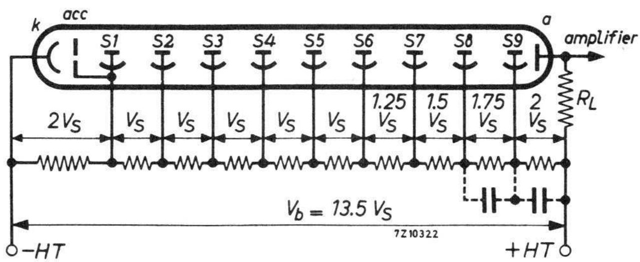
LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	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 [1]	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]) 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.

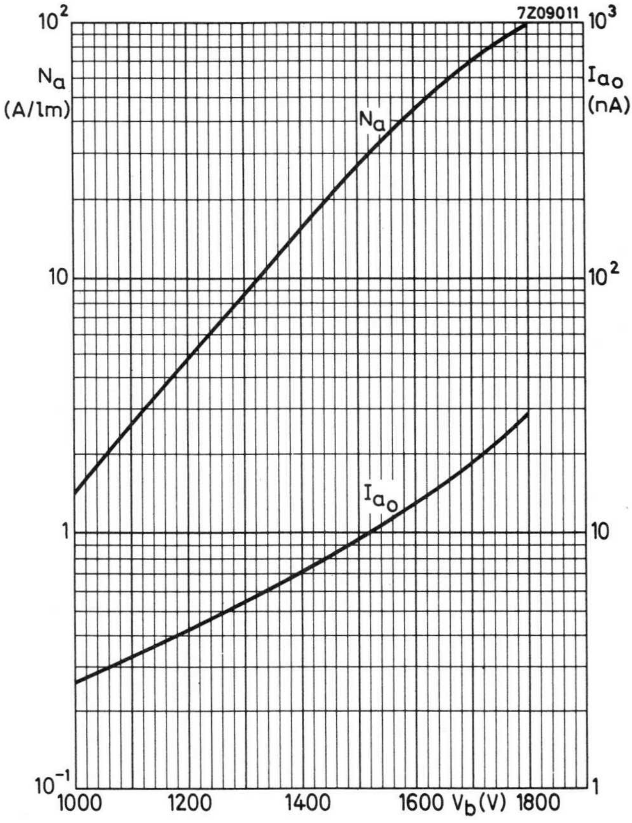
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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)
10
1
10^{-1}
10^3
I_{ao}
(nA)
10^2
10
1
N_a
I_{ao}
1000
1200
1400
1600
V_b(V)
1800

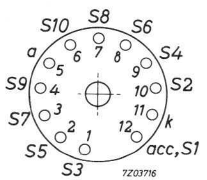
10 STAGE PHOTOMULTIPLIER TUBE

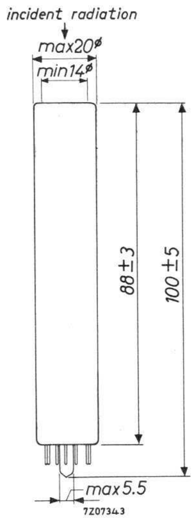
The tube is intended for use in optical applications which require a good sensitivity in the ultraviolet region, under limited dimensional conditions.

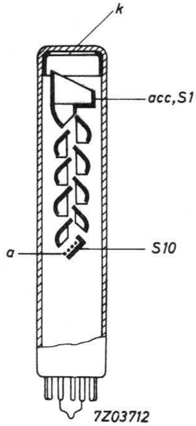
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	14	mm
Anode sensitivity (at 1800 V)	250	A/lm

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: 12-pin (glass)







ACCESSORIES

Socket	type	56073
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. min.	70 40	µA/lm 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. min.	250 30	A/lm A/lm
Anode dark current at N_a = 30 A/lm [3]	I_{a_o}	av. max.	0.02 0.10	µA 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 (continued)

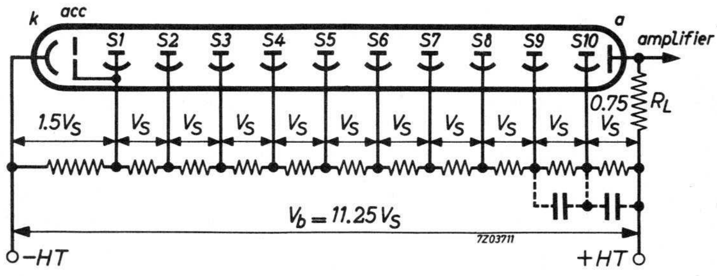
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 30	mA
Anode pulse rise time at V_b = 1800 V [1]	3.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [1]	4.10^{-9}	s
Total transit time at V_b = 1800 V [1]	25.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

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

RECOMMENDED CIRCUITS

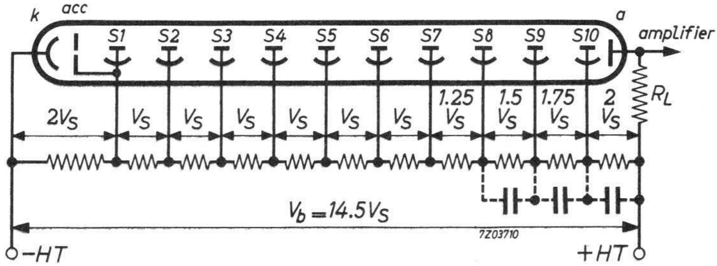


Voltage divider type A

[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.

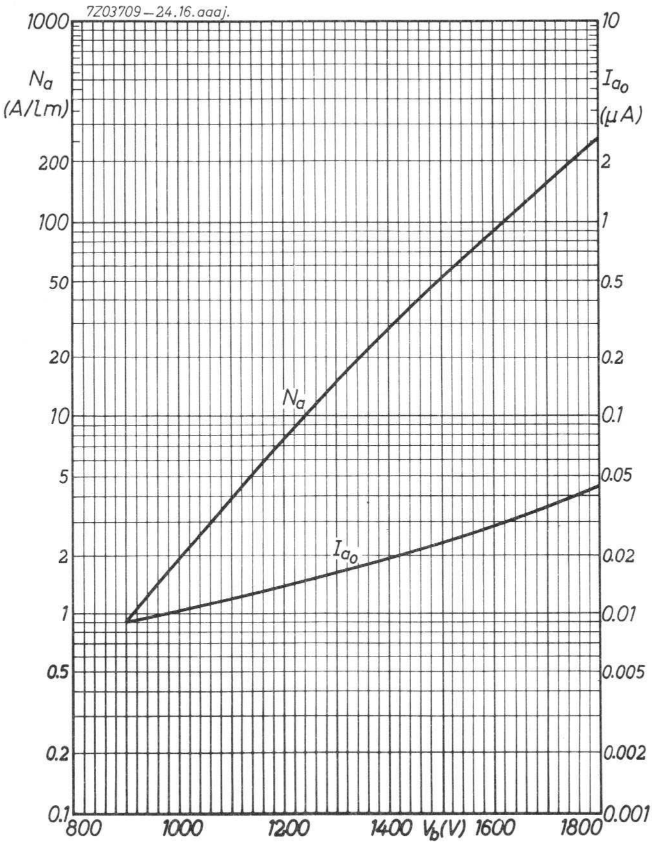
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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.

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.


7Z03709—24.16.aaaj.
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}
800
1000
1200
1400
V_b(V)
1600
1800

WINDOWLESS PHOTOMULTIPLIER

The tube is intended for use in applications such as spectroscopy in the far ultraviolet region (λ < 1500 Å) and soft X-ray counting (λ > 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^{-10}	A
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

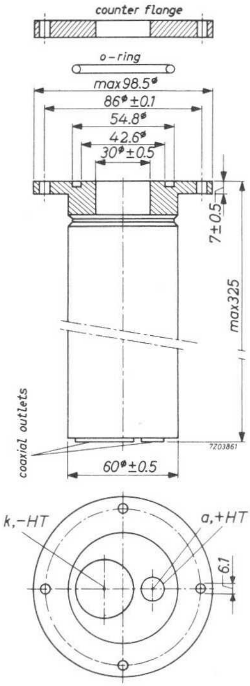
Number of stages	17
Dynode material	Cu-Be-O

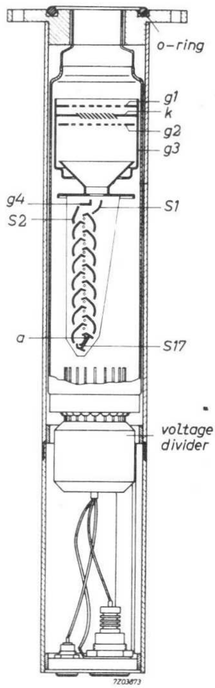
Capacitances

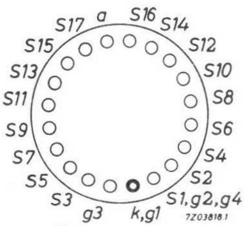
Anode to final dynode	$C_{a/S_{17}}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

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

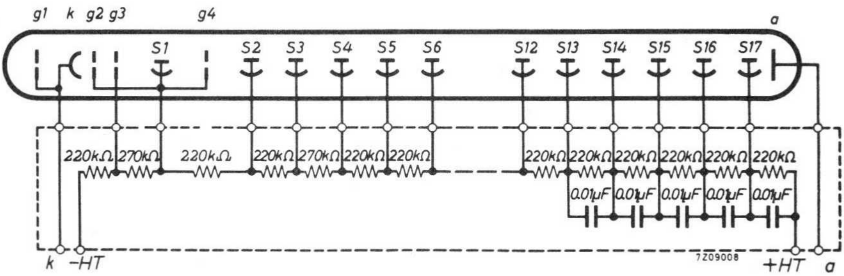
With potted voltage divider

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

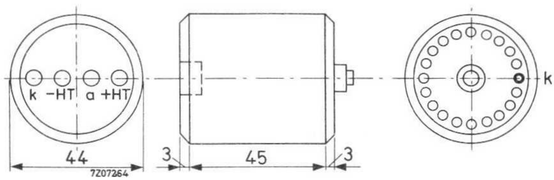
LIMITING VALUES (Absolute max. rating system)

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.

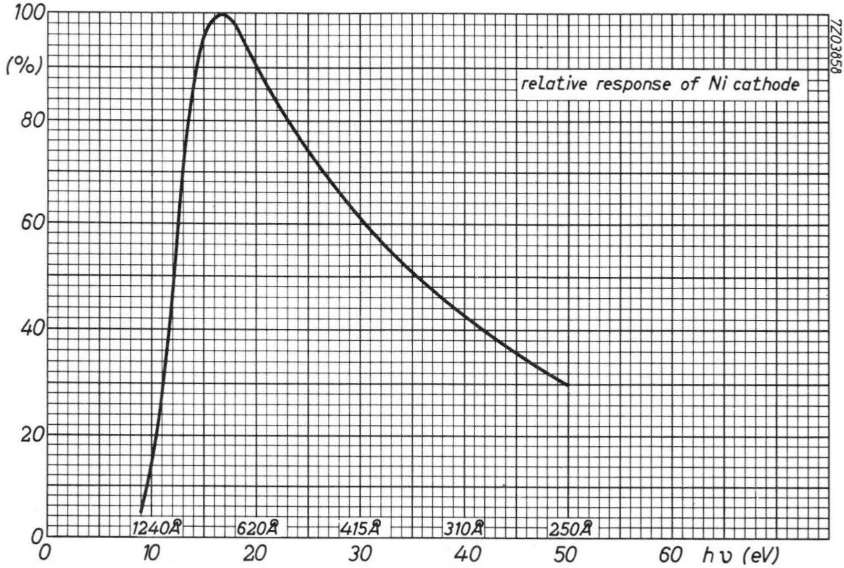
The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically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

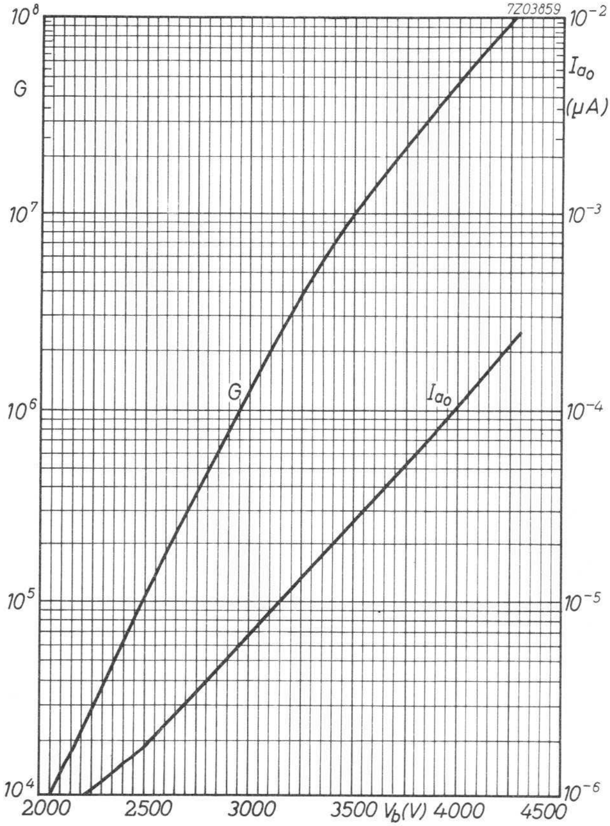
The tube has a glass envelope which is sealed to a metal flange to facilitate mounting to a vacuum system (vacuum seal with O-ring). The glass envelope is protected by a nickel plated iron mantle, which contains a complete potted voltage divider. The external connections are made via two coaxial connectors. 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
10
20
30
40
50
60
hν (eV)
1240Å
620Å
415Å
310Å
250Å
relative response of Ni cathode
7Z03858


7Z03859
G
10^8
10^7
10^6
10^5
10^4
I_{ao}
(μA)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
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^{-10}	A
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

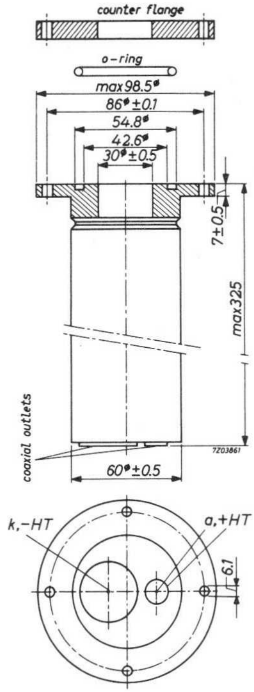
Number of stages	17
Dynode material	Cu-Be-O

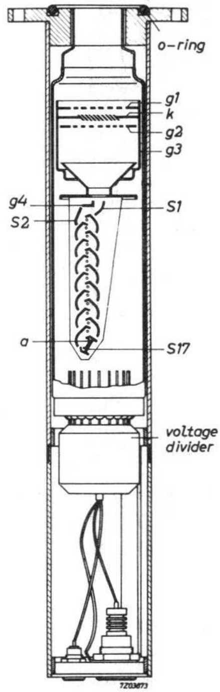
Capacitances

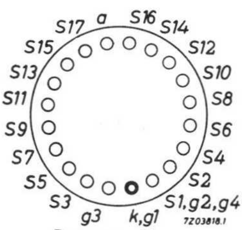
Anode to final dynode	C_a/S_{17}	7	pF
Anode to all other electrodes	C_a	9.5	pF

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

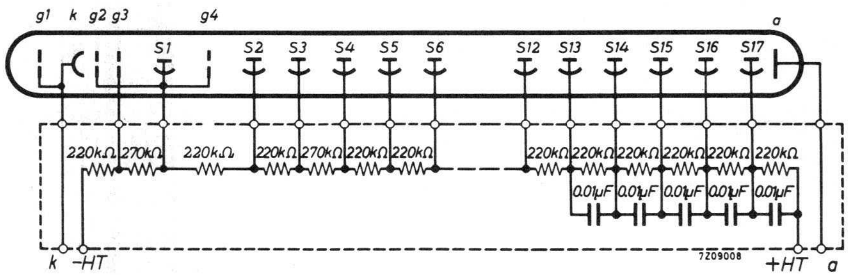
With potted voltage divider

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

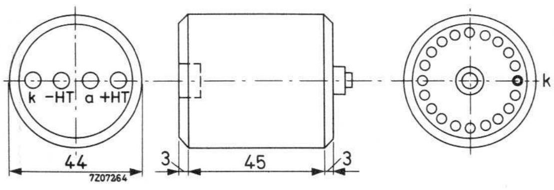
LIMITING VALUES (Absolute max. rating system)

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.	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 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.

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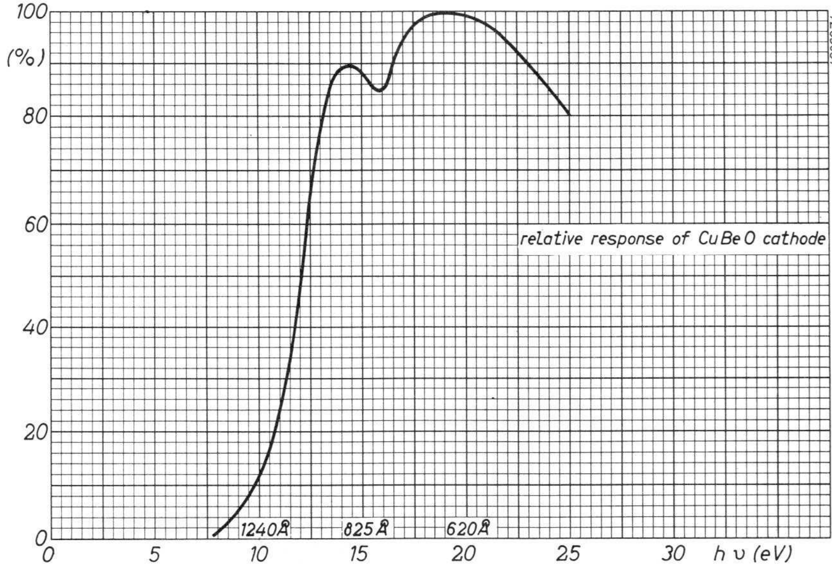
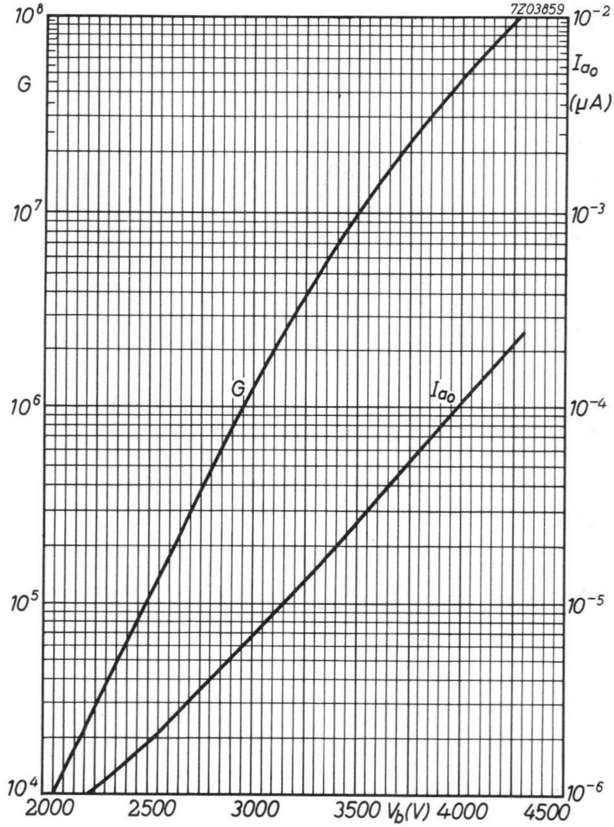
The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

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


7Z03859
G
10^8
10^7
10^6
10^5
10^4
10^{-2}
I_{a_0} (μA)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
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^{-10}	A
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

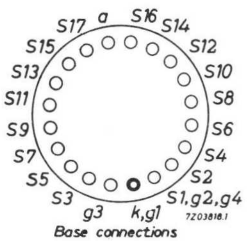
Number of stages	17
Dynode material	Cu-Be-O

Capacitances

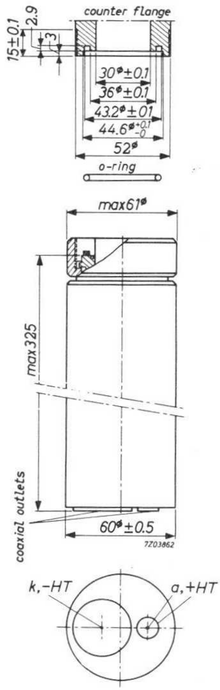
Anode to final dynode	C_a/S_{17}	7	pF
Anode to all other electrodes	C_a	9.5	pF

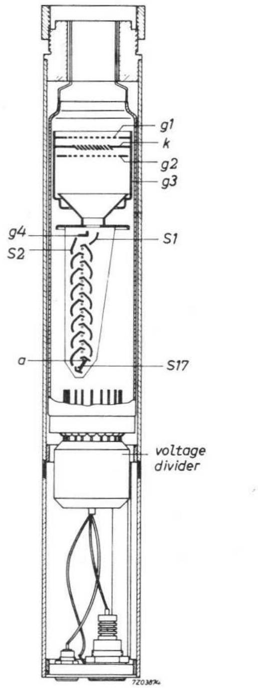
DIMENSIONS AND CONNECTIONS

Dimensions in mm



Base connections





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

Signal connector "LEMO" type OC50

TYPICAL CHARACTERISTICS

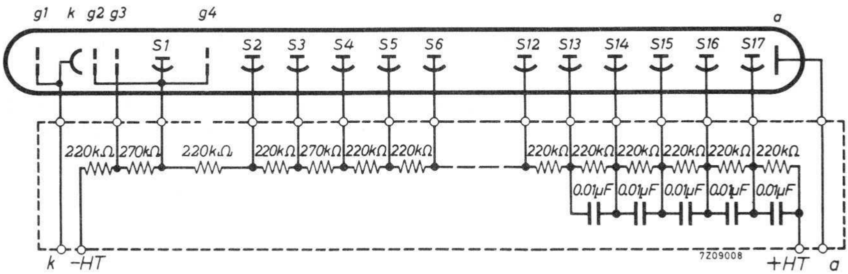
With potted voltage divider

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

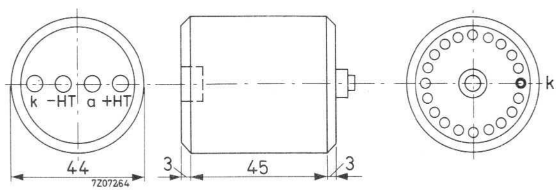
LIMITING VALUES (Absolute max. rating system)

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



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[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.

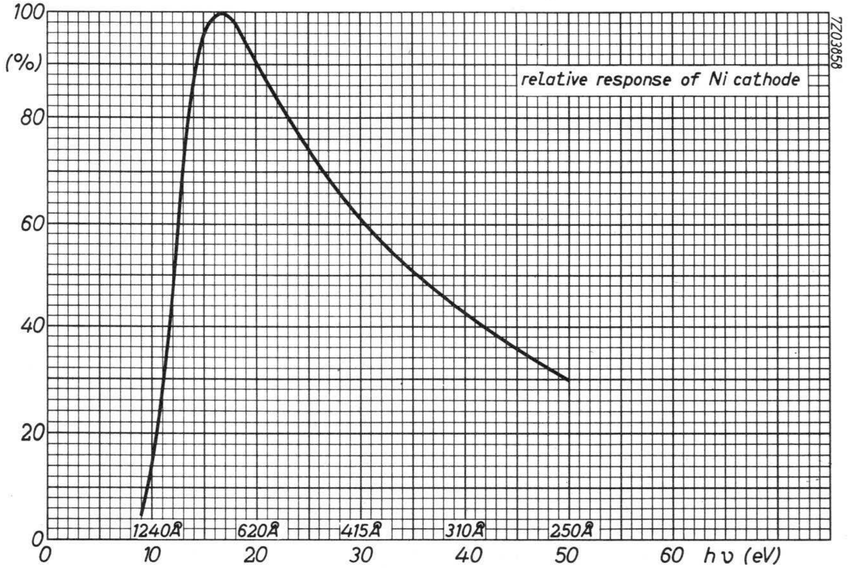
The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically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

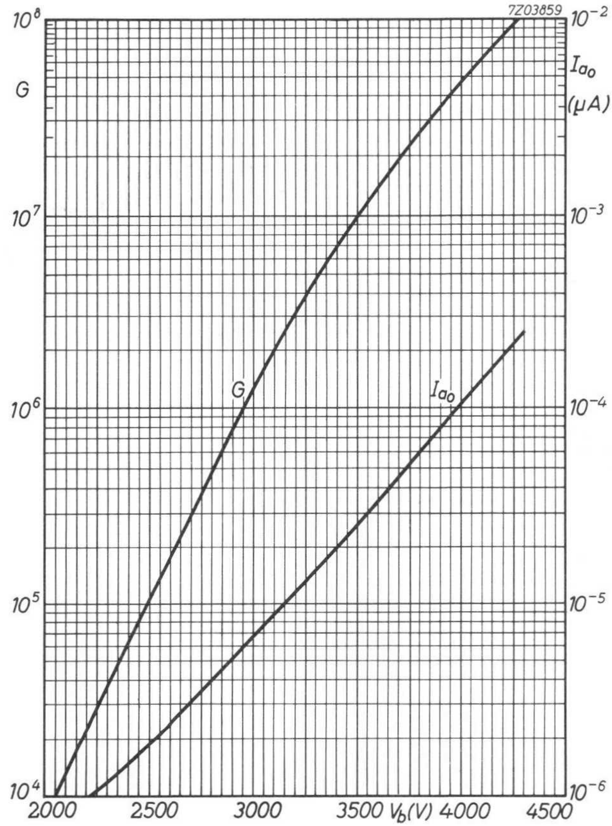
The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

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


7Z03859
10^8
G
10^7
10^6
10^5
10^4
10^{-2}
I_{a_0}
(μA)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
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^{-10}	A
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

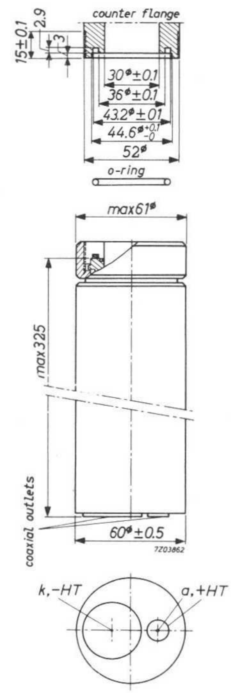
Number of stages	17
Dynode material	Cu-Be-O

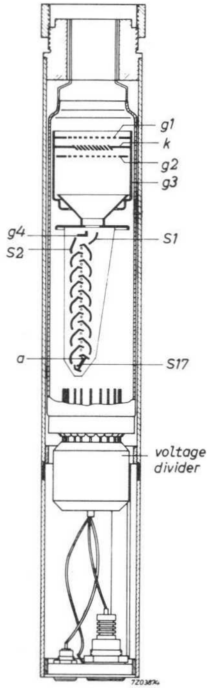
Capacitances

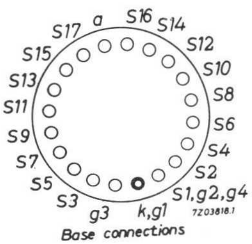
Anode to final dynode	$C_{a/S17}$	7	pF
Anode to all other electrodes	C_a	9.5	pF

DIMENSIONS AND CONNECTIONS

Dimensions in mm







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

TYPICAL CHARACTERISTICS

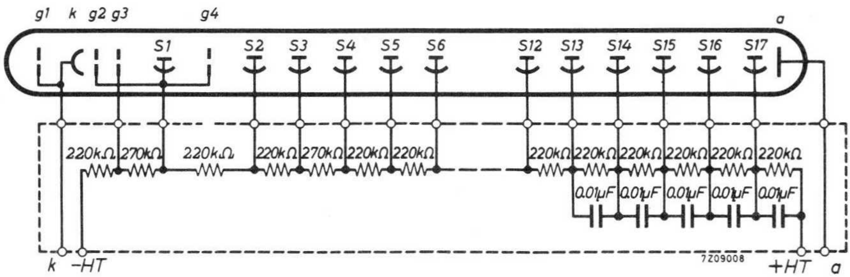
With potted voltage divider

Gain at V_b = 4000 V	G	av.	5.10^7
Anode dark current at V_b = 4000 V	I_{a_0}	av.	10^{-4} μA

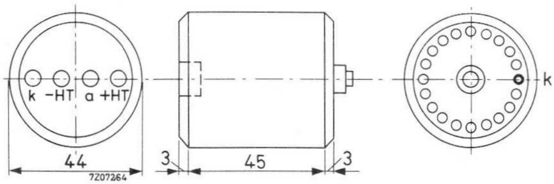
LIMITING VALUES (Absolute max. rating system)

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 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.

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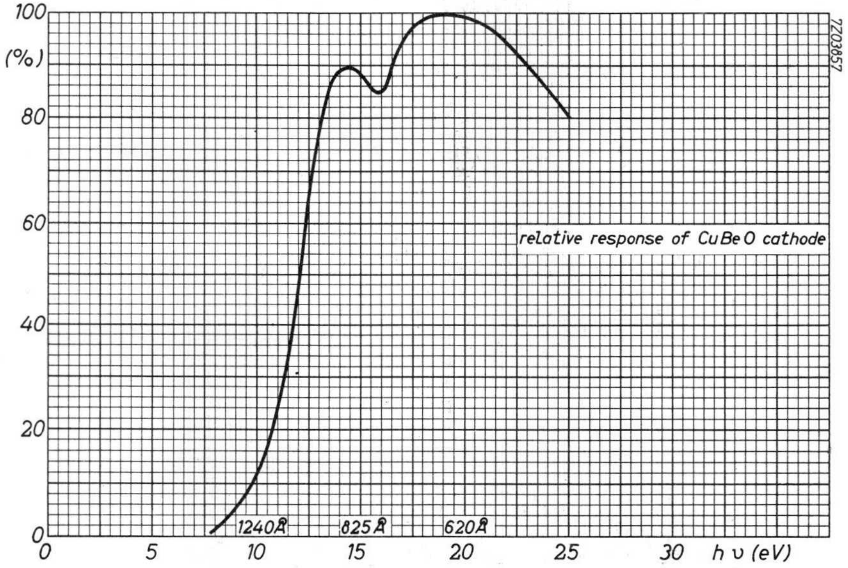
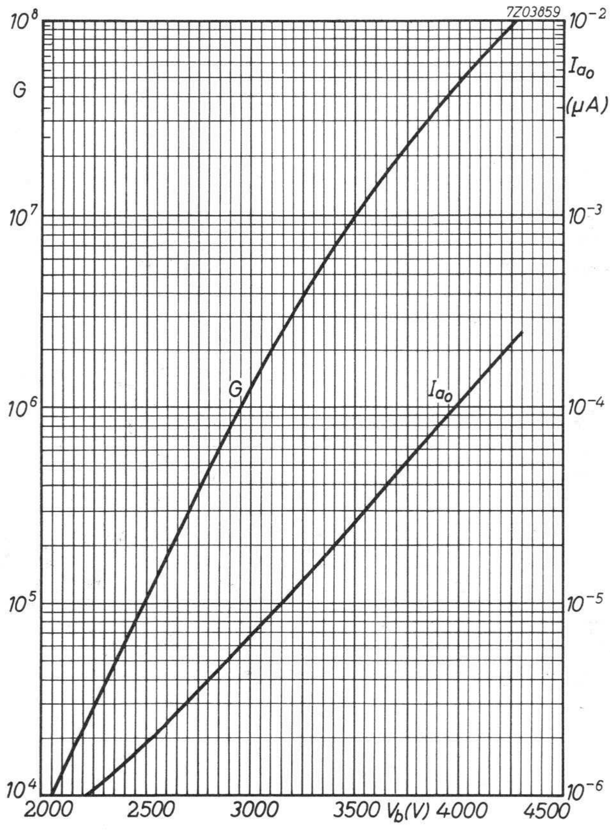
The high-vacuum pumps must be provided with a liquid nitrogen trap to avoid oil deposits on the dynodes.

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


7Z03859
G
10^8
10^7
10^6
10^5
10^4
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
I_{ao}
(μA)
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 ($\lambda < 1500$ 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^{-10}	A
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 $\pm$ 100	Å
Quantum efficiency for UV-photons at 800 Å	10	%

Multiplier system

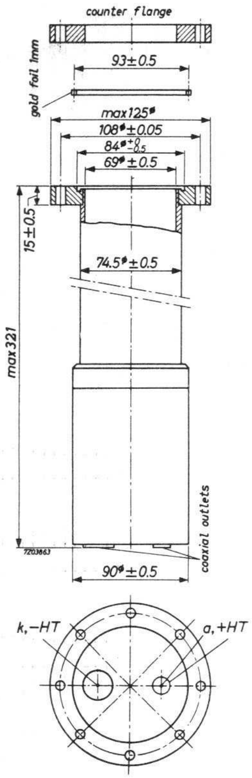
Number of stages	17
Dynode material	Cu-Be-O

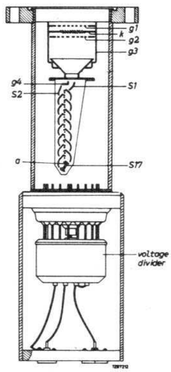
Capacitances

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

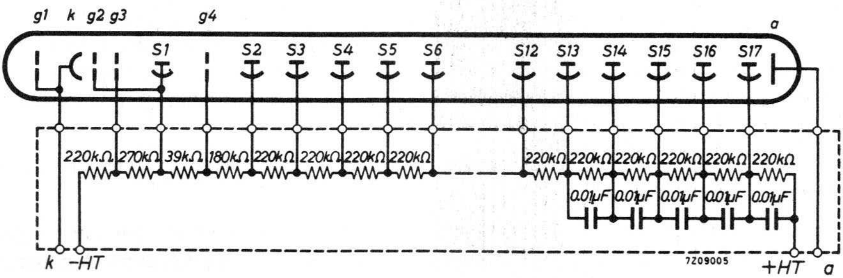
With potted voltage divider

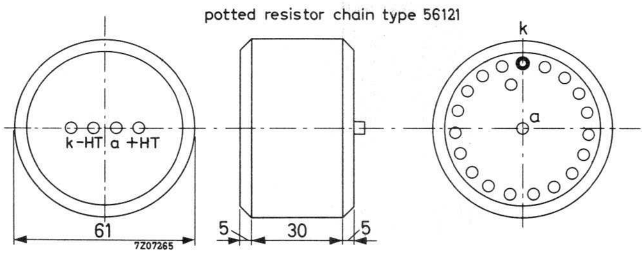
Gain at V_b = 4000 V	G	av.	5.10^7	
Anode dark current at V_b = 4000 V	I_{ao}	av.	10^{-4}	μA

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 min. 80	V V
Voltage between anode and final dynode	$V_{a/S_{17}}$	max. 300 min. 80	V 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.

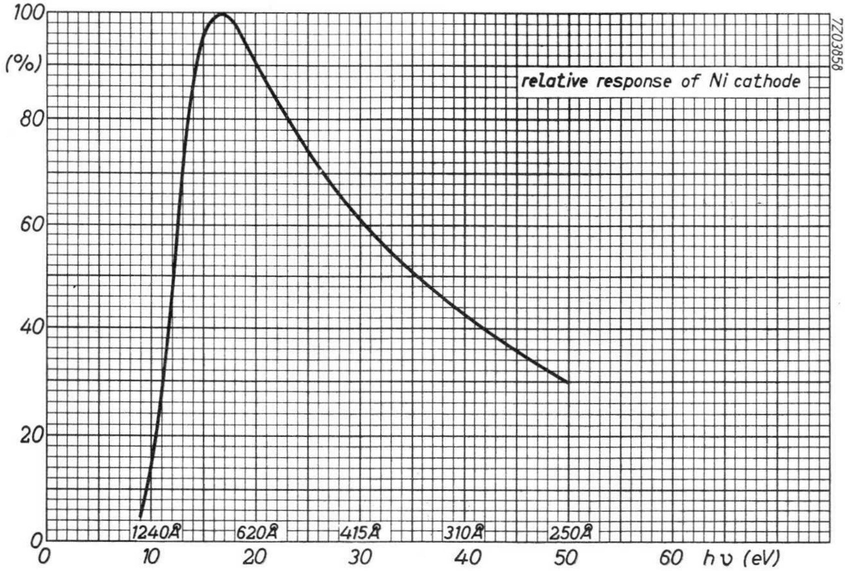
The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically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

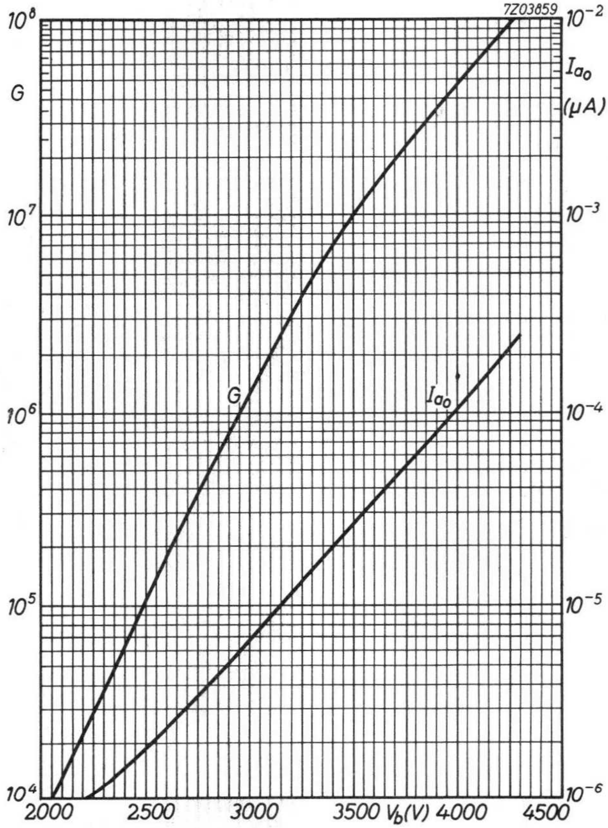
The tube has a stainless steel envelope and a heavy flange to facilitate mounting to a vacuum system (gold foil vacuum seal). The envelope contains also a complete potted voltage divider. The external connections are made via two coaxial connectors.

The tube may be heated to 300 ^{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
relative response of Ni cathode
7Z03858
1240Å
620Å
415Å
310Å
250Å
0
10
20
30
40
50
60
h υ (eV)


7Z03859
G
10^8
10^7
10^6
10^5
10^4
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
I_{a_0}
(μA)
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^{-10}	A
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

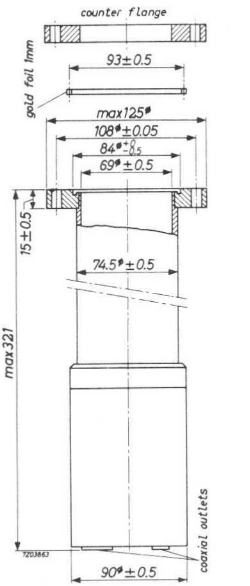
Number of stages	17
Dynode material	Cu-Be-O

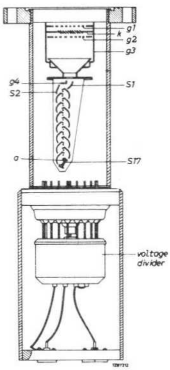
Capacitances

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

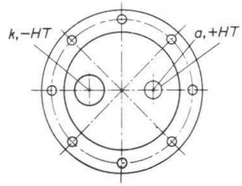
DIMENSIONS AND CONNECTIONS

Dimensions in mm





Base connections



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

TYPICAL CHARACTERISTICS

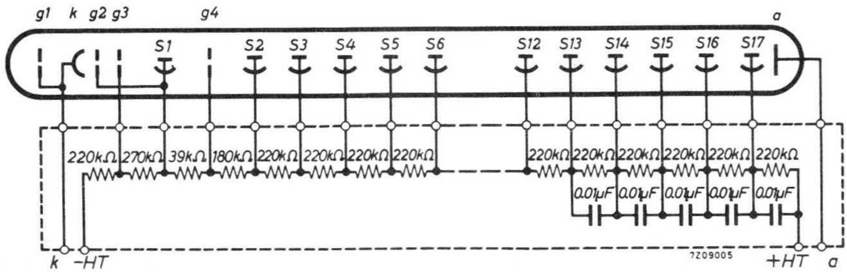
With potted voltage divider

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

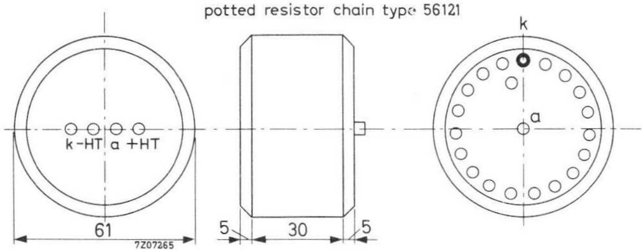
LIMITING VALUES (Absolute max. rating system)

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.

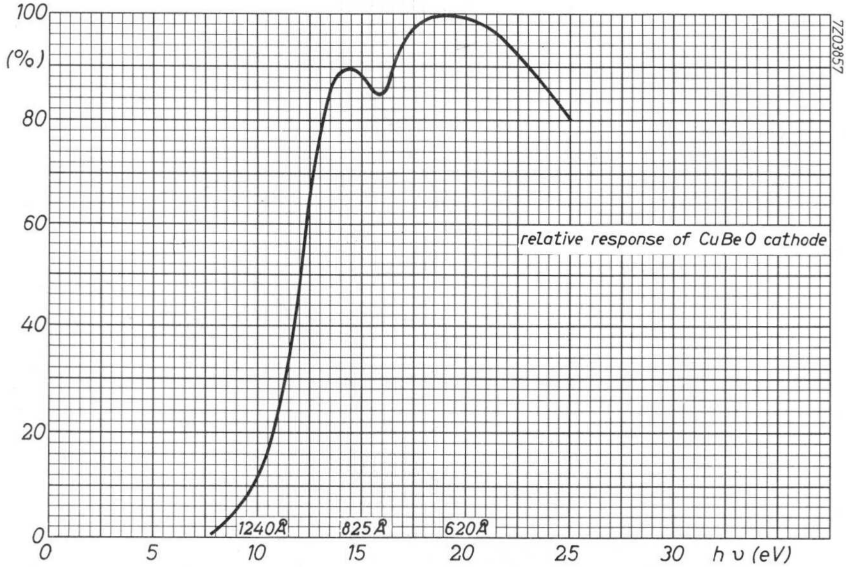
The tube may be used both in counting circuits and integrating current circuits. In the latter case the cathode emission should be at least 10^3 el/sec (approx. 10^{-17} A) while the anode current may never mount to values over 1 μA. If the cathode emission is lower than 10^3 el/sec it is practically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

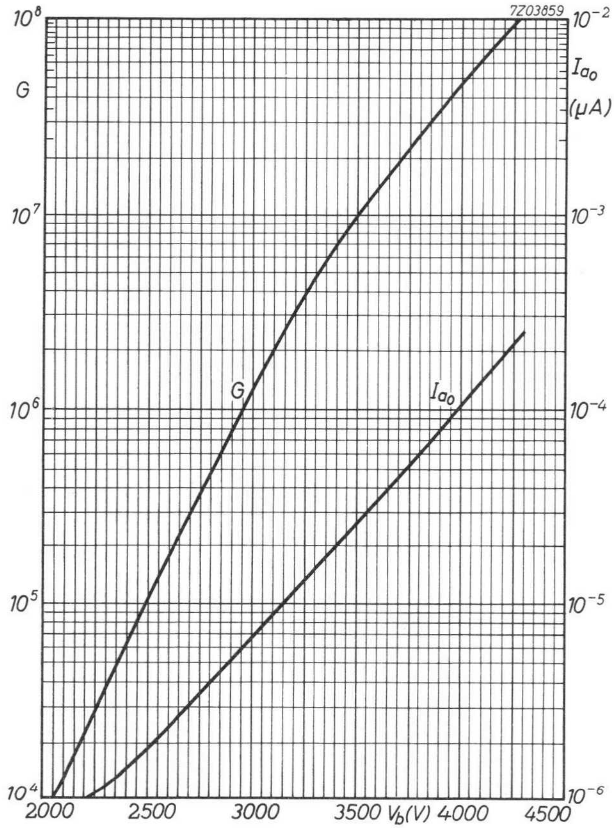
The tube has a stainless steel envelope and a heavy flange to facilitate mounting to a vacuum system (gold foil vacuum seal). The envelope contains also a complete potted voltage divider. The external connections are made via two coaxial connectors.

The tube may be heated to 300 $^{\circ}$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
h υ (eV)
1240Å
825Å
620Å
relative response of CuBeO cathode
7Z03857


7Z03859
10^8
G
10^7
10^6
10^5
10^4
10^{-2}
I_{a_0}
(μA)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
G
I_{a_0}
2000
2500
3000
3500 V_b(V) 4000
4500

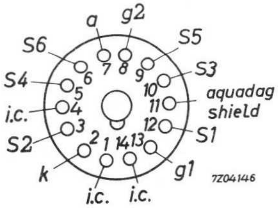
6 STAGE PHOTOMULTIPLIER TUBE

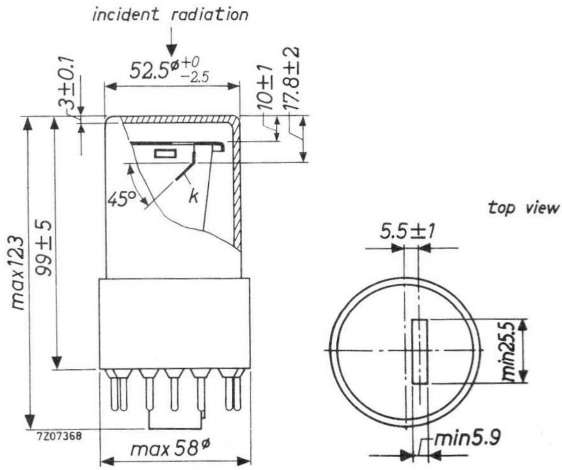
The tube is intended for use in plasma physics where high light flashes must be measured and other applications where a high degree of time definition and linearity is required.

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

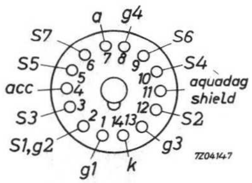
7 STAGE PHOTOMULTIPLIER TUBE

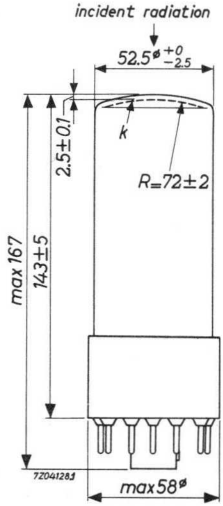
The tube is intended for use in plasma physics where high light flashes must be measured and other applications where a high degree of time definition and linearity is required.

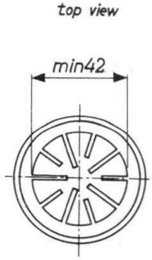
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	42	mm
Gain (at 3500 V)	10^4	
Anode pulse rise time	1.9	ns
Linearity	up to 1	A
Peak current	3	A

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 μ'
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

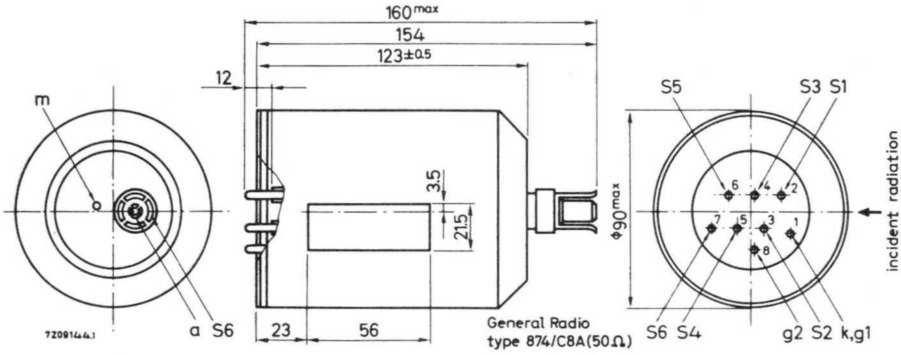
3) At an ambient temperature of 25 °C

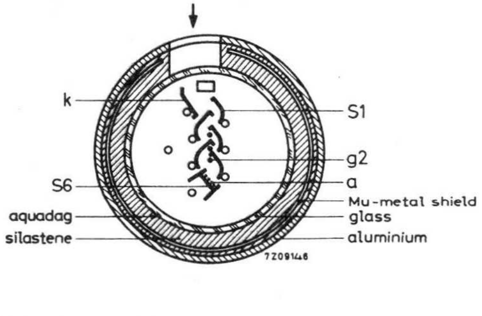
6 STAGE PHOTOMULTIPLIER TUBE

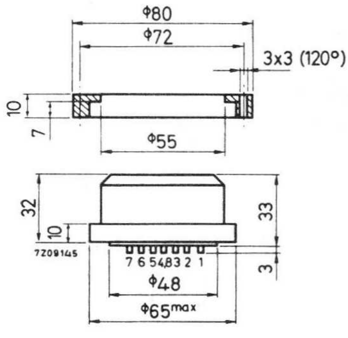
Photomultiplier tube intended for measuring very short light pulses having a very high luminous flux.

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







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.	45	μA/lm
having a colour temperature of 2854 °K	max.	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

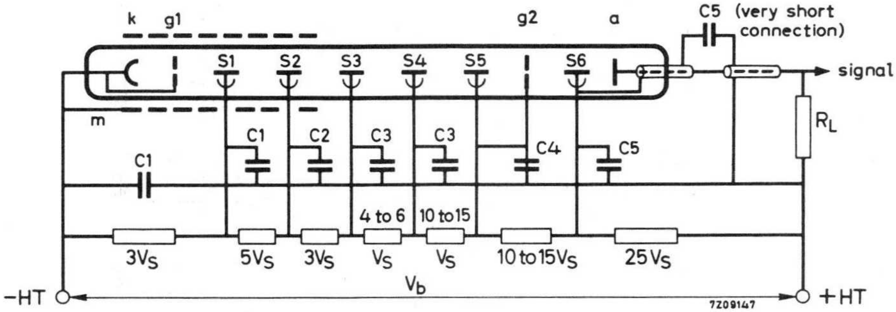
Supply voltage for $G = 10^4$	V_b	av.	3500	V
		max.	7000	V
Anode dark current at $G = 10^4$ (ambient temperature 25 °C)	I_{a_o}	av.	1	μA
		max.	6	μA
Linearity (within 5%) between anode pulse amplitude and input light pulse		up to	5	A
Supply voltage for a linearity of 5 A	V_b	av.	6500	V
		max.	7000	V
Anode pulse rise time		<	1.10^{-9}	s [1]
Anode pulse width at half height		<	2.10^{-9}	s [1]
Total transit time			10.10^{-9}	s [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)

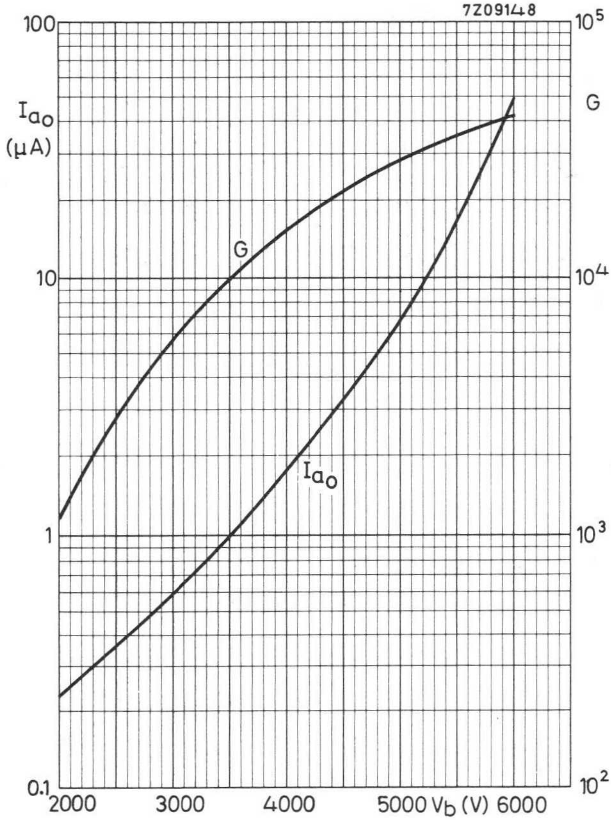
Supply voltage	V_b	max.	7500	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	1000	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	2000	V
Voltage between anode and final dynode	V_{a/S_6}	max.	2750	V

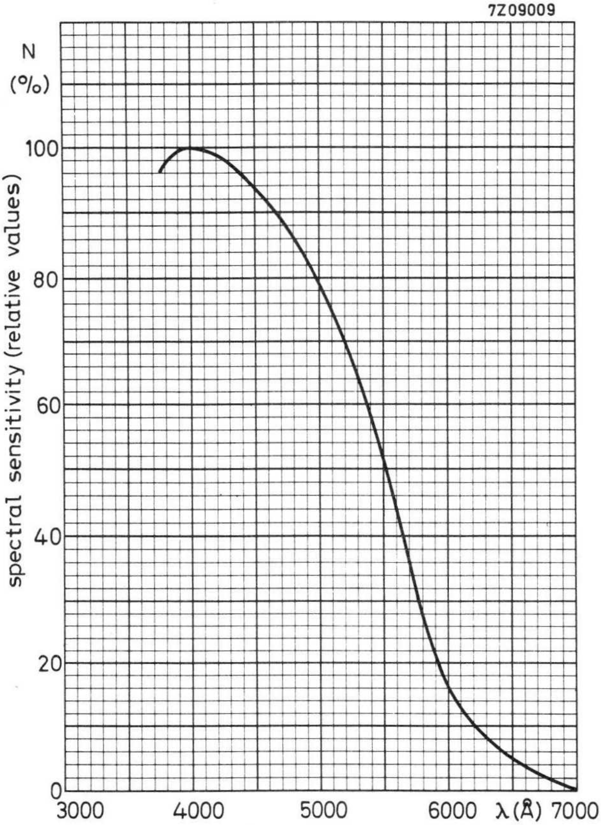
RECOMMENDED CIRCUIT



Voltage divider

C_1 = 2.2 nF, 7.5 kV		
C_2 = 2.2 nF, 7 kV		
C_3 = 2.2 nF, 6 kV		Ceramic capacitors (low inductance)
C_4 = 30 nF, 4 kV		
C_5 = 50 nF, 3 kV		
R_L = 50 Ω		


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

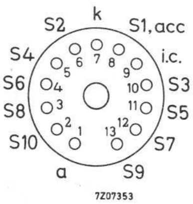
The tube is intended for use in applications such as X-ray spectrometry and scintillation counting, in small medical probes or in portable equipment or any optical or nuclear application in which a small diameter is required.

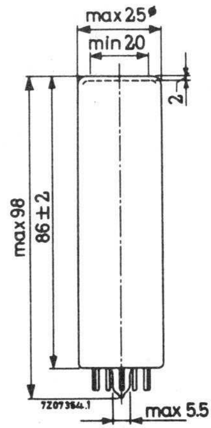
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	20	mm
Anode sensitivity (at 1800 V)	200	A/lm
Energy resolution for ^{137}Cs (0.661 MeV)	11	%

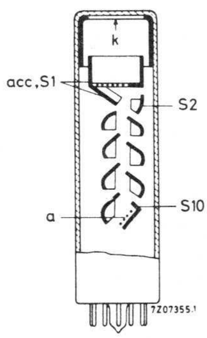
DIMENSIONS AND CONNECTIONS

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]	5.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [4]	$8,5.10^{-9}$	s
Total transit time at V_b = 1500 V [4]	29.10^{-9}	s

---

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

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

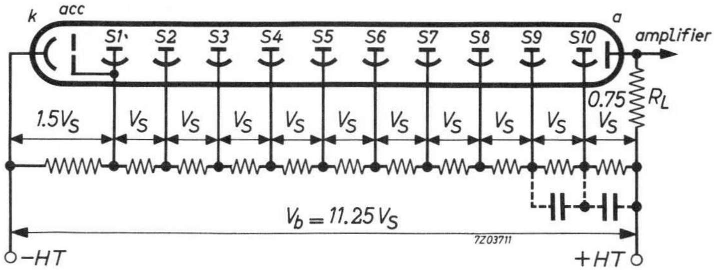
[3]) At an ambient temperature of 25 °C

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

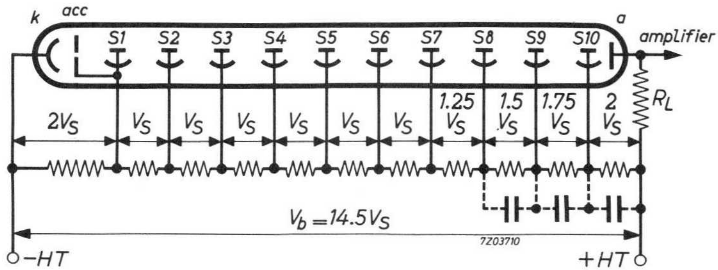
LIMITING VALUES (Absolute max. rating system)

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
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.

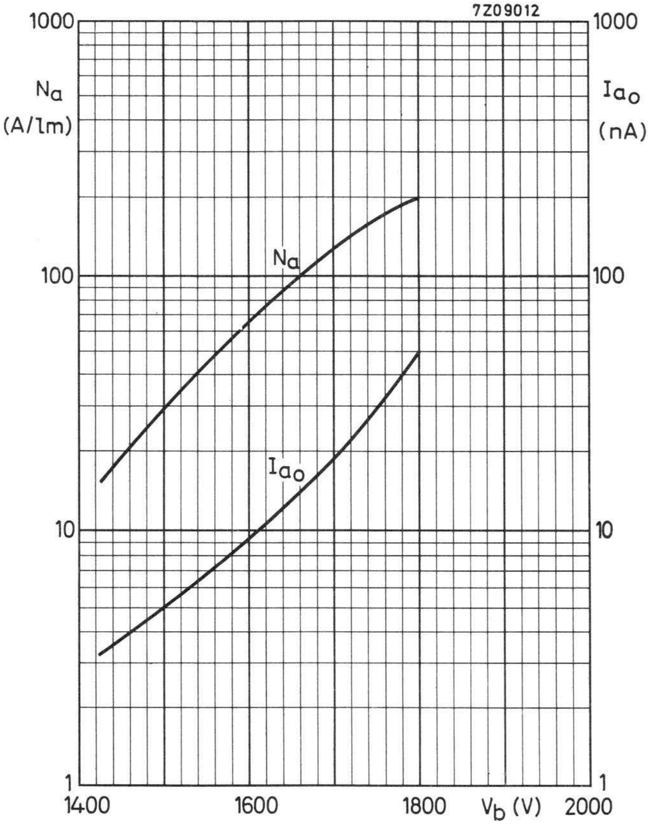
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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
Na
(A/lm)
100
10
1
1000
Iao
(nA)
100
10
1
Na
Iao
1400
1600
1800
Vb (V)
2000

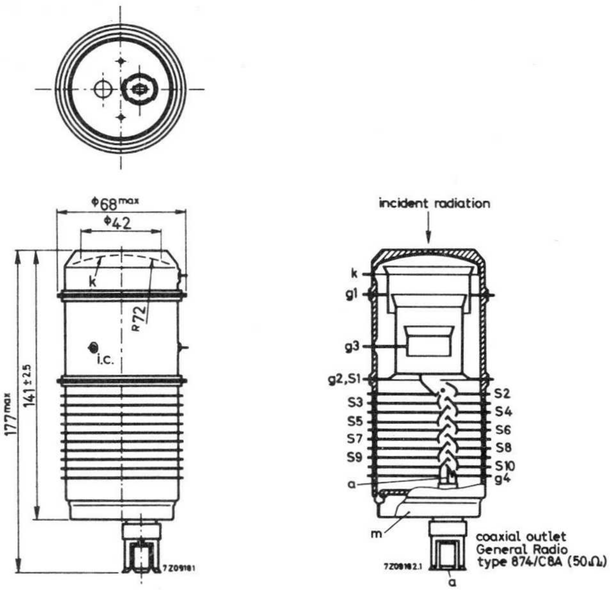
10 STAGE PHOTOMULTIPLIER TUBE

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

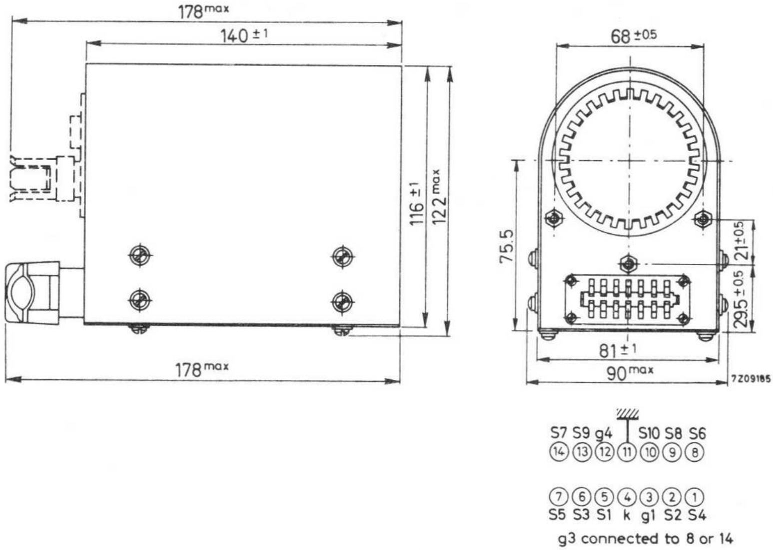
Dimensions in mm



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

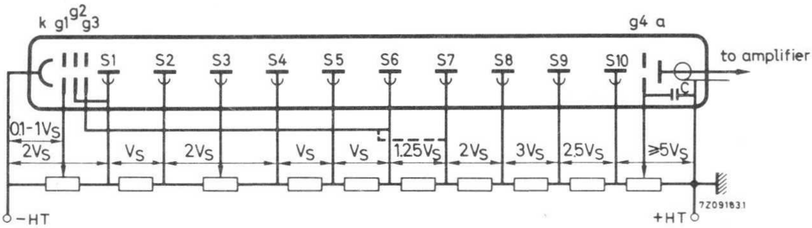
Supply voltage for G = 10^7	V_b	av. 4000 V max. 5000 V
Anode dark current at G = 10^7 3)	I_{a_o}	max. 1 μA
Linearity within 5% between anode pulse amplitude and input light pulse		min. up to 75 mA
Anode pulse rise time at V_b = 5000 V 4)		max. 1×10^{-9} s ←
Anode pulse width at half height at V_b = 5000 V 4)		1.5×10^{-9} s ←
Transit time difference between the centre of the photocathode and the edge at V_b = 5000 V 4)		max. 0.2×10^{-9} s
Total transit time at V_b = 5000 V 4)		20×10^{-9} s

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

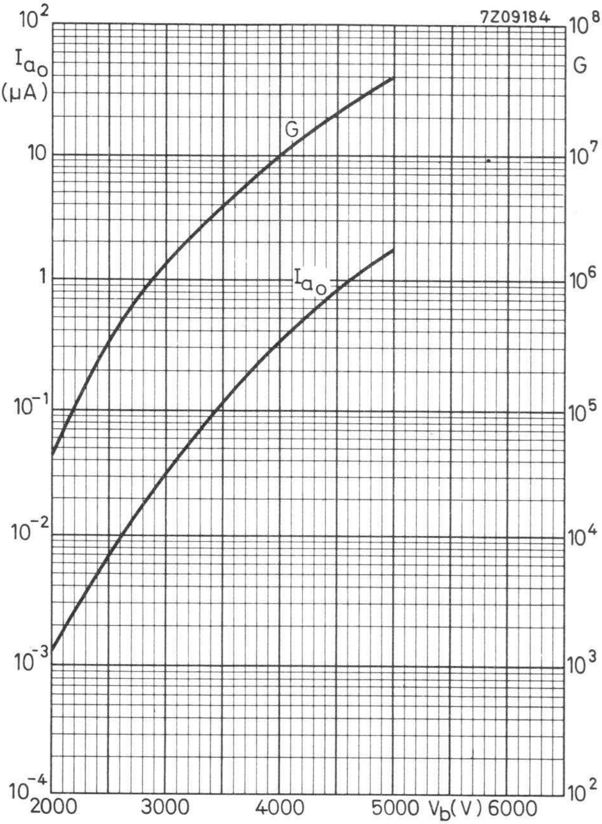
RECOMMENDED CIRCUIT



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 A 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.

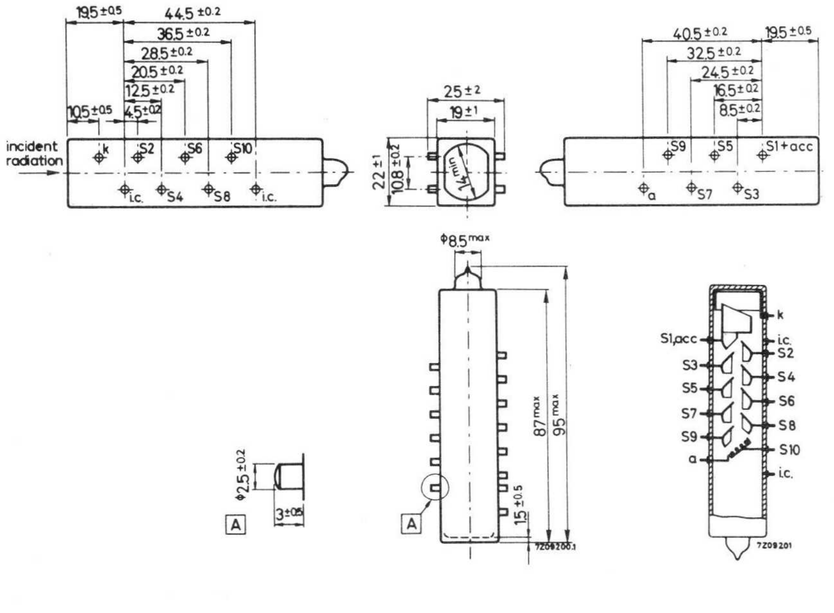

7Z09184
10^2
I_{a_o}
(μA)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^8
G
10^7
10^6
10^5
10^4
10^3
10^2
G
I_{a_o}
2000
3000
4000
5000
V_b(V)
6000

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	approx. 14	mm
Gain (at approx. 3000 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			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.	35	µA/lm
Radiant sensitivity at 4200 Å			50	mA/W

Multiplier system

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

TYPICAL CHARACTERISTICS

With voltage divider A

Supply voltage for $G = 10^7$	V_b	max.	3000	V
Anode dark current at $G = 10^7$ 3)	I_{a_o}	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)			25×10^{-9}	s
Anode pulse width at half height at V_b = 2400 V 4)			4×10^{-9}	s
Total transit time at V_b = 2400 V 4)			19×10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	3000	V

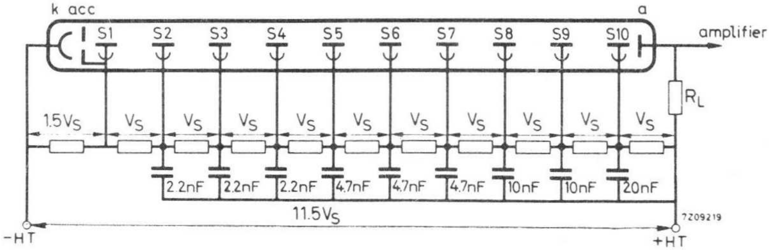
1) See spectral response curve in front of the Handbook section "Photomultiplier tubes".

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

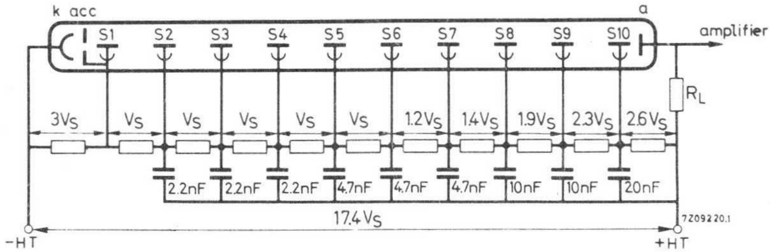
3) At an ambient temperature of 25 °C.

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

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.

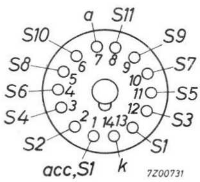
11 STAGE PHOTOMULTIPLIER TUBE

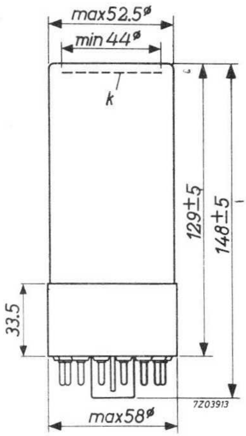
The tube is intended for use in applications such as scintillation counting of α, β, γ, n radiation and X rays, in flying-spot apparatus and different kinds of optical instruments.

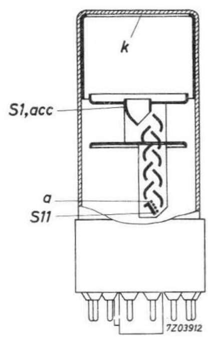
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm

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 A (S11)	
Wavelength at maximum response			4200 ± 300	Å
Luminous sensitivity 2)	N_k	av. min.	70 40	µA/lm 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. min.	400 250	A/lm A/lm
Anode dark current at N_a = 60 A/lm 3)	I_{a_o}	av. max.	0.015 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)

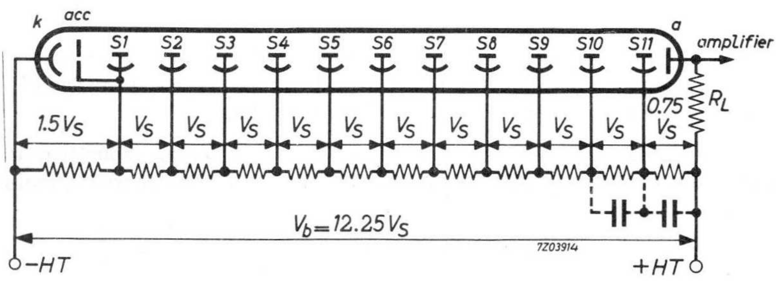
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1500 V [1]	5.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [1]	14.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9}	s
Total transit time at V_b = 1500 V [1]	45.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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



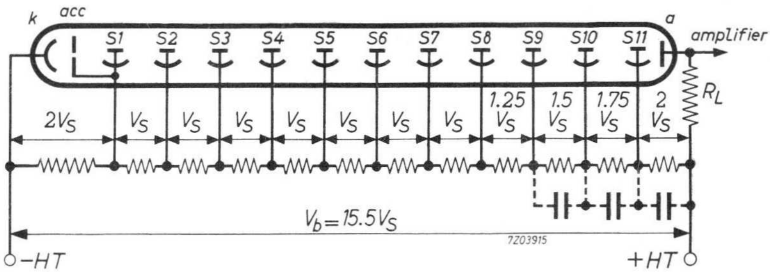
Voltage divider type A

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 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 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.

11 STAGE PHOTOMULTIPLIER TUBE

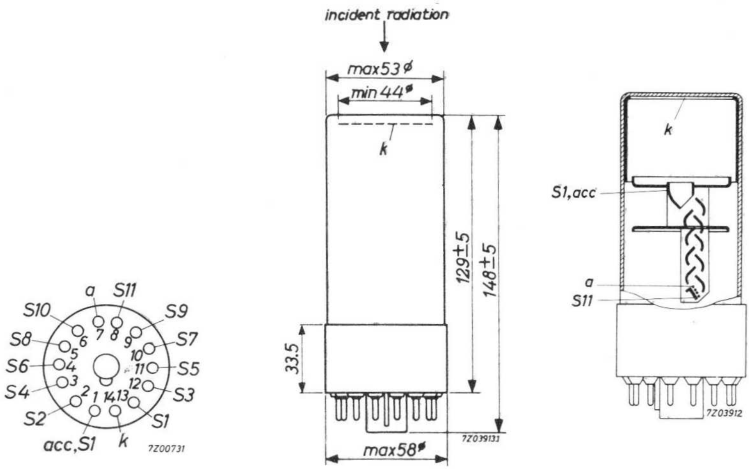
The tube is intended for optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

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.	0.015	µA
		max.	0.050	µA
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)

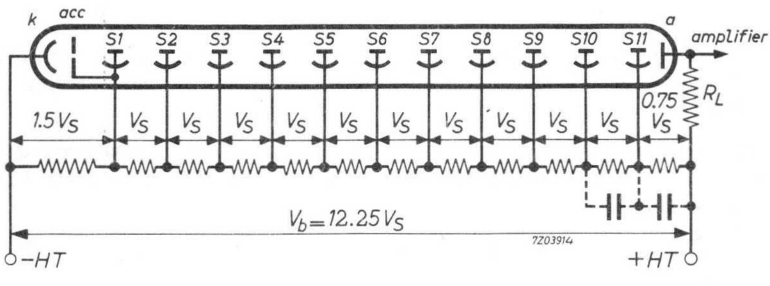
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100 mA
Anode pulse rise time at V_b = 1500 V [1]	5.10^{-9} s
Anode pulse width at half height at V_b = 1500 V [1]	14.10^{-9} s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V	4.10^{-9} s
Total transit time at V_b = 1500 V [1]	45.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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



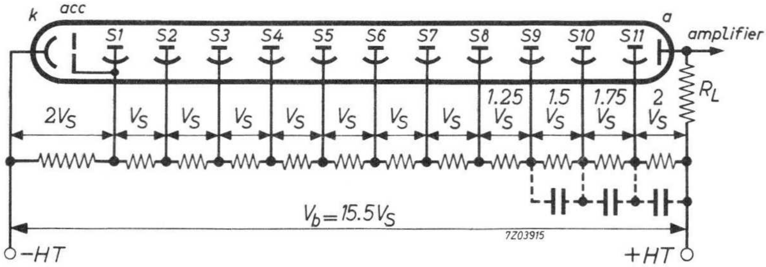
Voltage divider type A

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.

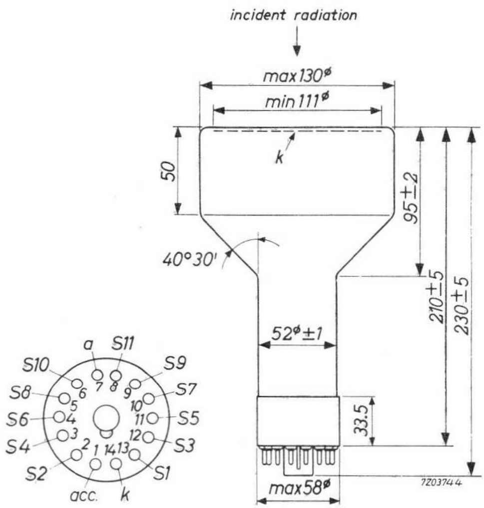
11 STAGE PHOTOMULTIPLIER TUBE

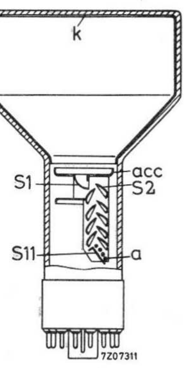
The tube is intended for use in applications such as scintillation counting with large crystals, or applications in which light must be gathered from a diffusely reflecting surface (e.g. flying-spot techniques in colour printing) or from a distant source.

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. min.	60 40	μA/lm 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. min.	500 100	A/lm A/lm
Anode dark current at N_a = 250 A/lm [3]	I_{a_o}	av. max.	0.2 0.5	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)

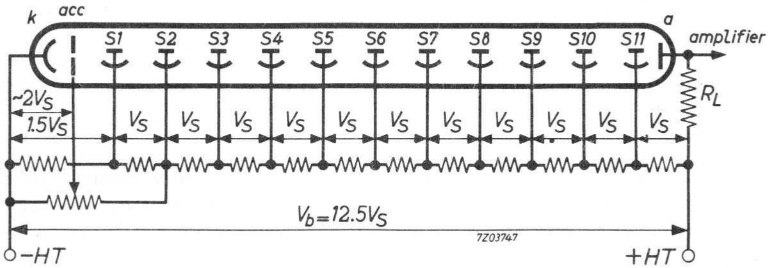
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1800 V [1]	15.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [1]	35.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V	15.10^{-9}	s
Total transit time at V_b = 1800 V [1]	120.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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



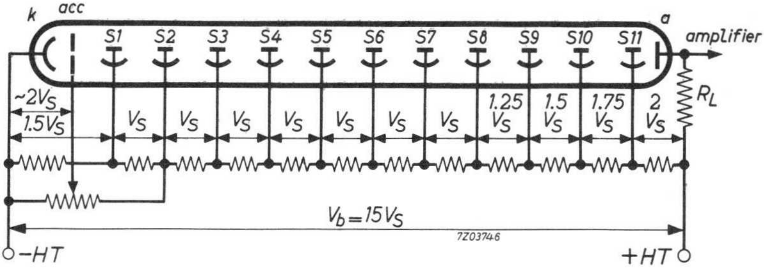
Voltage divider type A

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 about 1 mA will be sufficient.

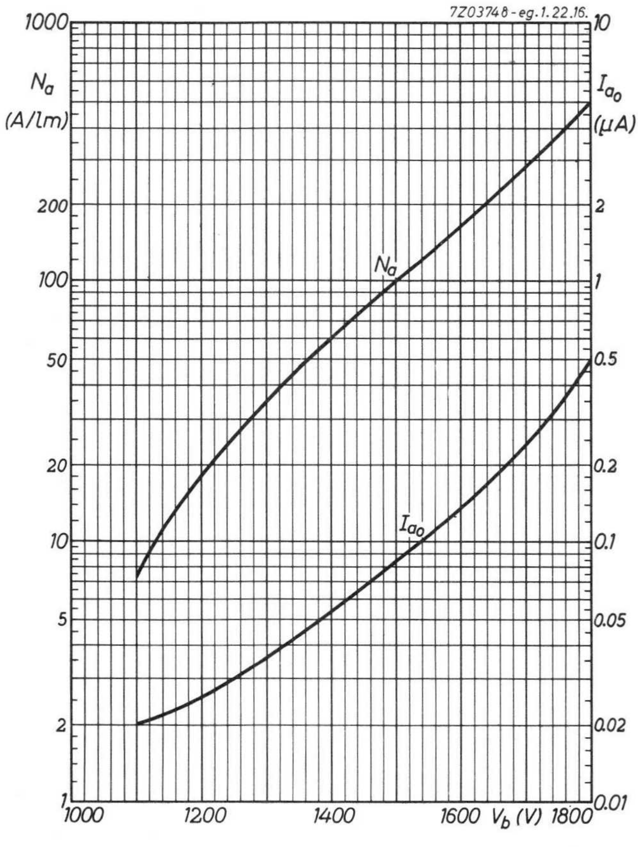
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

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

11 STAGE PHOTOMULTIPLIER TUBE

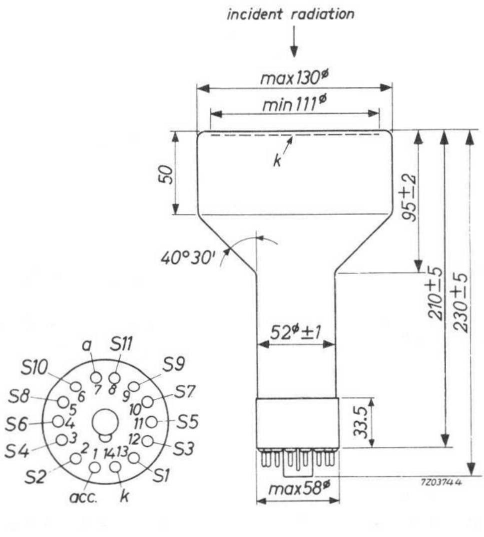
The tube is intended for use in applications which require a good sensitivity in the ultra-violet region, combined with a photosensitive area larger than usual.

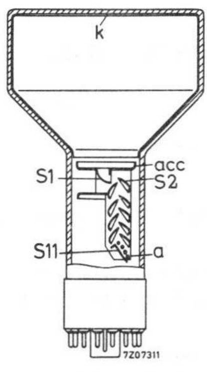
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	111	mm
Anode sensitivity (at 1800 V)	500	A/lm

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)

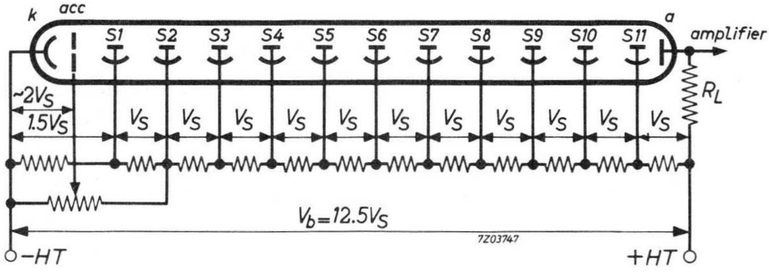
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1800 V [1]		15.10^{-9}	s
Anode pulse width at half height at V_b = 1800 V [1]		35.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		15.10^{-9}	s
Total transit time at V_b = 1800 V [1]		120.10^{-9}	s

LIMITING VALUES

Supply voltage	V_b	max.	2000	V
Continuous anode current	I_a	max.	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



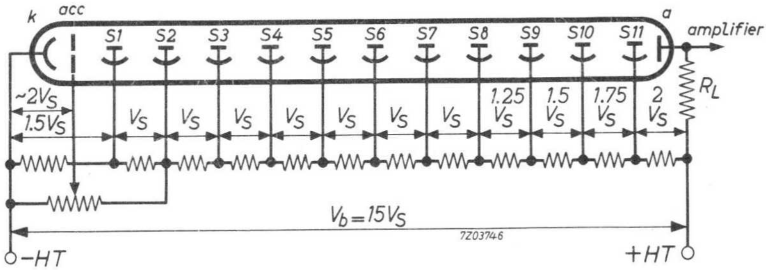
Voltage divider type A

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.

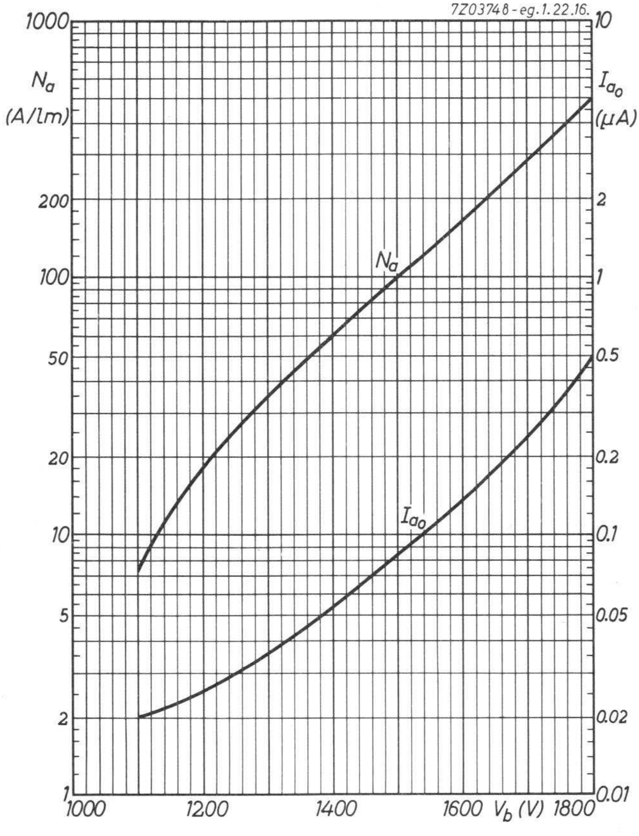
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

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
1000
1200
1400
1600
V_b (V)
1800
N_a
I_{a_0}

14 STAGE PHOTOMULTIPLIER TUBE

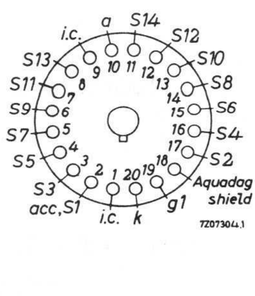
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidences, life of unstable particles, Cerenkov counters).

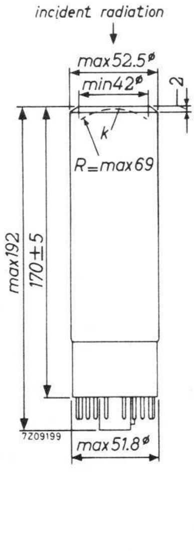
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	42	mm
Gain (at 2200 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

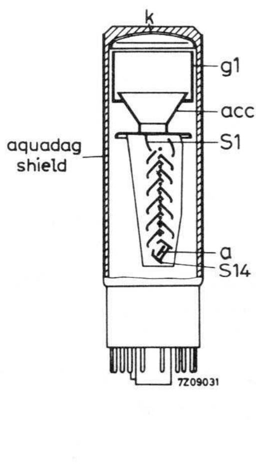
DIMENSIONS AND CONNECTIONS Dimensions in mm

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.	65	µA/lm
		min.	45	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. max.	2200 2500	V V
Anode dark current at G = 10^8 1)	I_{a_o}	av. max.	0.5 5.0	μA 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)			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)			$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)			43.10^{-9}	s
Maximum peak currents			0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)			3.10^{-9}	s
Total transit time at V_b = 2500 V 2)			39.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	2500	V
Continuous anode current	I_a	max.	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

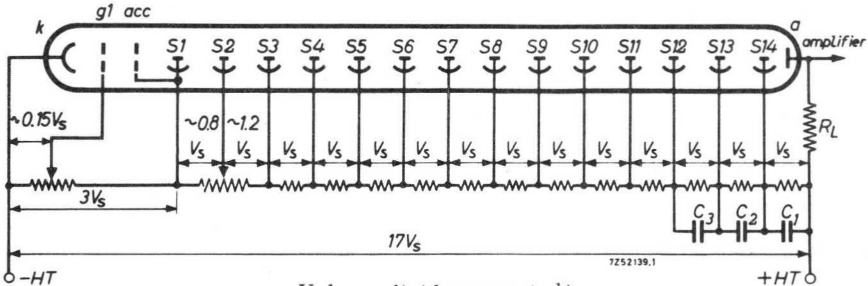
1) At an ambient temperature of 25 °C.

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

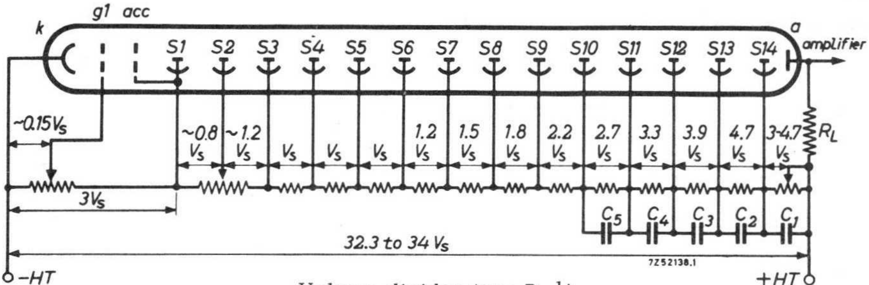
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

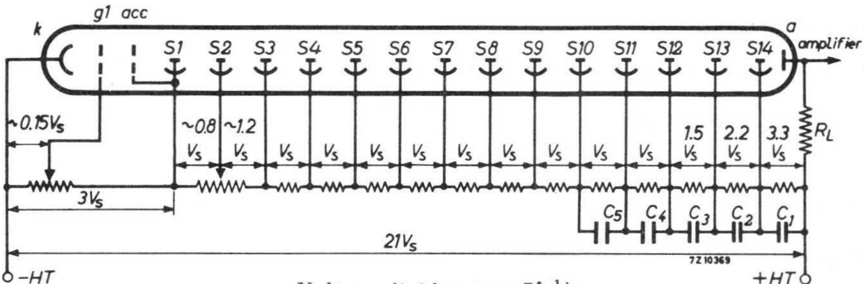
→ RECOMMENDED CIRCUITS



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 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)

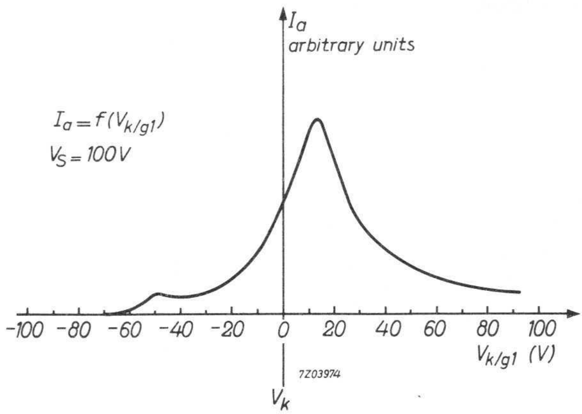


Fig. 1 Anode current variation with the adjustment of g_1

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.

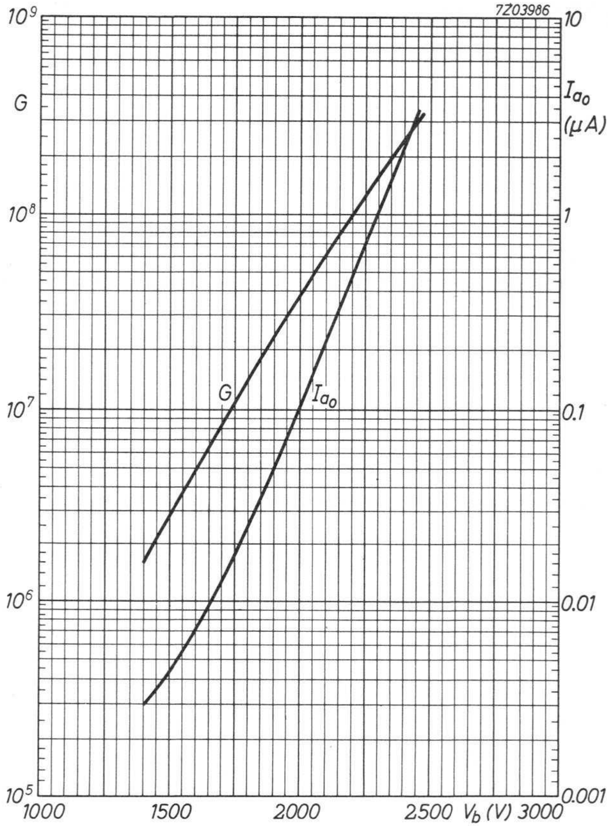

7Z03986
10^9
G
10^8
10^7
10^6
10^5
10
I_{ao}
(μA)
1
0.1
0.01
0.001
G
I_{ao}
1000
1500
2000
2500
V_b (V)
3000

Fig.2

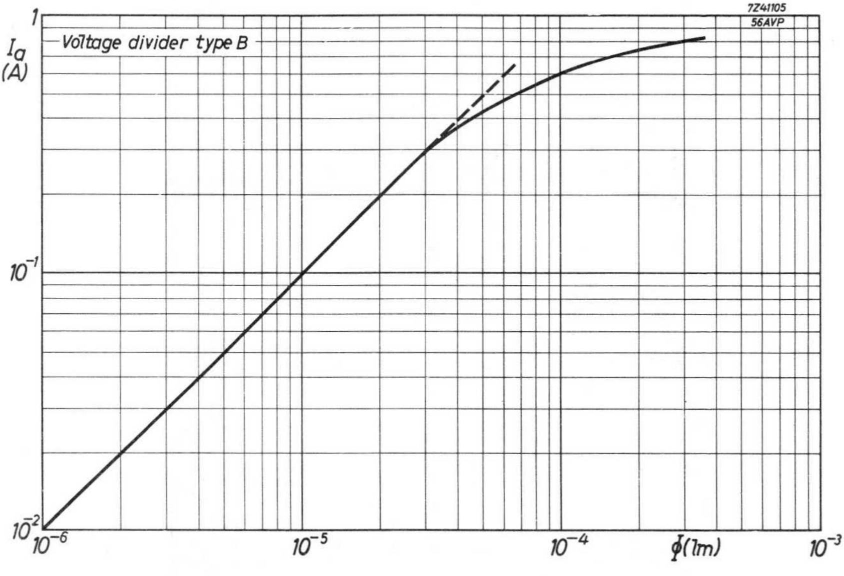

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
Φ(lm)
10^{-3}

Fig.3

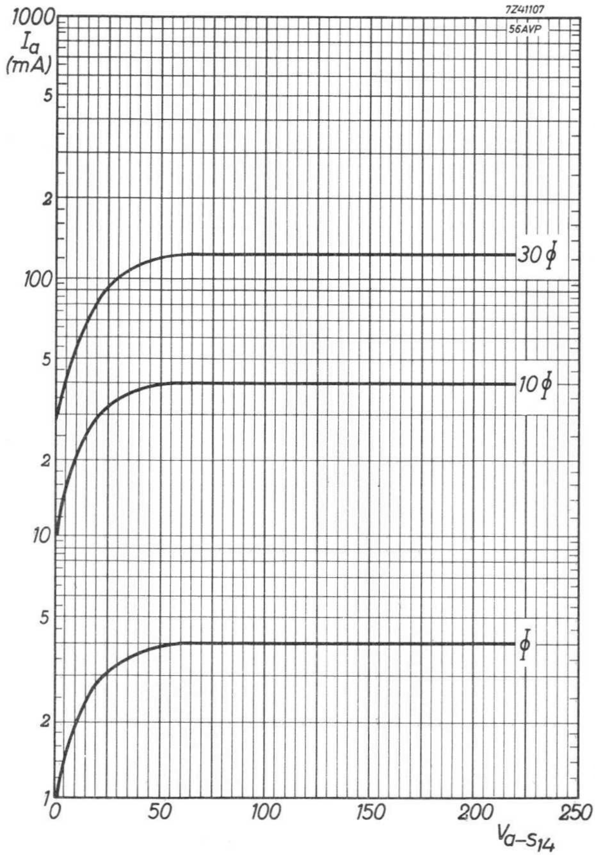

7Z41107
56AVP
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 Φ
10 Φ
Φ

Fig.4

14 STAGE PHOTOMULTIPLIER TUBE

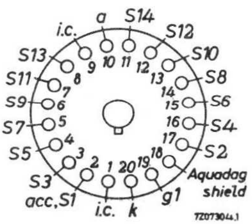
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for detecting of soft β-radiation (^{14}C and ^{3}H counting). Its fast time characteristics make the tube especially useful for fast coincidence measurements, thus reducing the background noise considerably.

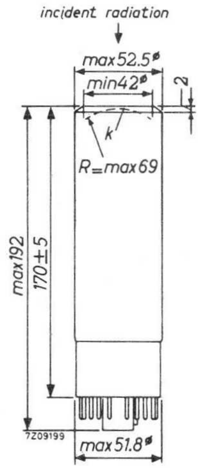
QUICK REFERENCE DATA			
Spectral response		type	A (S11)
Useful diameter of the photocathode		42	mm
Gain (at 2150 V)		10^8	
Anode pulse rise time		2	ns
Efficiency for single photons (1600 V)	min.	7	%
Background noise (1600 V)		350	counts/s

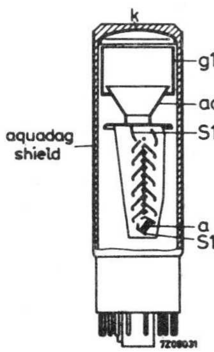
DIMENSIONS AND CONNECTIONS

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			69	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	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) 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.	2150	V
		max.	2500	V
Anode dark current at G = 10^8 1)	I_{a_o}	av.	0.1	μA
		max.	1	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)			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)			$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)			43.10^{-9}	s
Maximum peak currents			0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)			3.10^{-9}	s
Total transit time at V_b = 2500 V 2)			39.10^{-9}	s

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

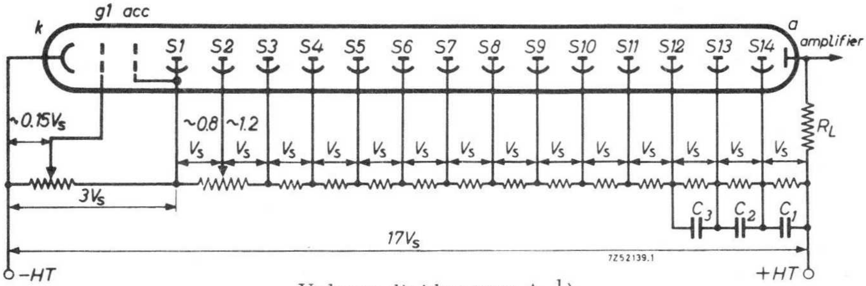
1) At an ambient temperature of 25 °C.

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

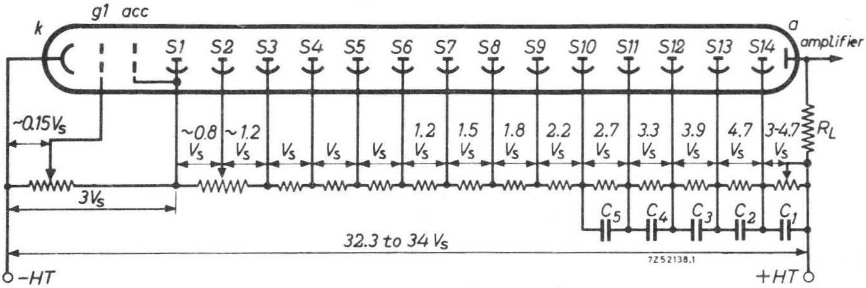
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 5.10^8 whichever is lowest.

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

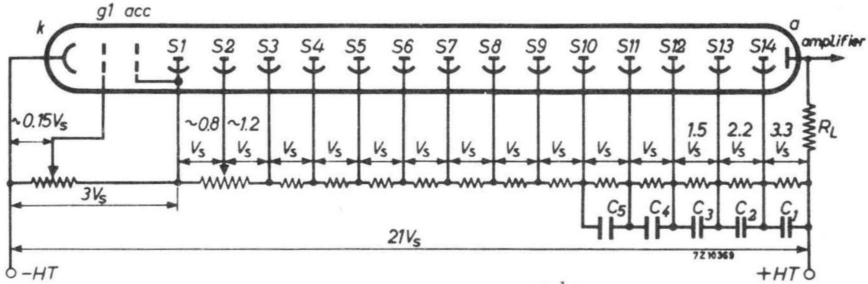
→ RECOMMENDED CIRCUITS



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.

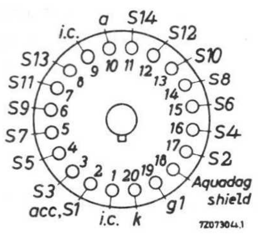
14 STAGE PHOTOMULTIPLIER TUBE

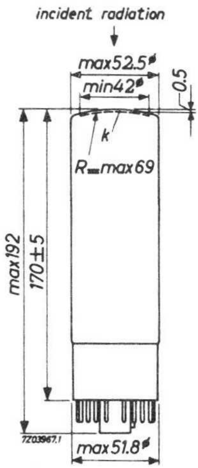
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the near-ultraviolet region.

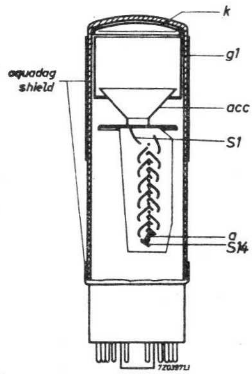
QUICK REFERENCE DATA		
Spectral response	type A/05 (extended S11)	
Useful diameter of the photocathode	42	mm
Window thickness	0.5	mm
Gain (at 2200 V)	10^8	
Anode rise time	2	ns
Linearity	up to 300	mA

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. min.	65 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. max.	2200 2500	V V
Anode dark current at $G = 10^8$ [1]	I_{a_o}	av. max.	0.5 5.0	μA 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]			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V [2]			$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V [2]			43.10^{-9}	s
Maximum peak currents			0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V [2]			2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V [2]			3.10^{-9}	s
Total transit time at V_b = 2500 V [2]			39.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage [3]	V_b	max.	2500	V
Continuous anode current	I_a	max.	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

---

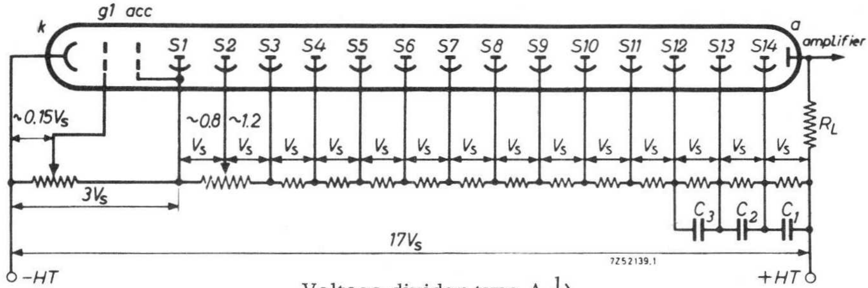
1) At an ambient temperature of 25 °C.

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

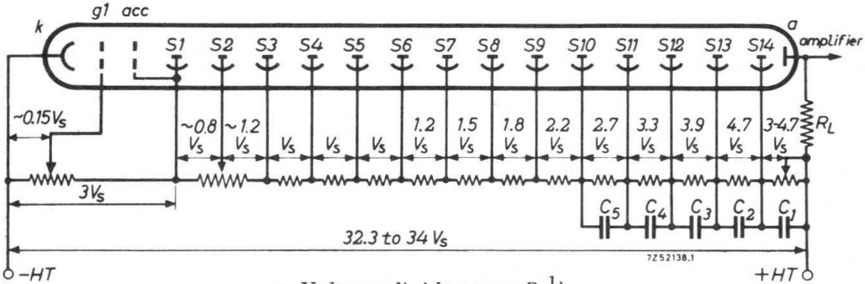
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

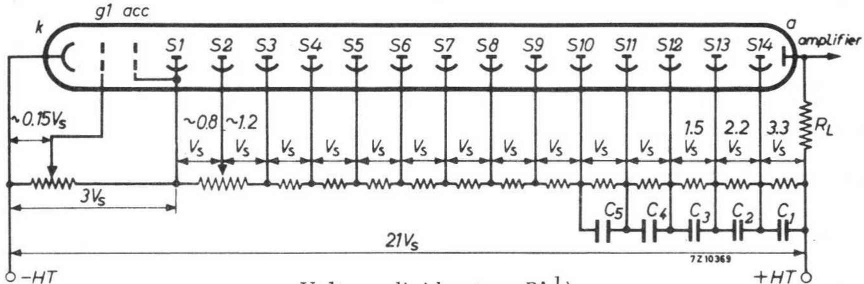
RECOMMENDED CIRCUITS



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.

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)

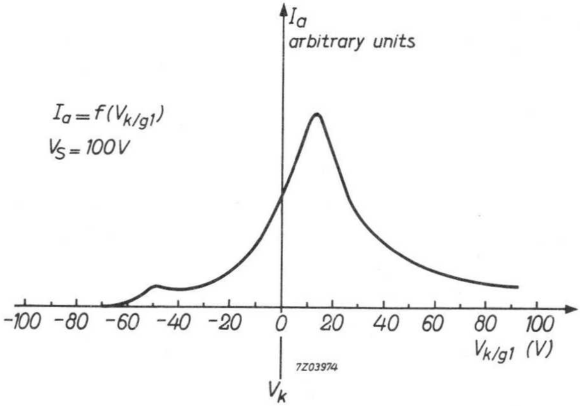


Fig.1 Anode current variation with the adjustment of g_1

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

B. The multiplier system consists of 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.

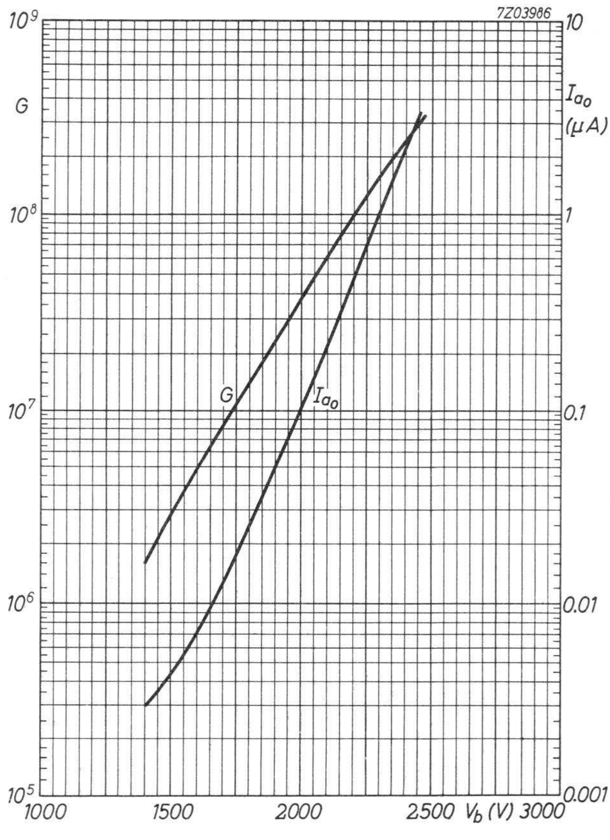

7Z03986
10^9
G
10^8
10^7
10^6
10^5
10
I_{a_0}
(μA)
1
0.1
0.01
0.001
G
I_{a_0}
1000
1500
2000
2500 V_b (V) 3000

Fig.2

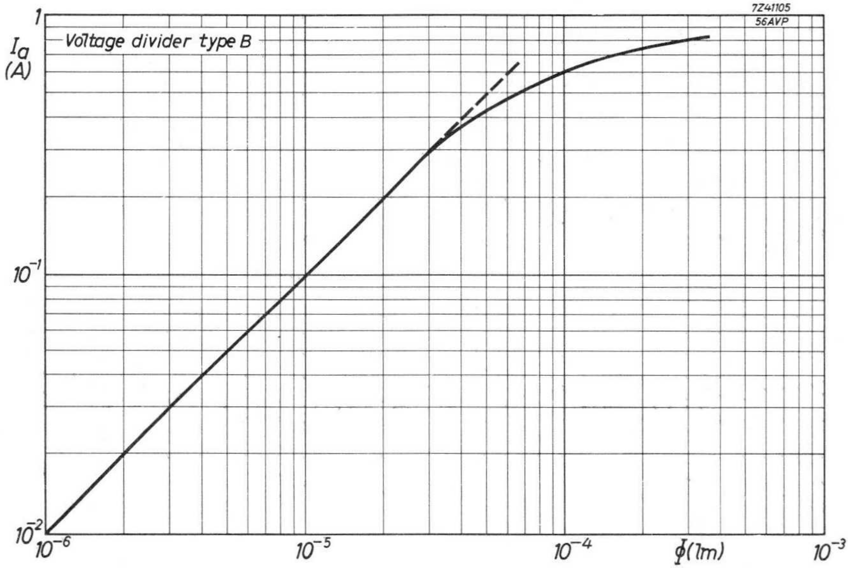

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
Φ(lm)
10^{-3}

Fig.3

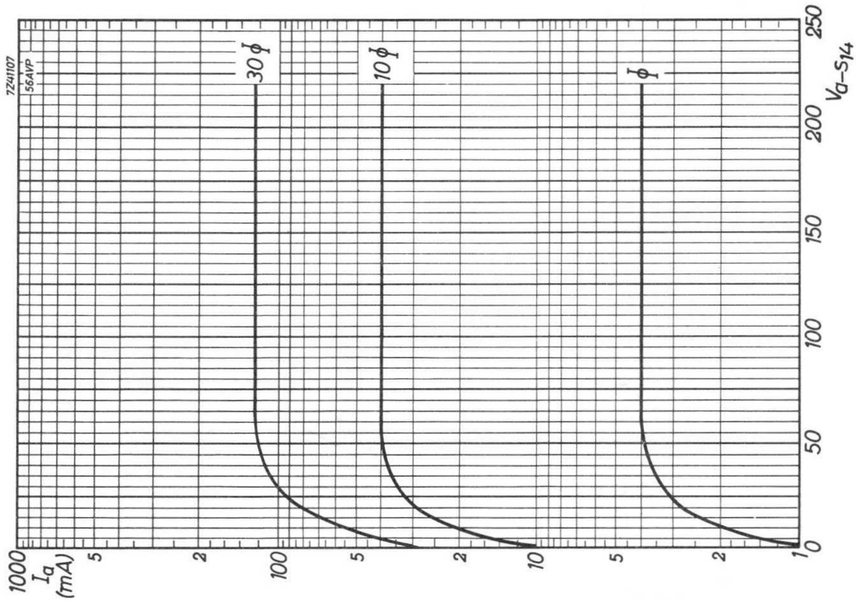
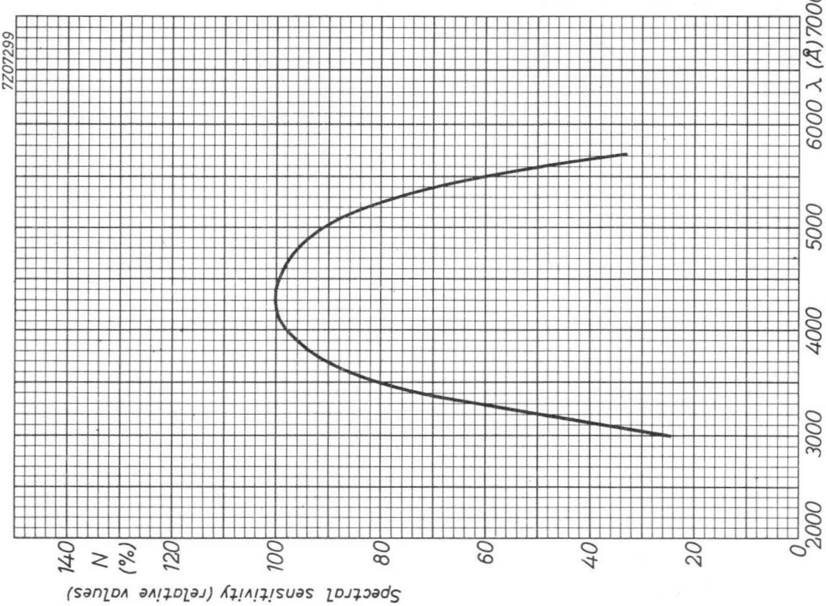


Fig.4



Spectral response curve A/05

Fig.5

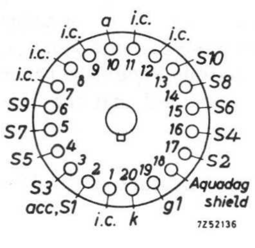
10 STAGE PHOTOMULTIPLIER TUBE

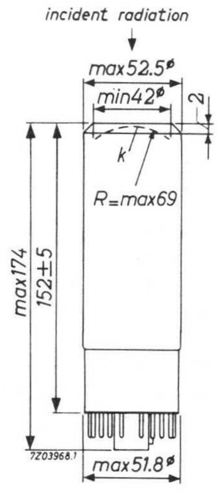
The tube is intended for use in such applications as infra-red telecommunication and ranging, and in optical experiments in which a fast response is required.

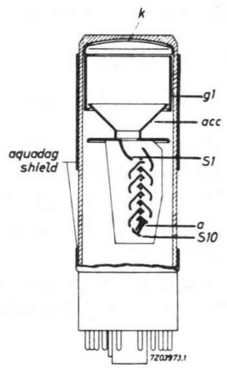
QUICK REFERENCE DATA		
Spectral response	type	C (S1)
Useful diameter of the photocathode	42	mm
Anode sensitivity (at 2750 V)	100	A/lm
Anode pulse rise time	2	ns

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.	25	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

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]		2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V [2]		3.10^{-9}	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V [2]		30.10^{-9}	s

With voltage divider B'

Anode pulse rise time at V_b = 2500 V [2]		2.10^{-9}	s
Anode pulse width at half heigth at V_b = 2500 V [2]		$2,5.10^{-9}$	s
Total transit time at V_b = 2500 V [2]		28.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

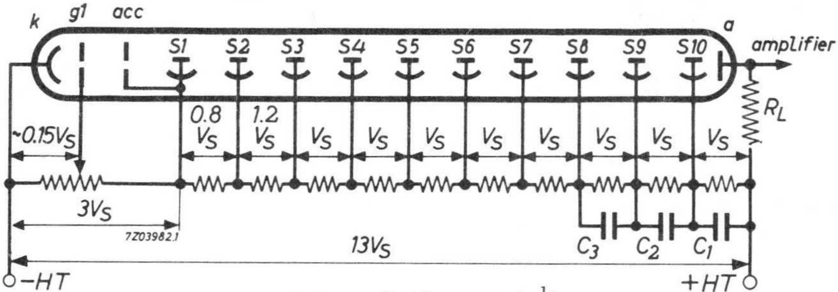
Supply voltage	V_b	max.	3000	V
Continuous anode current	I_a	max.	30	μA
Voltage between cathode and first dynode	V_{k/S_1}	max.	800	V
		min.	250	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	100	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{10}}$	max.	500	V
		min.	80	V

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

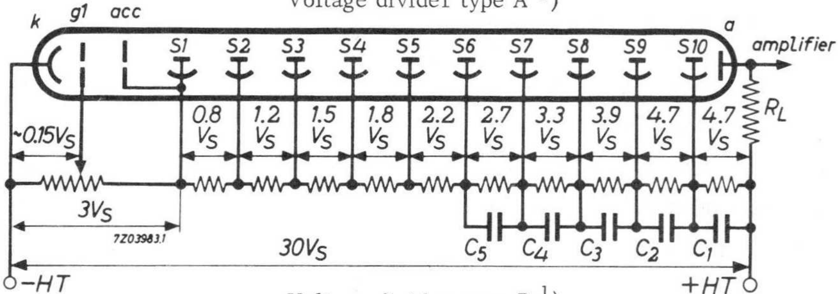
[2] For an infinitely short light pulse,fully illuminating the photocathode.

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

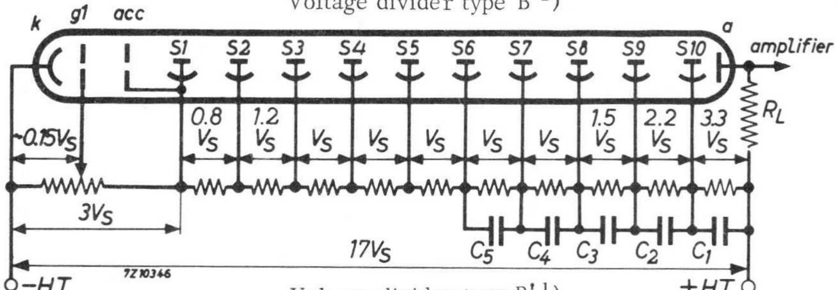
RECOMMENDED CIRCUITS



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)

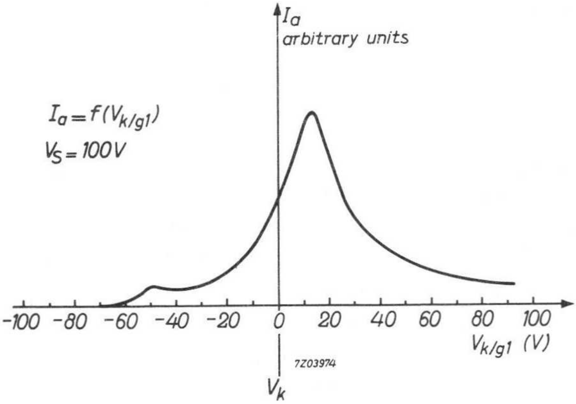


Fig.1 Anode current variation with the adjustment of g_1

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.

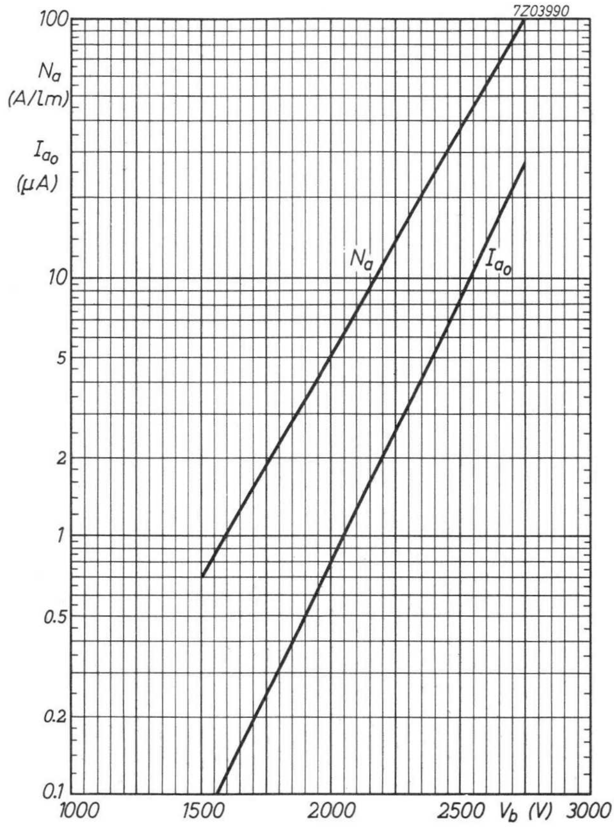

7Z03990
100
N_a
(A/lm)
I_{a_0}
(μA)
N_a
I_{a_0}
10
5
2
1
0.5
0.2
0.1
1000
1500
2000
2500
V_b (V)
3000

Fig. 2

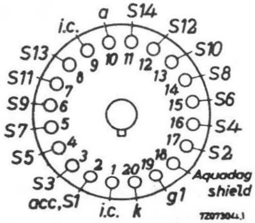
14 STAGE PHOTOMULTIPLIER TUBE

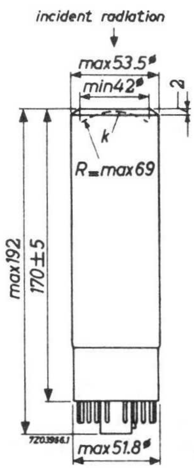
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. The polished optical quartz window gives it a sensitivity that extends into the ultra-violet region and guarantees a very low background because of the absence of ^{40}K radiation.

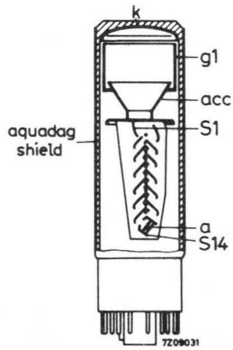
QUICK REFERENCE DATA		
Spectral response	bialkali type DU	
Useful diameter of the photocathode	42	mm
Gain (at 2100 V)	10^8	
Anode pulse rise time	2	ns
Quantum efficiency (at 4000 Å)	25	%
Efficiency for single photons (at 2100 V)	> 15	%
Collection efficiency	80	%

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	$C_{g1/acc,S_1}$	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. 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 at 4240 Å 3)	$\eta_{s.p.}$	>	15	%
Supply voltage for $\eta_{s.p.}$ = 15%	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)		$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)		43.10^{-9}	s
Maximum peak currents		0.5 to 1.0	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)	2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)	3.10^{-9}	s
Transit time spread	$0,5.10^{-9}$	s
Total transit time at V_b = 2500 V 2)	39.10^{-9}	s

1) At an ambient temperature of 25 °C.

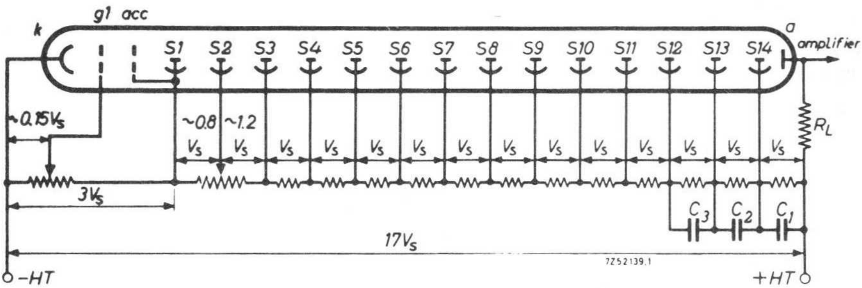
2) For an infinitely short light pulse, fully illuminating the photocathode.

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.

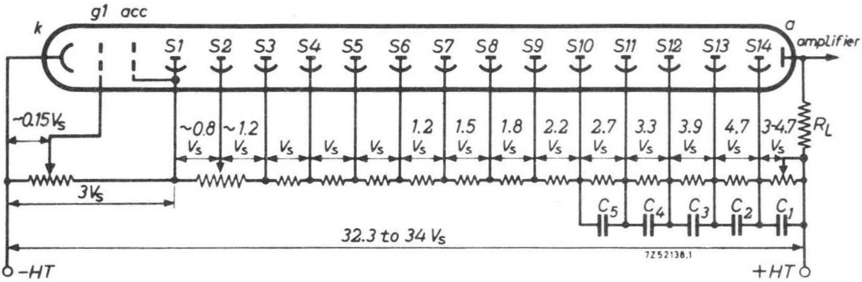
LIMITING VALUES (Absolute max. rating system)

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

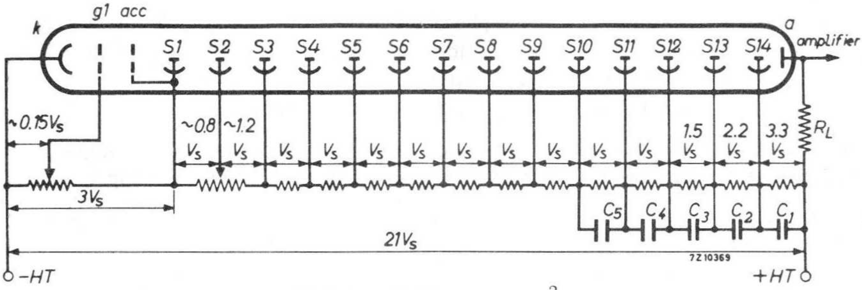


Voltage divider type A [3]



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).

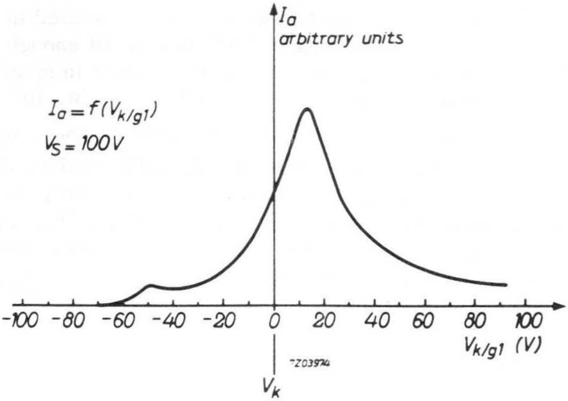


Fig.1 Anode current variation with the adjustment of g_1.

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 again 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 $\pm$ 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).

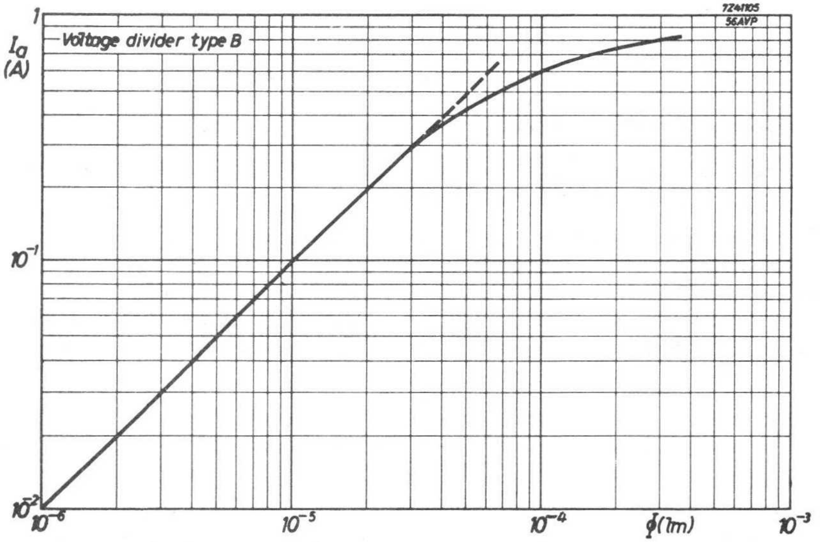


Fig.2

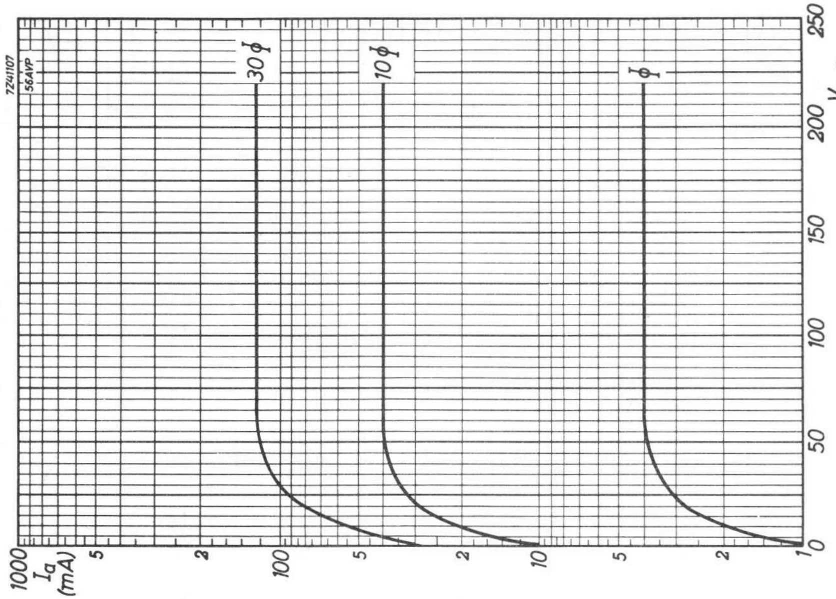

7Z41107
56AVP
1000
Ia
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
Va-S14
30 ϕ
10 ϕ
ϕ

Fig. 3

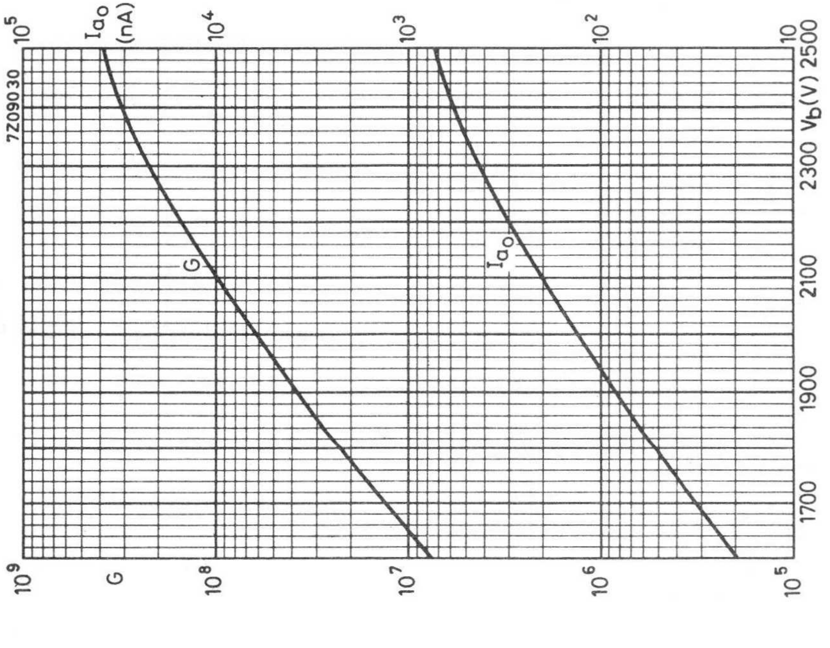
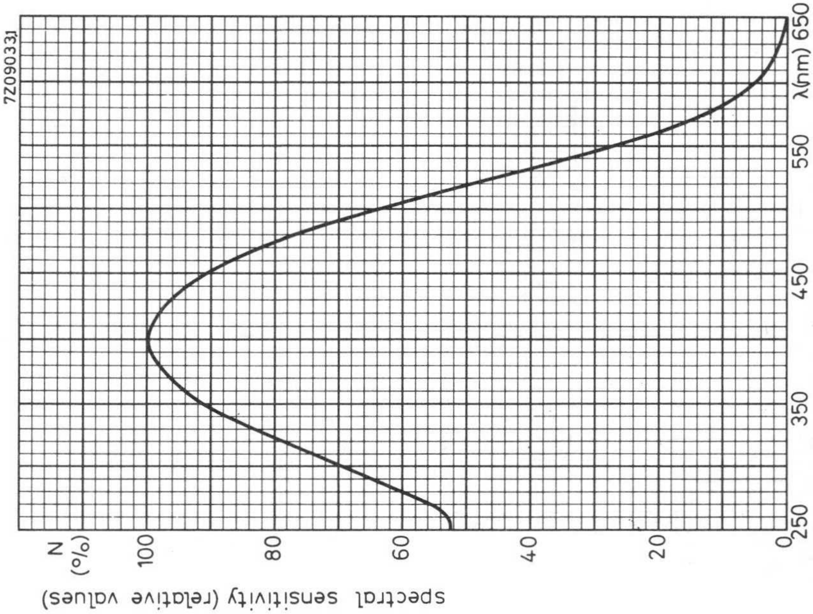

7Z09030
10^9
G
10^8
10^7
10^6
10^5
10^5
Iao
(nA)
10^4
10^3
10^2
10
1700
1900
2100
2300
2500
Vb(V)
G
Iao

Fig. 4



spectral response curve type DU
Fig. 5

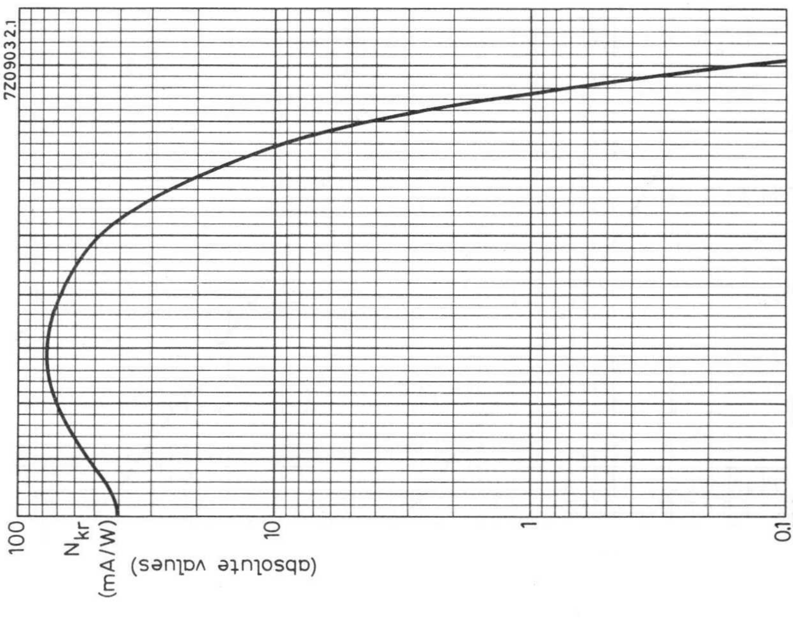


Fig. 6

14 STAGE PHOTOMULTIPLIER TUBE

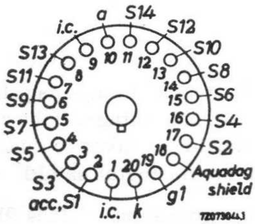
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. It has a very high single photon efficiency and a low background noise. The polished optical quartz window gives it a sensitivity that extends into the ultra-violet region and guarantees a very low background because of the absence of ^{40}K radiation.

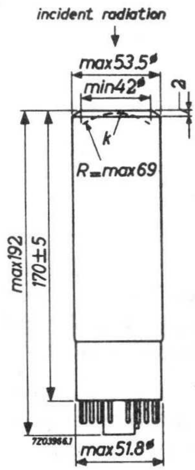
QUICK REFERENCE DATA		
Spectral response	bialkali	type DU
Useful diameter of the photocathode	42	mm
Gain (at 2100 V)	10^8	
Anode pulse rise time	2	ns
Quantum efficiency (at 400 nm)	25	%
Efficiency for single photons (at 2100 V)	> 20	%
Background noise (at 2100 V)	< 1000	counts/s
Collection efficiency	80	%

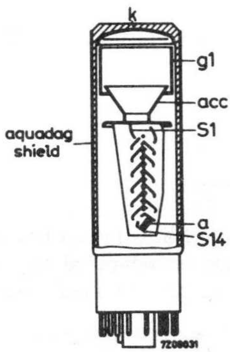
DIMENSIONS AND CONNECTIONS

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 mm		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		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.

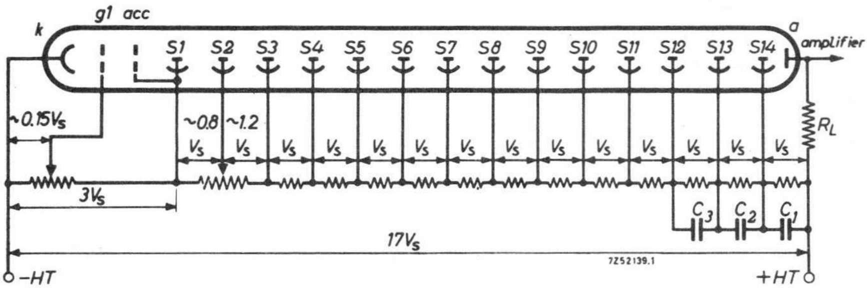
2) For an infinitely short light pulse, fully illuminating the photocathode.

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.

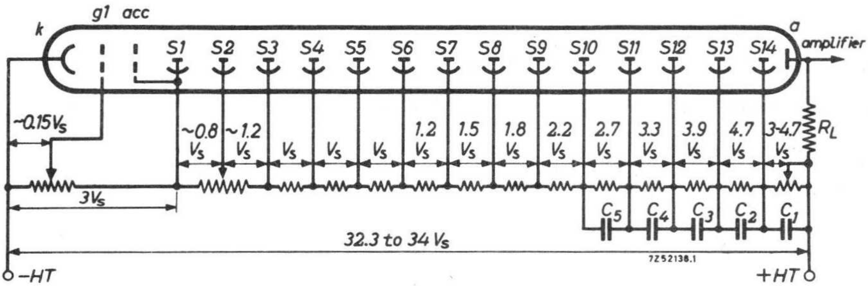
LIMITING VALUES (Absolute max. rating system)

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



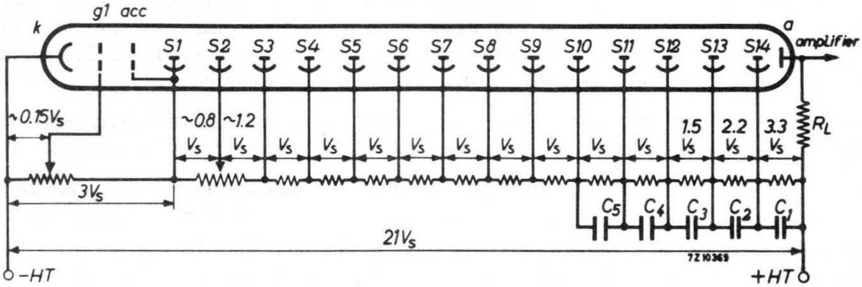
Voltage divider type A [3]



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 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 °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 for 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).

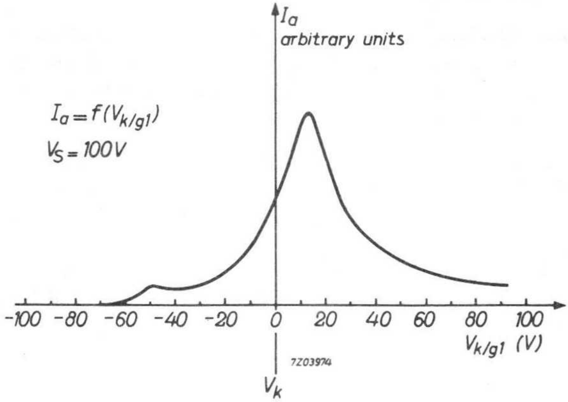


Fig. 1 Anode current variation with the adjustment of g_1.

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 again 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).

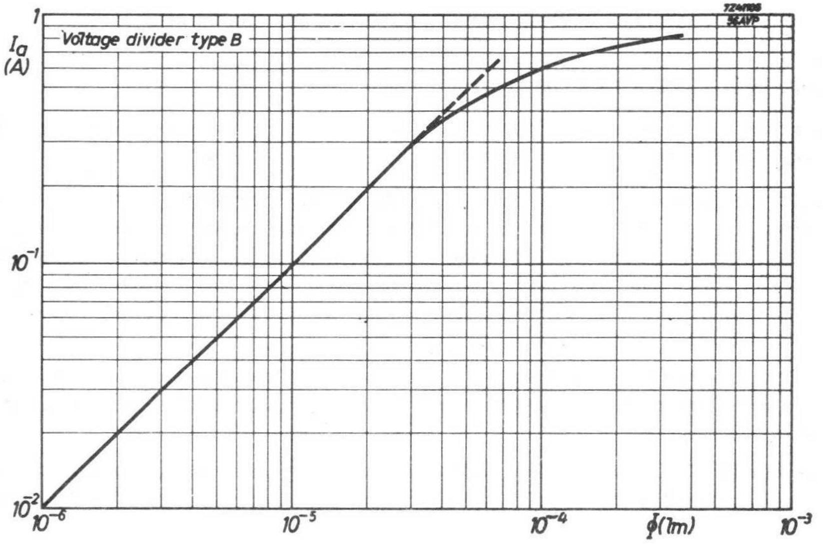


Fig. 2

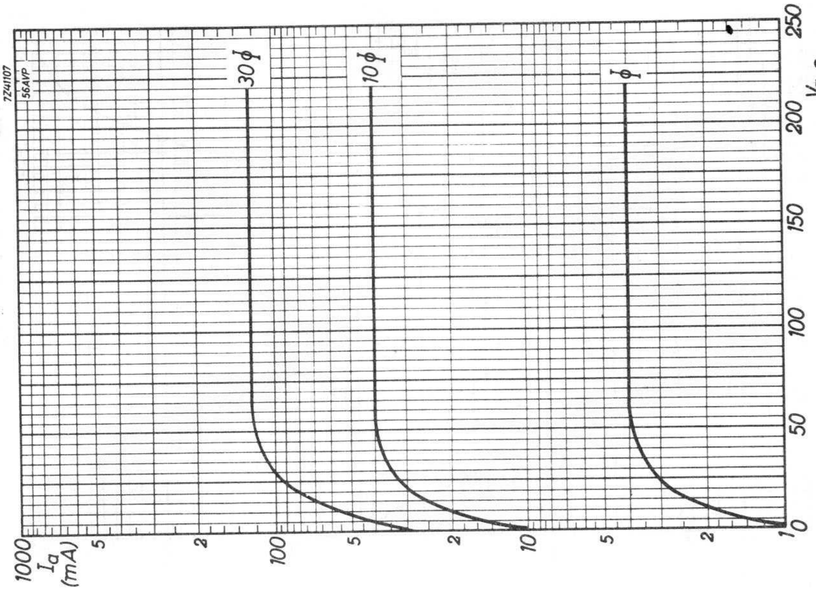

7Z41107
56AVP
30 φ
10 φ
φ
1000
Ia
(mA)
100
10
1
0
50
100
150
200
250
Va-S14

Fig.3

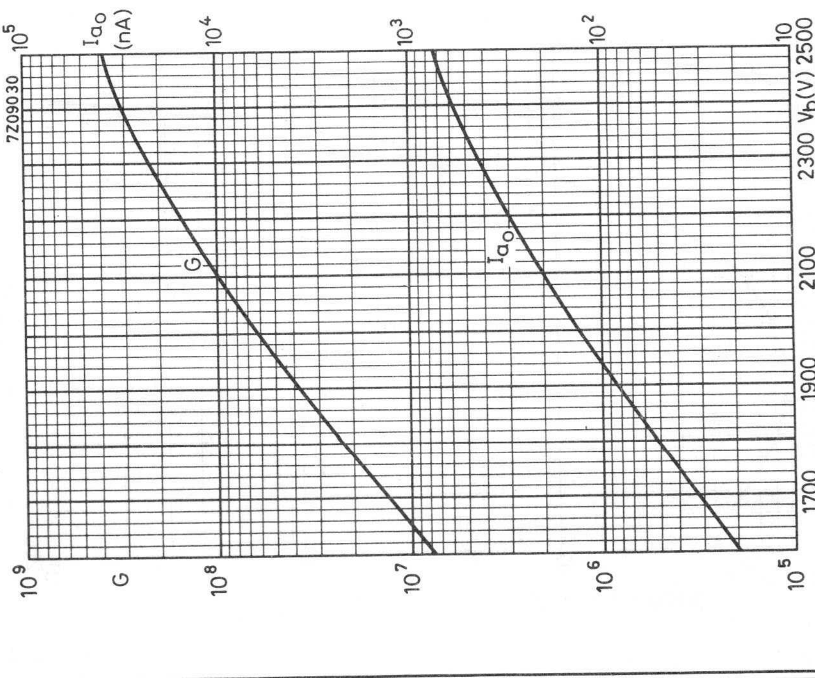
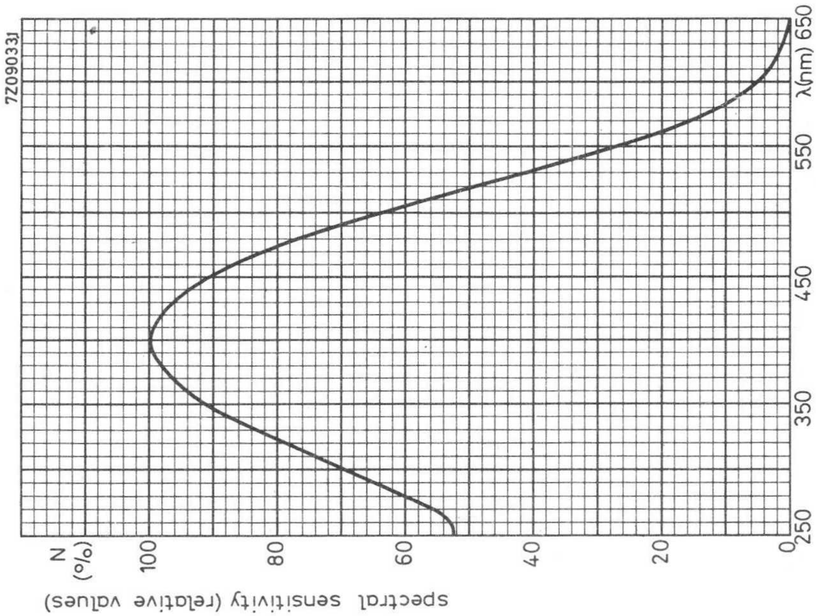

7Z09030
G
Iao
Iao
(nA)
10^9
10^8
10^7
10^6
10^5
10^5
10^4
10^3
10^2
10
1700
1900
2100
2300
2500
Vb(V)

Fig. 4



spectral response curve type DU
Fig.5

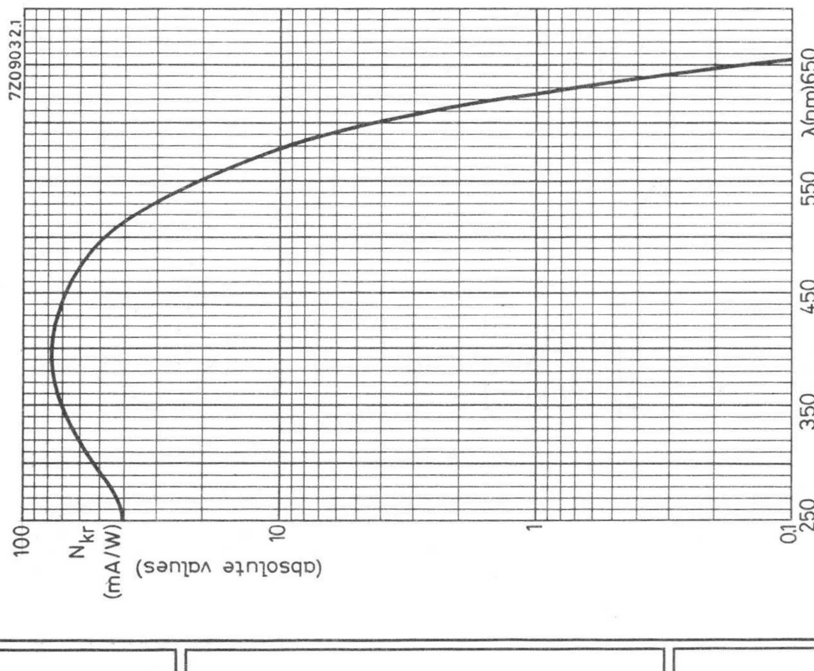


Fig.6

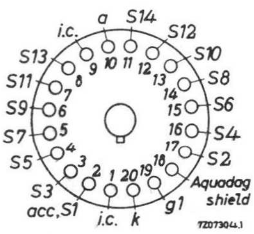
14 STAGE PHOTOMULTIPLIER TUBE

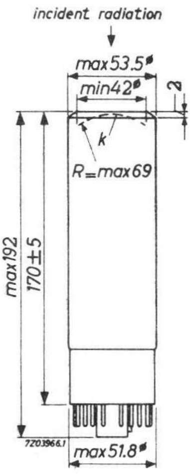
The tube is intended for use in spectrometry and other applications where very low luminous fluxes are to be measured (single photon counting) and for detection of soft β-radiation.
If features a high quantum efficiency and a very good collection efficiency.
Its fast time characteristics make the tube especially useful for fast coincidence measurements, thus reducing the background noise considerably.

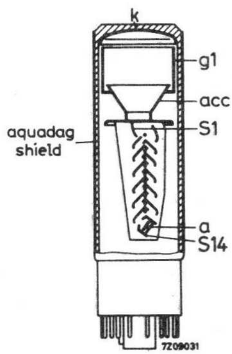
QUICK REFERENCE DATA			
Spectral response		bialkali type D	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^8	
Anode pulse rise time		2	ns
Quantum efficiency (at 400 nm)		25	%
Efficiency for single photons (at 2100 V)	>	15	%
Collection efficiency		80	%

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	$C_{a/S_{14}}$	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 [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.	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 $V_b = 2500$ 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.

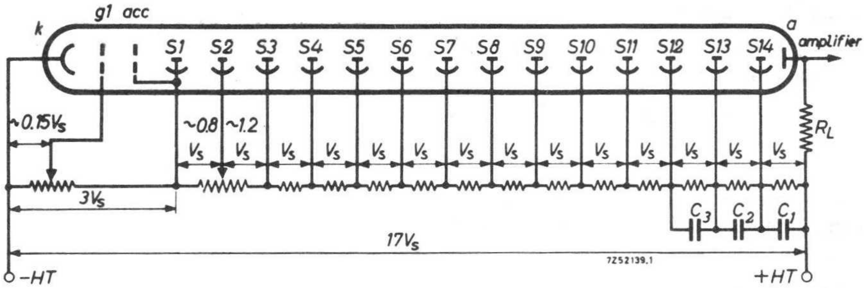
[2] For an infinitely short light pulse, fully illuminating the photocathode.

[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.

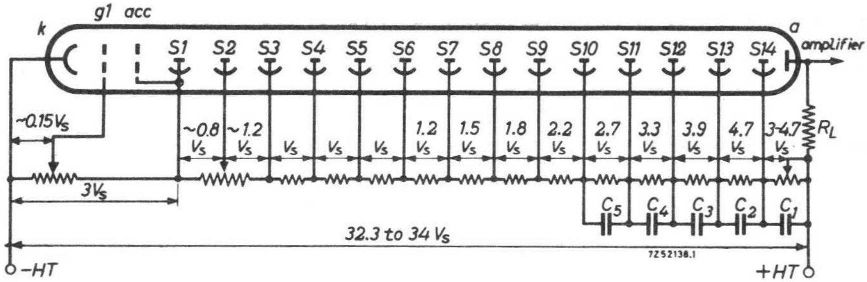
LIMITING VALUES (Absolute max. rating system)

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

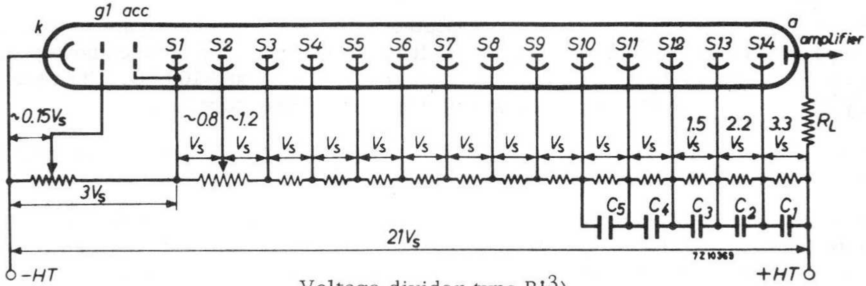


Voltage divider type A [3]



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 D-type photocathodes it is recommended not to expose the tube to too high intensities of radition. 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 resistivily 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).

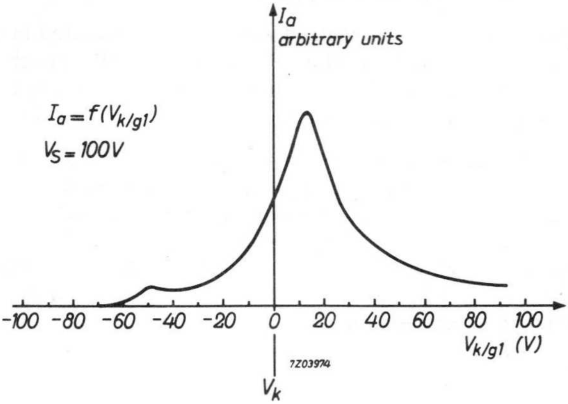


Fig.1 Anode current variation with the adjustment of g_1

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 again 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).

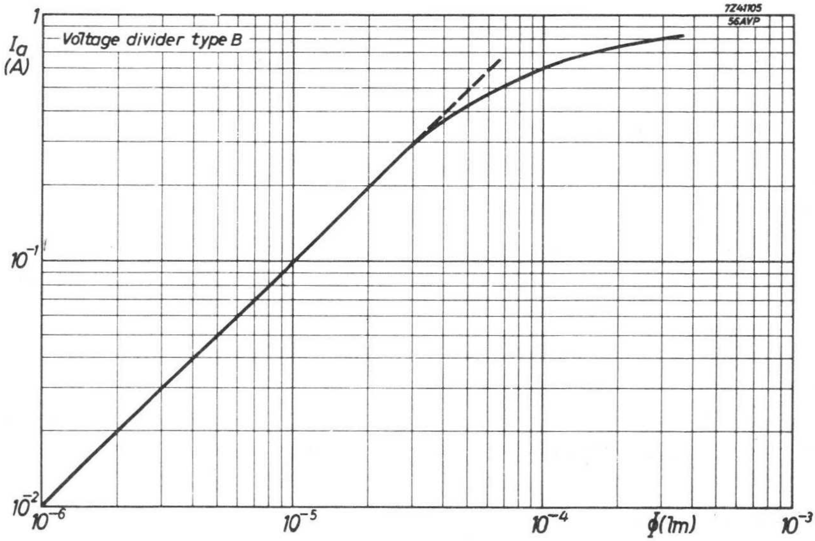


Fig.2

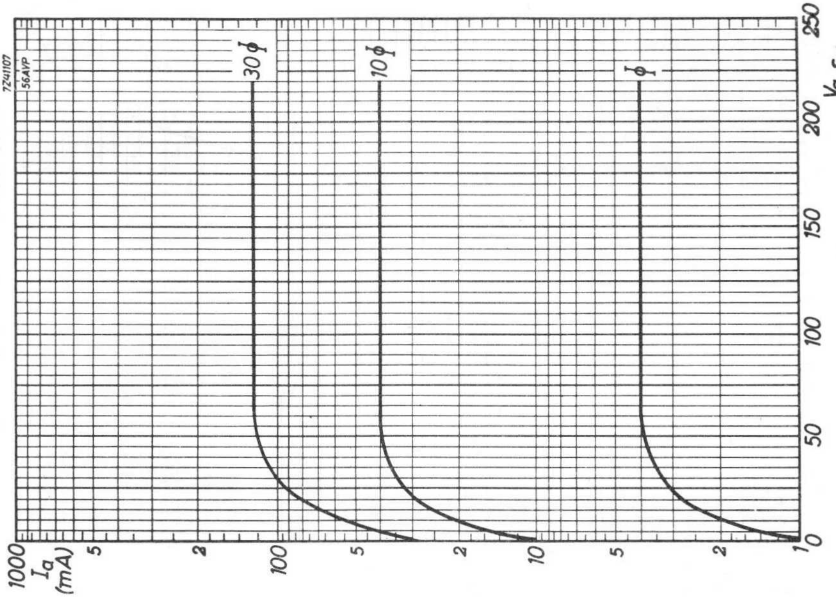

7Z41107
56AVP
1000
Ia (mA)
5
2
100
5
2
10
5
2
1
30ϕ
10ϕ
ϕ
0
50
100
150
200
250
Va-S14

Fig. 3

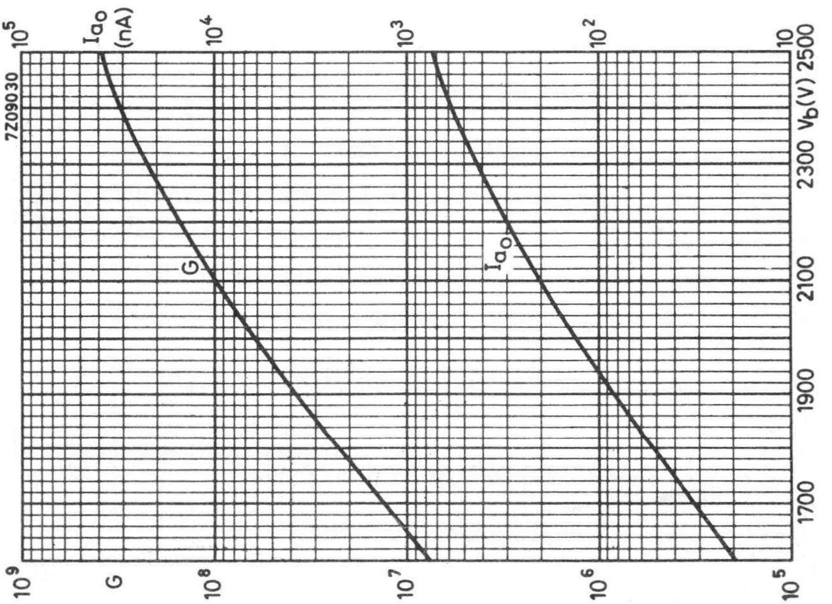
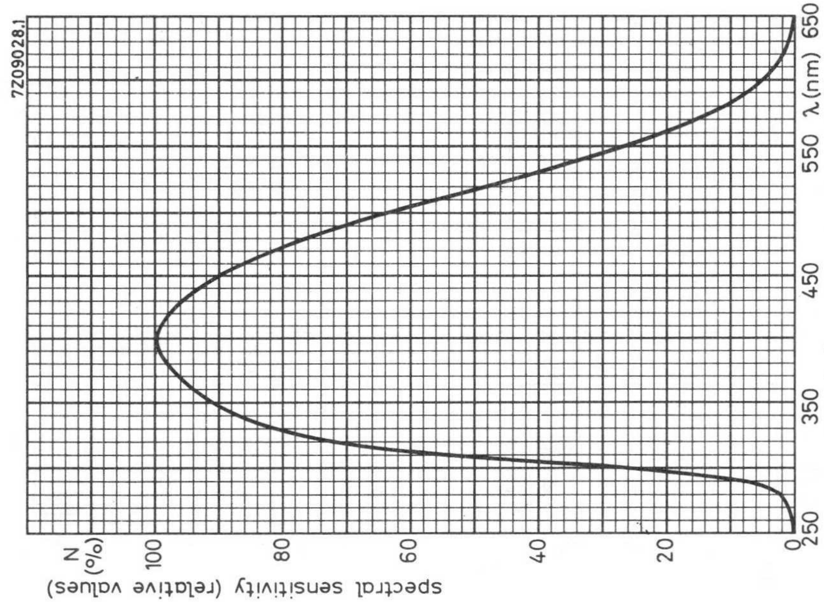

7Z09030
10^9
G
10^8
10^7
10^6
10^5
10^5
Ia0 (nA)
10^4
10^3
10^2
10
G
Ia0
1700
1900
2100
2300
2500
Vb(V)

Fig. 4



spectral response curve type D

Fig. 5

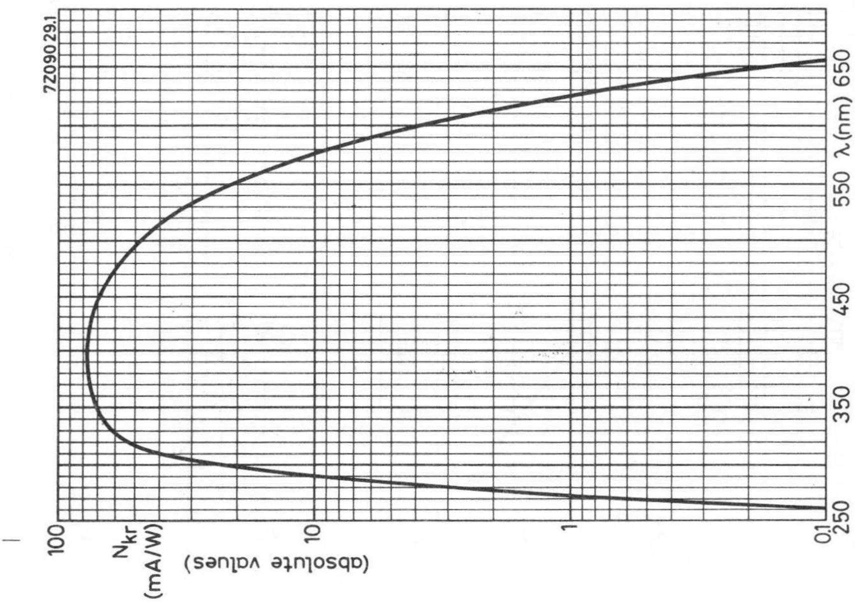


Fig. 6

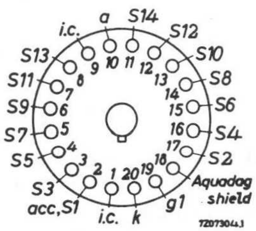
14 STAGE PHOTOMULTIPLIER TUBE

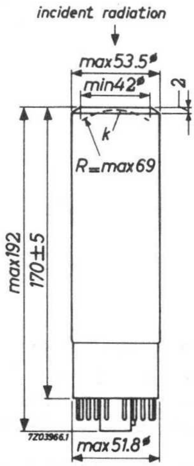
The tube is intended for use in spectrometry where very low luminous fluxes are to be measured (single photon counting) and for liquid scintillation counting of ^{14}C and ^{3}H. It has a very high single photon efficiency and a low background noise.
Its fast time characteristics make the tube especially useful for fast coincidence measurements, thus reducing the background noise considerably.

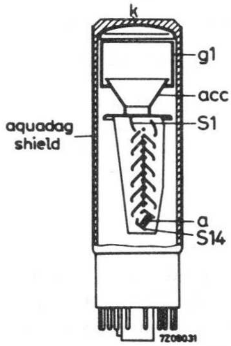
QUICK REFERENCE DATA			
Spectral response		bialkali type D	
Useful diameter of the photocathode		42	mm
Gain (at 2100 V)		10^8	
Anode pulse rise time		2	ns
Quantum efficiency (at 400 nm)		25	%
Efficiency for single photons (at 2100 V)	min.	20	%
Background noise (at 2100 V)	max.	1000	counts/s
Collection 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. 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 at 424 nm [3]	$\eta_{s.p.}$	min.	20	%
Supply voltage for $\eta_{s.p.}$	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.

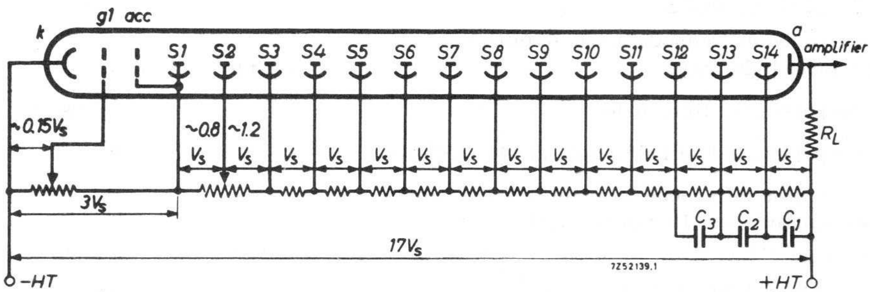
[2] For an infinitely short light pulse, fully illuminating the photocathode.

[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.

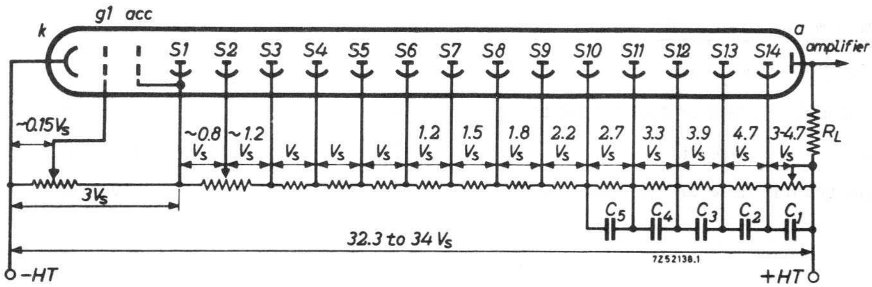
LIMITING VALUES (Absolute max. rating system)

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.	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

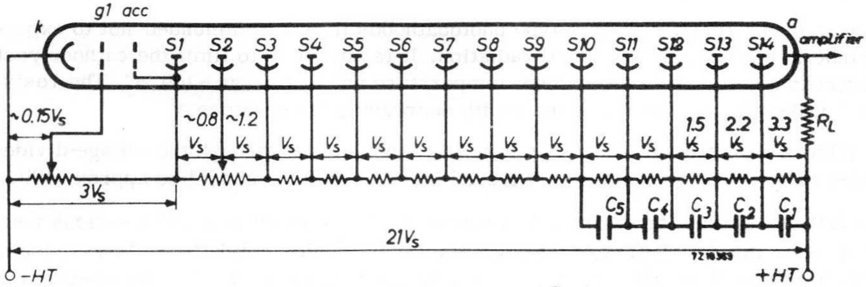


Voltage divider type A [3]



Voltage divider type B [3]

For notes see page 5



Voltage divider type B' 3)

RECOMMENDED CIRCUITS

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).

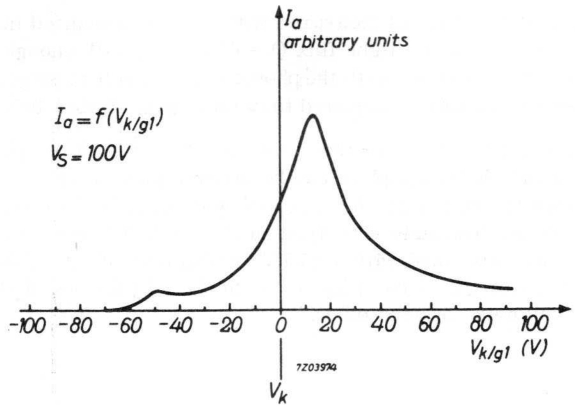


Fig.1 Anode current variation with the adjustment of g_1

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 again 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 $\pm$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).

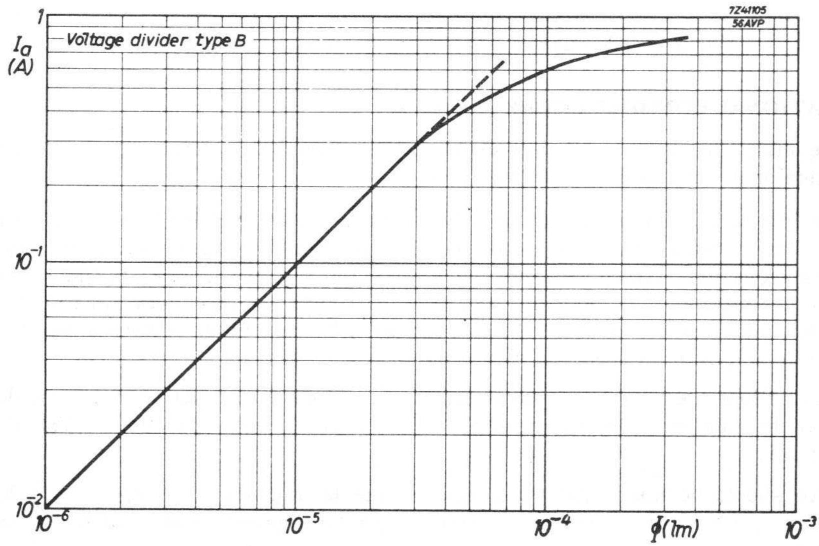


Fig. 2

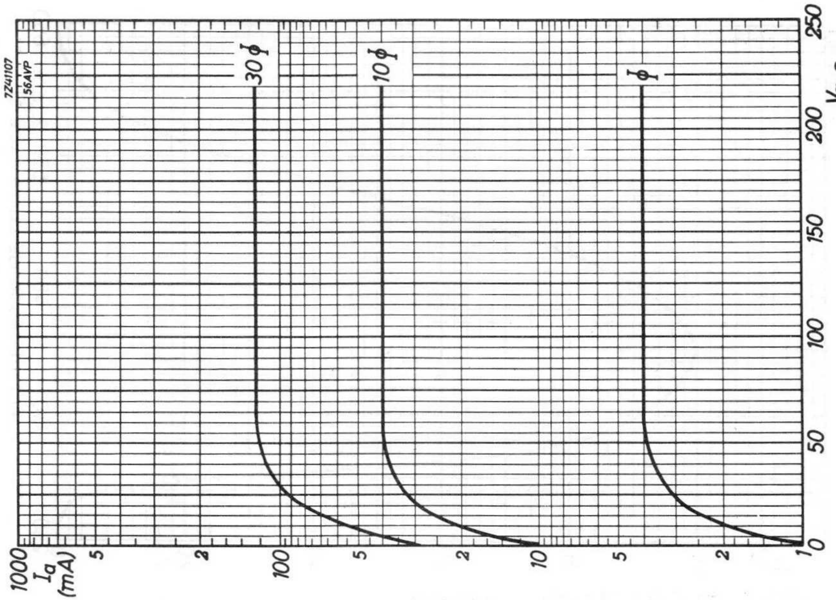

7Z41107
56AVP
30 ϕ
10 ϕ
ϕ
1000
I_a (mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_{a-S_{14}}$

Fig.3

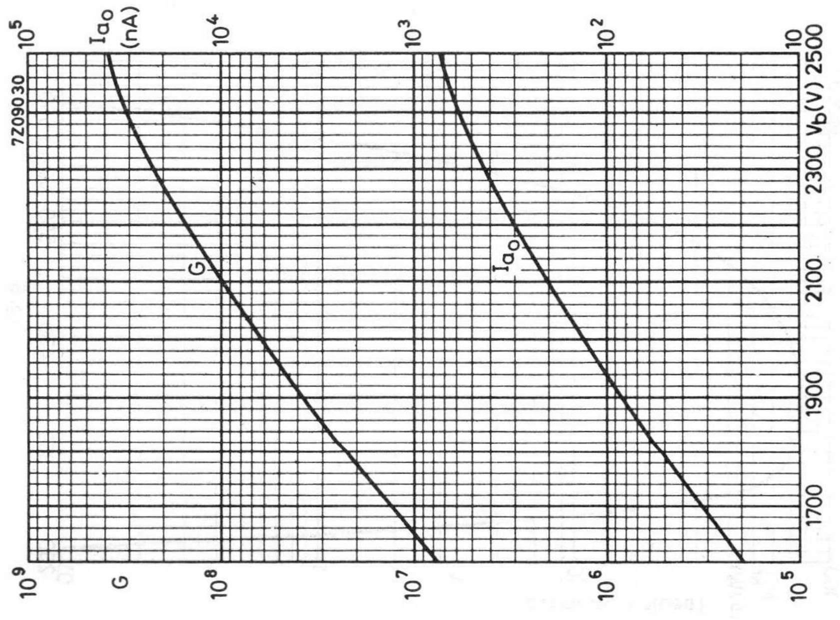
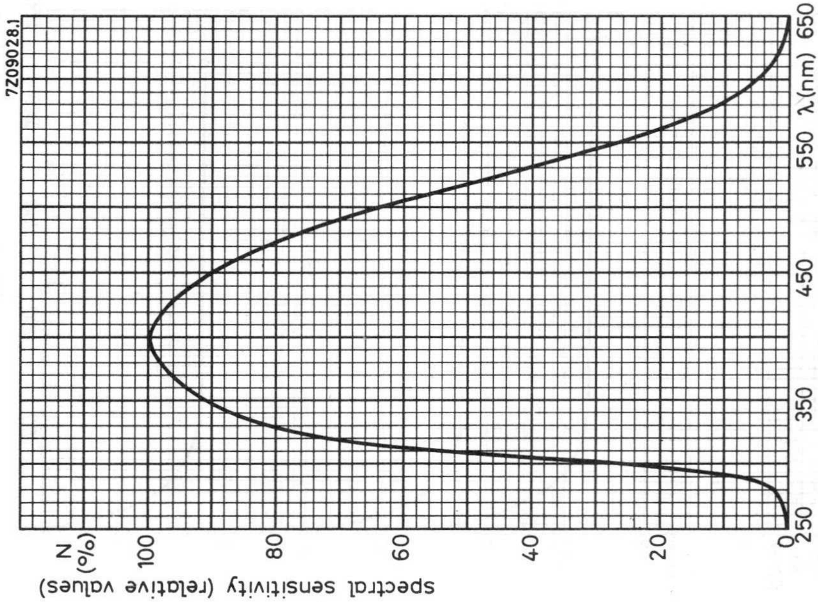

7Z09030
10^9
G
10^8
10^7
10^6
10^5
10^5
I_{a_0} (nA)
10^4
10^3
10^2
10
G
I_{a_0}
1700
1900
2100
2300
2500
V_b(V)

Fig.4



spectral response curve type D

Fig. 5

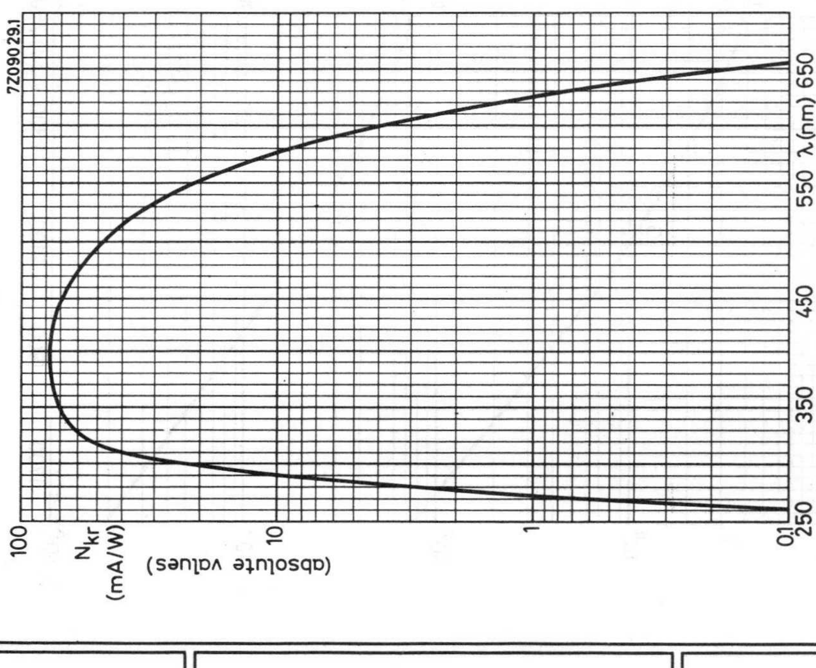


Fig. 6

14 STAGE PHOTOMULTIPLIER TUBE

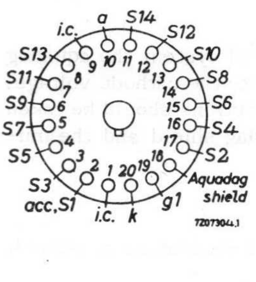
The tube is intended for use in applications such as telecommunication and ranging and in optical experiments where a high-sensitivity in the whole visible and ultraviolet region is required combined with a high degree of time definition.

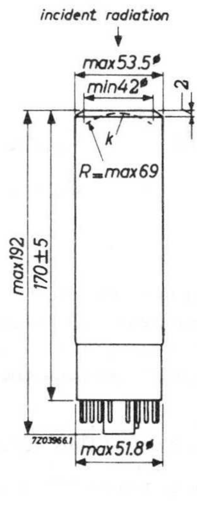
QUICK REFERENCE DATA

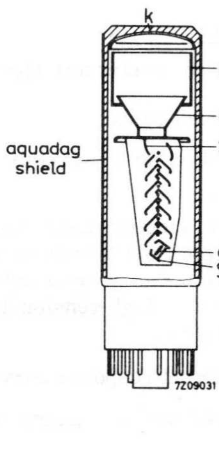
Spectral response	type TU (extended S20)	
Window material	quartz	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

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	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

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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. 2500 max. 2750	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)		2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)		$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V		max. $0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)		43.10^{-9}	s
Maximum peak currents		0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)		2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)		3.10^{-9}	s
Total transit time at V_b = 2500 V 2)		39.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max. 2750	V
Continuous anode current	I_a	max. 2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. 800 min. 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. 500 min. 80	V V
Voltage between anode and final dynode 4)	$V_{a/S_{14}}$	max. 500 min. 80	V V

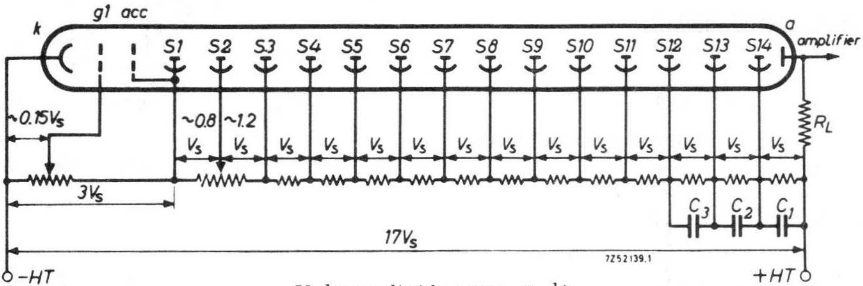
1) At an ambient temperature of 25 °C.

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

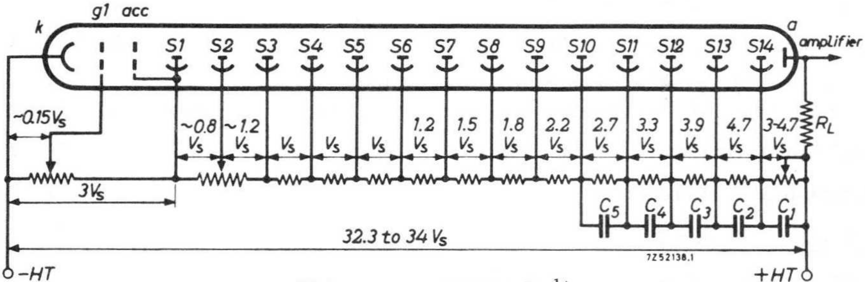
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

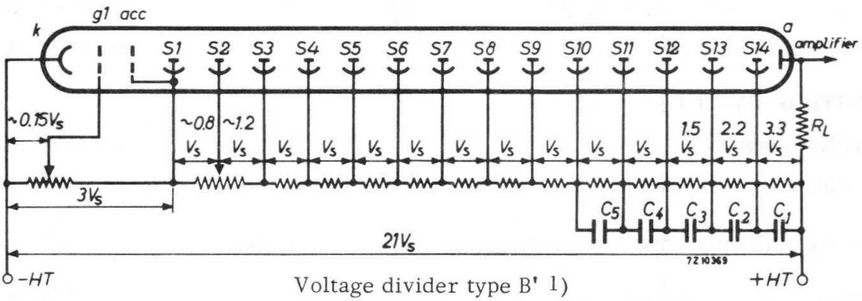
→ **RECOMMENDED CIRCUITS**



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)

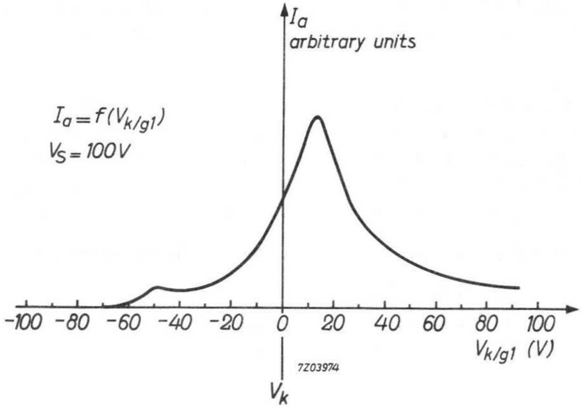


Fig.1 Anode current variation with the adjustment of g_1

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.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.

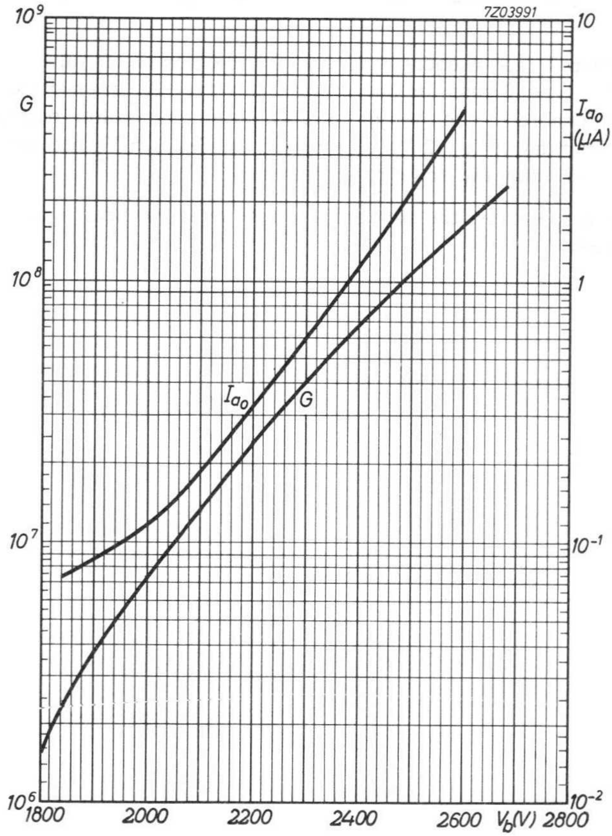
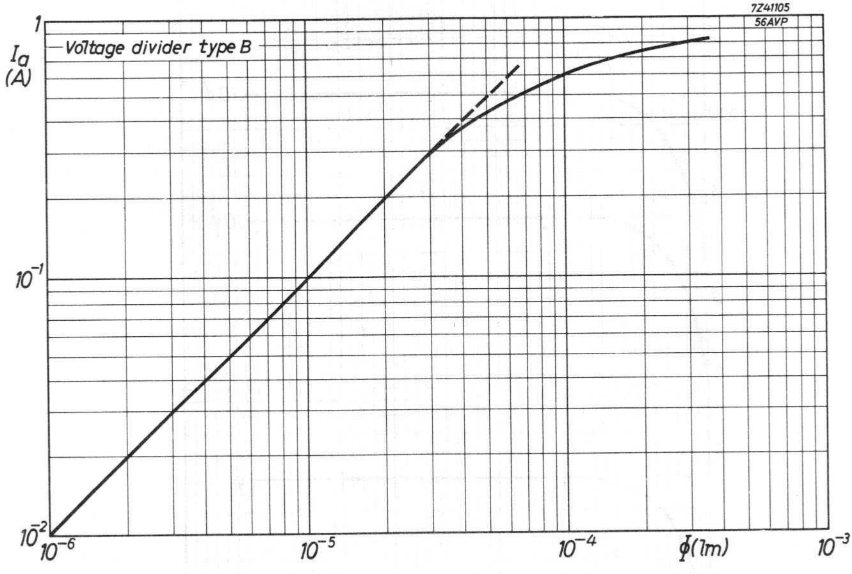

7Z03991
10^9
G
10^8
10^7
10^6
10
I_{a_0} (μA)
1
10^{-1}
10^{-2}
I_{a_0}
G
1800
2000
2200
2400
2600
V_b(V)
2800

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

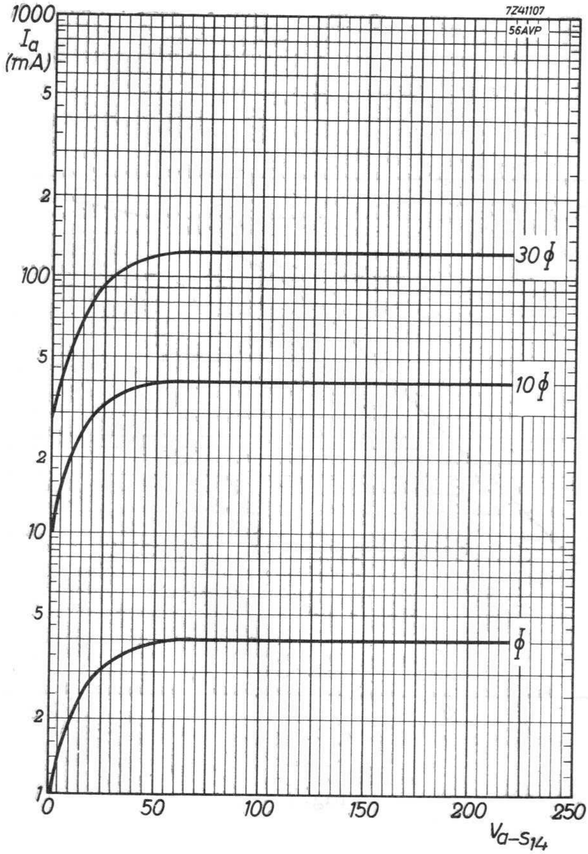

7Z41107
56AVP
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 Φ
10 Φ
Φ

Fig. 4

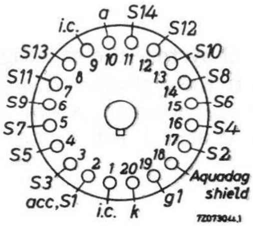
14 STAGE PHOTOMULTIPLIER TUBE

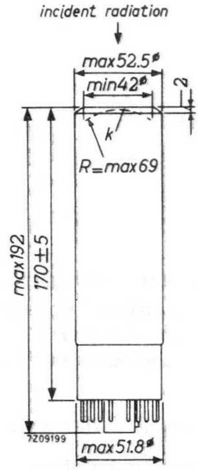
The tube is intended for use in laser-technics working in the orange, yellow and green range.

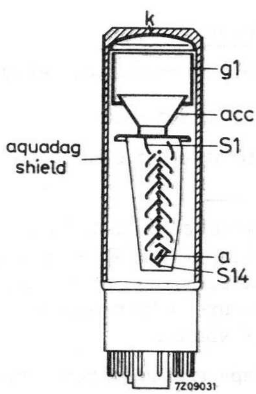
QUICK REFERENCE DATA		
Spectral response	type T (S20)	
Useful diameter of the photocathode	42	mm
Gain (at 2500 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

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)	2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)	$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max. $0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)	43.10^{-9}	s
Maximum peak currents	0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)	2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)	3.10^{-9}	s
Total transit time at V_b = 2500 V 2)	39.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	2750	V
Continuous anode current	I_a	max.	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

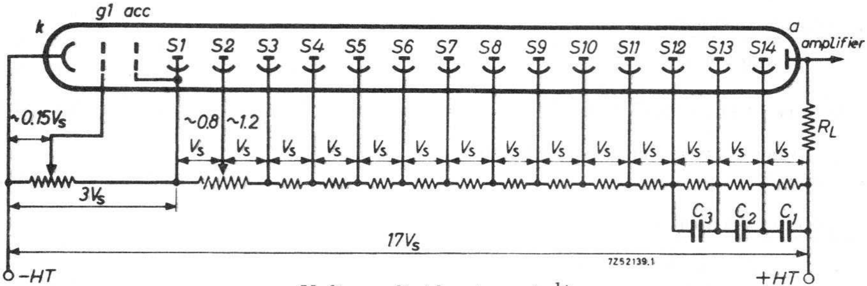
1) At an ambient temperature of 25 °C.

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

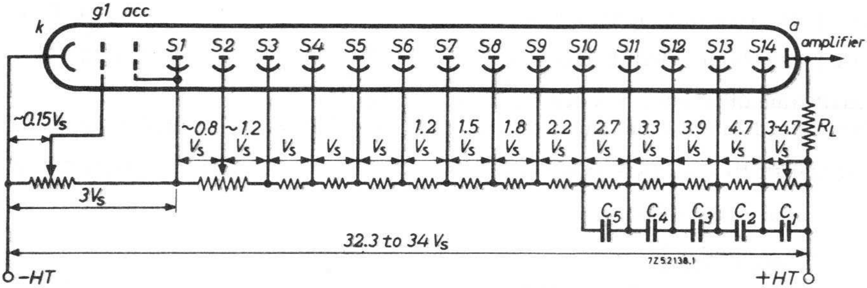
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

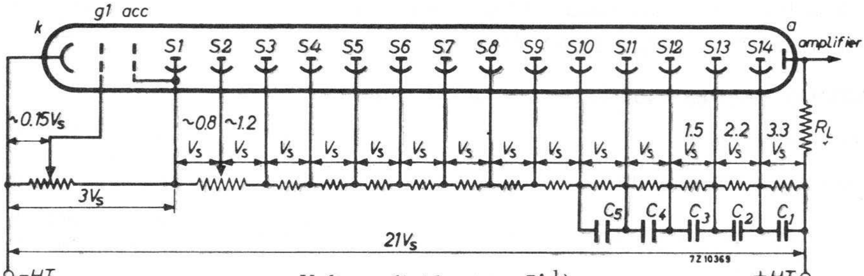
→ **RECOMMENDED CIRCUITS**



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)

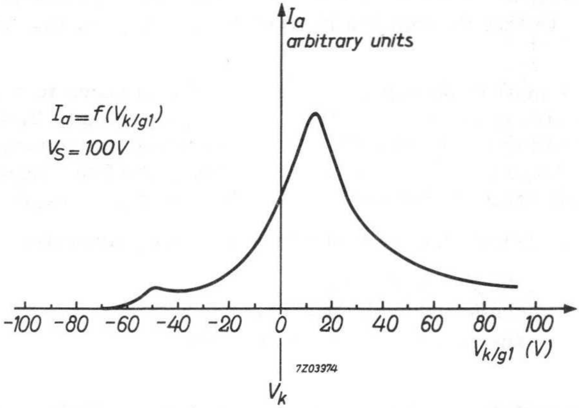


Fig. 1 Anode current variation with the adjustment of g_1

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.

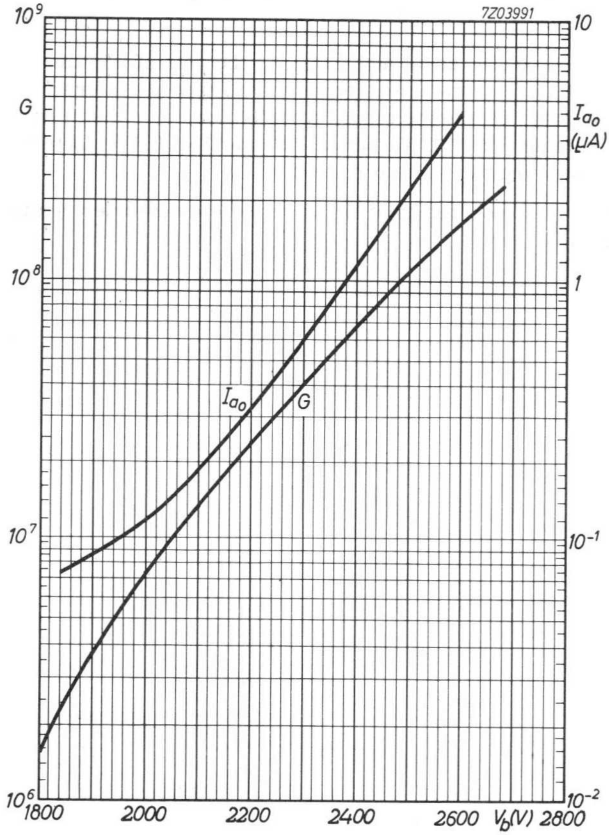
OPERATIONAL CONSIDERATIONS (continued)

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}
1800
2000
2200
2400
2600
V_b(V)
2800
I_{a_0}
G

Fig. 2

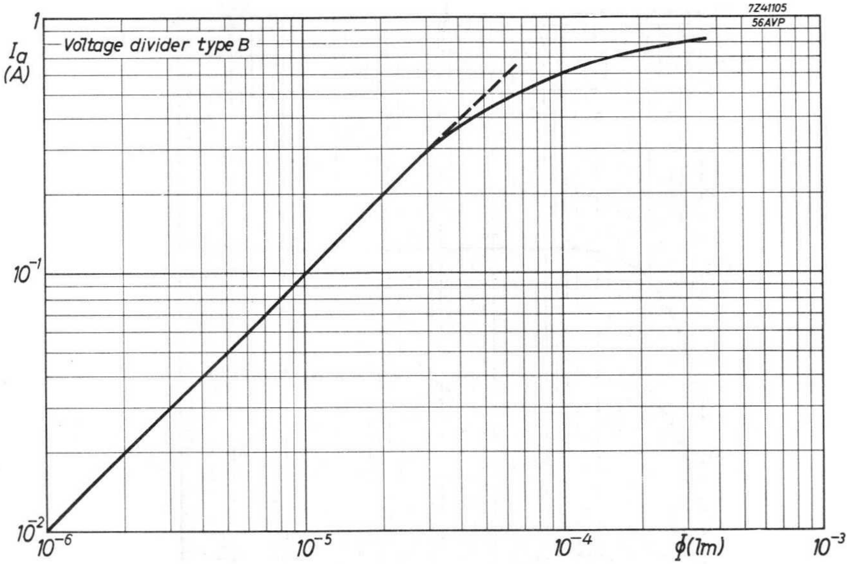

7Z41105
56AVP
Voltage divider type B
I_a
(A)
1
10^{-1}
10^{-2}
10^{-6}
10^{-5}
10^{-4}
Φ(lm)
10^{-3}

Fig. 3

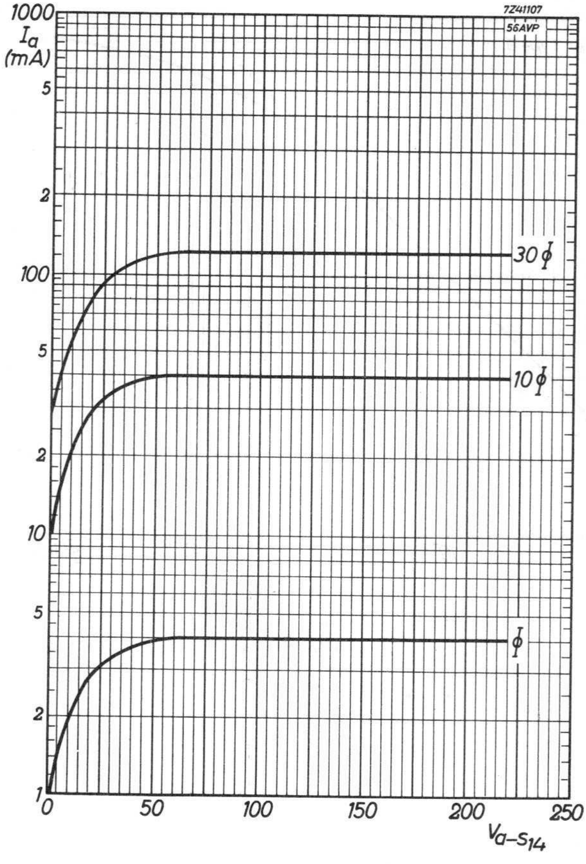

7Z41107
56AVP
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
V_{a-s14}
30 ϕ
10 ϕ
ϕ

Fig.4

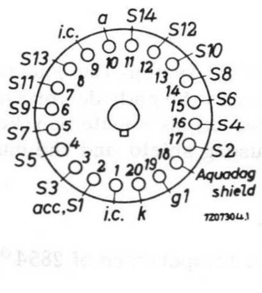
14 STAGE PHOTOMULTIPLIER TUBE

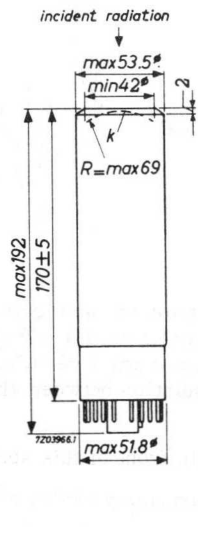
The tube is intended for use in nuclear physics where a high degree of time definition or a high time resolution is required, combined with a good sensitivity in the ultraviolet region.

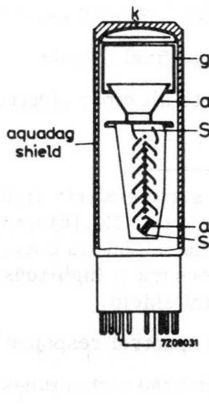
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	42	mm
Gain (at 2200 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

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

---

[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)		2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)		$3,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and 18 mm out of the centre at V_b = 2500 V	max.	$0,8.10^{-9}$	s
Total transit time at V_b = 2500 V 2)		43.10^{-9}	s
Maximum peak current		0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2500 V 2)	2.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V 2)	3.10^{-9}	s
Total transit time at V_b = 2500 V 2)	39.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 3)	V_b	max.	2500	V
Continuous anode current	I_a	max.	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

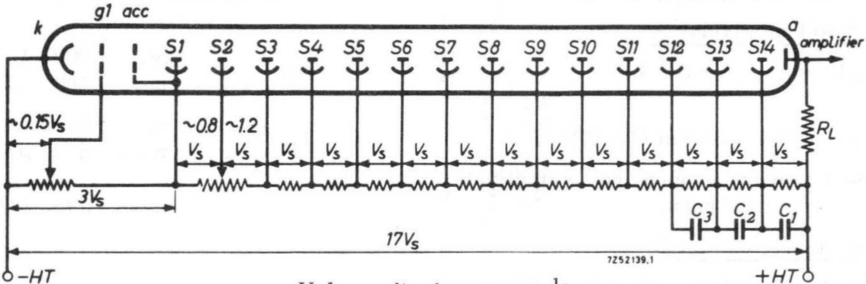
1) At an ambient temperature of 25 °C.

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

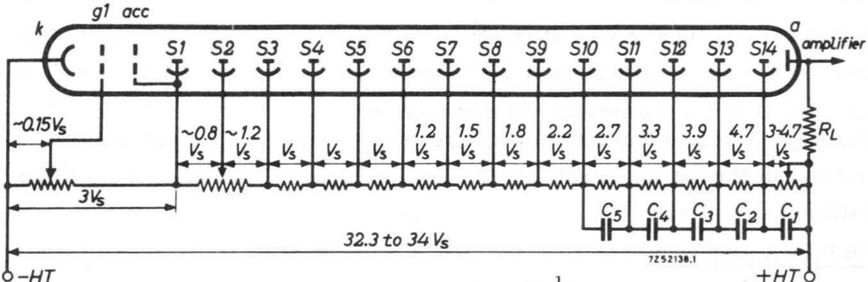
3) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

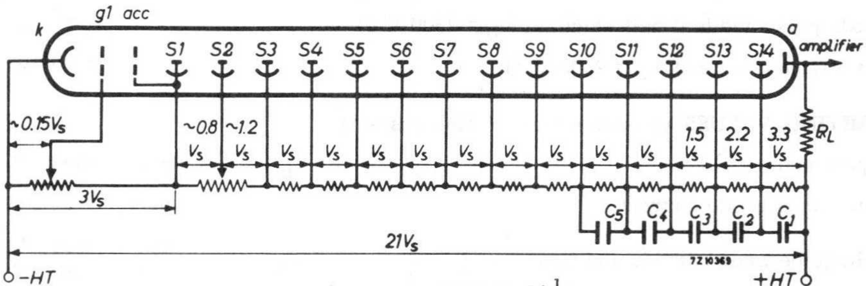
RECOMMENDED CIRCUITS



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.

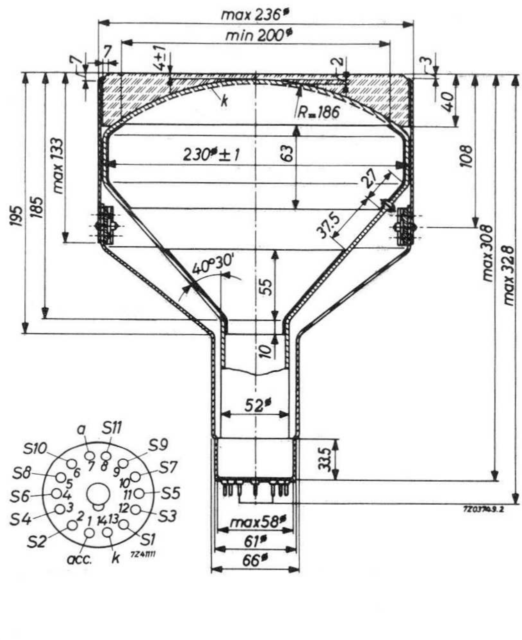
11 STAGE PHOTOMULTIPLIER TUBE

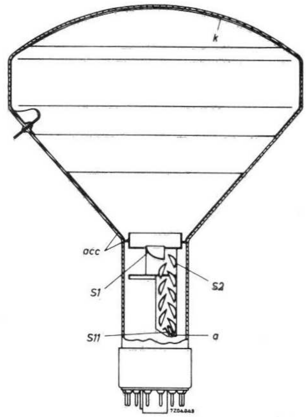
The tube is intended for use in applications such as total body radiation measurements, uranium prospecting with very large scintillators, Cerenkov light measurements in large transparent objects.

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	µA/lm
		min.	35	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	A/lm
		min.	60	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]		6.10^{-9}	s
Anode pulse width at half height at V_b = 2500 V [1]		20.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 2500 V		4.10^{-9}	s
Total transit time at V_b = 2500 V [1]		75.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2500	V
Continuous anode current	I_a	max. 1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max. 1000 min. 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. 300 min. 80	V V
Voltage between anode and final dynode [2]	$V_{a/S_{11}}$	max. 300 min. 80	V V

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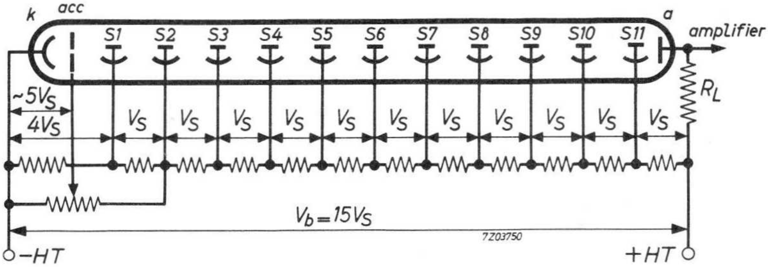
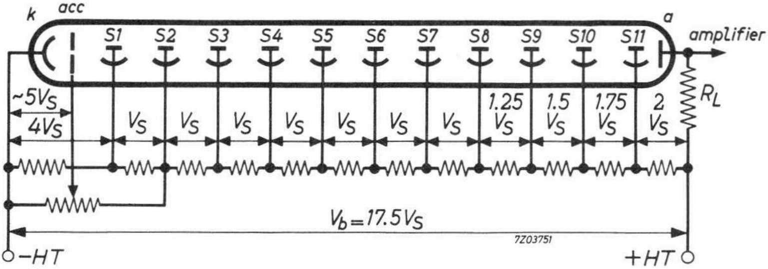
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

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

RECOMMENDED CIRCUITS



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 about 1 mA will be sufficient.

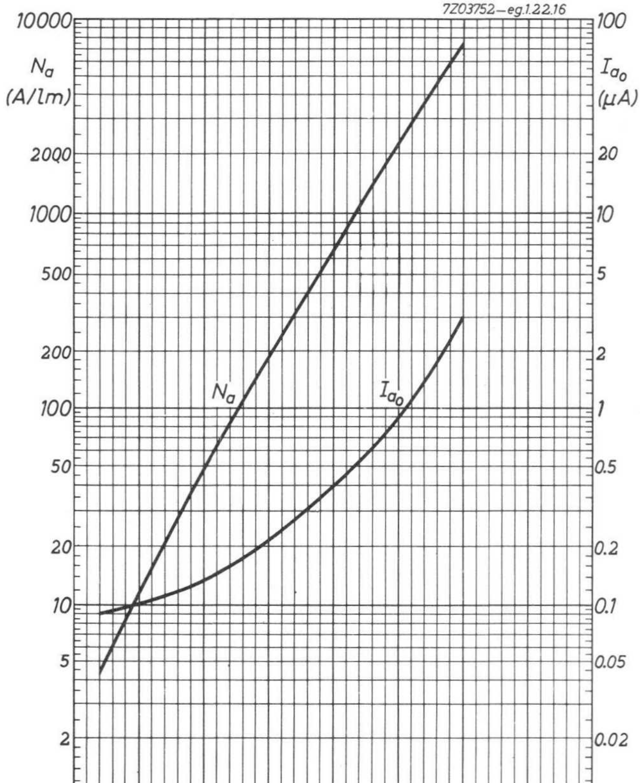
With the voltage divider type A the tube gives the highest gain, while with the voltage divider type B the tube can deliver a higher anode current output with better time characteristics.

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.



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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

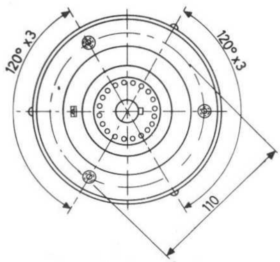
The tube is intended for use in nuclear-physics applications where a high degree of time definition is required (fast coincidences, Cerenkov counters).

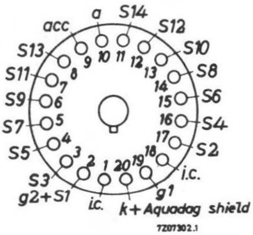
QUICK REFERENCE DATA		
Spectral response	type A (S11)	
Useful diameter of the photocathode	110	mm
Gain (at 2400 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

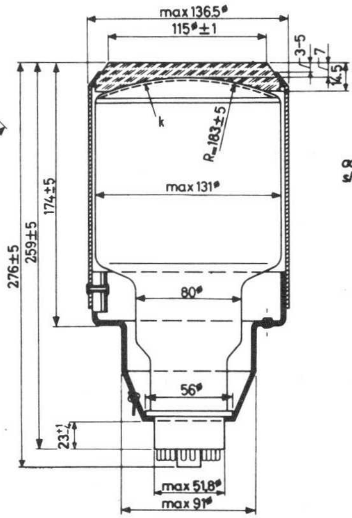
DIMENSIONS AND CONNECTIONS

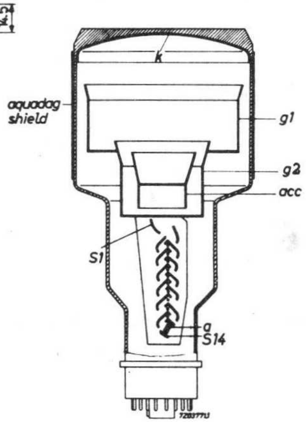
Dimensions in mm

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/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_0}	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]	2.10^{-9}	s
Anode pulse width at half height at V_b = 2800 V [1]	3.10^{-9}	s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	10^{-9}	s
Total transit time at V_b = 2800 V [1]	46.10^{-9}	s
Maximum peak currents	0.5 to 1	A

With voltage divider B'

Anode pulse rise time at V_b = 2800 V [1]	2.10^{-9}	s
Anode pulse width at half height at V_b = 2800 V [1]	3.10^{-9}	s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	10^{-9}	s
Transit time spread	10^{-9}	s
Total transit time at V_b = 2800 V [1]	48.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

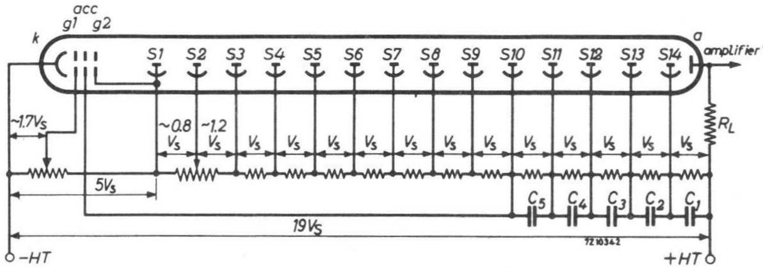
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$		1400 to 1800	V
Voltage between grid No.1 and cathode	V_{k/g_1}	max.	300	V
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.

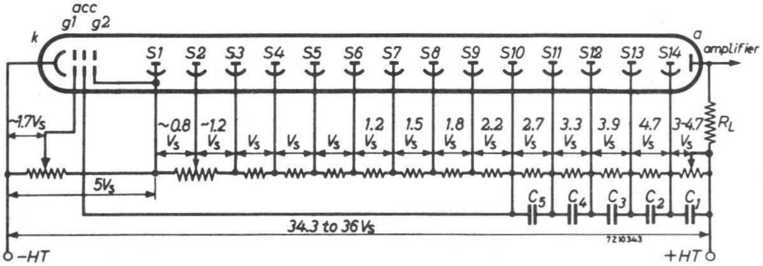
2) Or the voltage at which the tube circuited in the voltage divider A has a gain of of about 10^9, whichever is lowest.

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

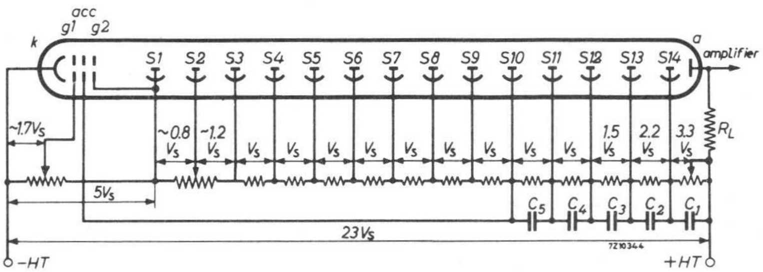
RECOMMENDED CIRCUITS



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 a plexiglass 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-accelerating voltage of about 1500 V (to be connected to the tenth or a subsequent 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.

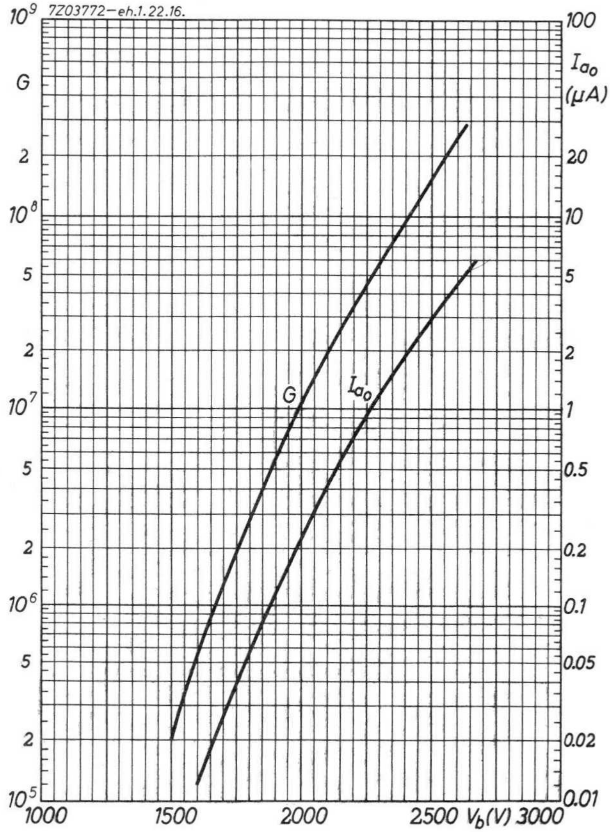
It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine 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 ≈ 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.



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10^9
G
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
100
I_{a_0}
(μA)
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
G
I_{a_0}
1000
1500
2000
2500
V_b(V)
3000

Fig.1

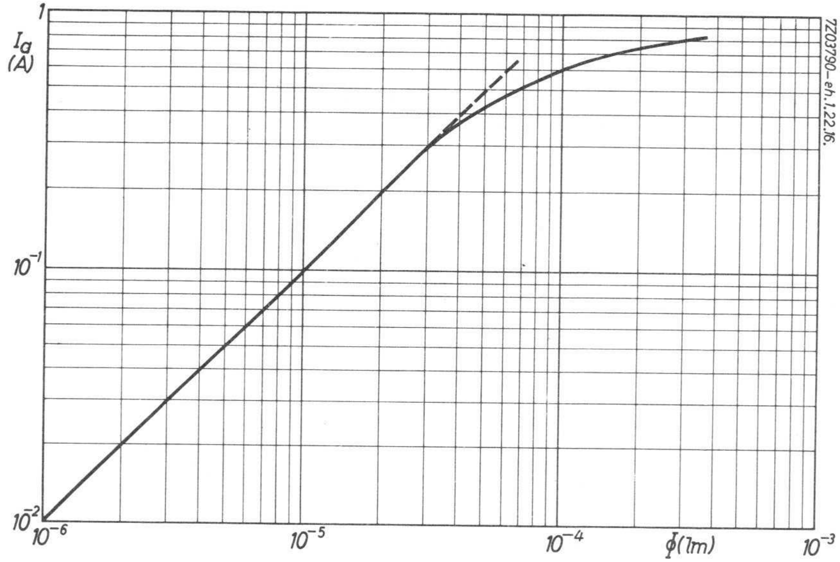
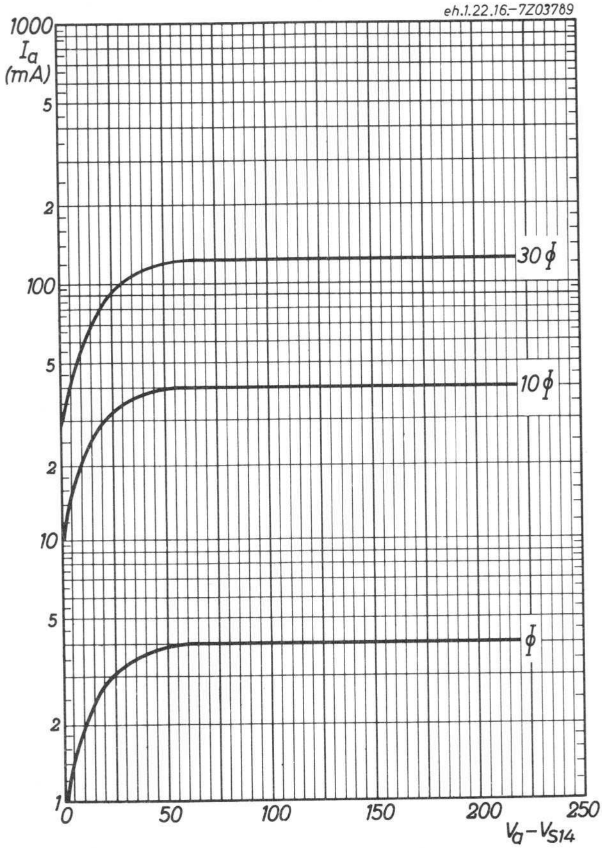


Fig. 2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1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 ϕ
10 ϕ
ϕ

Fig. 3

14 STAGE PHOTOMULTIPLIER TUBE

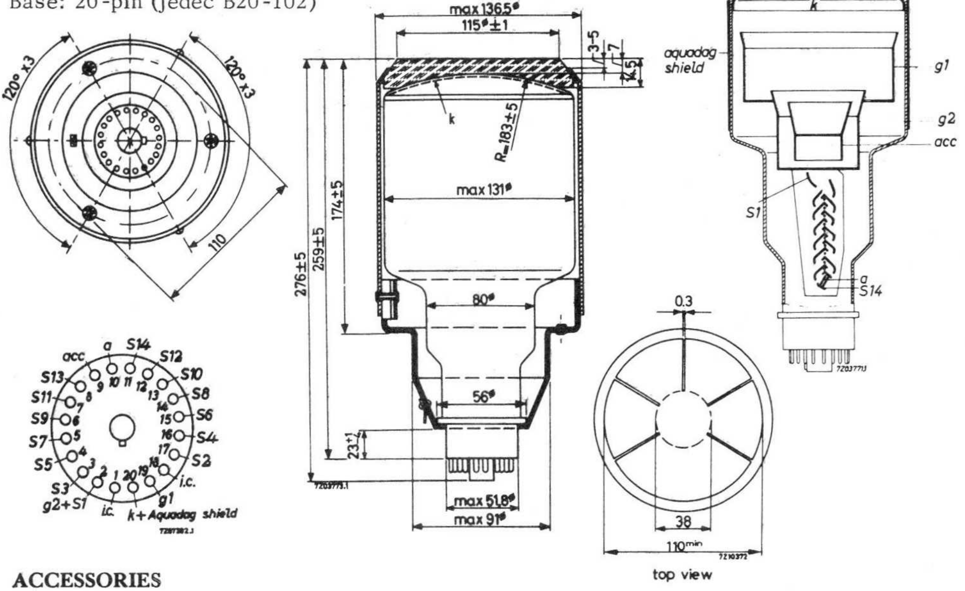
The tube is intended for use in nuclear-physics applications where very low luminous fluxes are to be measured and where a high degree of time definition is required.

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)



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	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

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 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)

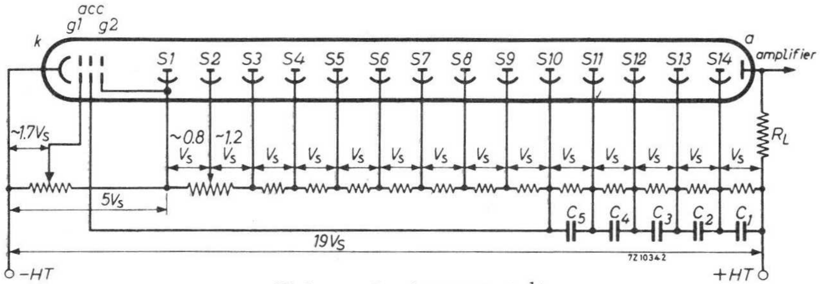
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	0.2	mA
Voltage between cathode and first dynode + grid No.2	V_{k/S_1+g_2}	max.	800	V
		min.	250	V
Voltage between cathode and accelerator electrode	$V_{k/acc}$	$14\ V_s$ to	18	V_s
Voltage between grid No.1 and cathode	V_{k/g_1}	max.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

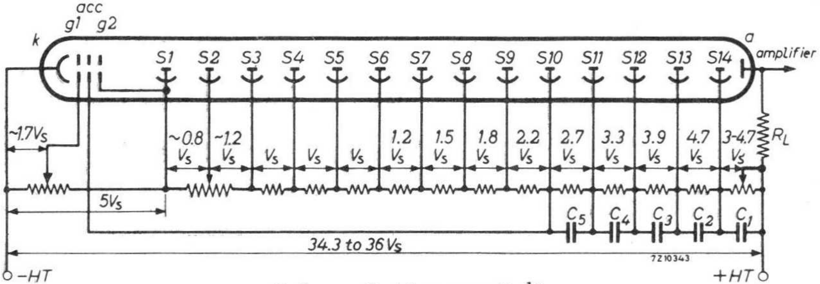
2) Or the voltage at which the tibe circuited in the voltage divider A has a gain of about 5×10^8, whichever is lowest.

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

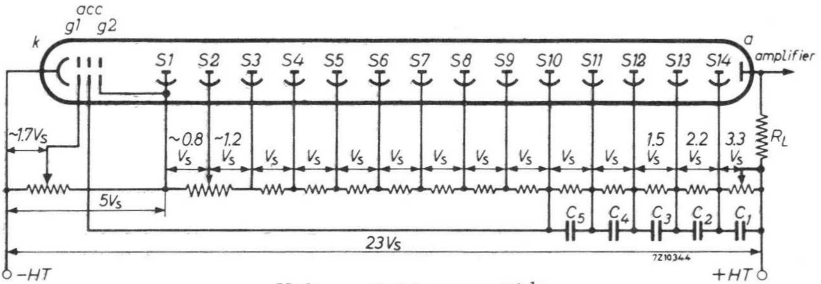
RECOMMENDED CIRCUITS



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 brought 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 C1 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 a plexiglass 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-accelerating 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.

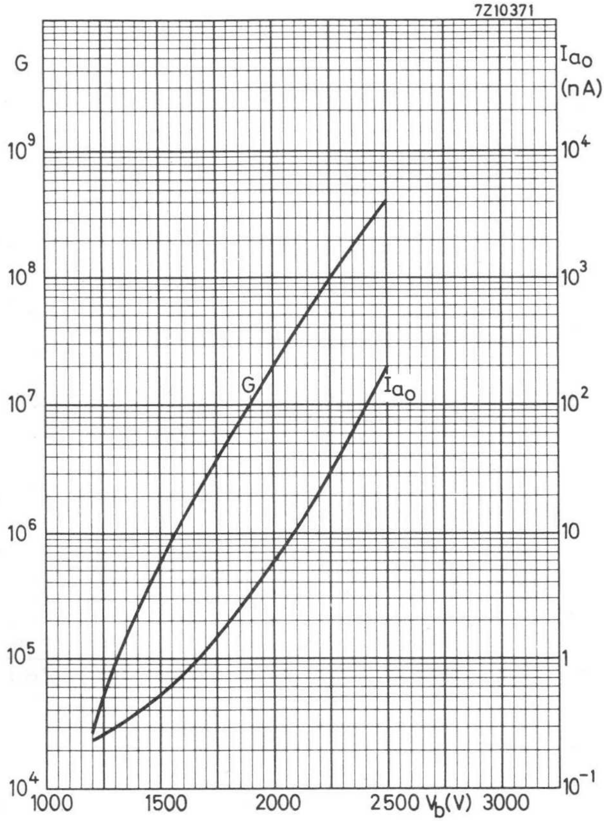
It should be noted that in a number of applications it is not necessary for the current to be proportional to the incident luminous flux. As a matter of fact, such pulses are needed for time measurements only, so not for spectrography purposes.
If at the same time it is required, however, to determine 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   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

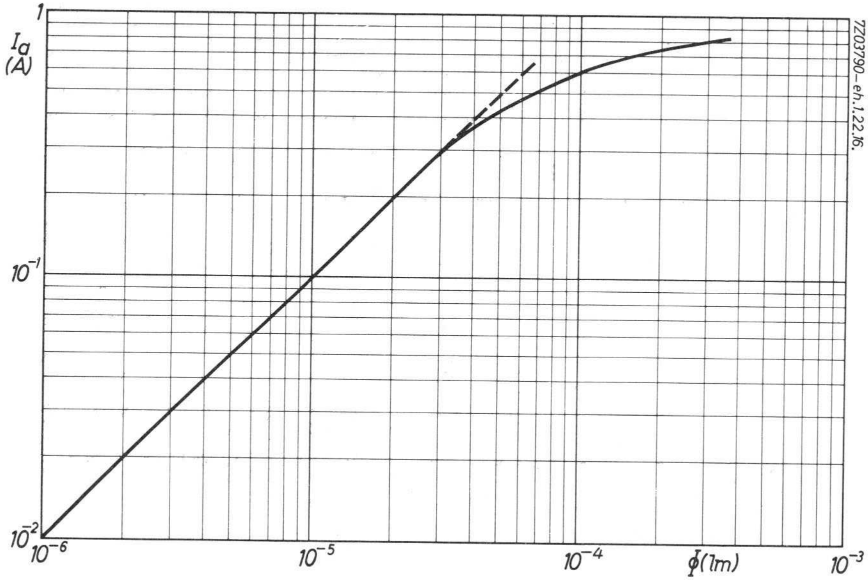


fig. 2

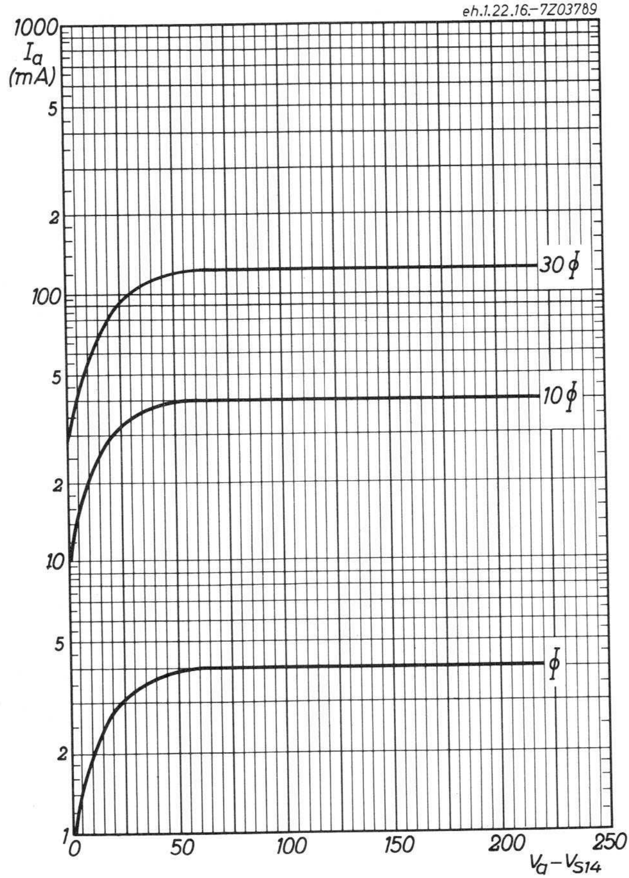

eh.1.22.16.-7Z03789
1000
I_a
(mA)
5
2
100
5
2
10
5
2
1
0
50
100
150
200
250
$V_a - V_{S14}$
30 ϕ
10 ϕ
ϕ

fig. 3

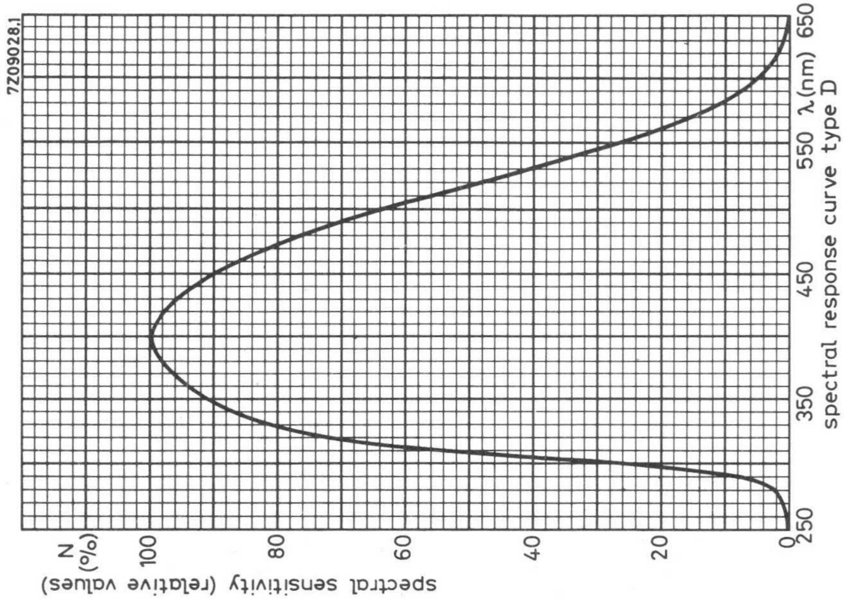

7Z09028.1
N (%)
spectral sensitivity (relative values)
100
80
60
40
20
0
250
350
450
550
650
λ (nm)
spectral response curve type D

fig.4

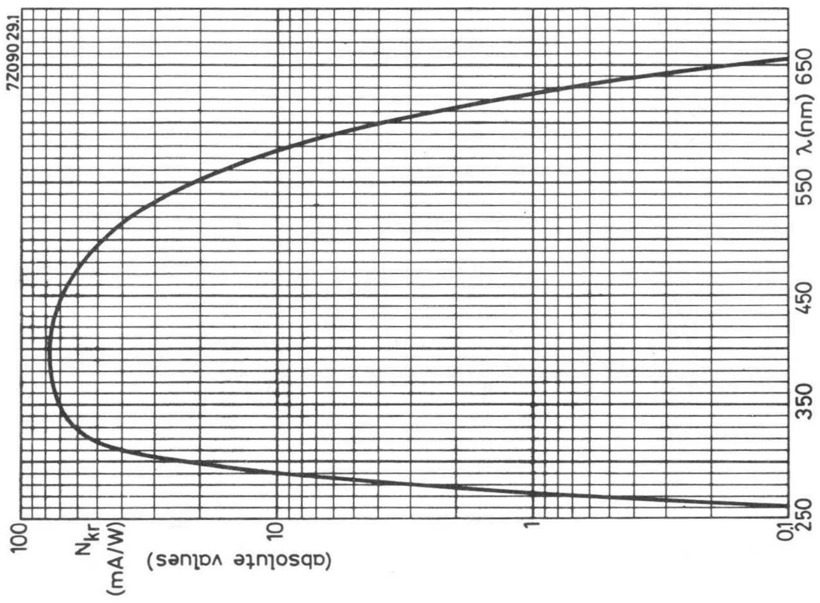

7Z09029.1
N_{kr} (mA/W)
(absolute values)
100
10
1
0.1
250
350
450
550
650
λ (nm)

Fig. 5

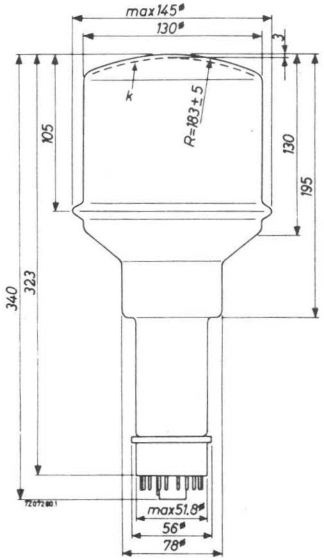
14 STAGE PHOTOMULTIPLIER TUBE

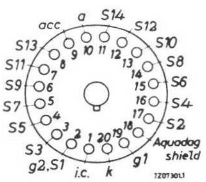
The tube is intended for use in nuclear-physics applications where a high degree of time definition is required, combined with a good sensitivity in the ultra-violet region.

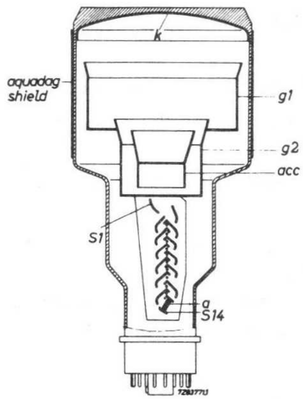
QUICK REFERENCE DATA		
Spectral response	type U (S13)	
Useful diameter of the photocathode	110	mm
Gain (at 2400 V)	10^8	
Anode pulse rise time	2	ns
Linearity	up to 300	mA

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 min. 45	μA/lm 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 max. 3000	V V
Anode dark current at $G = 10^8$ [4]	I_{a_o}	av. 2 max. 12	μA 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)	2.10^{-9} s
Anode pulse width at half height at V_b = 2800 V 5)	3.10^{-9} s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	10^{-9} s
Total transit time at V_b = 2800 V 5)	46.10^{-9} s
Maximum peak currents	0.5 to 1 A

With voltage divider B'

Anode pulse rise time at V_b = 2800 V 5)	2.10^{-9} s
Anode pulse width at half height at V_b = 2800 V 5)	3.10^{-9} s
Transit time difference between the centre of the photocathode and 45 mm out of the centre at V_b = 2800 V	10^{-9} s
Transit time spread	10^{-9} s
Total transit time at V_b = 2800 V 5)	43.10^{-9} s

LIMITING VALUES (Absolute max. rating system)

Supply voltage 6)	V_b	max.	3000	V
Continuous anode current	I_a	max.	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.

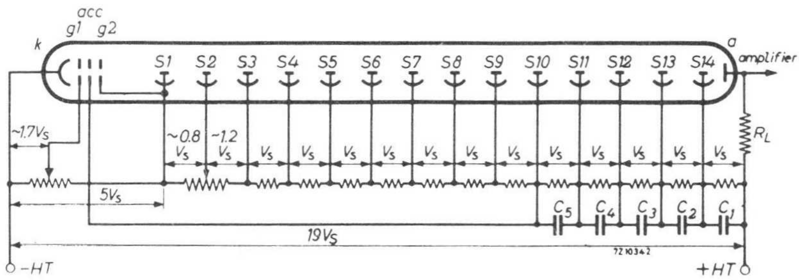
4) At an ambient temperature of 25 °C.

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

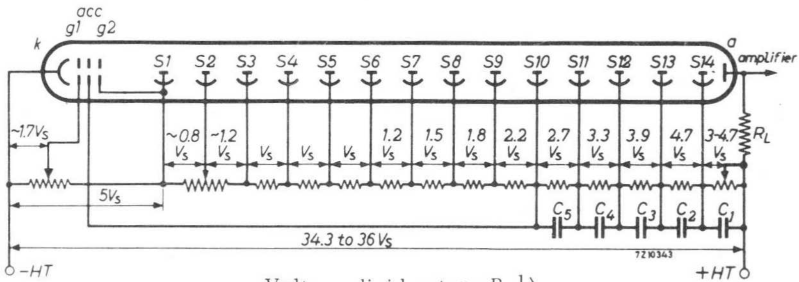
6) Or the voltage at which the tube circuited in the voltage divider A has a gain of about 10^9, whichever is lowest.

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

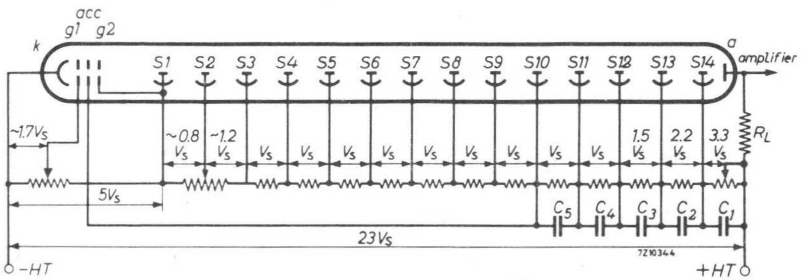
RECOMMENDED CIRCUITS



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-accelerating voltage of about 1500 V (to be connected to the tenth or a subsequent 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.

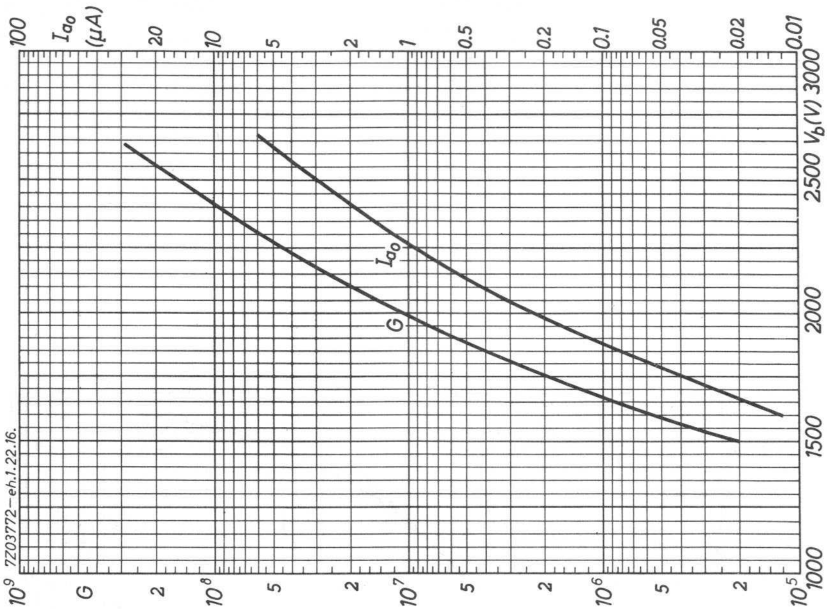

7Z03772–eh.1.22.16.
I_{a_0} (μA)
G
V_b(V)

Fig.1

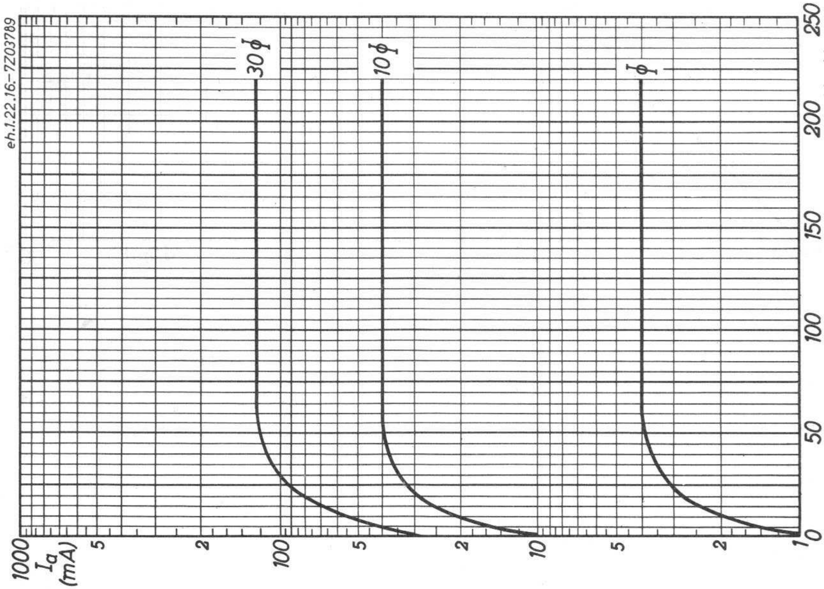

eh.1.22.16.–7Z03789
I_a (mA)
30 ϕ
10 ϕ
ϕ
$V_a - V_{S14}$

Fig.2

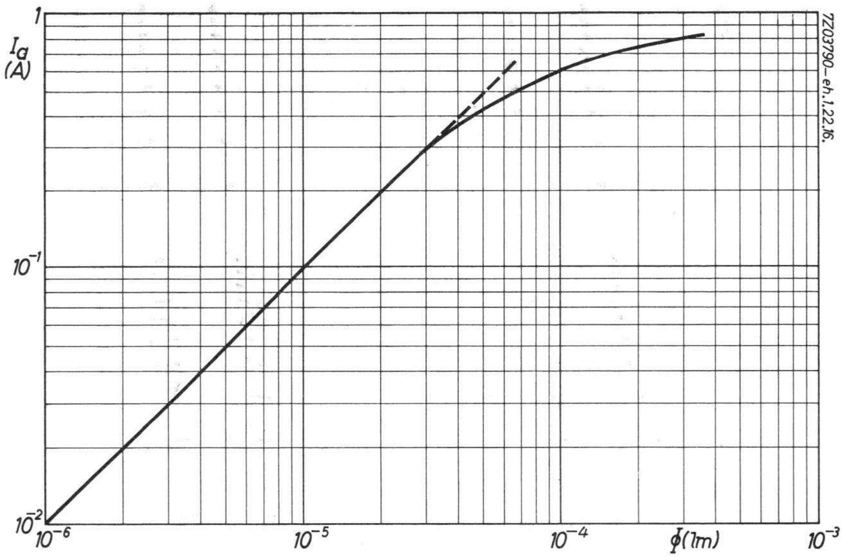


Fig.3

12 STAGE PHOTOMULTIPLIER TUBE

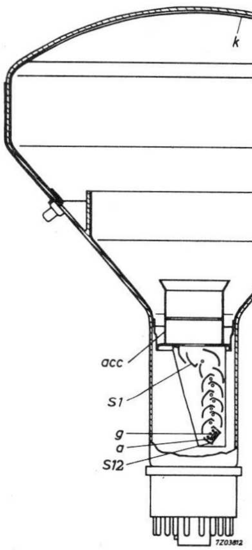
The tube is intended for use in large solid or liquid scintillator detectors, when a high time resolution is required.

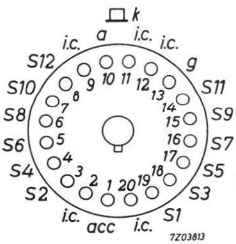
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	200	mm
Gain (at 3000 V)	10^8	
Anode pulse rise time	2.5	ns
Linearity	up to 300	mA

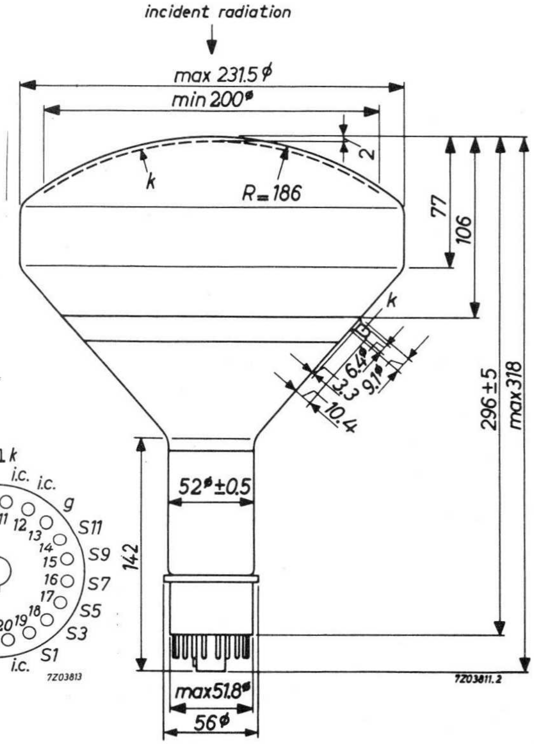
DIMENSIONS AND CONNECTIONS

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. 50 min. 35	μA/lm 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. 50	μA
Supply voltage for $G = 10^8$	V_b	av. 3000 max. 3500	V 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]	$2.1.10^{-9}$ s
Anode pulse width at half height at V_b = 3000 V [1]	$3.5.10^{-9}$ s
Transit time difference between the centre of the photocathode and 80 mm out of the centre at V_b = 3000 V	2.10^{-9} s
Total transit time at V_b = 3000 V [1]	48.10^{-9} s
Maximum peak current	0.5 to 1 A

LIMITING VALUES (Absolute max. rating system)

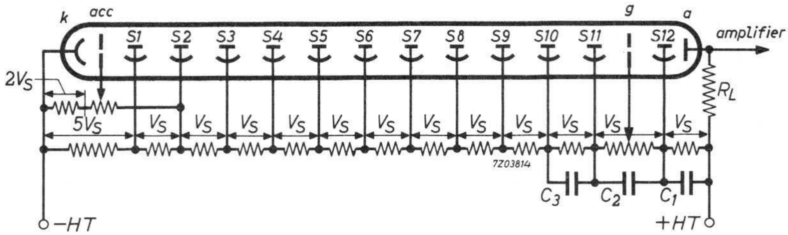
Supply voltage [2]	V_b	max.	3000	V
Continuous anode current	I_a	max.	2	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	1000	V
		min.	350	V
Voltage between consecutive dynodes	$V_{S_n/S_{n+1}}$	max.	500	V
		min.	80	V
Voltage between anode and final dynode [3]	$V_{a/S_{12}}$	max.	500	V
		min.	80	V

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

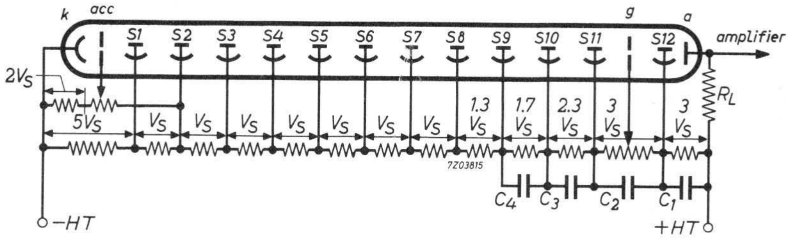
[2]) Or the voltage at which the tube circuited in the voltage divider A has a gain of 10^9, whichever is lowest.

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

RECOMMENDED CIRCUITS



Voltage divider type A



Voltage divider type B

The accelerator to be adjusted for maximum gain
The grid to be adjusted for fastest response

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 5 mA will be sufficient.

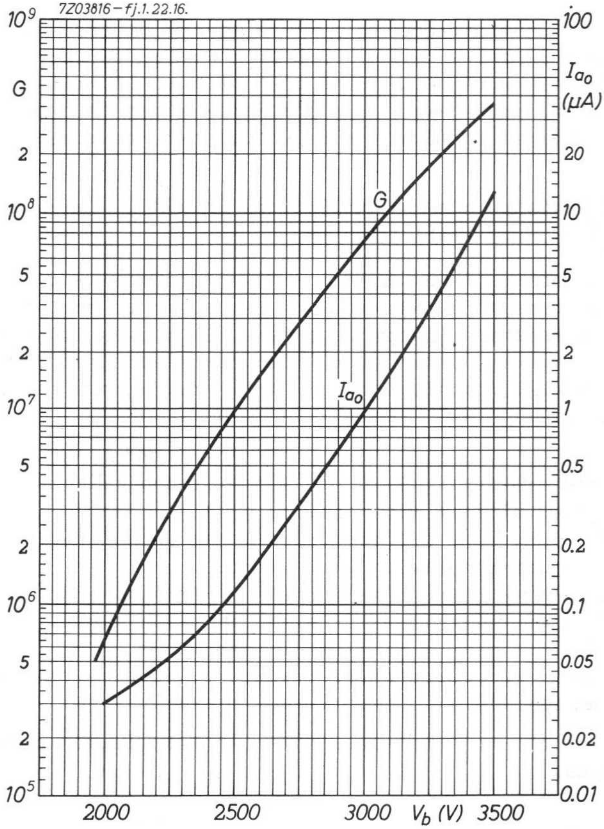
The last stages must be decoupled by means of capacitances to avoid a serious voltage drop on the dynodes. A practical value for C_1 could be 2.10^{-9} F. In the case of high counting rates and large peak power output, and to avoid a high-tension supply of large power, it is possible to supply the first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

The multiplier system consists of 12 stages, providing a total current amplification of 10^8 at about 3000 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.

To avoid the effects, which are responsible for rounding of the leading edge and the "jagged" trailing edges, a grid (g) 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.
It should be noted that at equal high tension 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.


7Z03816-fj.1.22.16.
10^9
G
2
10^8
5
2
10^7
5
2
10^6
5
2
10^5
100
I_{a_o}
(μA)
20
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
G
I_{a_o}
2000
2500
3000
V_b (V)
3500

10 STAGE PHOTOMULTIPLIER TUBE

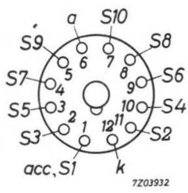
The tube is intended for use in applications such as scintillation counting, flying spot scanners, different kinds of optical and industrial instruments.

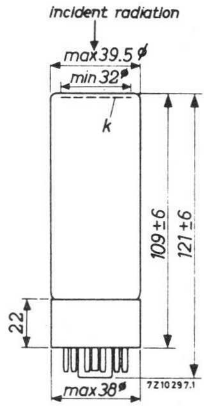
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

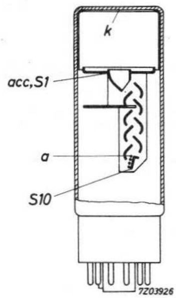
DIMENSIONS AND CONNECTIONS

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 diameter			32	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.	700	A/lm
		min.	250	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)

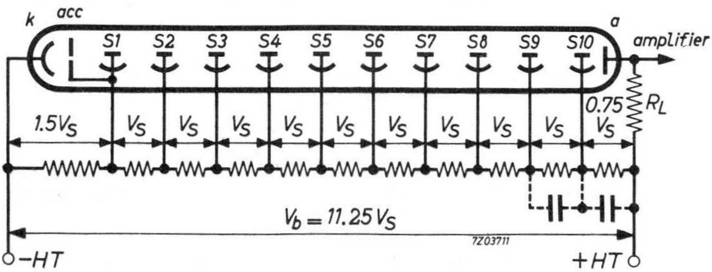
With voltage divider B

Linearity between anode amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1800 V [1])	$3.5.10^{-9}$	s
Anode pulse width at half height at V_b = 1800 V [1])	$6.5.10^{-9}$	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V	3.10^{-9}	s
Total transit time at V_b = 1800 V [1])	33.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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



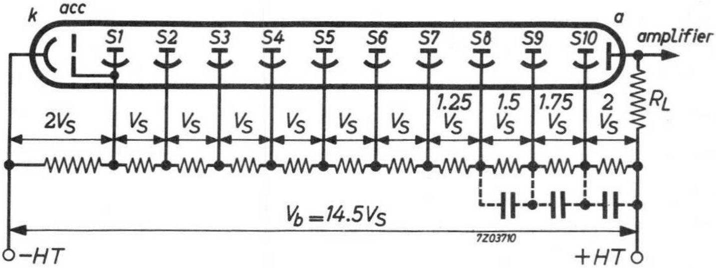
Voltage divider type A

k	=	cathode	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.

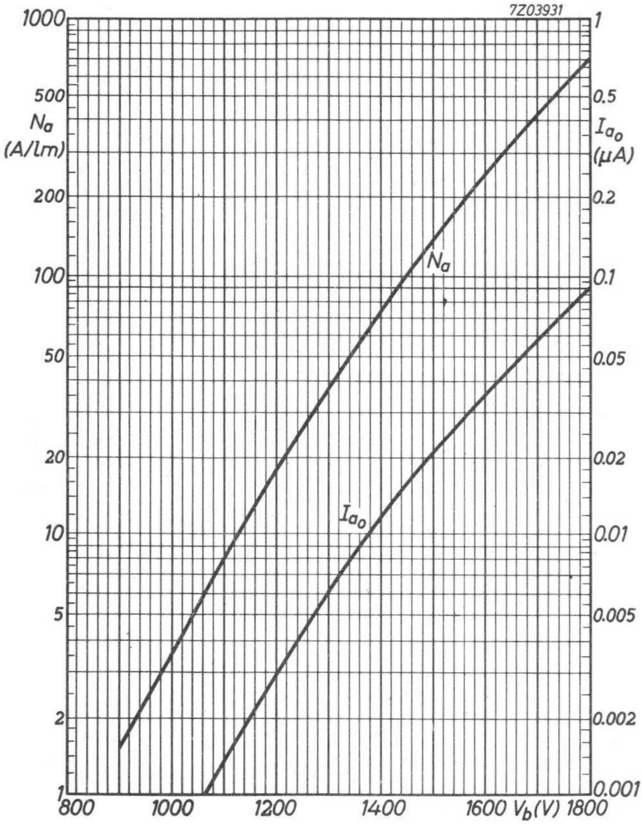
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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 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
1000
500
Na
(A/lm)
200
100
50
20
10
5
2
1
1
0.5
I_{a_0}
(μA)
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
Na
I_{a_0}
800
1000
1200
1400
1600 V_b(V) 1800

10 STAGE PHOTOMULTIPLIER TUBE

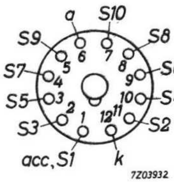
The tube is intended for use in applications such as infra-red telecommunication and ranging, and in optical instruments operating in the far red and near infra-red region (astronomical measurements, spectrometry, optical pyrometry, infra-red radiation intensity control instruments).

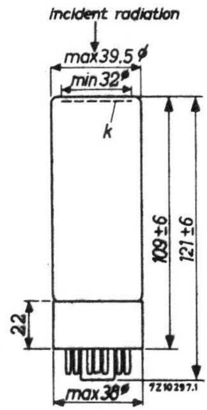
QUICK REFERENCE DATA		
Spectral response curve	type	C (S1)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	100	A/lm

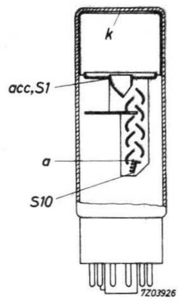
DIMENSIONS AND CONNECTIONS

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)

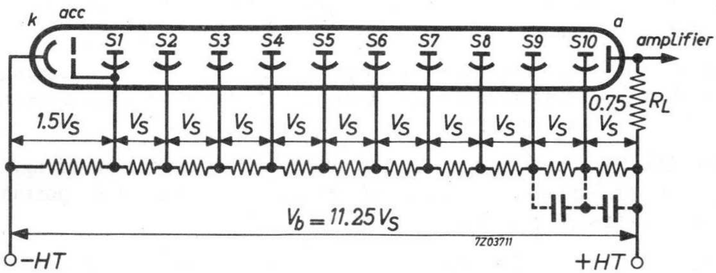
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	10	mA
Anode pulse rise time at V_b = 1800 V [1]		$3,5.10^{-9}$	s
Anode pulse width at half heigth at V_b = 1800 V [1]		$6,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V		3.10^{-9}	s
Total transit time at V_b = 1800 V		33.10^{-9}	s

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

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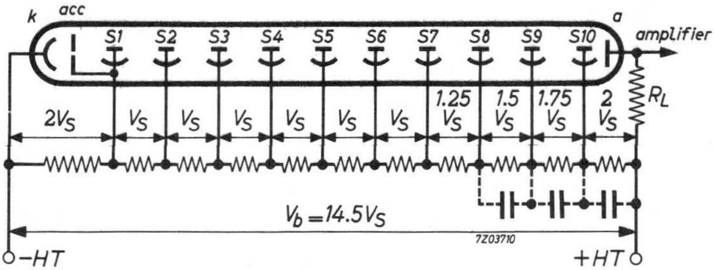
[1]) For an infinitely short light pulse, fully illuminating the photocathode.

[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.

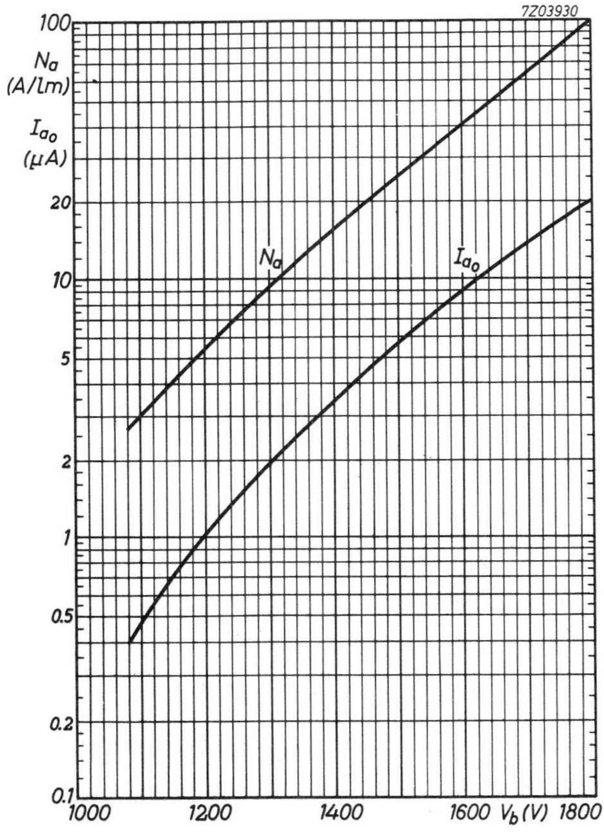
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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.


7Z03930
100
Na
(A/lm)
Iao
(μA)
20
10
5
2
1
0.5
0.2
0.1
Na
Iao
1000
1200
1400
1600 Vb (V) 1800

10 STAGE PHOTOMULTIPLIER TUBE

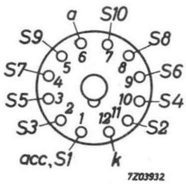
The tube is intended for optical spectrometry, ultraviolet photometry and other applications which require a good sensitivity in the ultraviolet region.

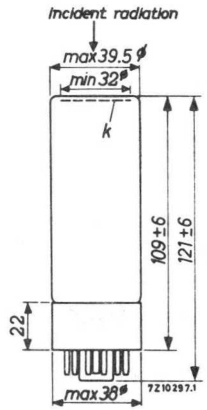
QUICK REFERENCE DATA		
Spectral response	type	U (S13)
Useful diameter of the photocathode	32	mm
Anode sensitivity (at 1800 V)	700	A/lm

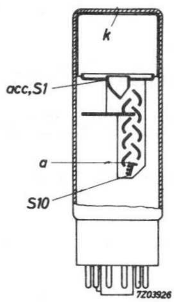
DIMENSIONS AND CONNECTIONS

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	$C_{a/S10}$		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 = 60 A/lm [3]	I_{a_0}	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 temperatue of 2854 °K

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

TYPICAL CHARACTERISTICS (continued)

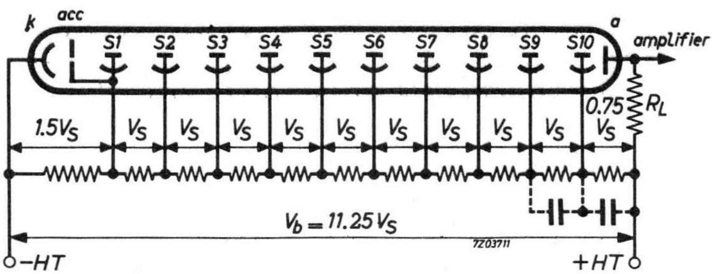
With voltage divider B

Linearity between anode amplitude and input light pulse	up to 100	mA
Anode pulse rise time at V_b = 1800 V 1)	$3.5.10^{-9}$	s
Anode pulse width at half height at V_b = 1800 V 1)	$6,5.10^{-9}$	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1800 V	3.10^{-9}	s
Total transit time at V_b = 1800 V 1)	33.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	1	mA
Voltage between cathode and first dynode	V_{k/S_1}	max.	500	V
		min.	120	V
Voltage between consecutive dynode	$V_{S_n/S_{n+1}}$	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



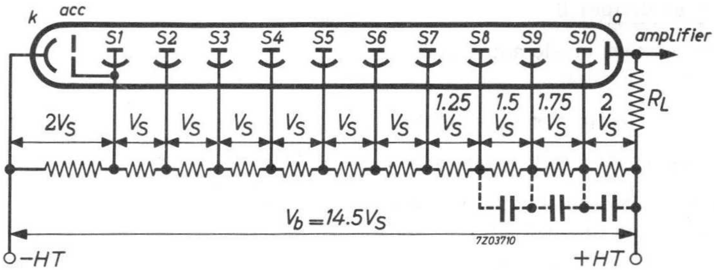
Voltage divider type A

k = cathode		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.

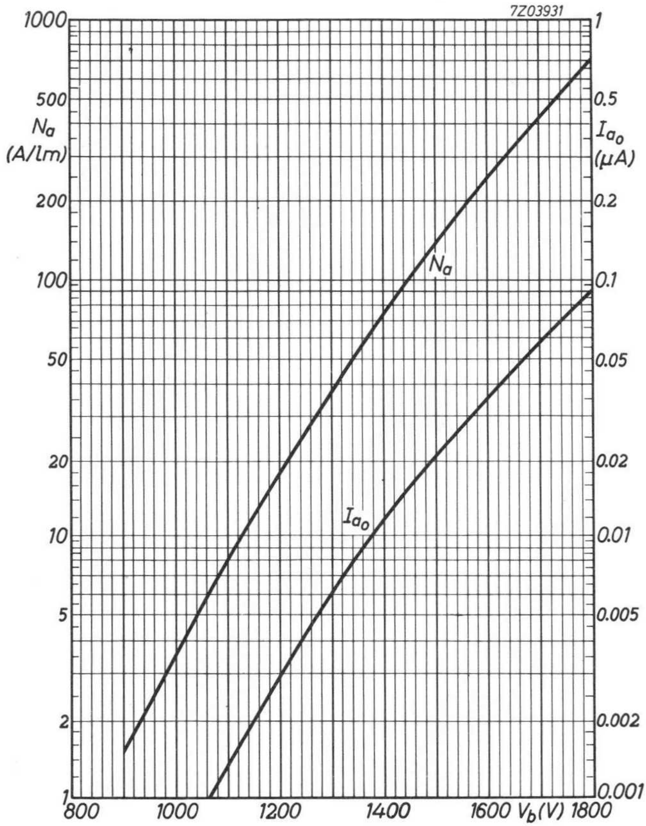
For moderate intensities of radiation a bridge current of approx. 0.5 mA will be sufficient.

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
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
N_a
I_{a_o}
800
1000
1200
1400
1600 V_b(V) 1800

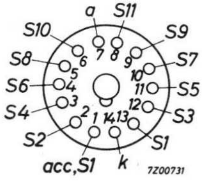
11 STAGE PHOTOMULTIPLIER TUBE

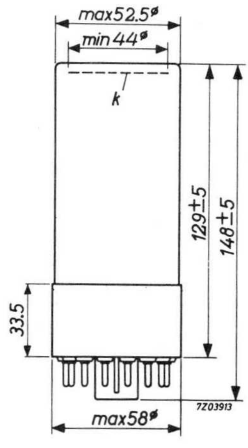
The tube is intended for use in applications such as gamma-ray spectrometry.

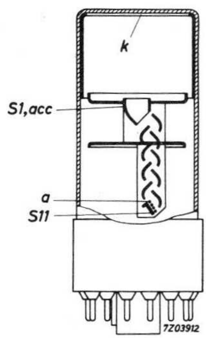
QUICK REFERENCE DATA		
Spectral response	type	A (S11)
Useful diameter of the photocathode	44	mm
Anode sensitivity (at 1800 V)	400	A/lm
Energy resolution for ^{137}Cs (0,661 MeV)	8.5	%

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 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			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.	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 in x 1 in NaI(Il) crystal

TYPICAL CHARACTERISTICS (continued)

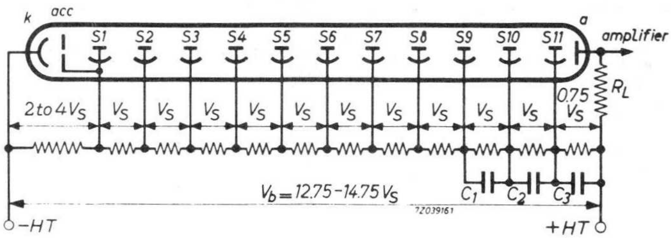
With voltage divider B

Linearity between anode pulse amplitude and input light pulse	up to	100	mA
Anode pulse rise time at V_b = 1500 V [1]		5.10^{-9}	s
Anode pulse width at half height at V_b = 1500 V [1]		14.10^{-9}	s
Transit time difference between the centre of the photocathode and the edge at V_b = 1500 V		4.10^{-9}	s
Total transit time at V_b 1500 V [1]		45.10^{-9}	s

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V
Continuous anode current	I_a	max.	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



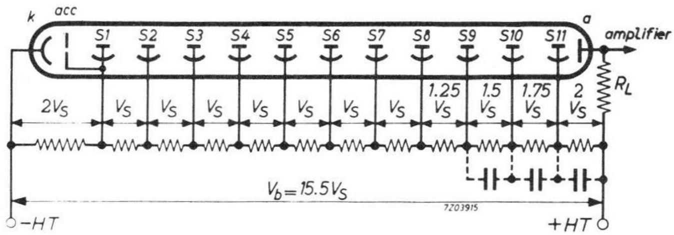
Voltage divider type A

C1 = 220 pF C2 = 470 pF C3 = 1000 pF

k = cathode 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 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 hours of operation.

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

Scintillators

ZnS-SCINTILLATOR FOR α AND α + β RADIATION DETECTION

SAM scintillator 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:

$$\frac{I_t}{I_o} = \frac{1}{(1+At)^2}$$

where A = 3 to 4.10^6
t = time in s

Standard dimensions:

Discs:

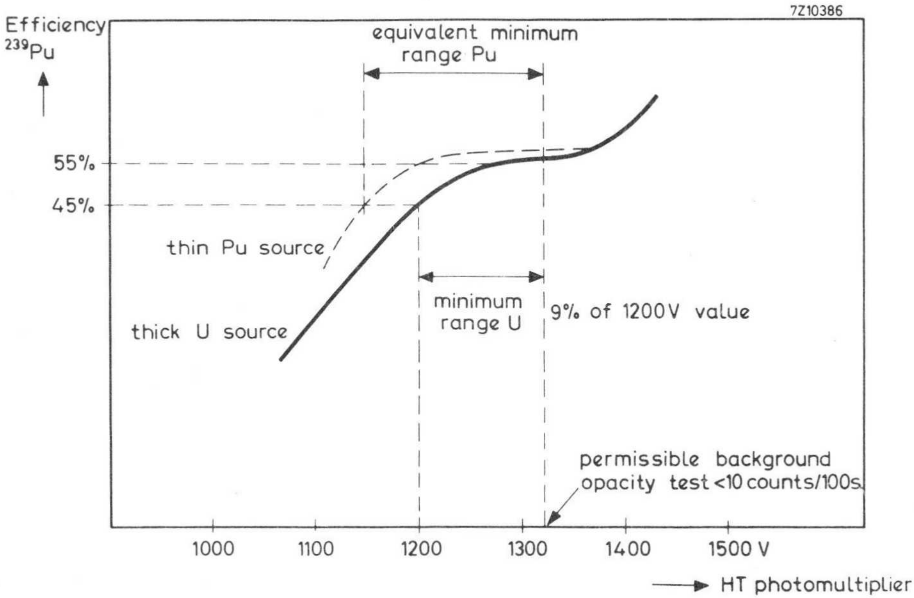
Type	Diameter (mm)	Thickness (mm)	Matching photomultiplier
SAM40	40	3	150AVP
SAM50	50	3	XP1000
SAM70	70	3	XP1030
SAM125	125	3	54AVP

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).

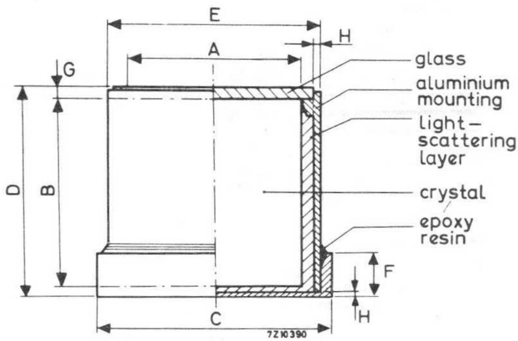
Standard dimensions of the crystal:

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

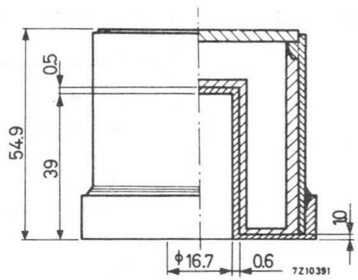
Other dimensions on request.

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

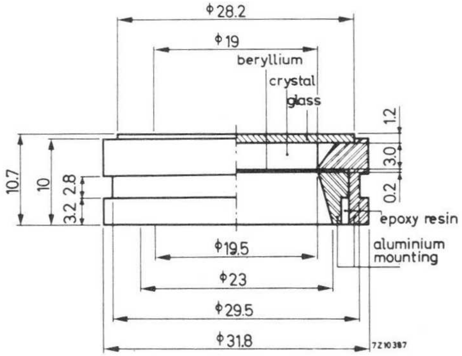
Scintillators for X-ray detection and counting

Standard dimensions of the crystal:

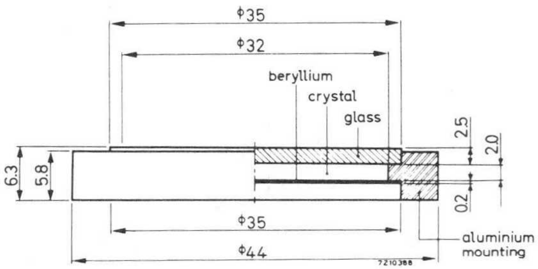
type	diameter (mm)	thickness (mm)
SIS 19x3	19	3
SIS 32x2	32	2
SIS 44x2	44	2

Thickness of the Be window is 0.2 mm

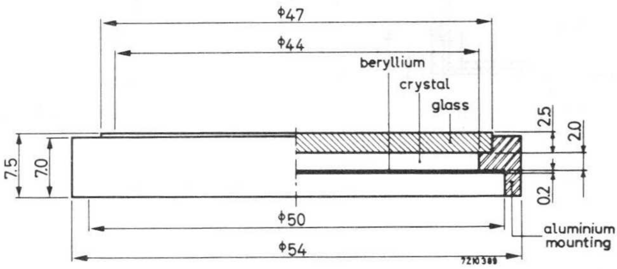
SIS 19x3

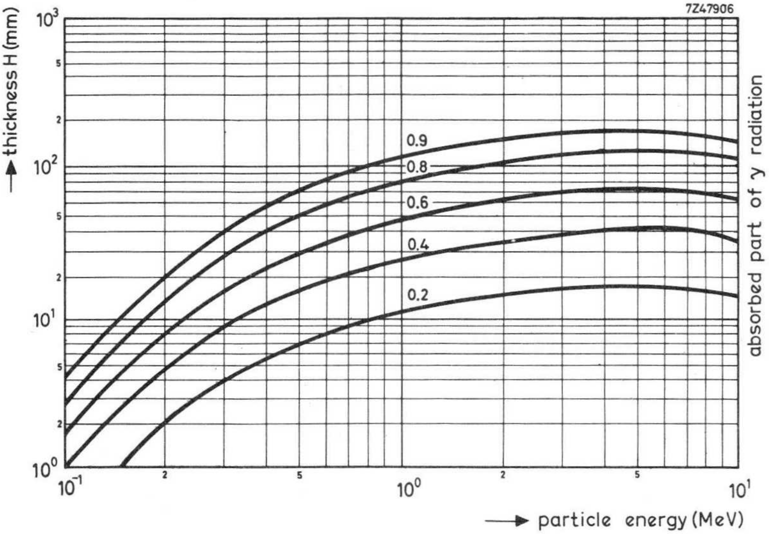


SIS 32x2



SIS 44x2





Absorption of γ radiation in the crystal

FLUORESCENT PLASTIC SCINTILLATOR FOR α, β, γ, 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.
They are delivered with an adhesive papercover to protect the surface against damage. Before use this paper can be easily removed.

CHARACTERISTICS

Time constant of fluorescence	$3{,}5.10^{-9}$	s
Time constant of phosphorescence	0	
Wavelength of maximum emission	4400	Å
Density	1.05	
Refractive index	1.594	
Softening point	85	^{o}C
Ambient temperature	max. 60	^{o}C
Light output % Anthracene	55 - 65	%
Coëfficient of linear expansion	6.10^{-5} - 8.10^{-5}	
Ratio no. of H-atoms to no. of C-atoms	0.998	

SCINTILLATORS FOR BÊTA DETECTION

Type SPFM (aluminized SPF)
The light-tight metalcover has a mass per unit area of 600 - 800 $\mu g/cm^2$.

SCINTILLATORS FOR ALPHA DETECTION

SPF foil with or without support, made of acrylate or glass.

SPECIAL SCINTILLATORS

- Compositions for increased temperatures (maximum 150 ^{o}C) -type SPF HT
- To obtain an improved efficiency the scintillators can be ordered with a metal or titanium dioxide reflective coating.

SPECIAL FORMS

All forms can be prepared to customers specifications.

Standard dimensions:

Disc and cylinders:

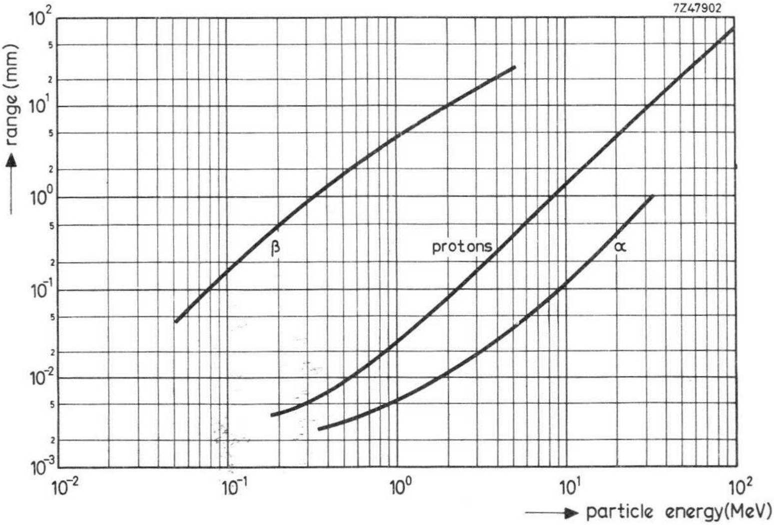
Type	Diameter (mm)	Standardized thicknesses (x) (mm)	Matching photomultiplier
SPF 25/x	25	0.2-0.5-1-1.5-3-20-100	XP1180
SPF 40/x	40	0.2-1.5-3-50-100-200	150AVP/XP1010
SPF 50/x	50	0.2-0.5-1-1.5-3-20-40-100-200	56AVP XP1000/XP1020/XP1021
SPF 70/x	70	0.2-1-1.5-3	XP1030
SPF125/x	125	0.2-0.5-1-1.5-2-3-5-20-80-100-200	54AVP/58AVP/XP1040

Sheets and blocks:

Type	Length (mm)	Width (mm)	Standardized thicknesses (x) (mm)
SPF 350/350/x	350	350	1-2-3-4-5-10
SPF 500/500/x	500	500	10-15
SPF 800/500/x	800	500	10-15-20-30
SPF1500/1000/x	1500	1000	10-15

Foil: thickness between 5 and 100 μm.

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.



Range of particles in dependence of energy

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.

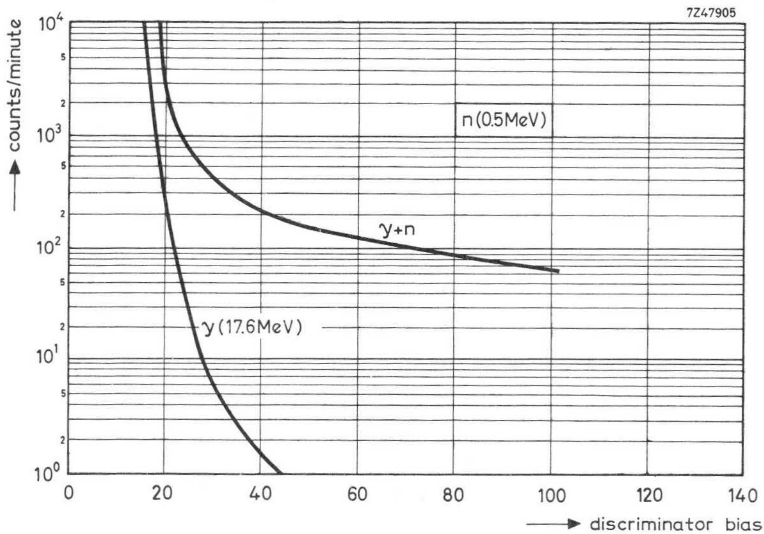
Available dimensions:

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

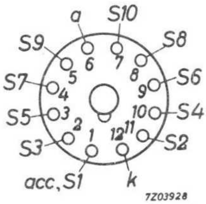
Photoscintillator intended for X-ray spectrometry.

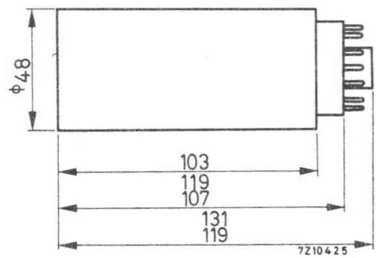
QUICK REFERENCE DATA	
Photomultiplier tube	XP 1010
Scintillator	Na I(Tl) 32 x 2 mm with Be window 0.2 mm
Voltage divider	not incorporated

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

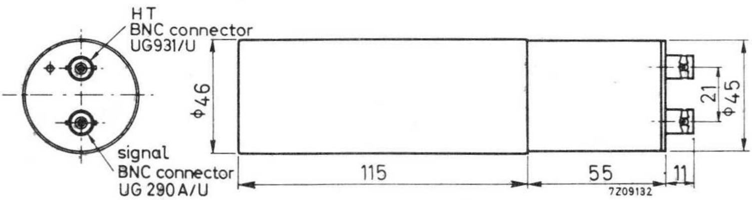
Photoscintillator intended for X-ray spectrometry.

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



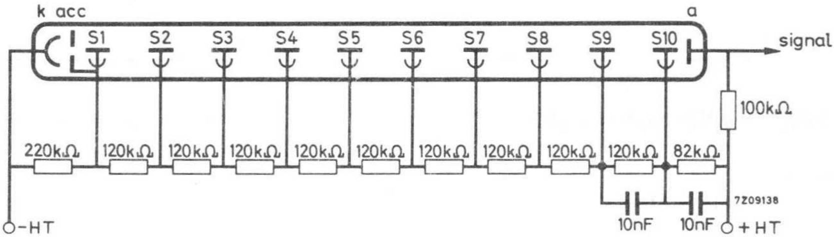
PHOTOMULTIPLIER TUBE

For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

SCINTILLATOR

NaI(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

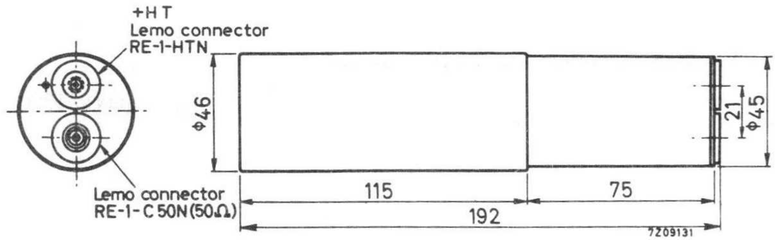
Watertight photoscintillator intended for X-ray spectrometry.

QUICK REFERENCE DATA	
Photomultiplier tube	XP1010
Scintillator	NaI(T1) 32 x 2 mm with Be window 0.2 mm
Voltage divider	incorporated

DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel



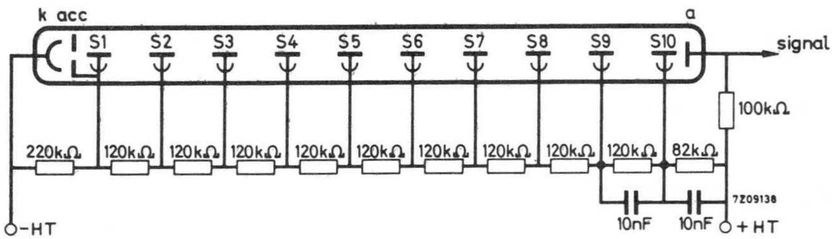
PHOTOMULTIPLIER TUBE

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	

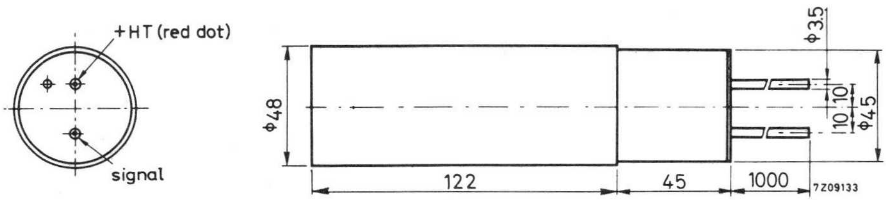
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connectors

Coaxial flexible leads (50 Ω)



PHOTOMULTIPLIER TUBE

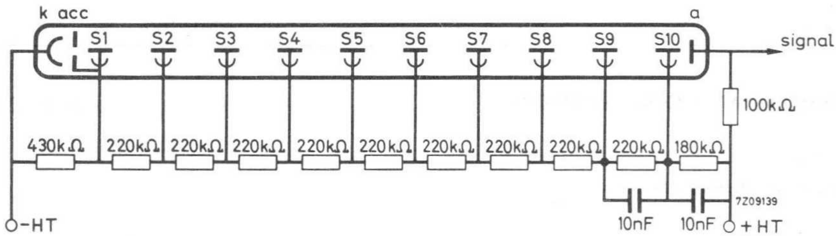
For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes" A mu-metal shield is incorporated.

SCINTILLATOR

NaI (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

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

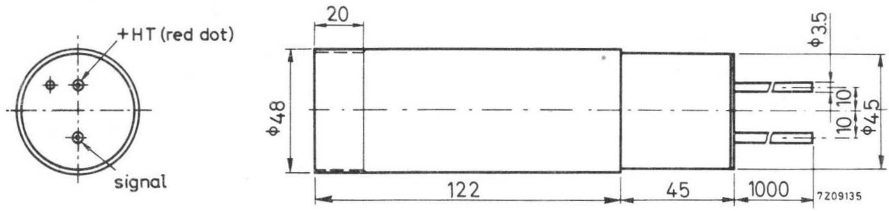
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



PHOTOMULTIPLIER TUBE

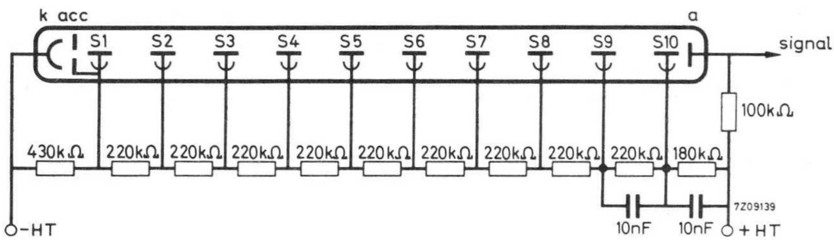
For data of the photomultiplier tube XP1010 see Handbook section "Photomultiplier tubes". A mu-metal shield is incorporated.

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 (T1) scintillators intended for medical applications.

QUICK REFERENCE DATA	
Photo multiplier tube	XP1010
Scintillator	not incorporated
Voltage divider	incorporated

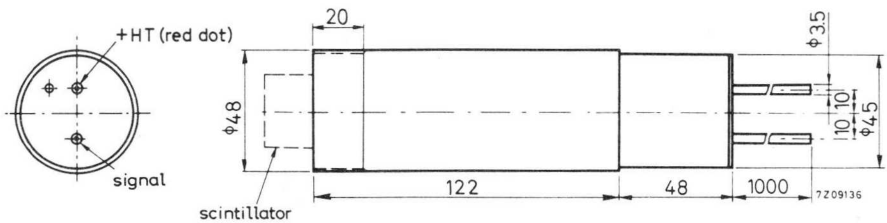
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



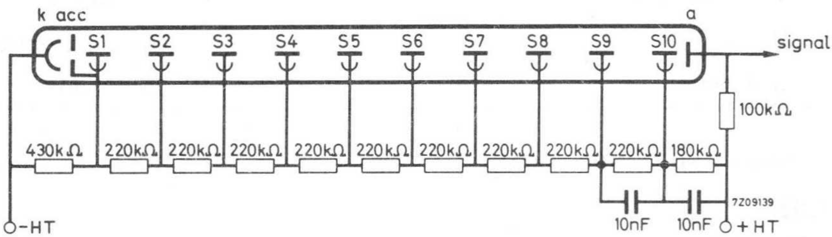
PHOTOMULTIPLIER TUBE

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

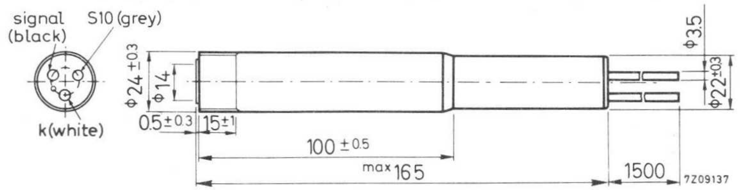
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

Coaxial flexible leads (50 Ω)



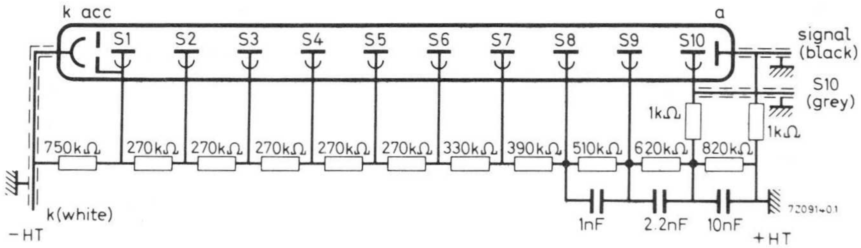
ACCESSORIES

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

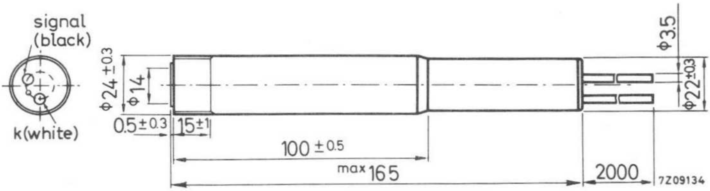
DIMENSIONS AND CONNECTIONS Dimensions in mm

Envelope

Material: stainless steel

Connections

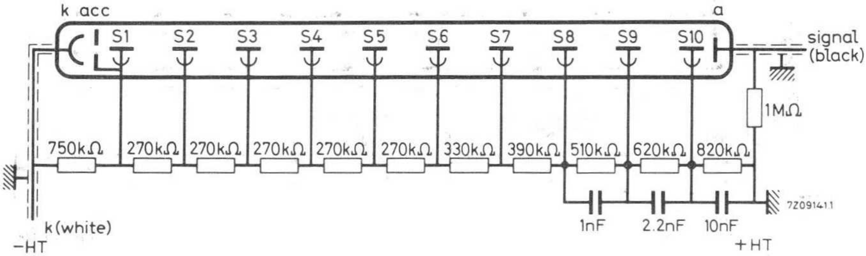
Coaxial flexible leads (50 Ω)



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.

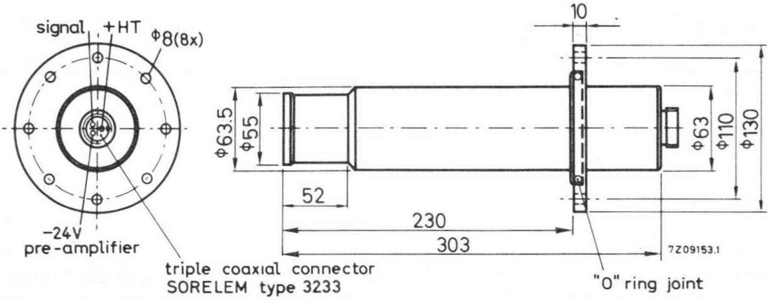
QUICK REFERENCE DATA	
Photomultiplier tube	53AVP
Scintillator	NaI(Tl) 44 x 50 mm with stainless steel window 0.5 mm
Voltage divider	incorporated
Pre-amplifier	incorporated

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.

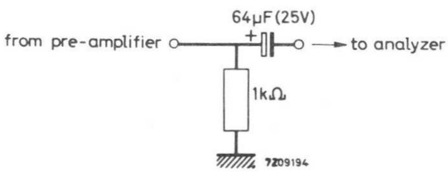
The average plateau length for a count rate of approx. 500 counts/s is 300 V.

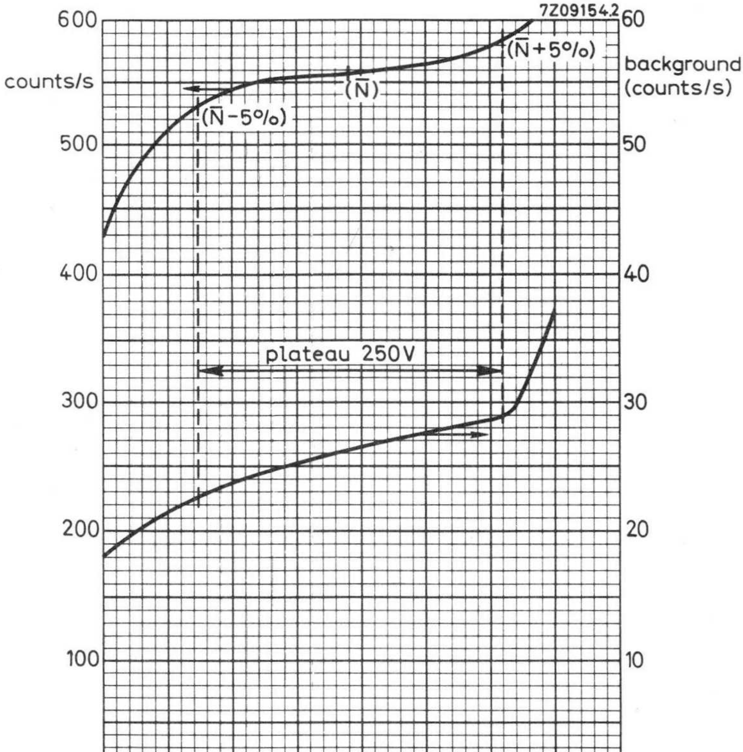
The background at the middle of the plateau, measured with a shield of 50 mm Pb, is 50 counts/s.

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

44 mm PHOTOSCINTILLATOR

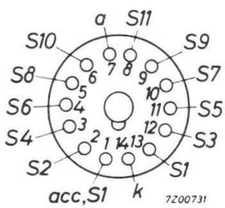
Photoscintillator intended for X-ray spectrometry.

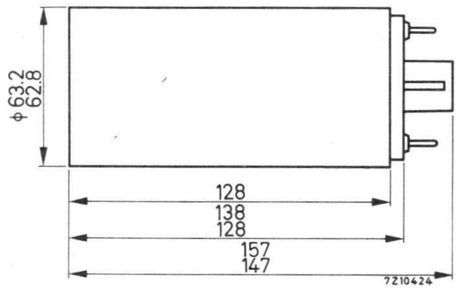
QUICK REFERENCE DATA	
Photomultiplier tube	53AVP/02
Scintillator	NaI(Tl) 44 x 2 mm
Voltage divider	not incorporated

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

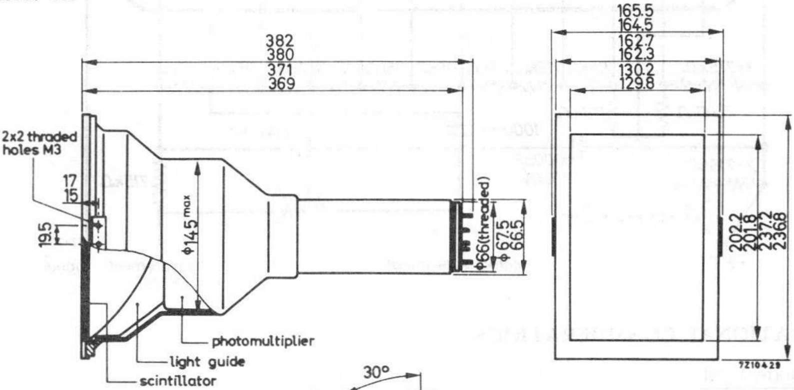
Photoscintillator intended for alpha and beta-counting. It is insensitive to light.

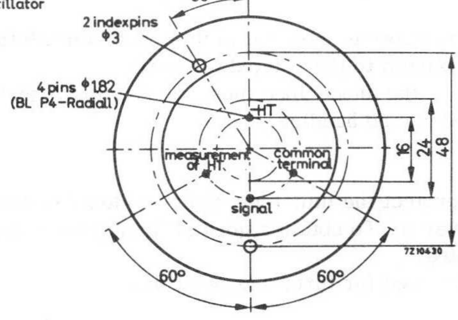
QUICK REFERENCE DATA	
Photomultiplier tube	54AVP
Scintillator	SPABM 139 x 209
Voltage divider	incorporated

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 Mumetal shield is incorporated.

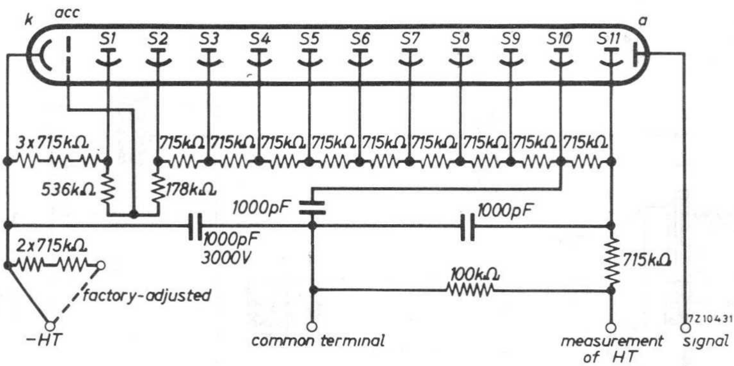
Scintillator

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 $\leq$ 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.

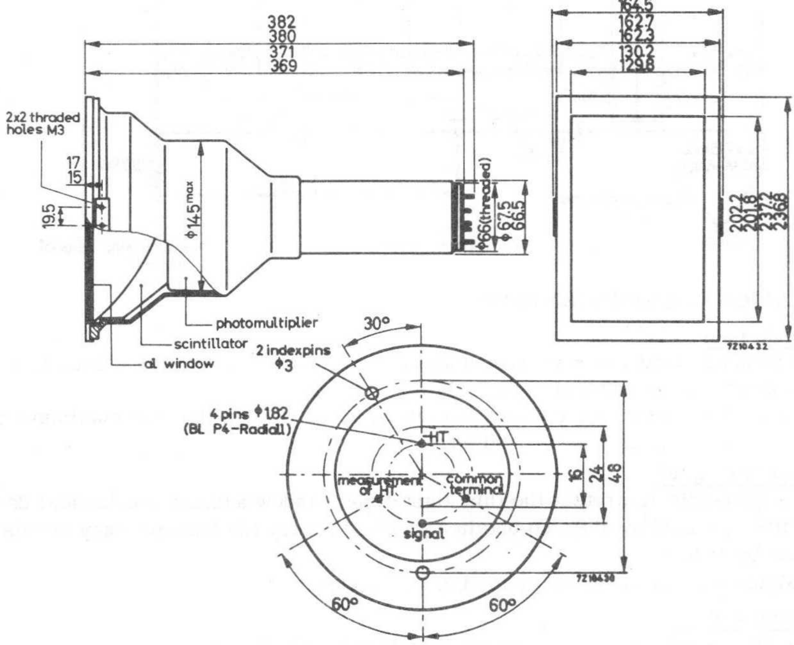
QUICK REFERENCE DATA	
Photomultiplier tube	54AVP
Scintillator	SPF 139 x 209
Voltage divider	incorporated

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Envelope

Material: Al



Photomultiplier tube

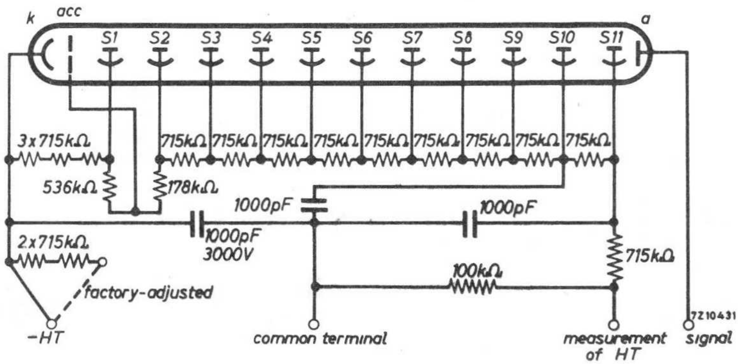
For data of the photomultiplier tube 54AVP see Data Handbook, section "Photomultiplier tubes"
A Mumetal shield is incorporated.

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 circuit boards carrying the voltage divider,
- 1 printed circuit 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	overall length	max.	465	mm
S5600/02	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.

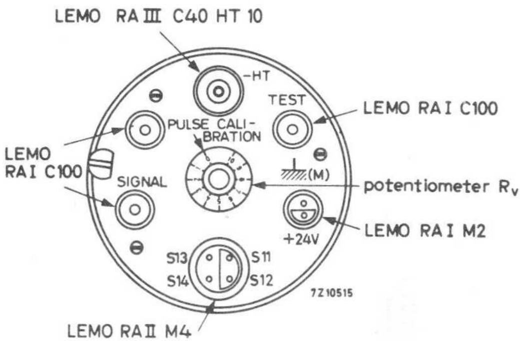
M/5600/AR: As M/5600/01 but without anti-magnetic shields and without fastening rings for light guide or scintillator.

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 circuit 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 circuit 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

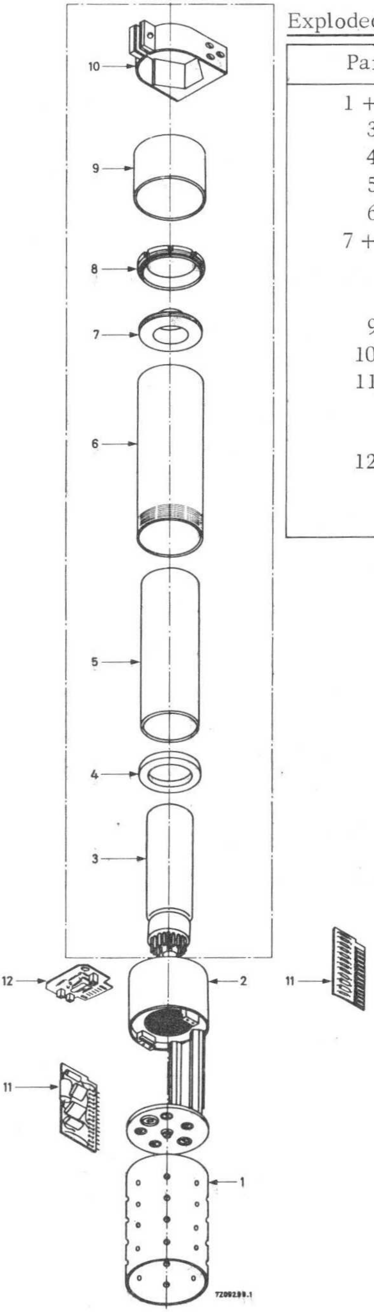
See also pages 4 and 5.

CONNECTIONS



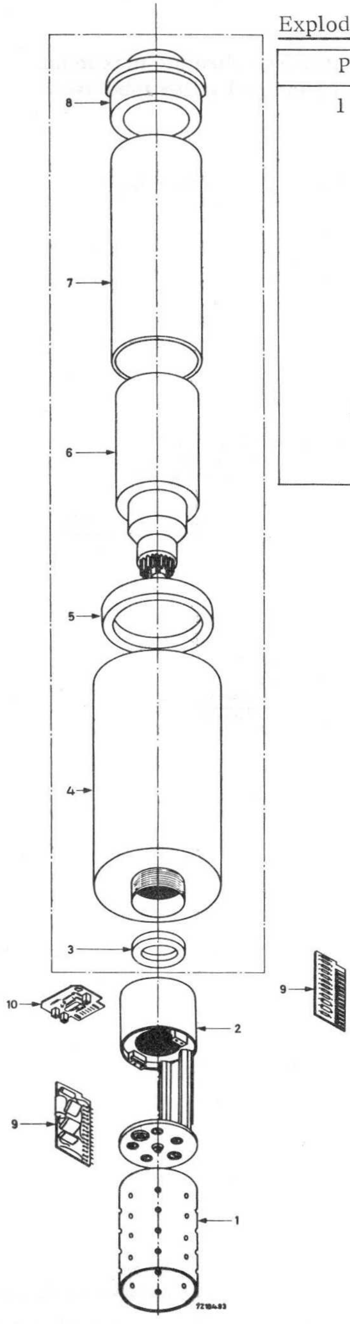
Matching connectors

-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 scintillator
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

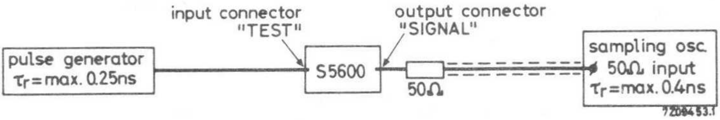
Part	Typenumber	Description
1 + 2	M/5600/AR	Rear assembly
3	PS A 108	Foam-plastic ring
4	PS A 117	Soft-iron shield
5	PS A 118	Foam-plastic ring
6	–	Photomultiplier
7	ϕ148-L = 335	Mu-metal shield
8	PS A 116	Fastening ring for light guide or scintillator
9	PS A 103	Voltage divider (2 circuits)
10	PS A 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 ± 10%.

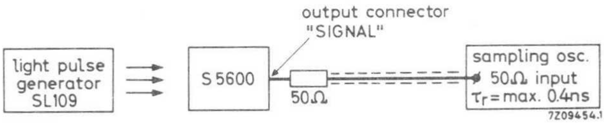
The supply voltage of the limiter must have a positive polarity (V_S = interstage voltage). This voltage is 24 V ± 1 V at a current of about 35 mA.

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.



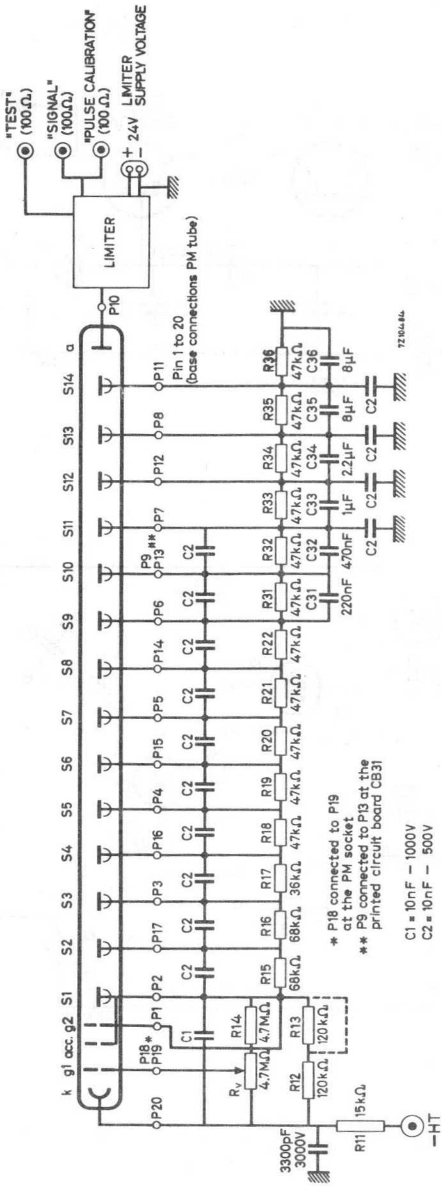
Characteristics of S5600 equipped with a photomultiplier tube type 56AVP or 56DVP

Measuring set-up



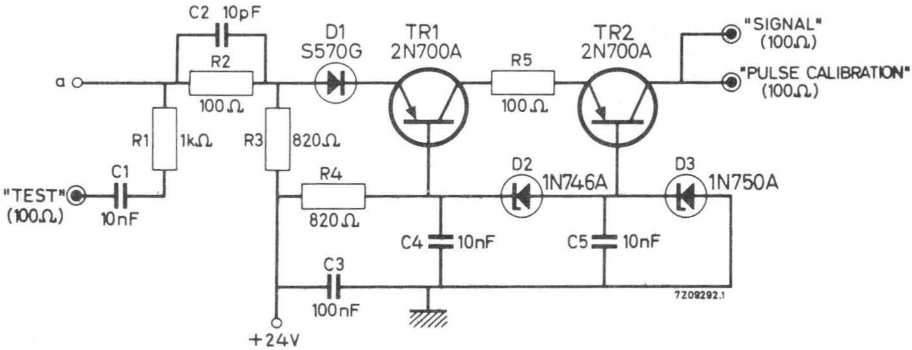
Light pulse rise time τ_r = max. 0.6 ns
Width at half height max. 0.9 ns
H.T. for a gain G = 10^8 : See photomultiplier tube data
Output pulse: τ_r = 4 ns

GENERAL CIRCUIT S5600

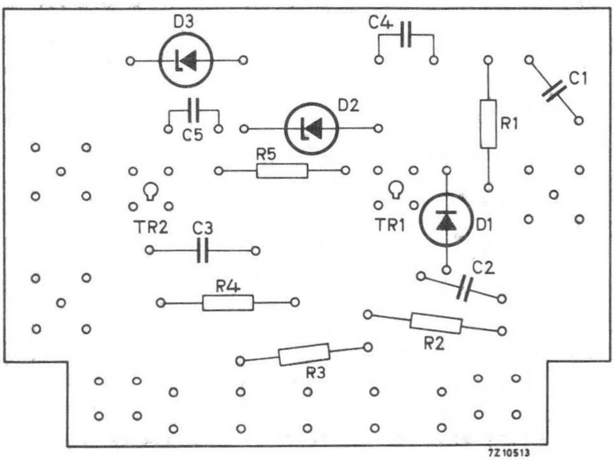


LIMITER PS A 104

Circuit

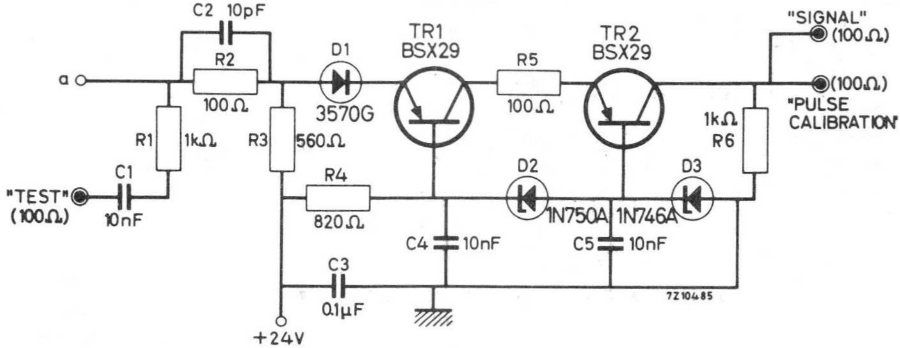


Printed circuit board

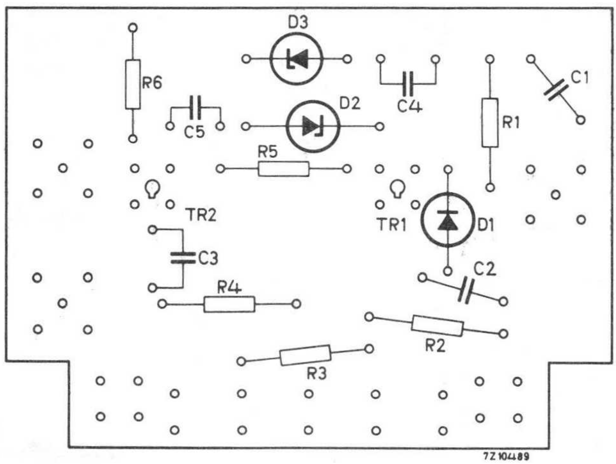


LIMITER PS A 104/0

Circuit

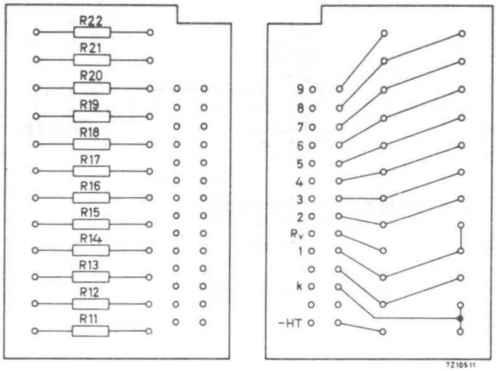


Printed circuit board

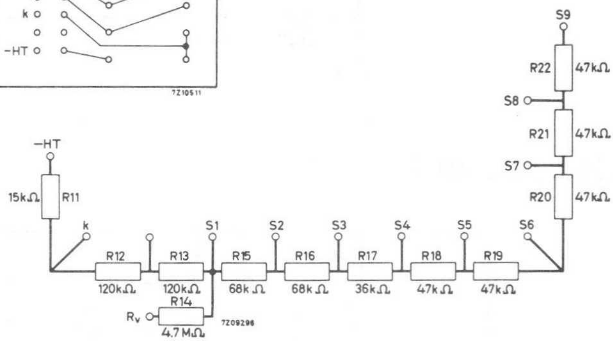


VOLTAGE DIVIDER PS A 101

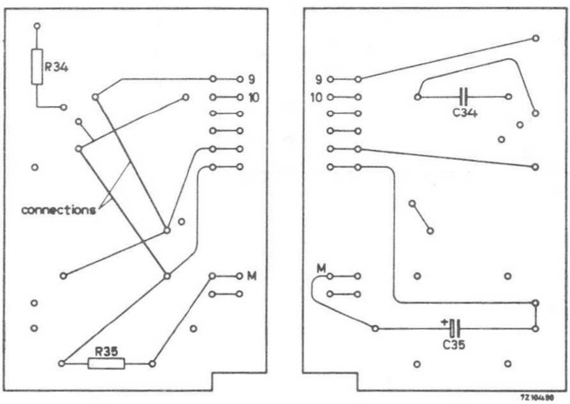
Printed circuit board 1



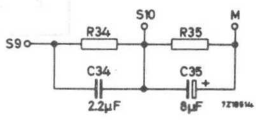
Circuit 1



Printed circuit board 2

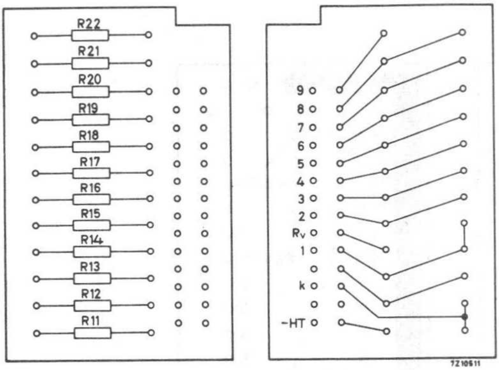


Circuit 2

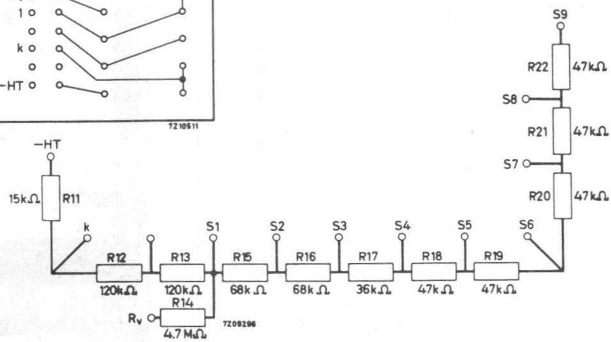


VOLTAGE DIVIDER PS A 103

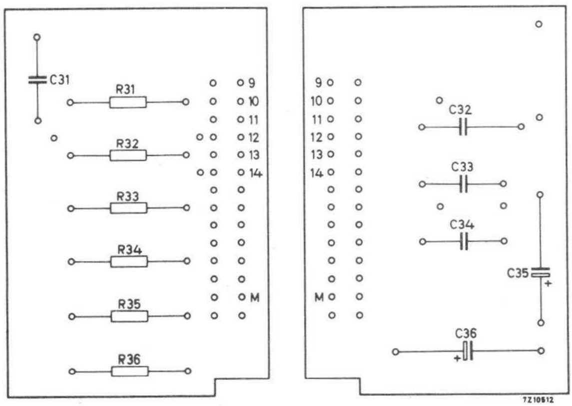
Printed circuit board 1



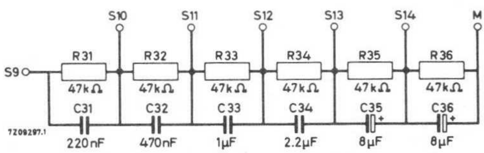
Circuit 1



Printed circuit board 2

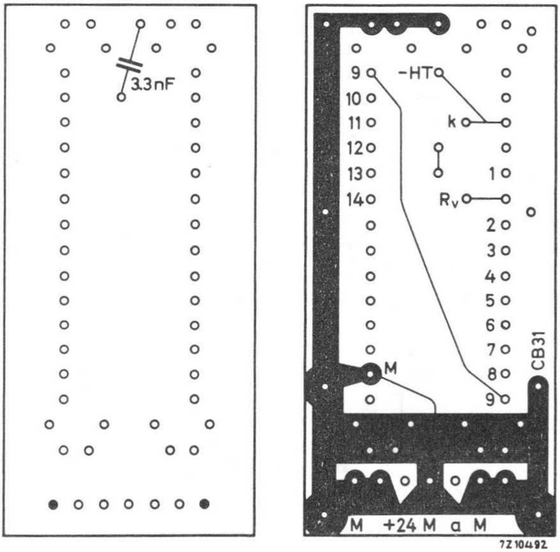


Circuit 2

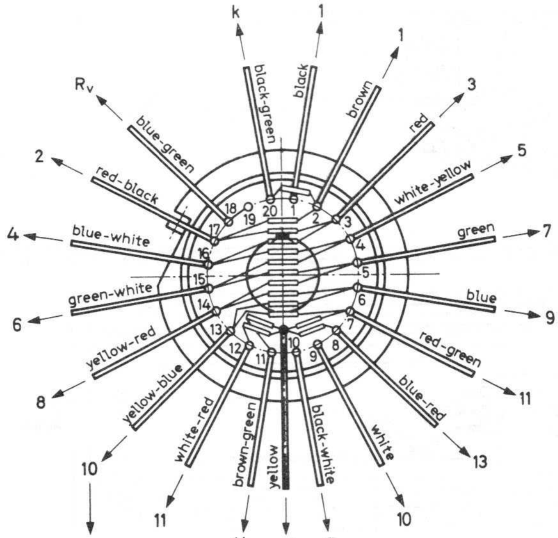


PRINTED CIRCUIT BOARD CB31

Used in all types S5600

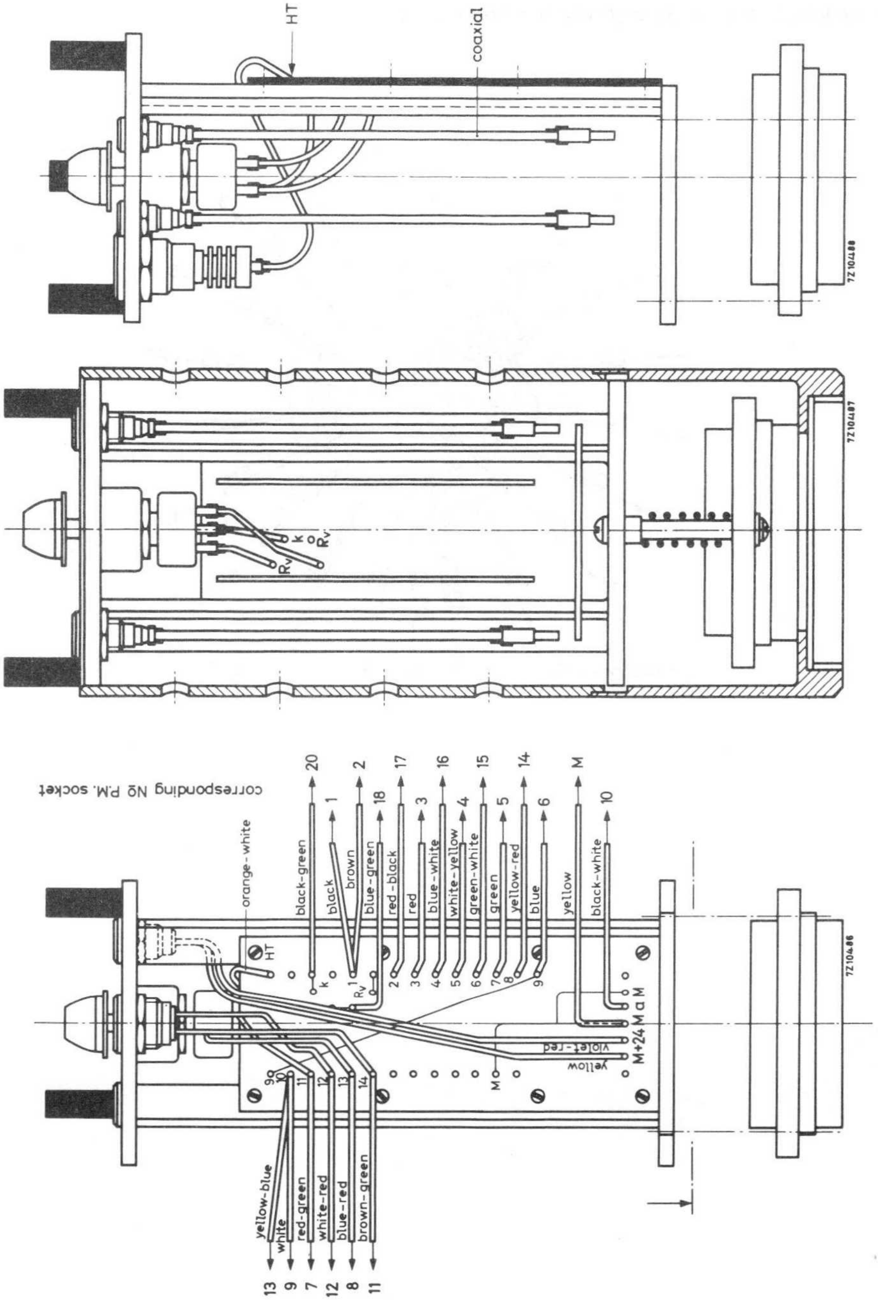


WIRING DIAGRAM PHOTOMULTIPLIER SOCKET



corresponding Nº
printed circuit board

GENERAL WIRING DIAGRAM



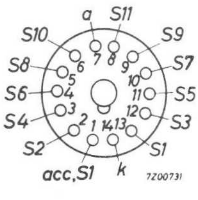
44mm PHOTOSCINTILLATOR

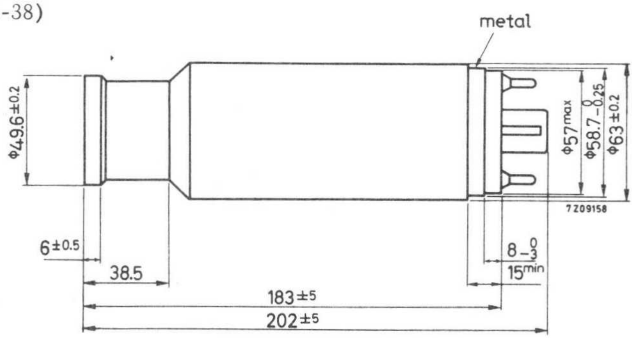
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA	
Photomultiplier tube	153AVP
Scintillator	Na I(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		≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

44mm PHOTOSCINTILLATOR

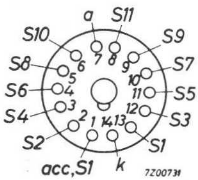
Photoscintillator intended for gamma-ray spectrometry.

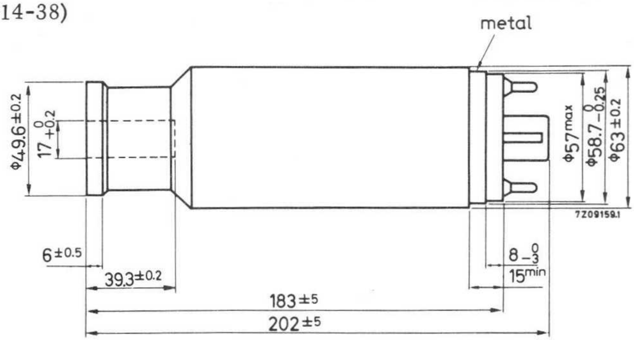
QUICK REFERENCE DATA	
Photomultiplier tube	153AVP
Scintillator	well type NaI(Tl) 44 x 50 mm
Voltage divider	not incorporated
Resolution (^{137}Cs : 661 keV)	≤ 10 %

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	≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

44mm PHOTOSCINTILLATOR

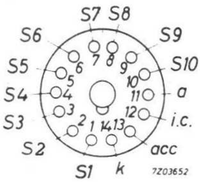
Photoscintillator intended for gamma-ray spectrometry.

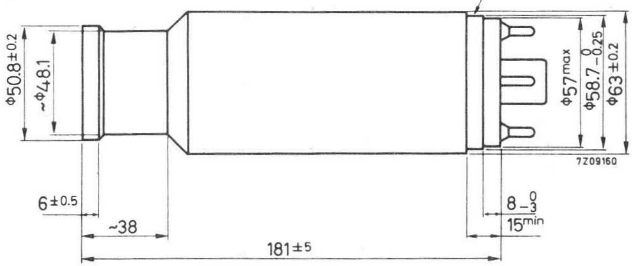
QUICK REFERENCE DATA		
Photomultiplier tube	XP1001	
Scintillator	Na I (Tl) 44 x 50	mm
	with Al window 0.5	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 8	%
Peak/valley ratio (^{60}Co)	≥ 8	

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		≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

44mm PHOTOSCINTILLATOR

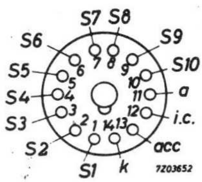
Photoscintillator intended for gamma-ray spectrometry.

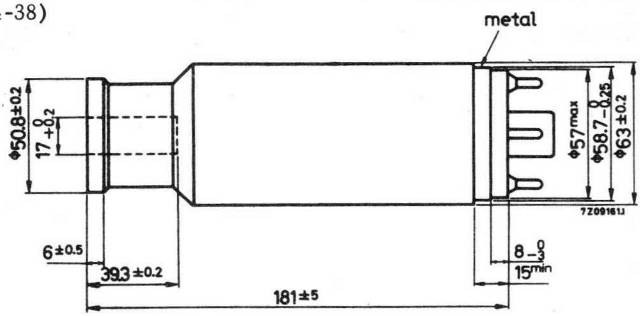
QUICK REFERENCE DATA	
Photomultiplier tube	XP1001
Scintillator	well type Na I (Tl) 44 x 50 mm
Voltage divider	not incorporated
Resolution (^{137}Cs : 661 keV)	≤ 10 %

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: 14-p (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	≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 1800	V

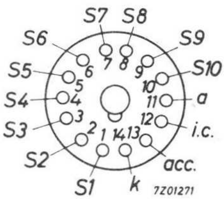
75 mm PHOTOSCINTILLATOR

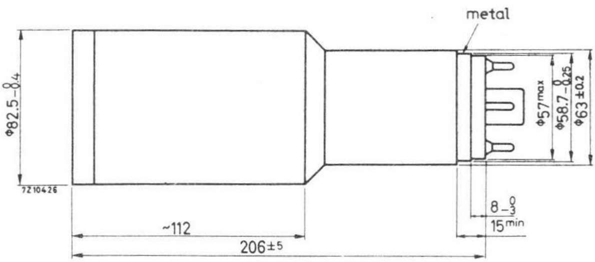
Photoscintillator intended for gamma-ray spectrometry.

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	≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2000	V

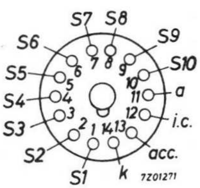
75mm PHOTOSCINTILLATOR

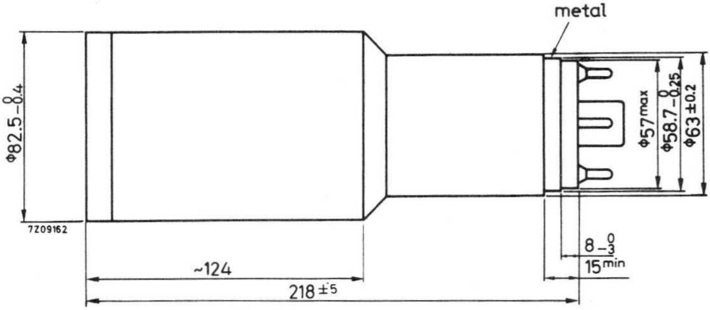
Photoscintillator intended for gamma-ray spectrometry.

QUICK REFERENCE DATA		
Photomultiplier tube	XP1031	
Scintillator	Na I (Tl) 75 x 75	mm
	with Al window 0.5	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	≈ 50 keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2000 V

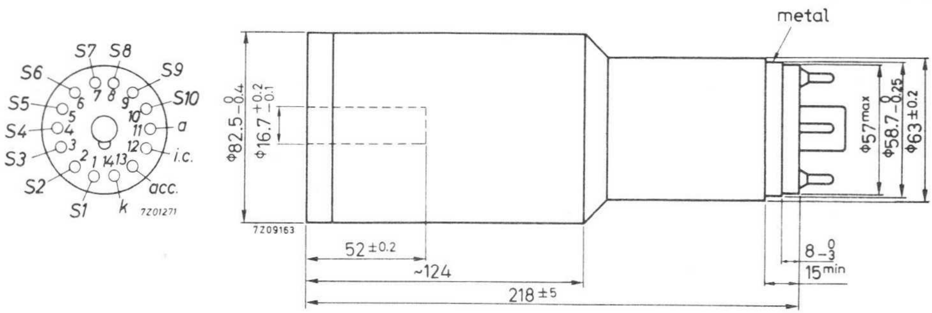
75mm PHOTOSCINTILLATOR

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	≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage V_b max. 2000 V

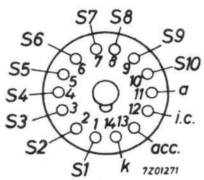
75mm PHOTOSCINTILLATOR

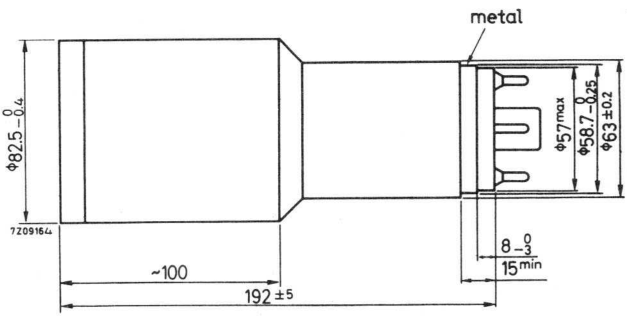
Photoscintillator intended for gamma-ray spectrometry.

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)	$\leq$ 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	≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max. 2000	V

38mm PHOTOSCINTILLATOR

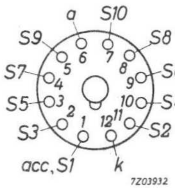
Photoscintillator intended for gamma-ray spectrometry.

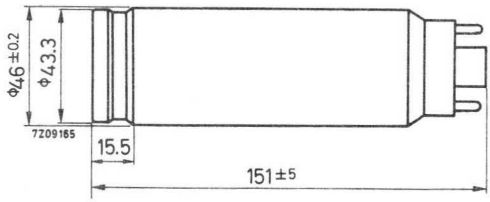
QUICK REFERENCE DATA		
Photomultiplier tube	selected 150AVP	
Scintillator	NaI (Tl) 38 x 25	mm
	with Al window 0.5	mm
Voltage divider	not incorporated	
Resolution (^{137}Cs : 661 keV)	≤ 9	%

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		≈ 50	keV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	1800	V

Radiation counter tubes

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.

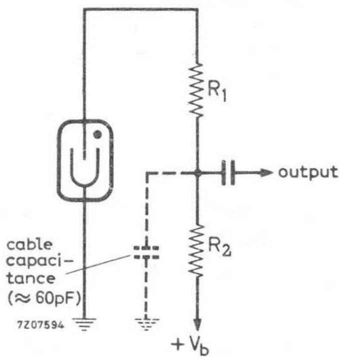
3.4 Plateau slope. The percentage change in count rate for a given change (usually 1 V) in anode supply voltage.

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.

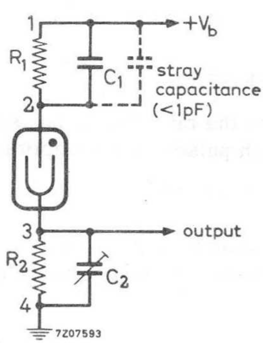
4. MEASURING CIRCUITS

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

$V_b = \frac{V_{b_1}+V_{b_2}}{2}$ and at $t_{amb} = 25\ ^oC$.

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, however, it is recommended to operate at a lower count rate than this maximum value.

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.

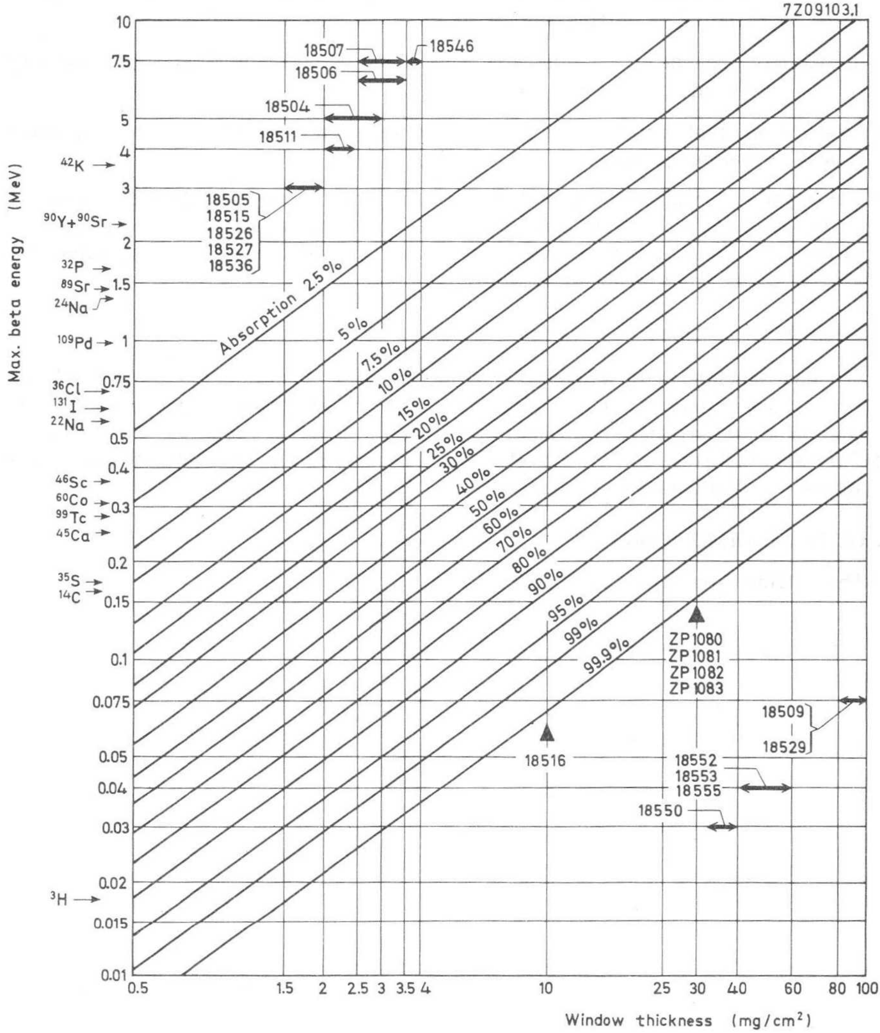
9. OUTSIDE PRESSURE

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

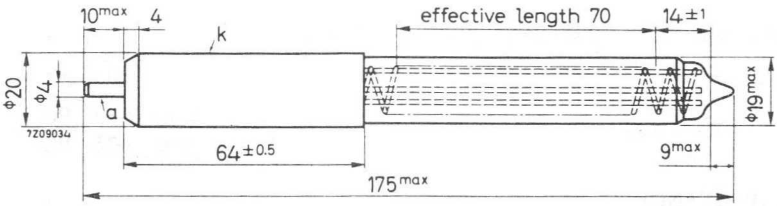
BETA AND GAMMA RADIATION COUNTER TUBE

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

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1 C_{stray} = R_2 C_2$

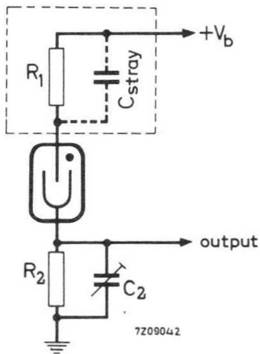
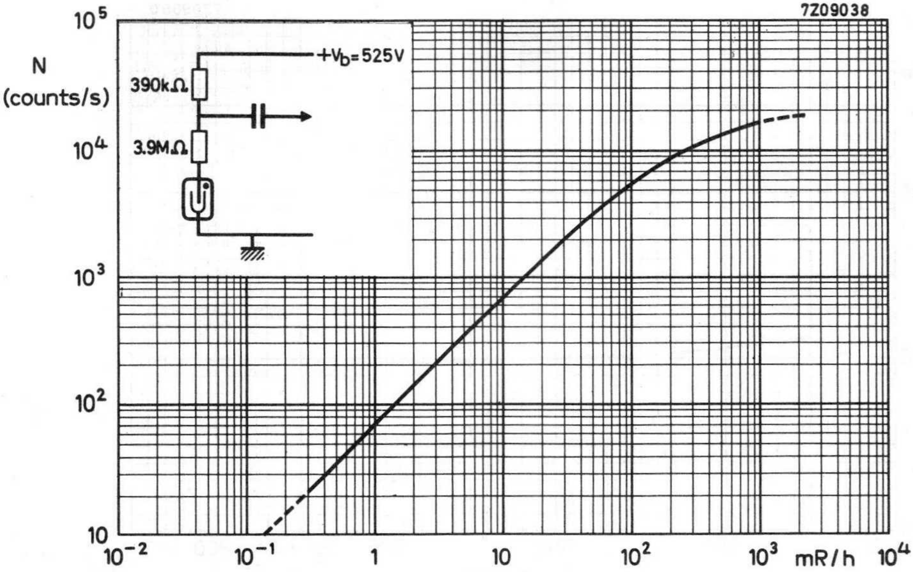


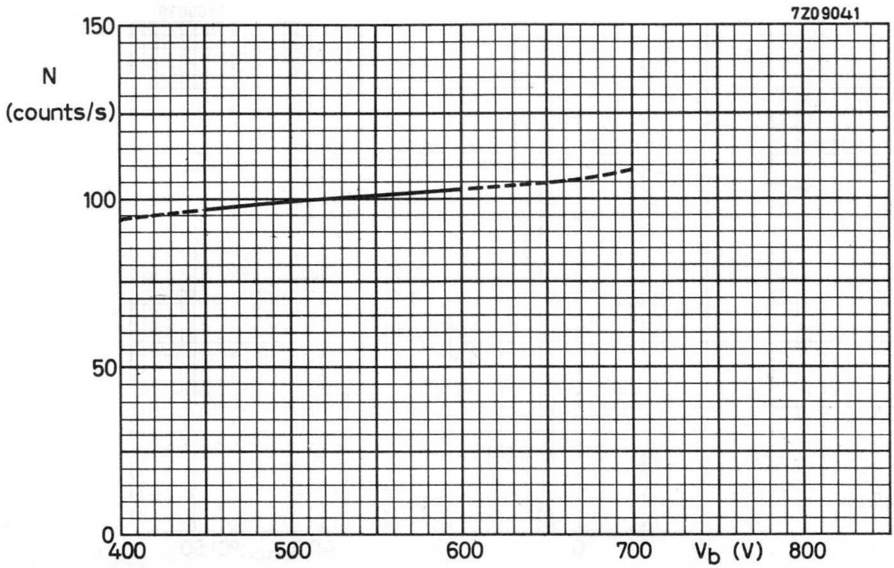
Fig.1

REMARK

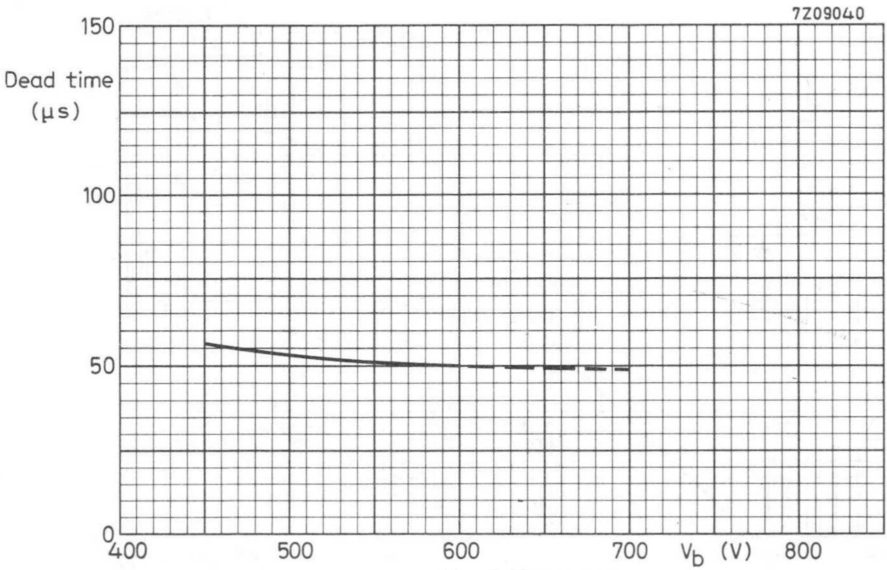
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



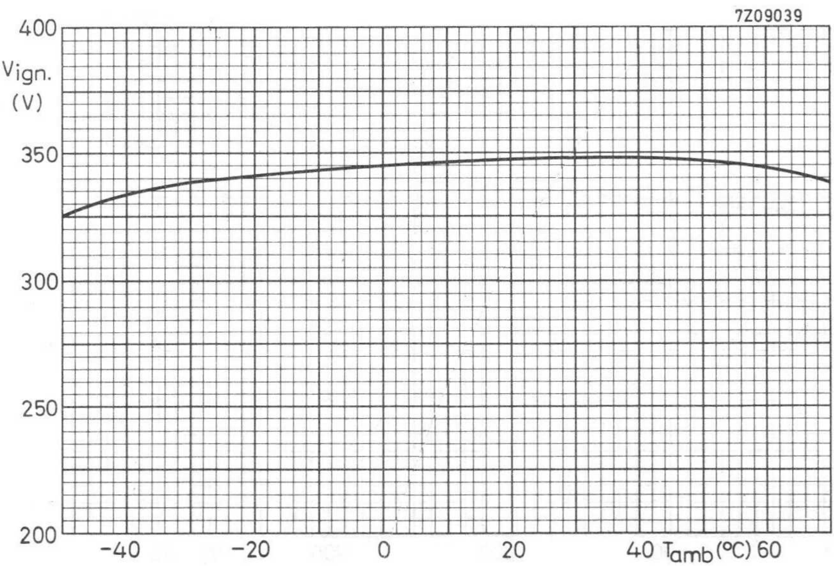
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

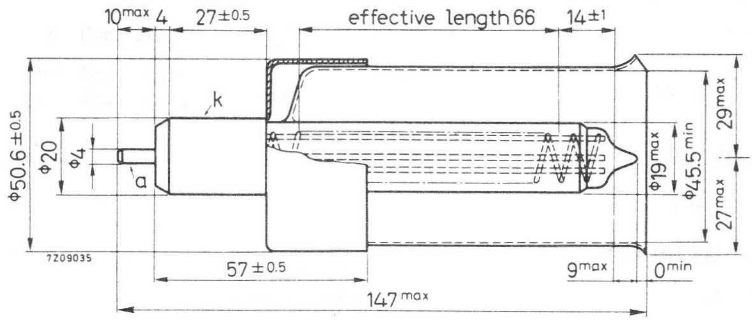
BETA AND GAMMA RADIATION COUNTER TUBE

Glass wall halogen quenched β and γ radiation pour-in 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
Liquid capacity	100	cm^3

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base matched to socket DIN 44421



GLASS WALL

Thickness	30	mg/cm^2
Effective length	66	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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1 C_{stray} = R_2 C_2$

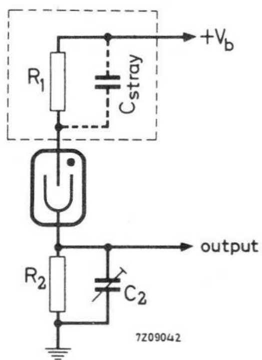
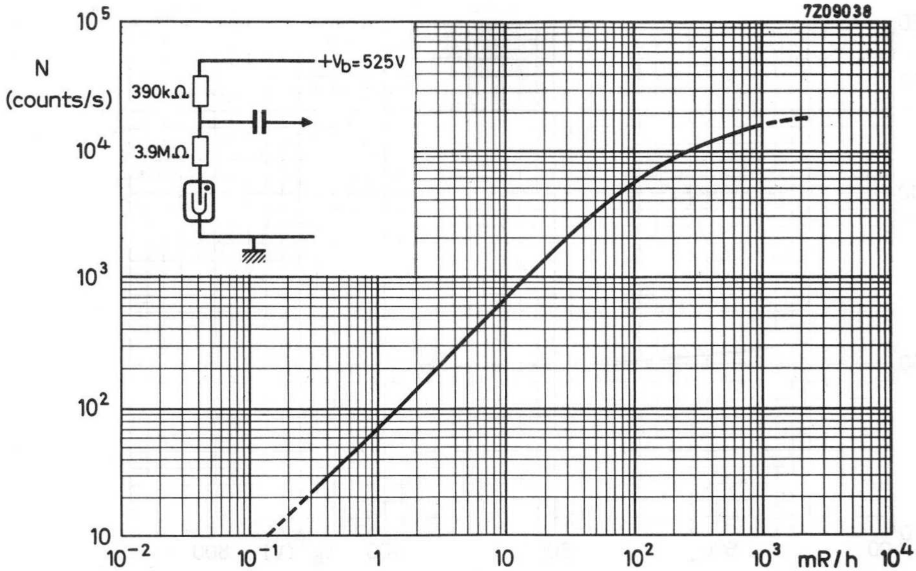


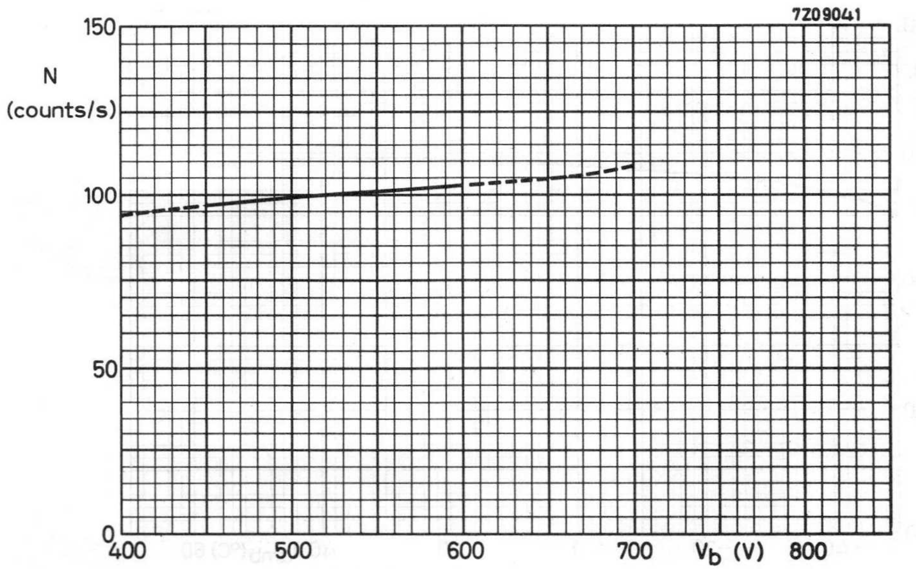
Fig.1

REMARK

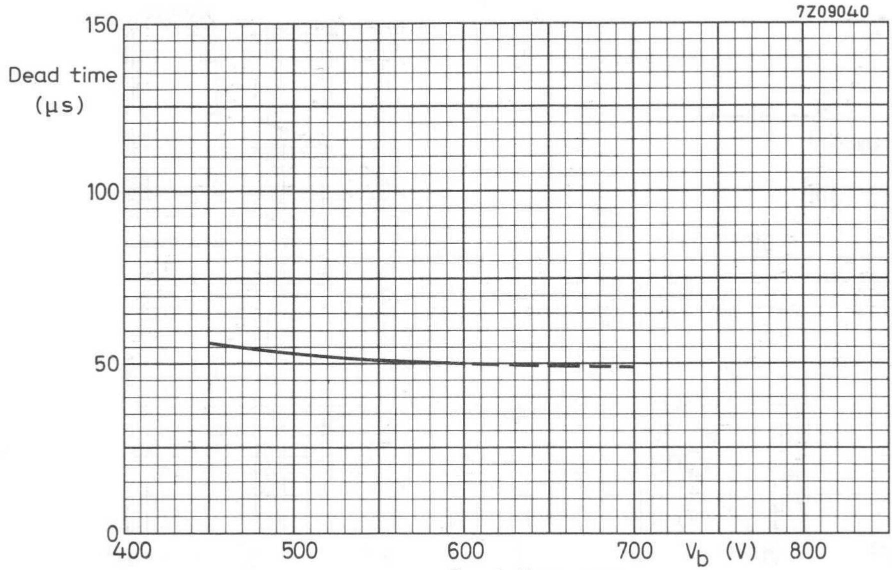
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



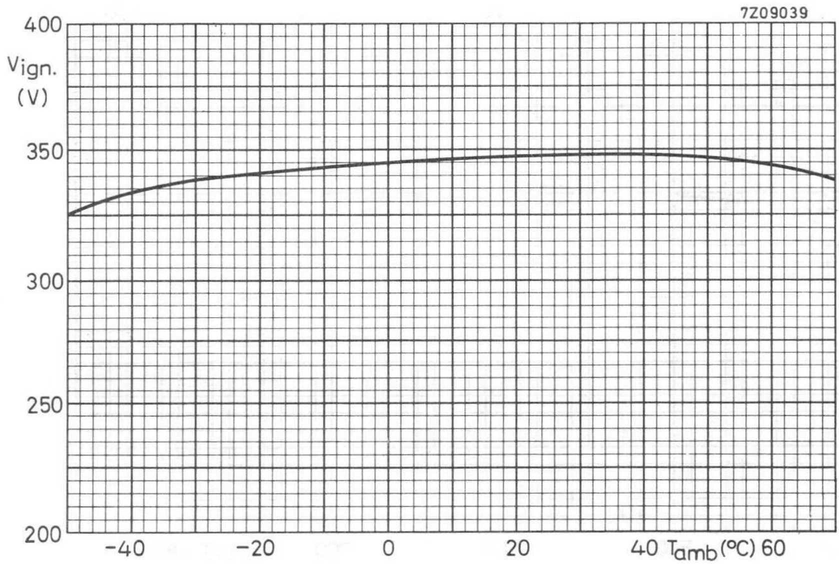
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

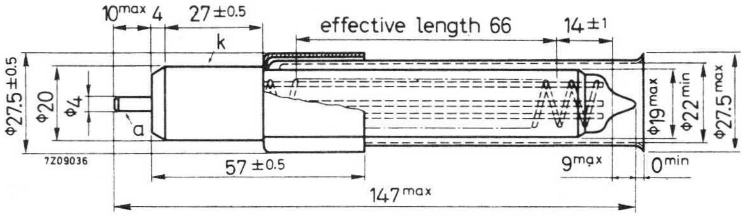
BETA AND GAMMA RADIATION COUNTER TUBE

Glass wall halogen quenched β and γ radiation pour-in 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
Liquid capacity	10	cm^3

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base matched to socket DIN 44421



GLASS WALL

Thickness	30	mg/cm^2
Effective length	66	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 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1C_{stray} = R_2C_2$

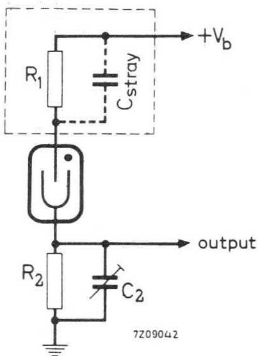
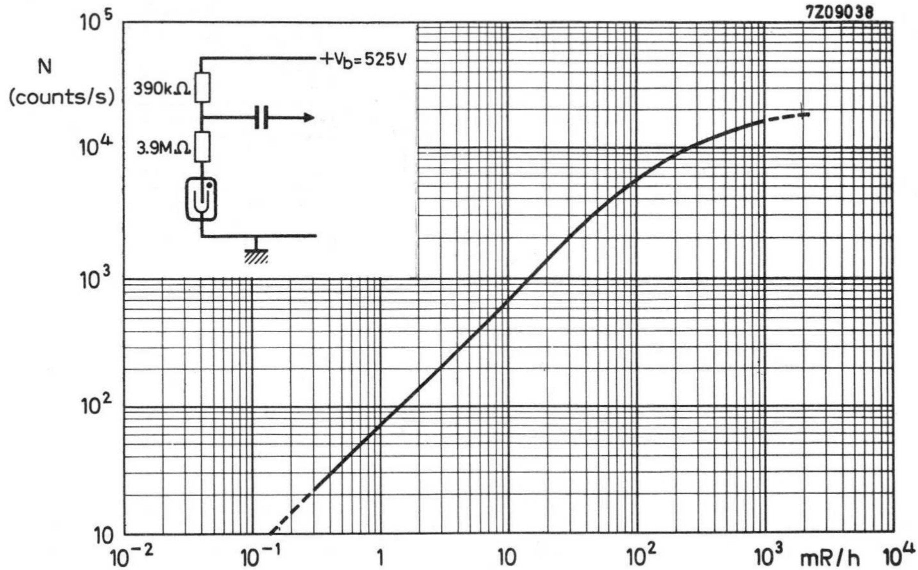


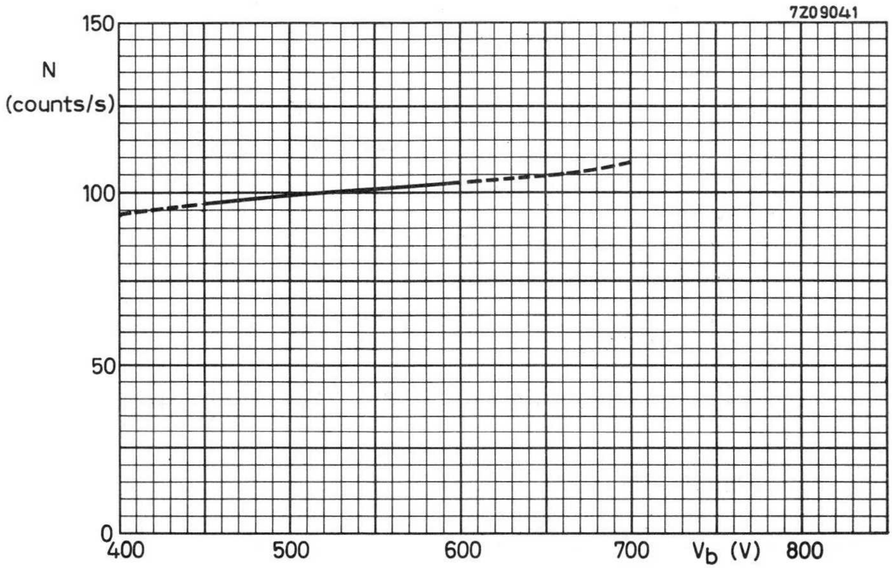
Fig.1

REMARK

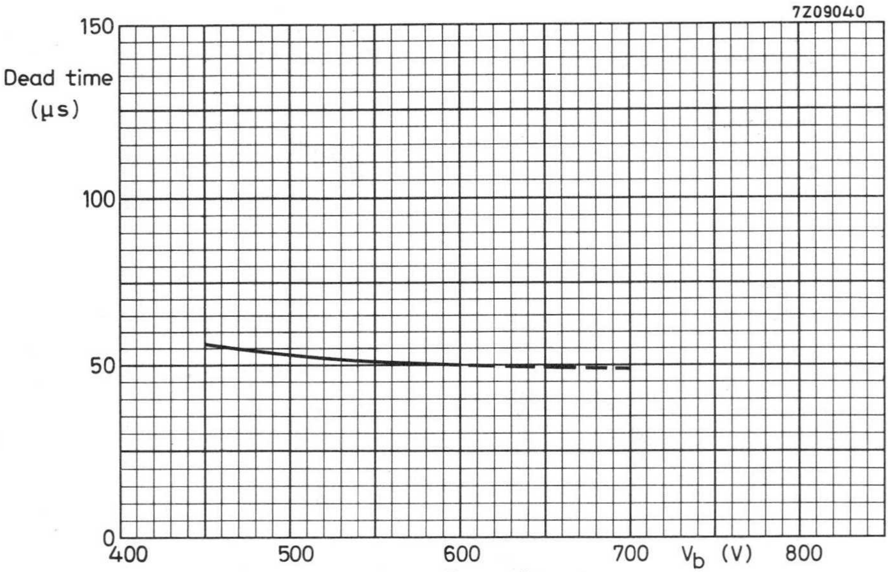
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



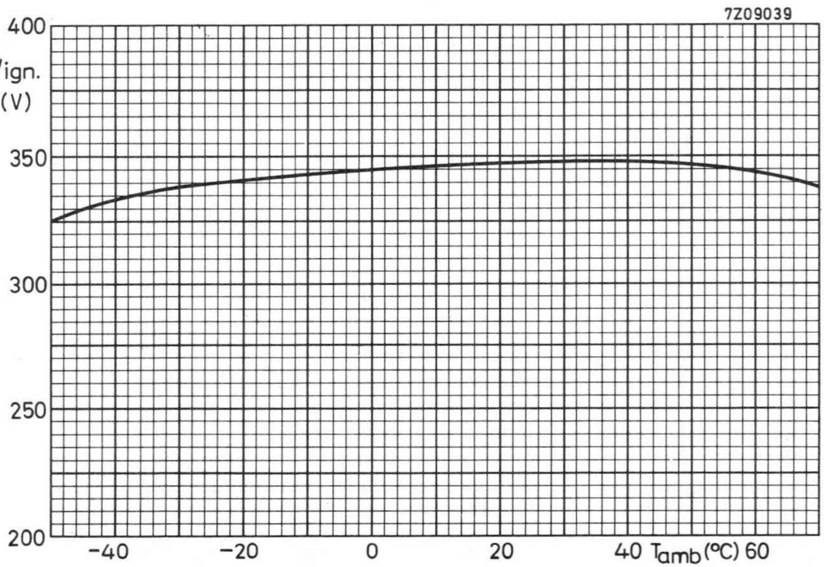
Count rate as function of dose rate



Plateau curve



Dead time curve



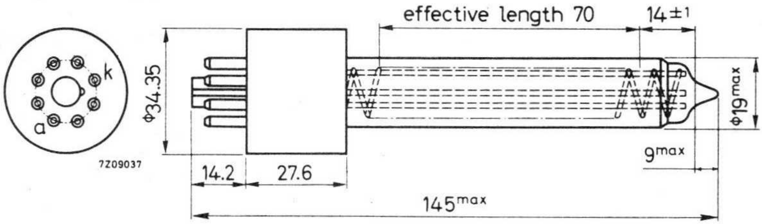
Starting voltage as function of ambient temperature

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 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 3.9 MΩ

R_2 = 68 kΩ

$R_1C_{stray} = R_2C_2$

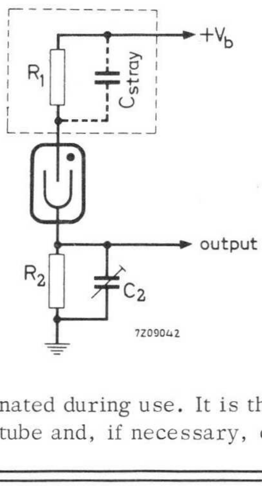
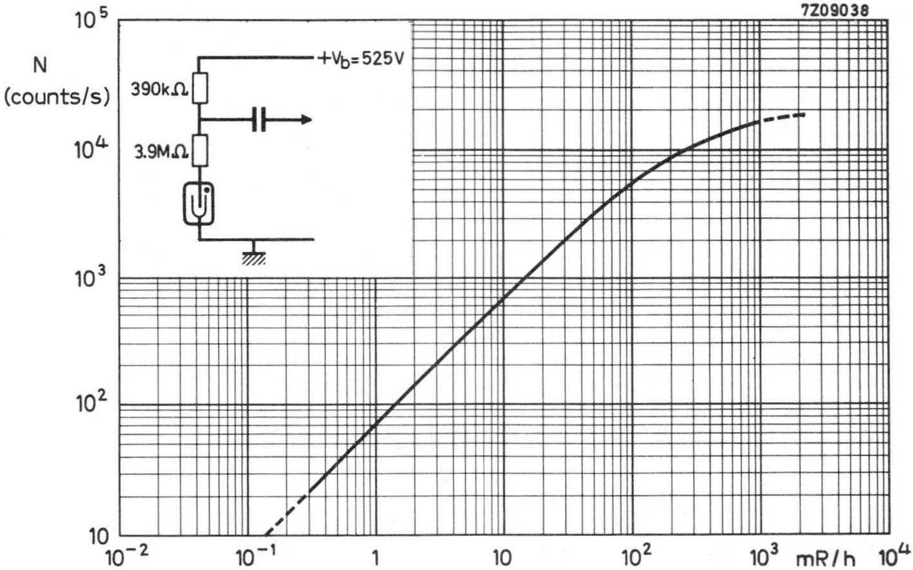


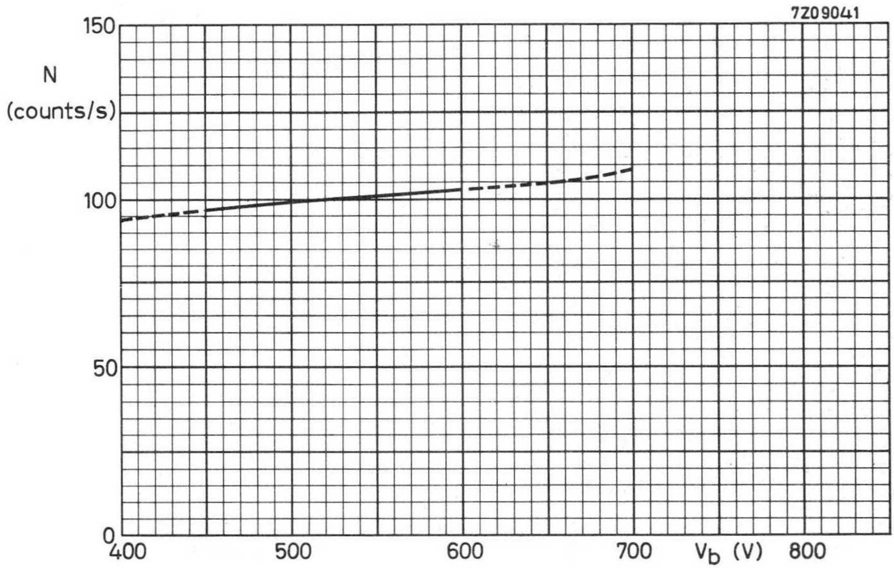
Fig.1

REMARK

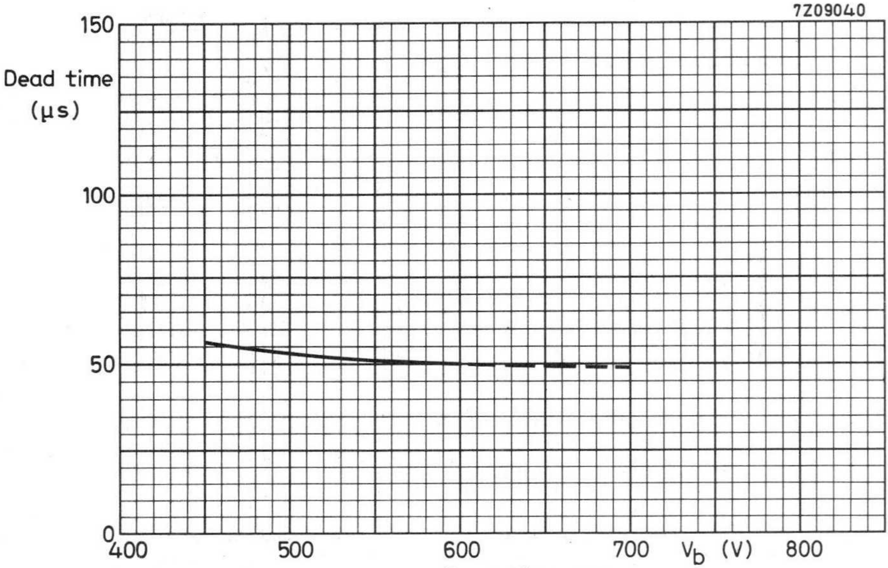
The glass wall may become contaminated during use. It is therefore recommended to check the background level of the tube and, if necessary, clean it.



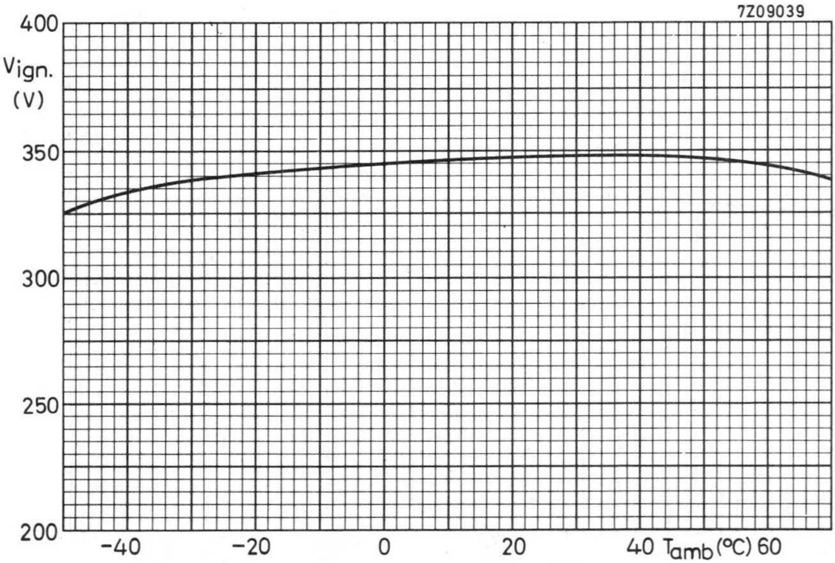
Count rate as function of dose rate



Plateau curve



Dead time curve



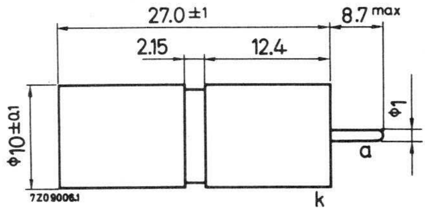
Starting voltage as function of ambient temperature

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUITS

R_1 = 2.2 MΩ

R_2 = 56 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

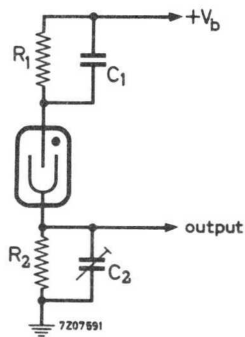
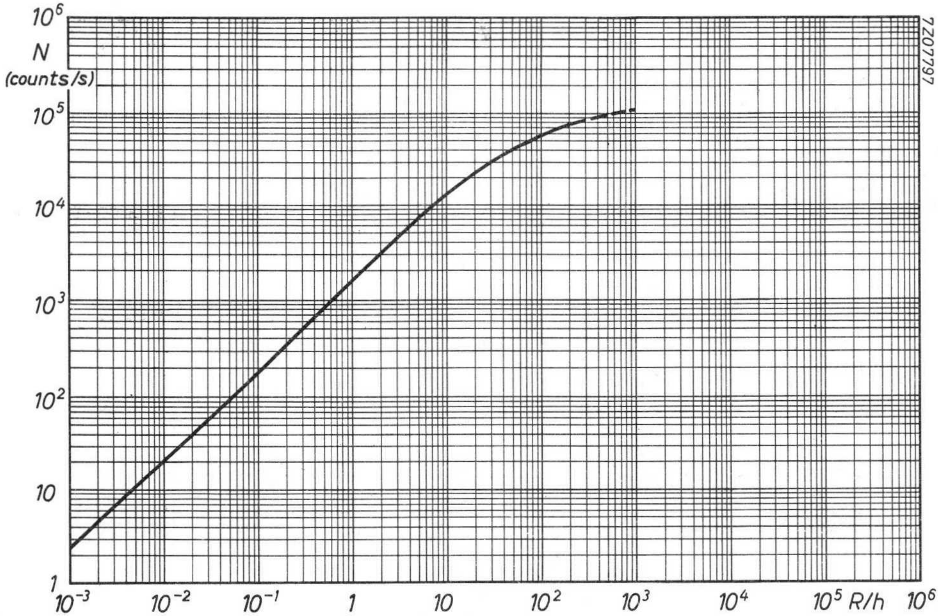
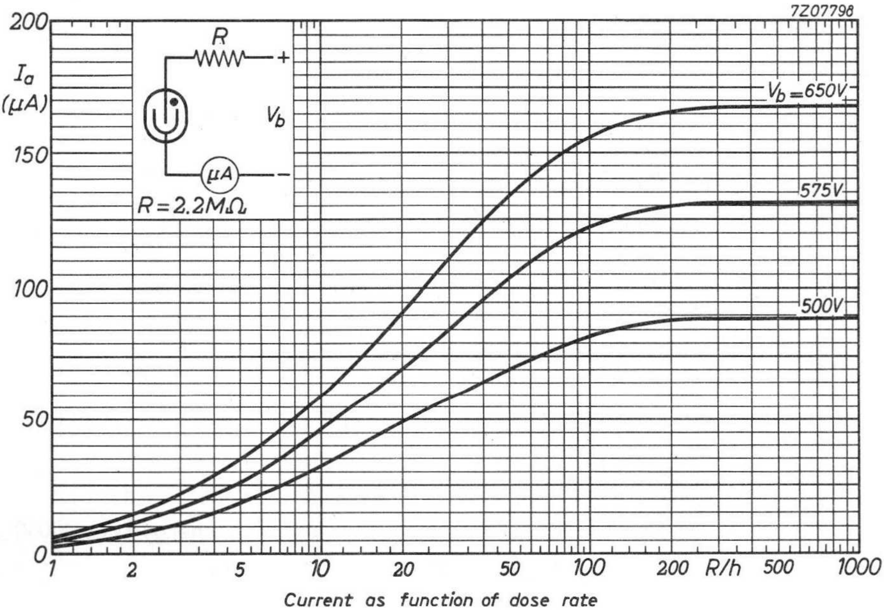


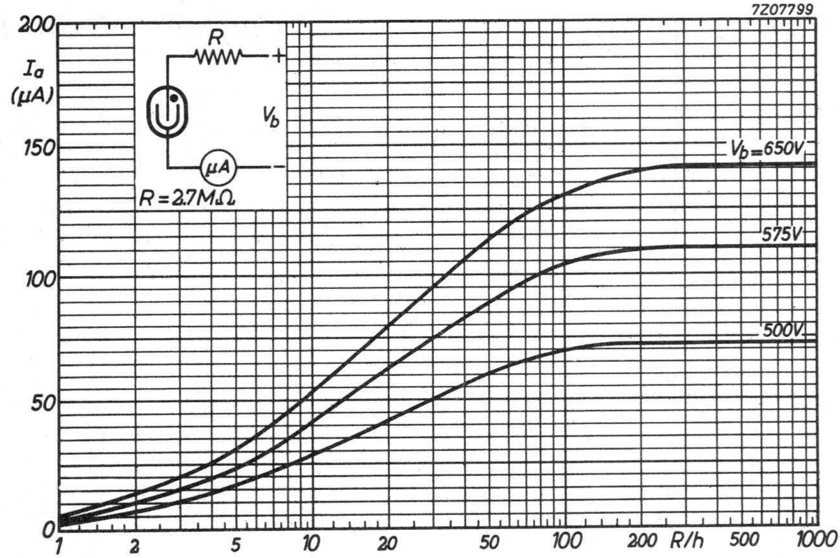
Fig.1



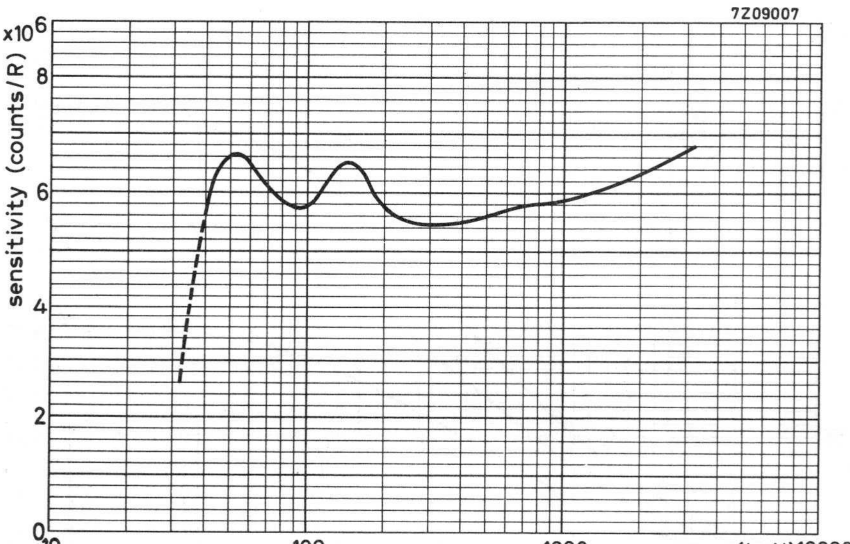
Count rate as function of dose rate



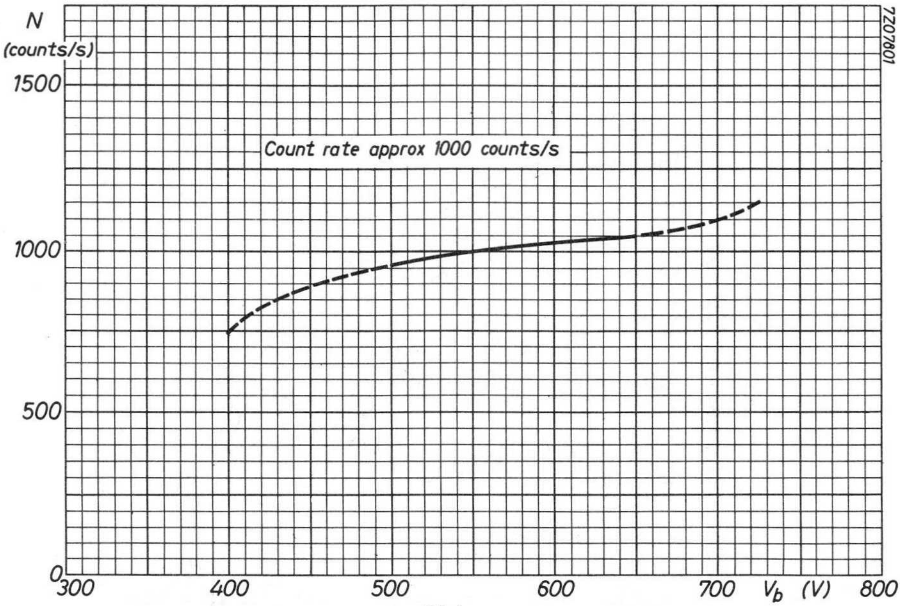
Current as function of dose rate



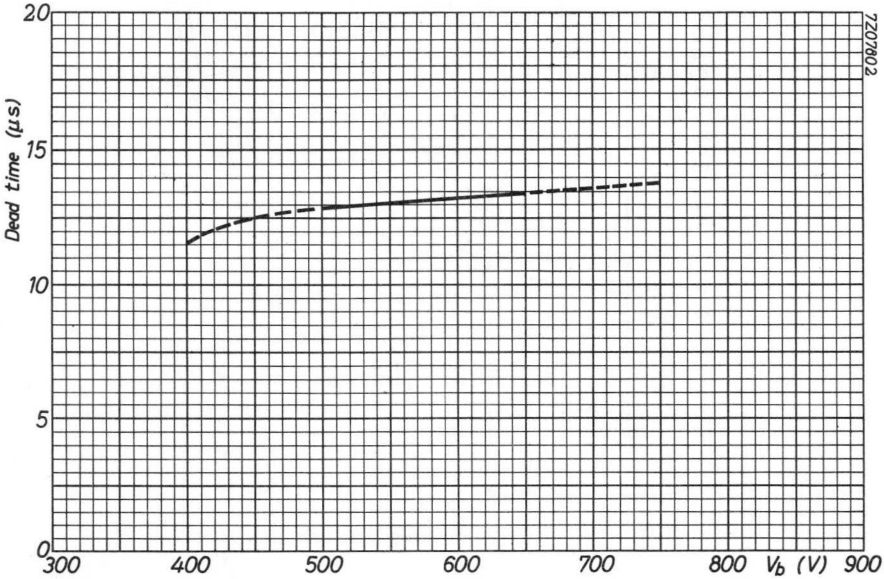
Current as function of dose rate



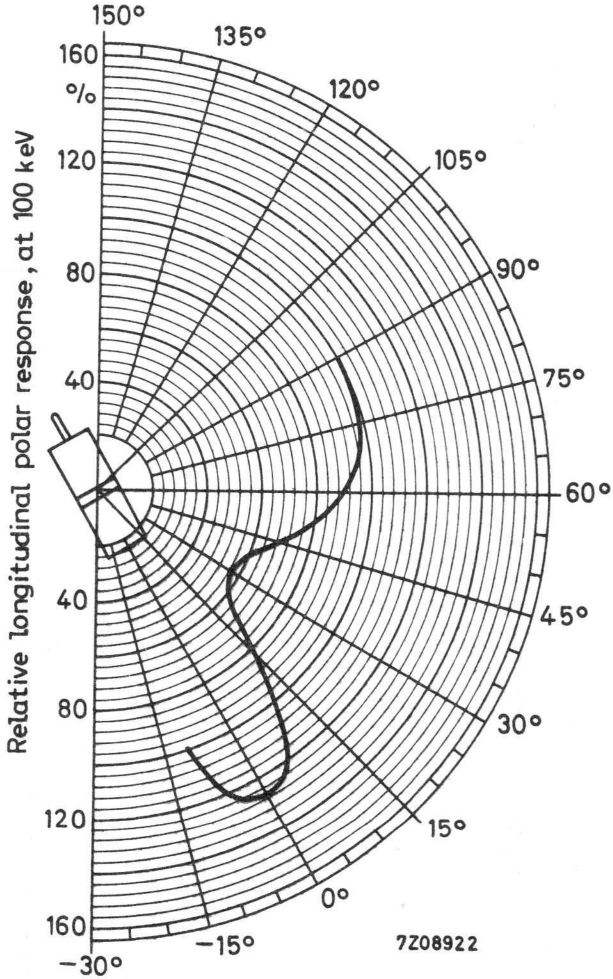
Energy response curve (side response)



Plateau curve



Dead time curve



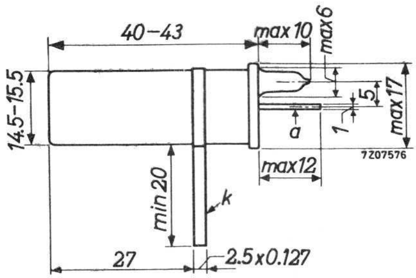
150°
135°
120°
105°
90°
75°
60°
45°
30°
15°
0°
−15°
−30°
160
%
120
80
40
40
80
120
160
Relative longitudinal polar response, at 100 keV
7Z08922

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.0.03	%/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 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy 5.10[10] counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

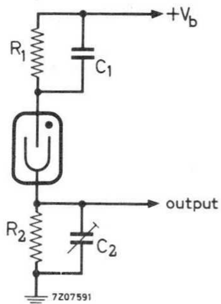
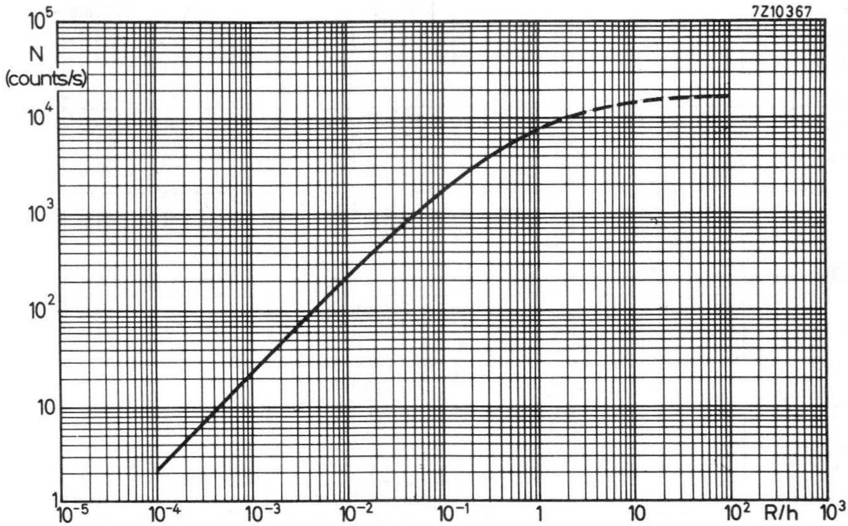
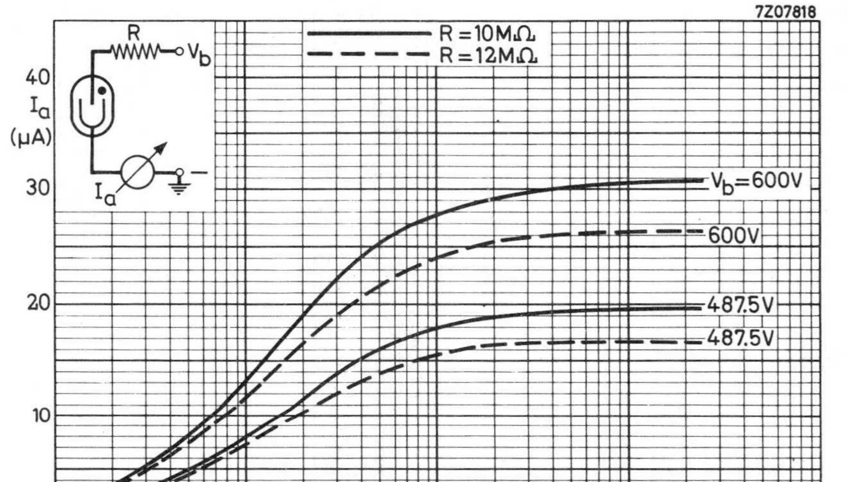


Fig.1

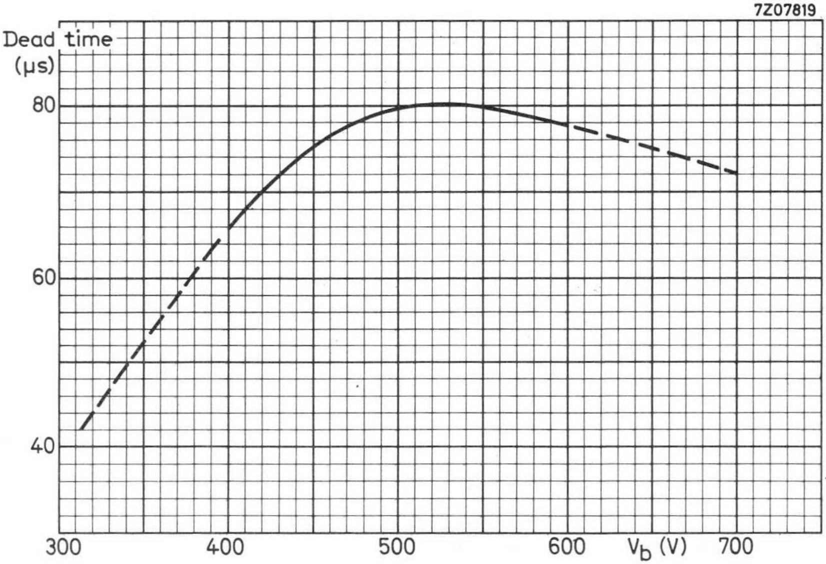
1) Temperature coefficient of starting voltage = 0.5 V/°C



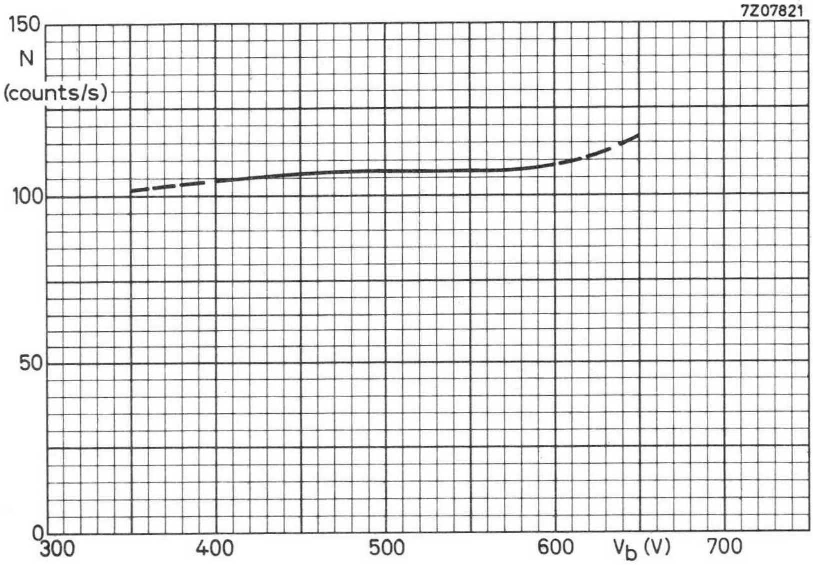
Count rate as function of dose rate



Current as function of dose rate



Dead time curve



Plateau curve

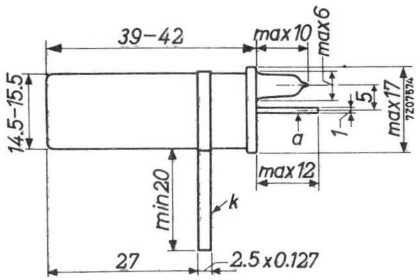
BETA AND GAMMA RADIATION COUNTER TUBE

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.	0.03	%/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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

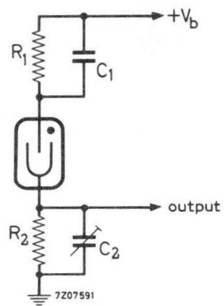
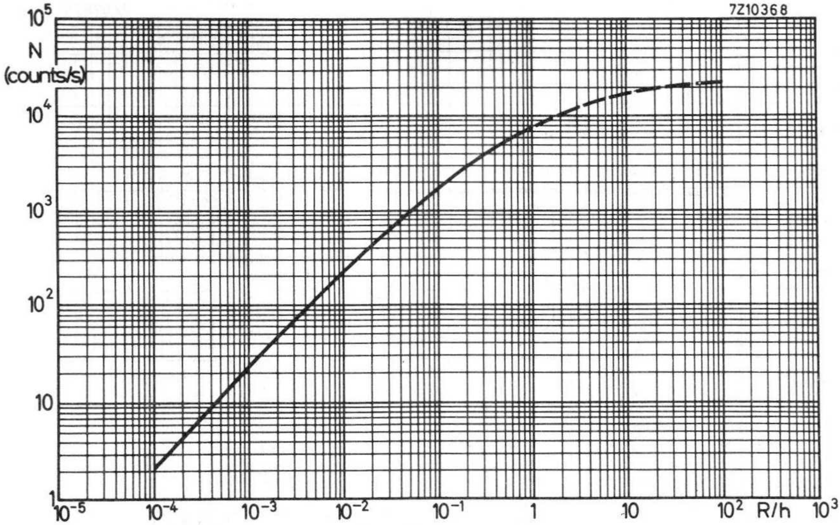
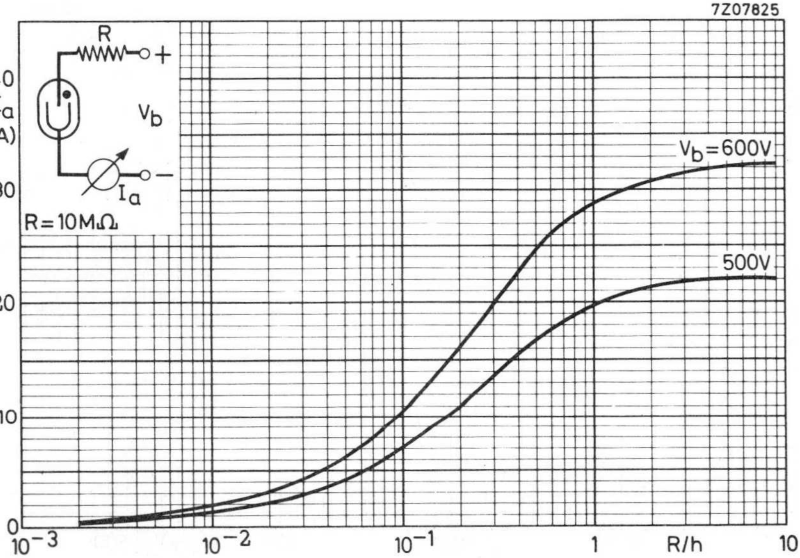


Fig.1

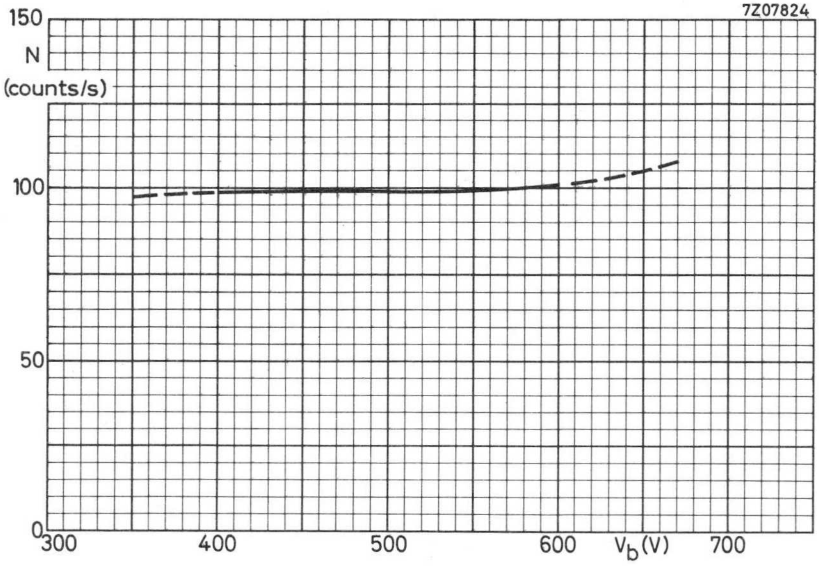
1) Temperature coefficient of starting voltage = 0.5 V/°C



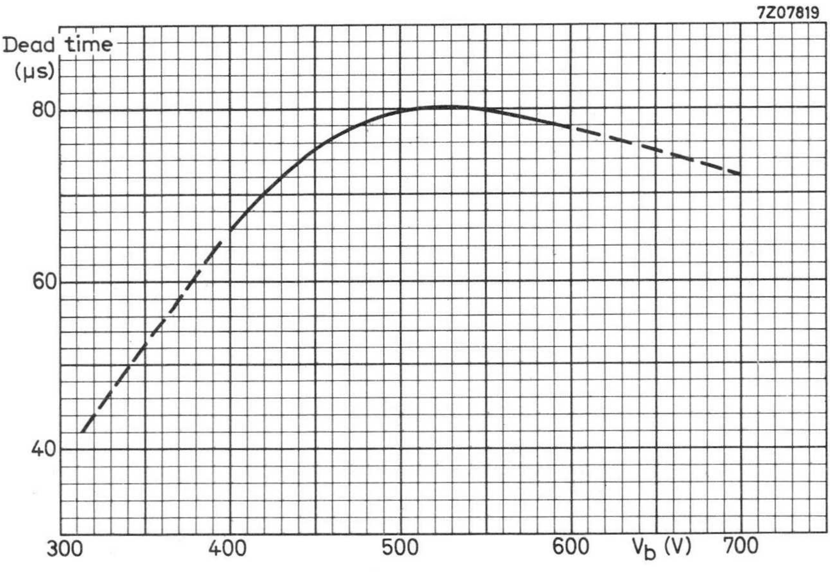
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



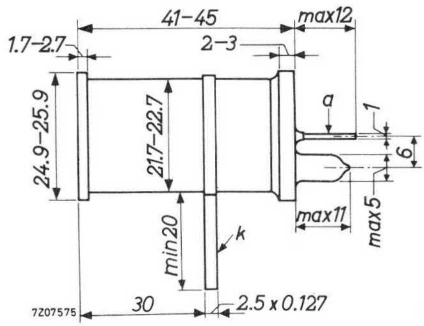
Dead time curve

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_l	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 10 MΩ

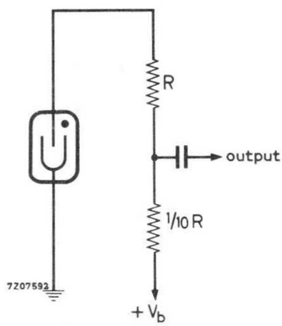
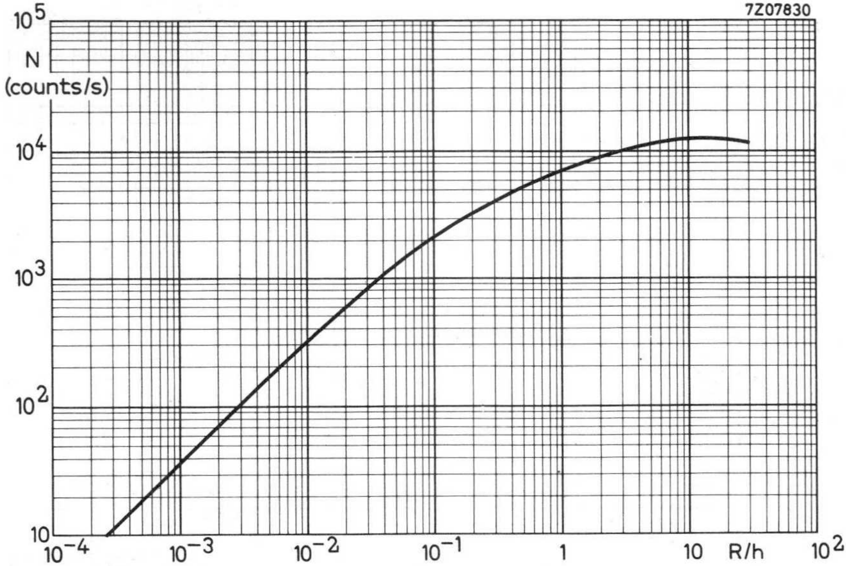
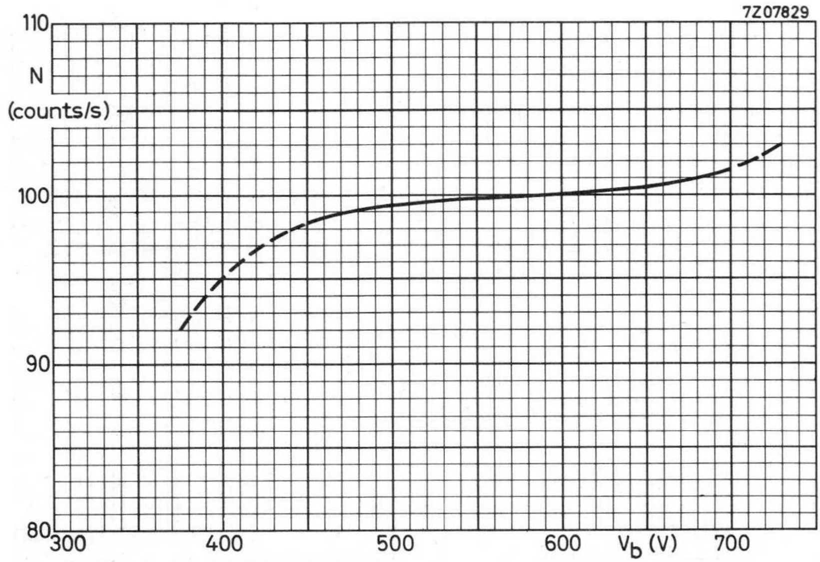


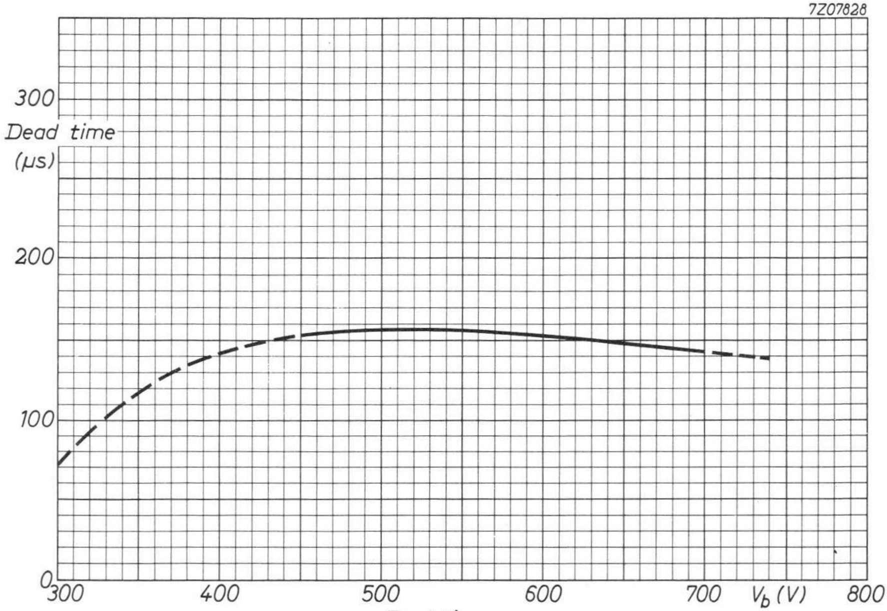
Fig.1



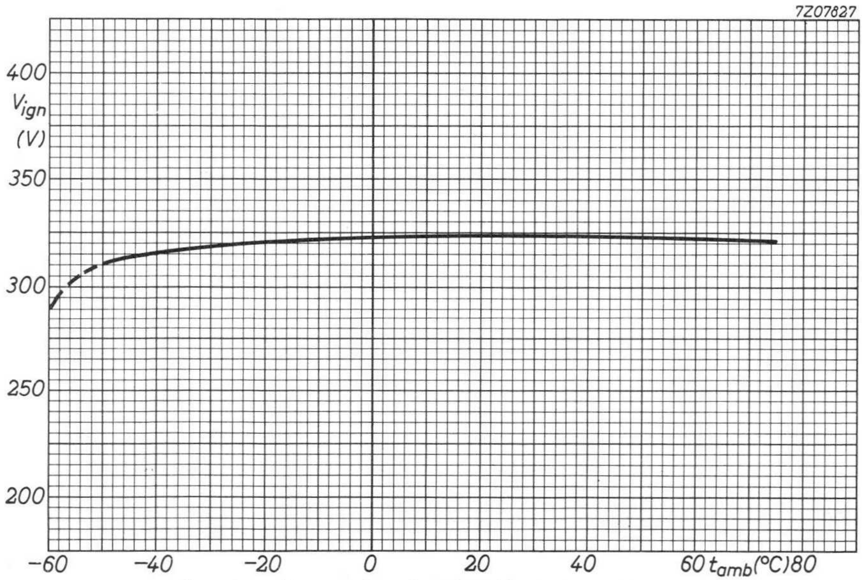
Count rate as function of dose rate



Plateau curve



Dead time curve



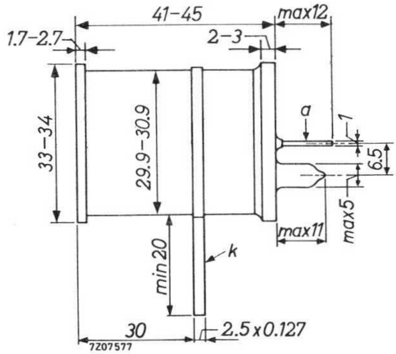
Starting voltage as function of ambient temperature

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

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

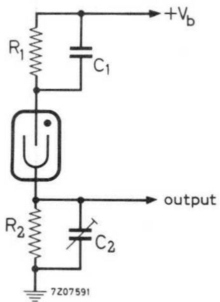
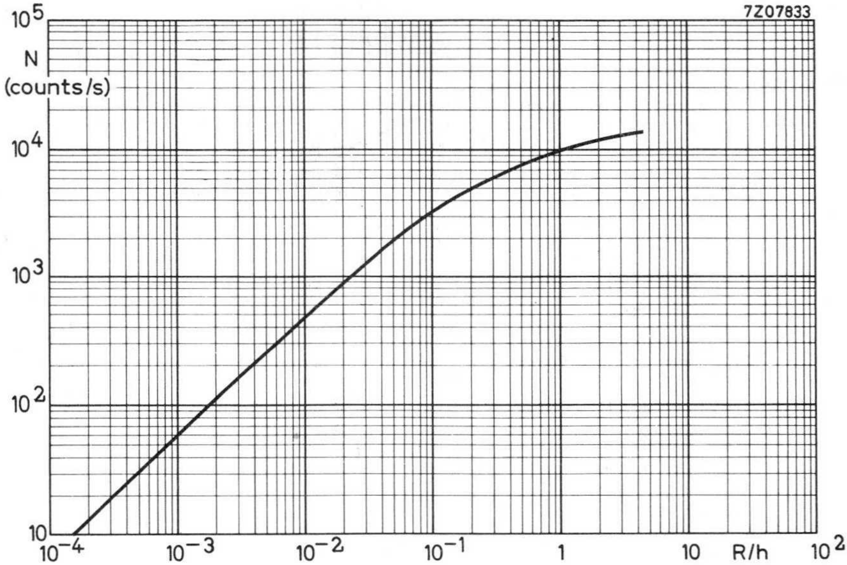
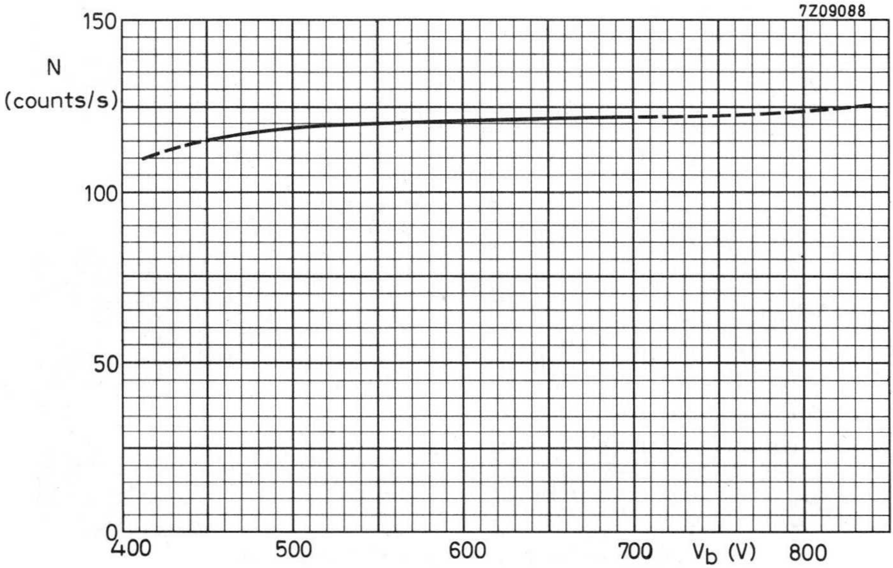


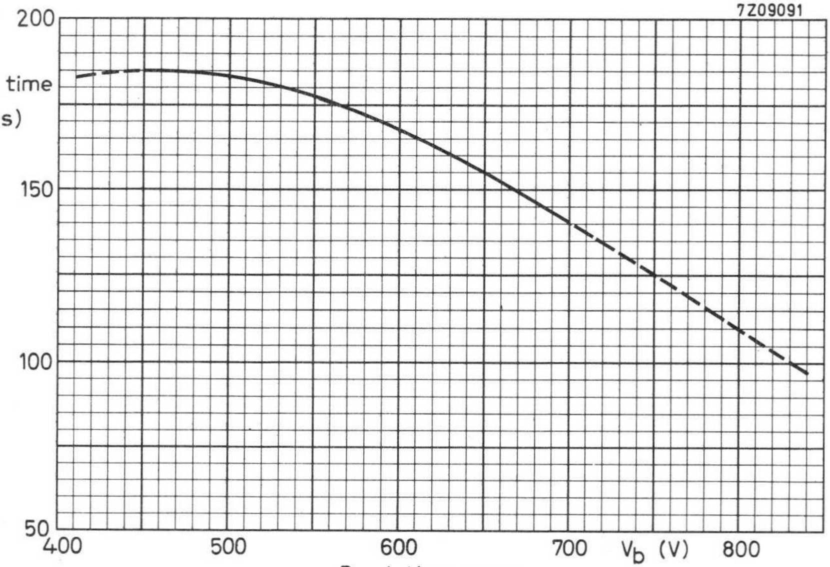
Fig.1



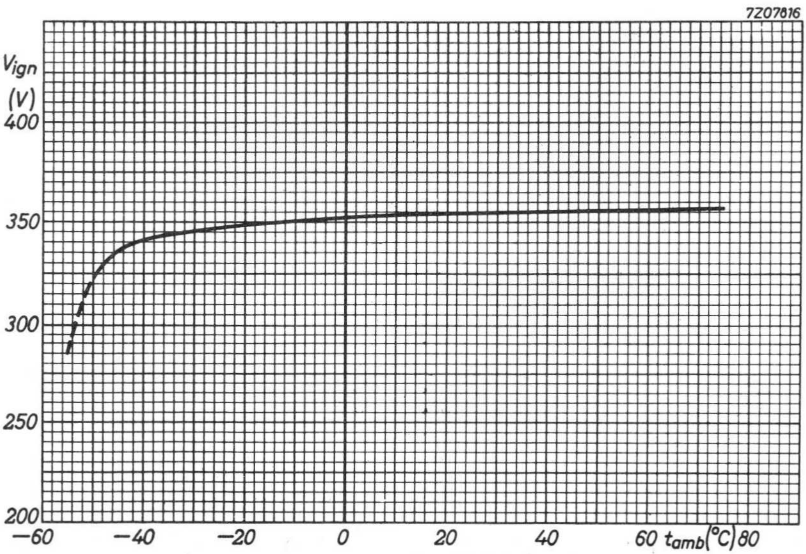
Count rate as function of dose rate (side response)



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

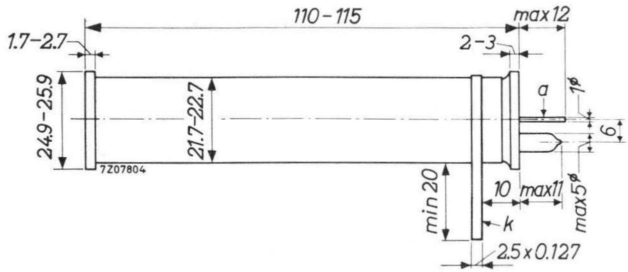
X-RAY COUNTER TUBE

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

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

LIFE EXPECTANCY

Life expectancy 10^{10} counts

MEASURING CIRCUIT

R = 5 MΩ

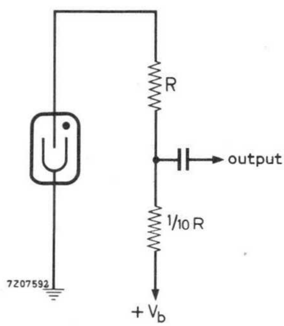
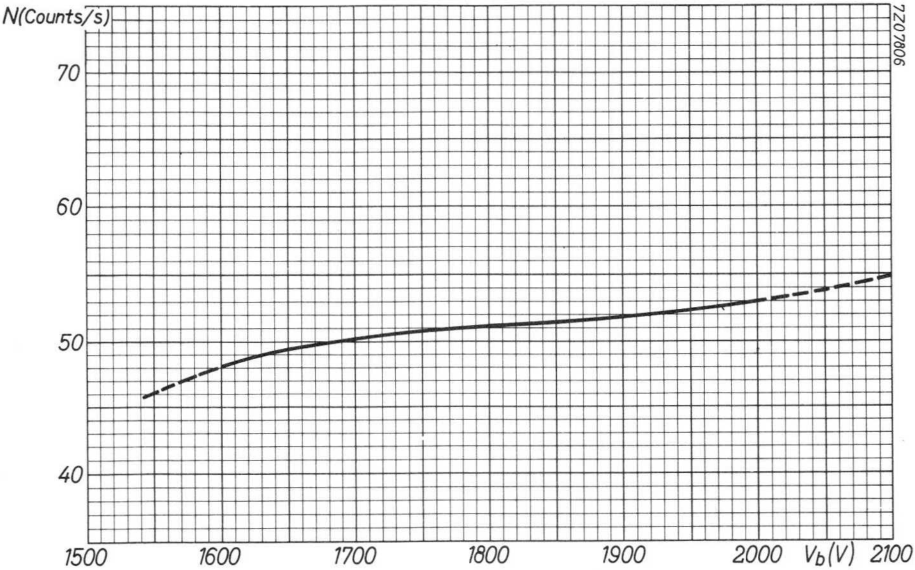
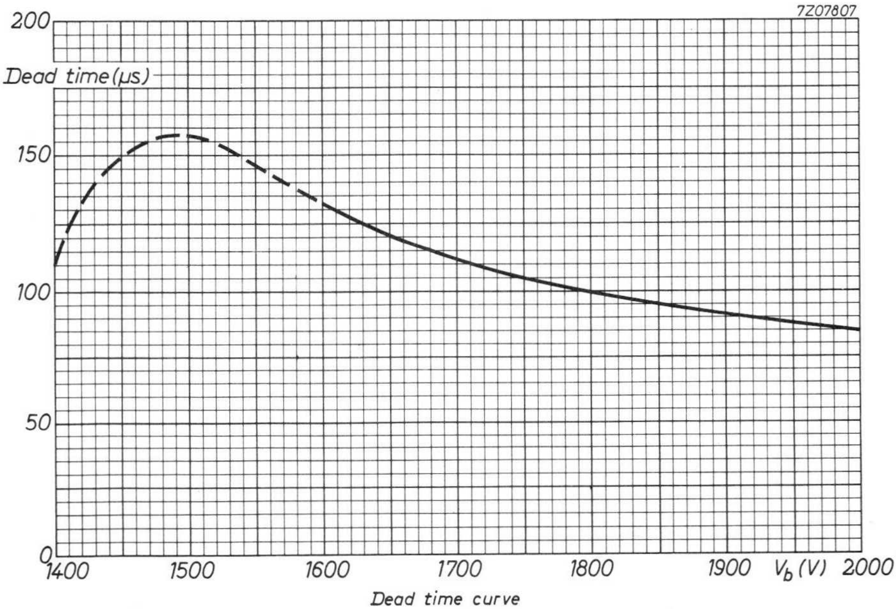


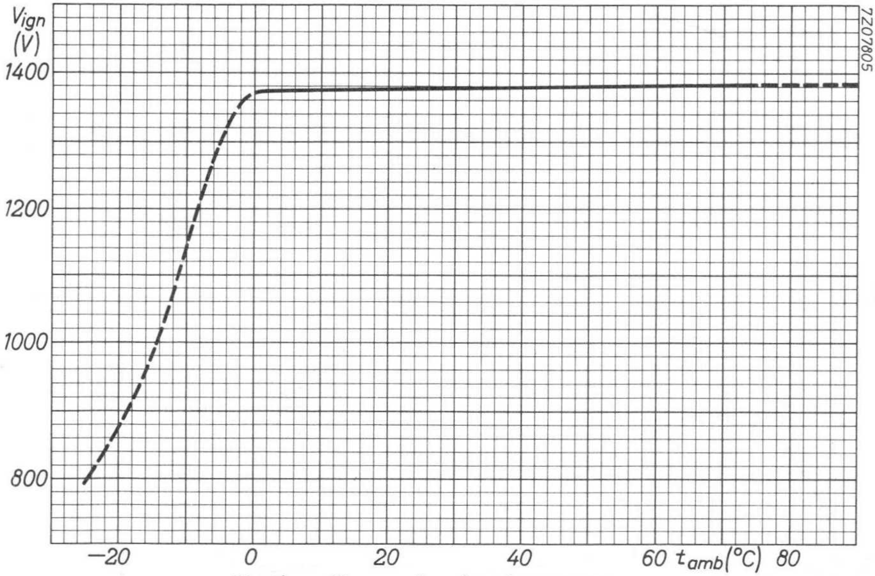
Fig.1



Plateau curve



Dead time curve



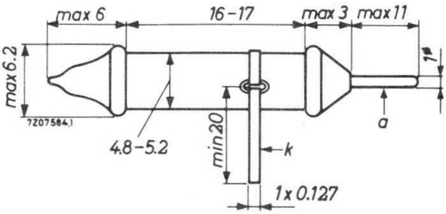
Starting voltage as function of temperature

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 56 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

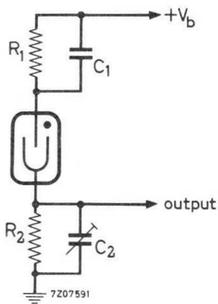
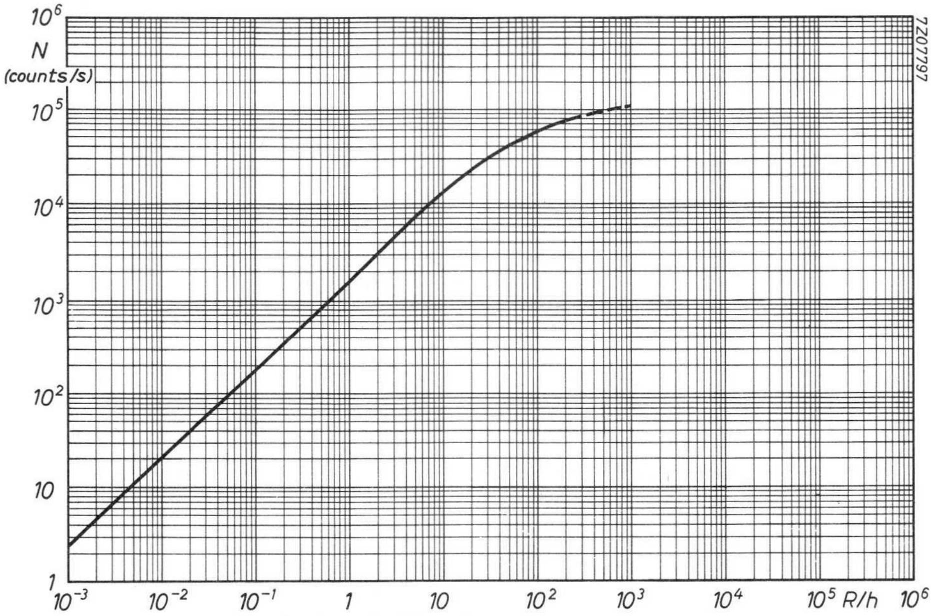
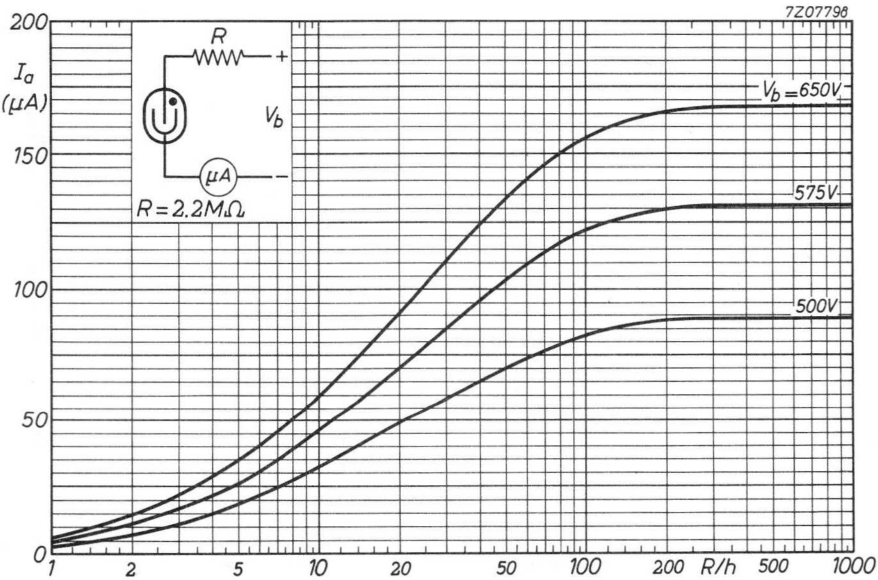


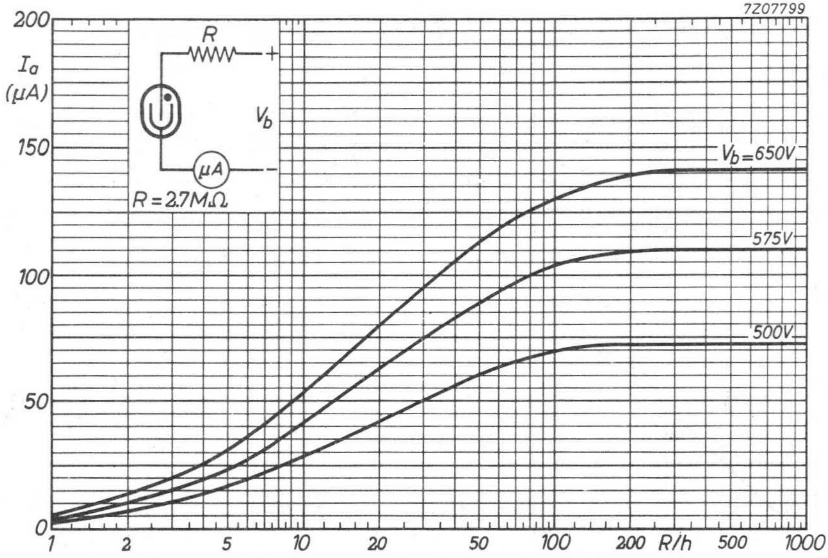
Fig.1



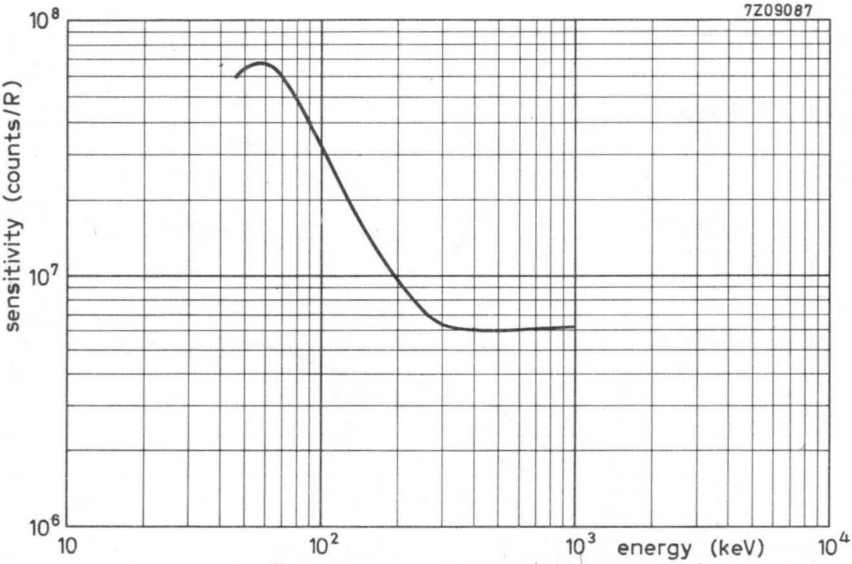
Count rate as function of dose rate



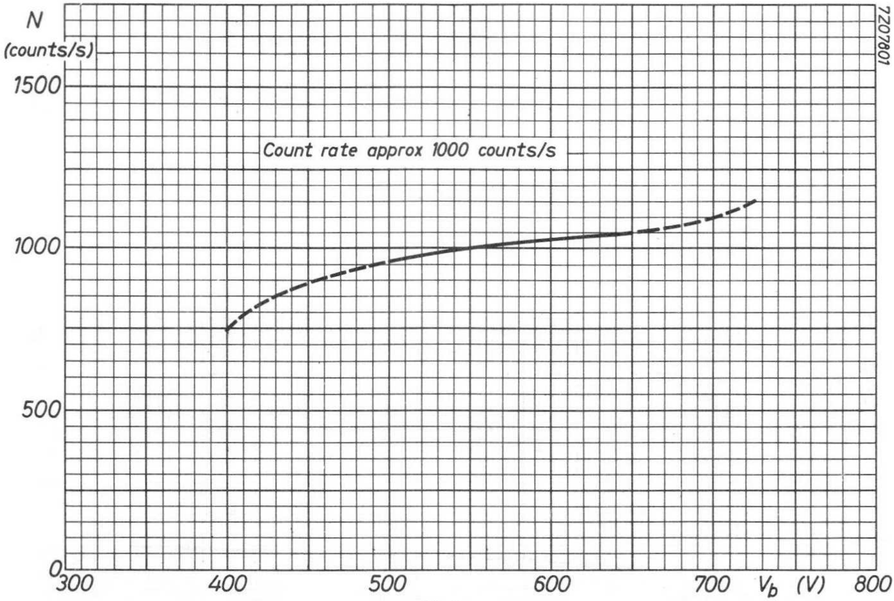
Current as function of dose rate



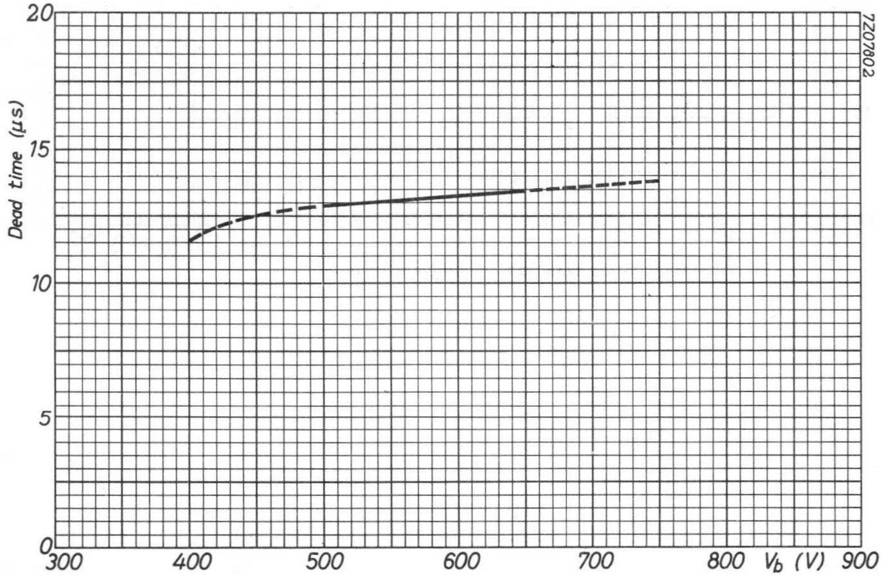
Current as function of dose rate



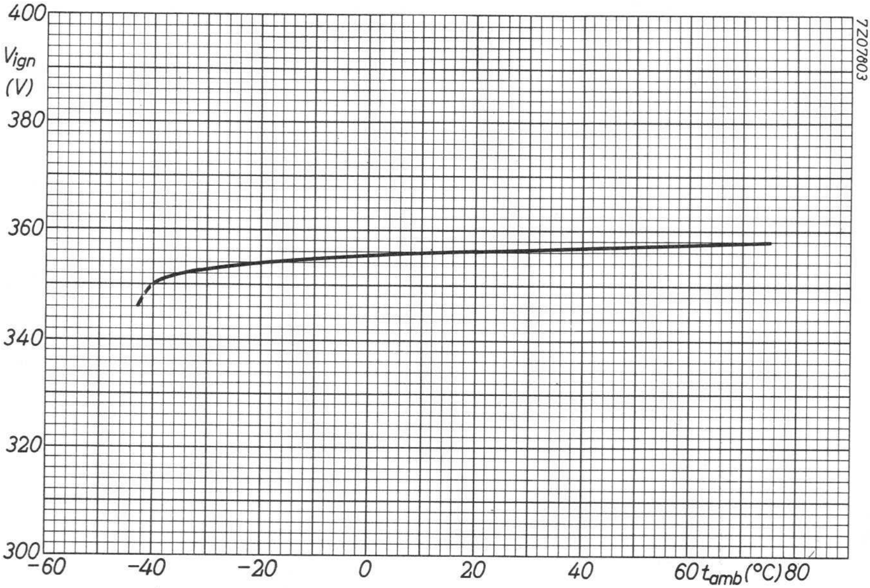
Energy response curve (side response)



Plateau curve



Dead time curve



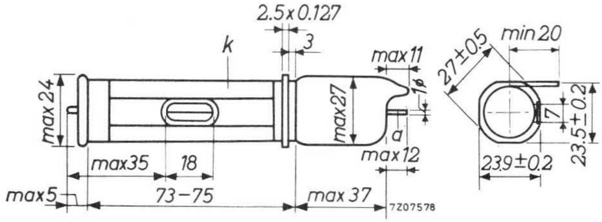
Starting voltage as function of ambient temperature

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

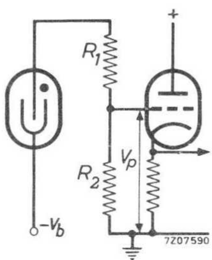
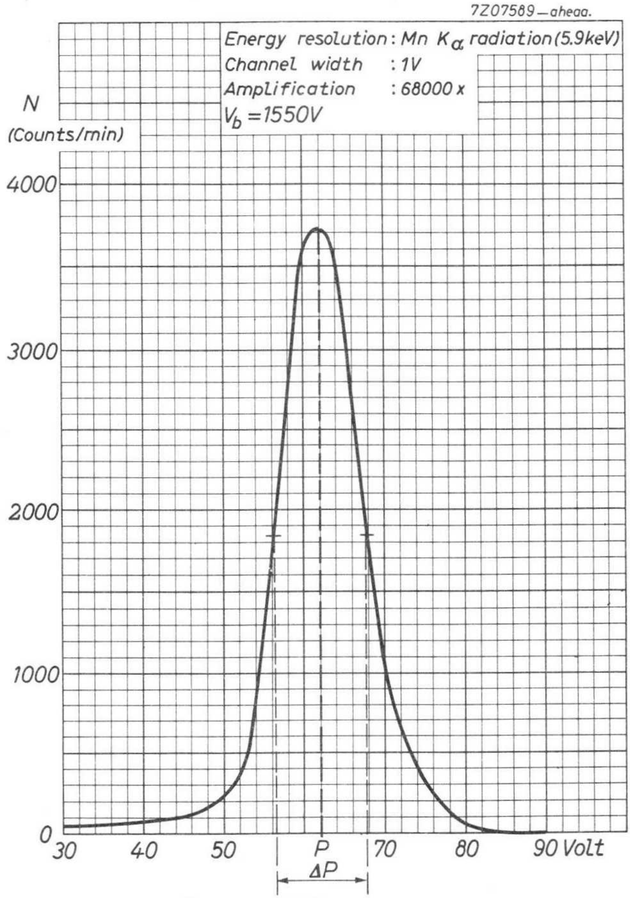


Fig.1

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.



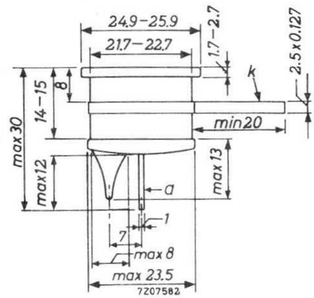
Energy resolution curve

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.1

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

→ MEASURING CIRCUIT

R_1 = 4.7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

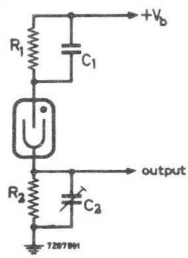


Fig.1

REMARK

In order to prevent leakage the tube should be kept dry and well cleaned.

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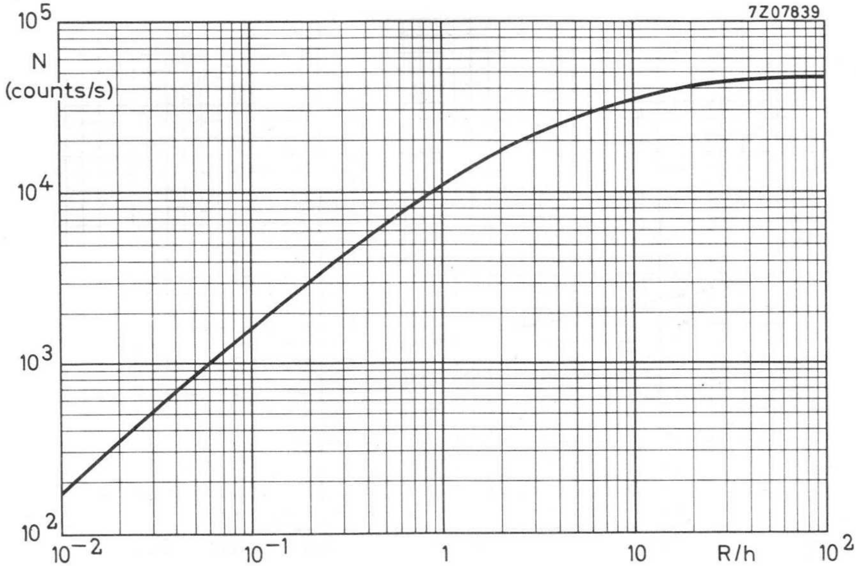
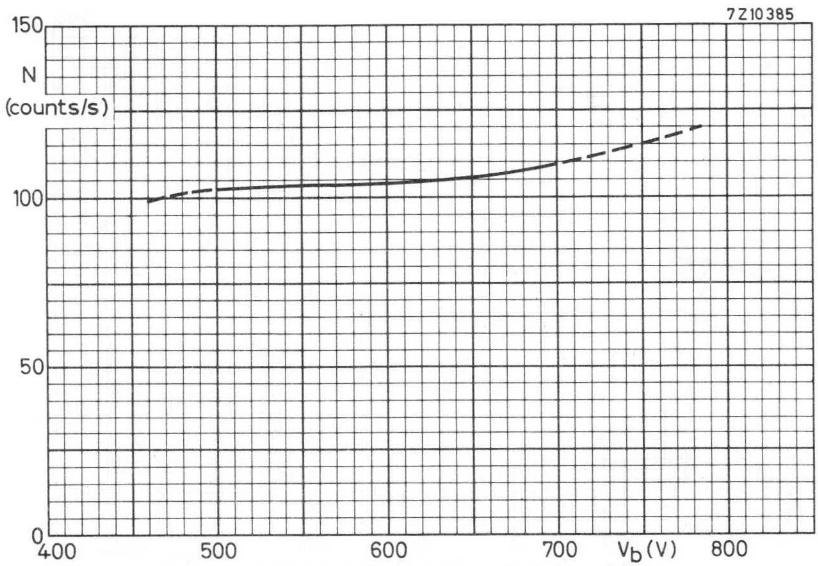
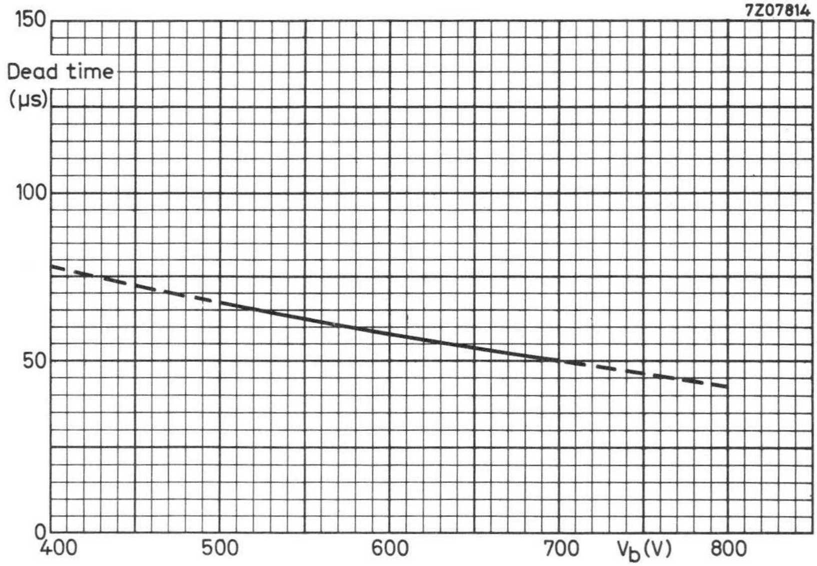
[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V.



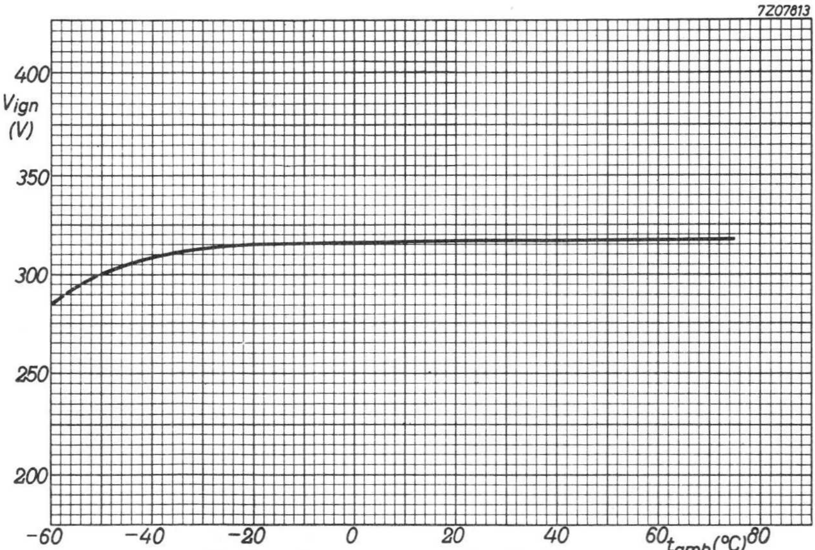
Count rate as function of dose rate



Plateau curve



Dead time curve



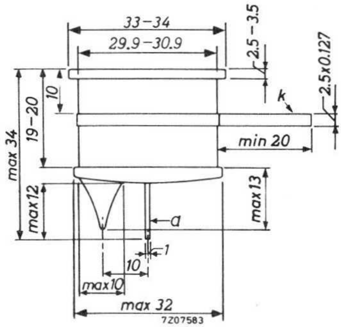
Starting voltage as function of ambient temperature

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_o	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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 10 MΩ

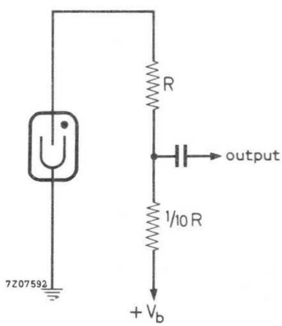


Fig. 1

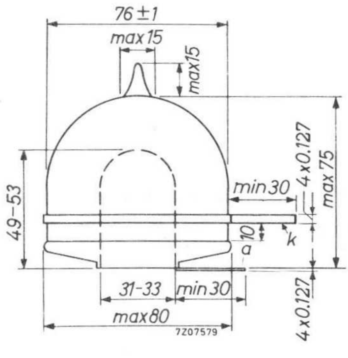
1) For application in anticoincidence circuits the recommended value of V_b = 600 V.

COSMIC RAY GUARD COUNTER TUBE

Halogen quenched cosmic ray guard counter tube for low background measurements together with a β counter tube (e.g. type 18515) in an anticoincidence circuit.

QUICK REFERENCE DATA		
Hollow anode diameter	32	mm
Operating voltage	800 to 1200	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



Connectors
0.127 mm thick

CATHODE AND ANODE

Thockness	1 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	5.5 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_b	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.	75	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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

CIRCUITS

For use as guard counter tube in anticoincidence circuits in combination with 18515: recommended circuit see fig.2.

R = 10 MΩ

R_1 = 10 MΩ

R_2 = 10 MΩ

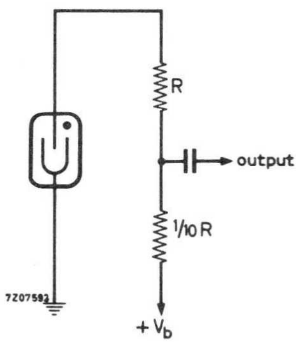


Fig.1

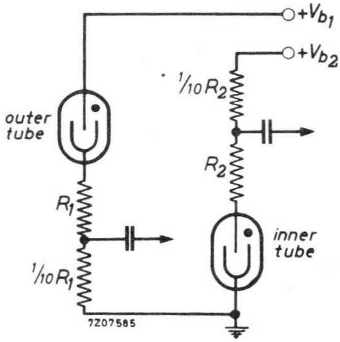


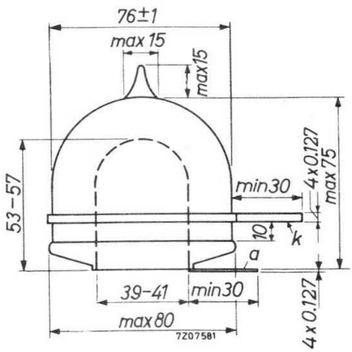
Fig.2

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

LIFE EXPECTANCY

Life expectancy 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

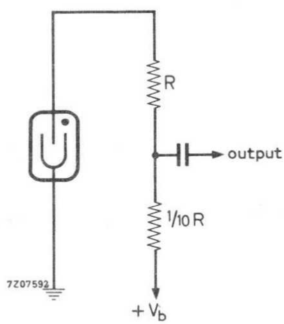


Fig.1

R_1 = 10 MΩ

R_2 = 10 MΩ

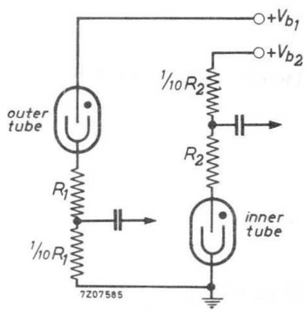
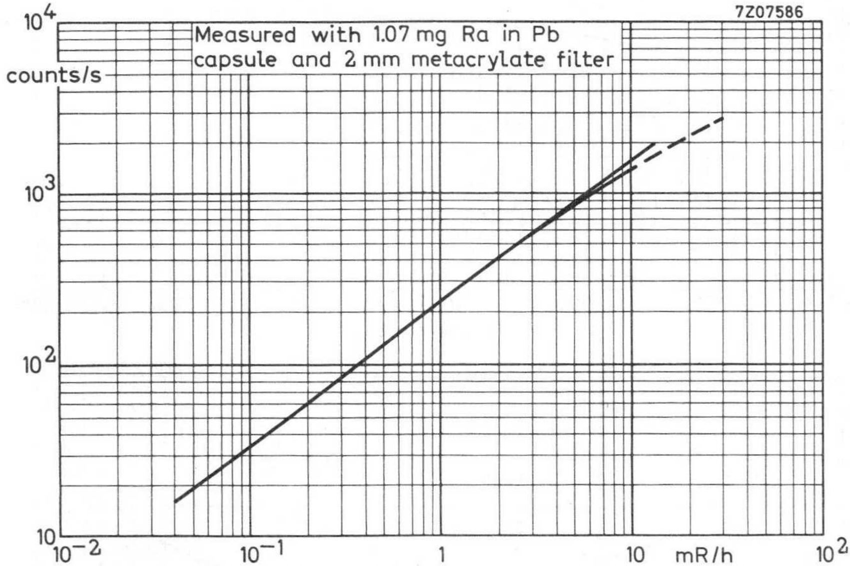
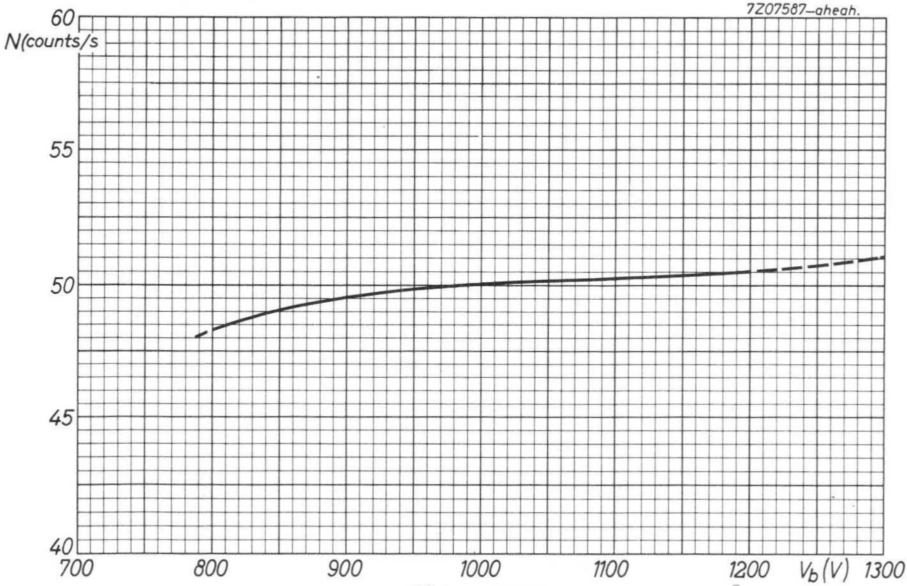


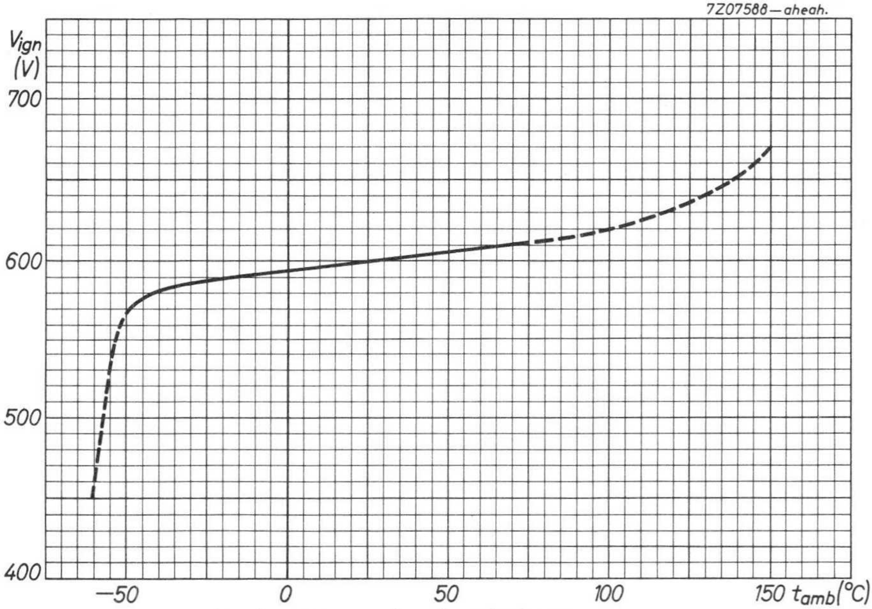
Fig.2



Count rate as function of dose rate



Plateau curve



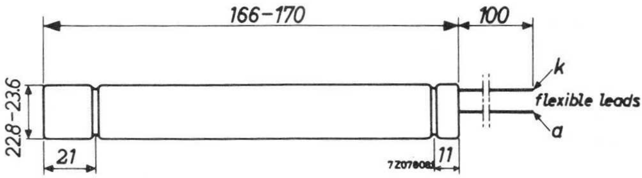
Starting voltage as function of temperature

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

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 2.7 MΩ

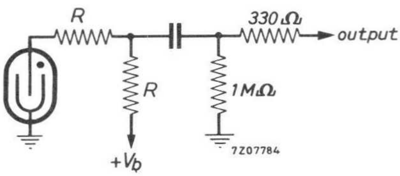
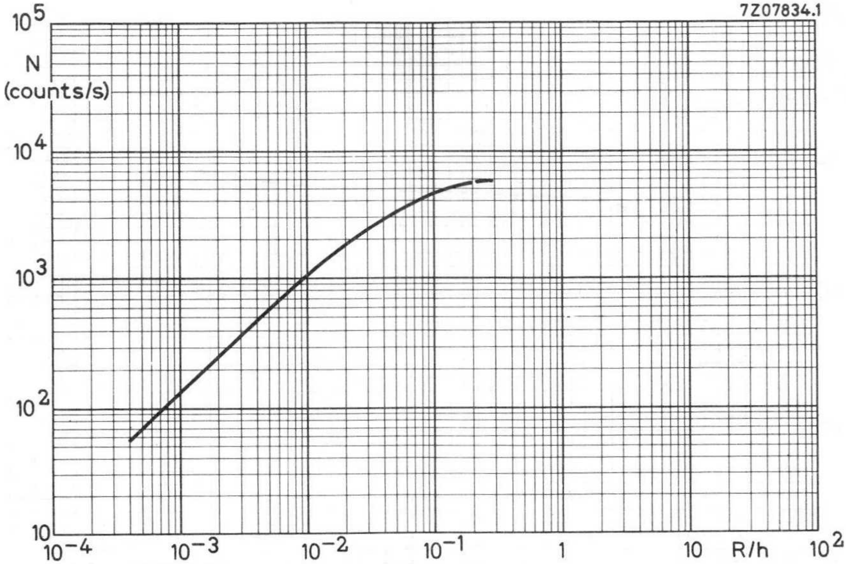
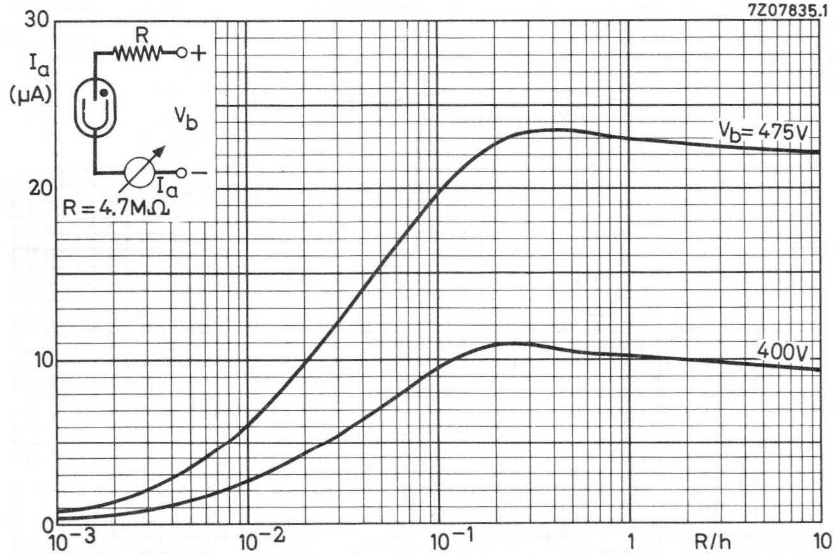


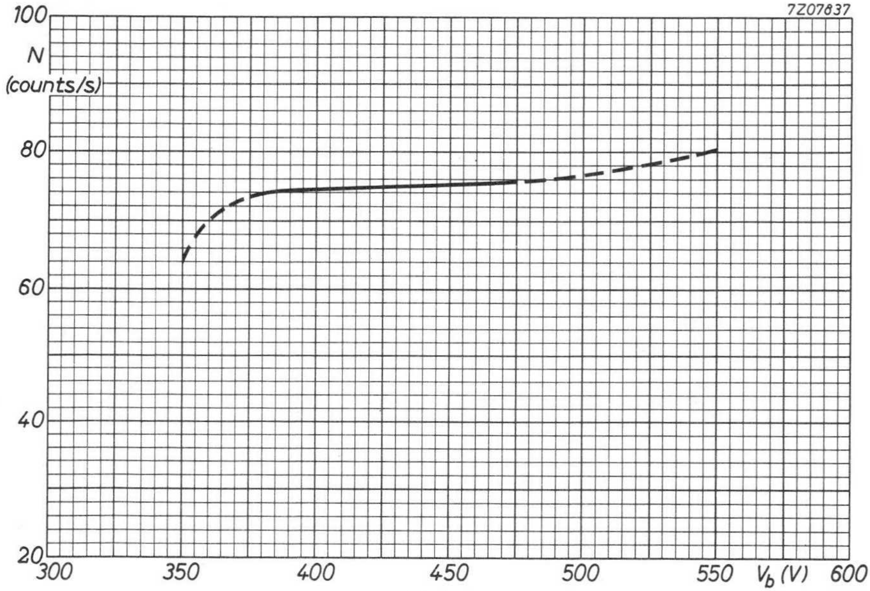
Fig.1



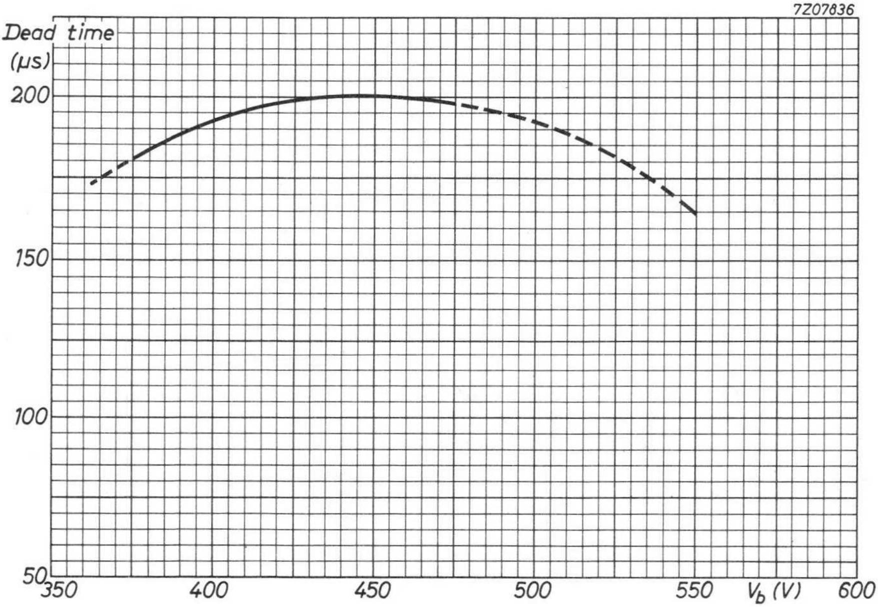
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



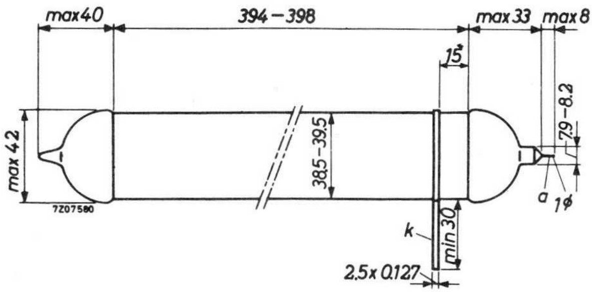
Dead time curve

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube.

QUICK REFERENCE DATA	
Range (60Co γ radiation)	10^{-5} to 3.10^{-2} R/h
Operating voltage	600 to 1000 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



Cathode connector: 0.127 mm thick

CATHODE

Thickness	0.5 mm
Effective length	400 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	15 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C) Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	500	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	600 to 1000		V
Plateau slope	S_{pl}	max.	0.03	%/ V
Background, shielded with 50 mm Pb at V_b = 800V	N_o	max.	160	counts/min.
Dead time at V_b = 800 V	τ	max.	550	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	10	MΩ
Anode voltage	V_a	max.	1000	V
Ambient temperature	t_{amb}	min.	-20	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 10 MΩ

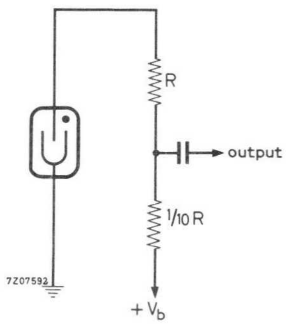


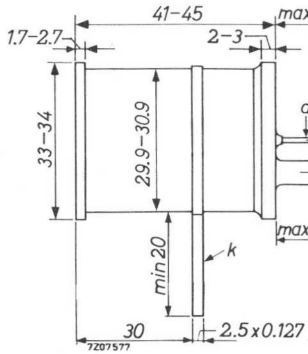
Fig.1

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	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	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	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

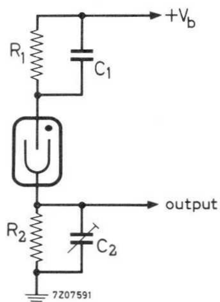
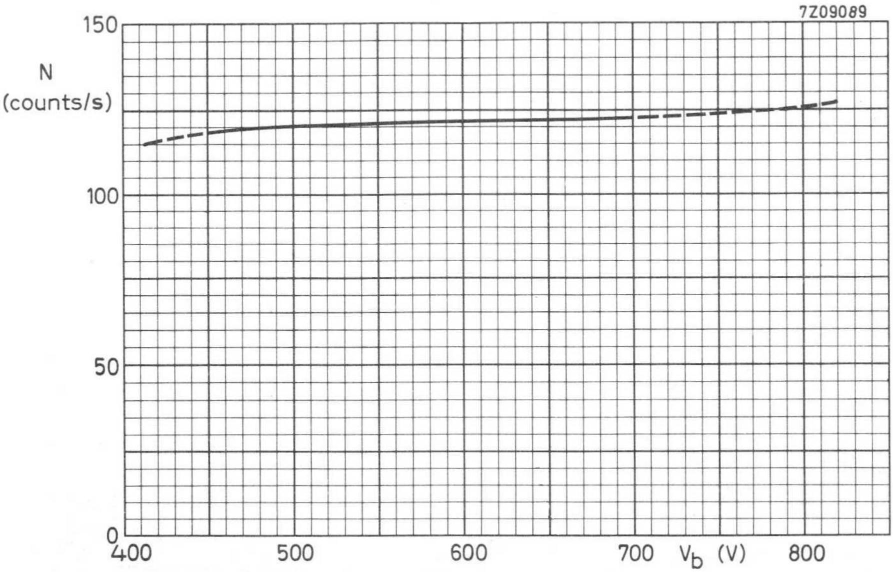
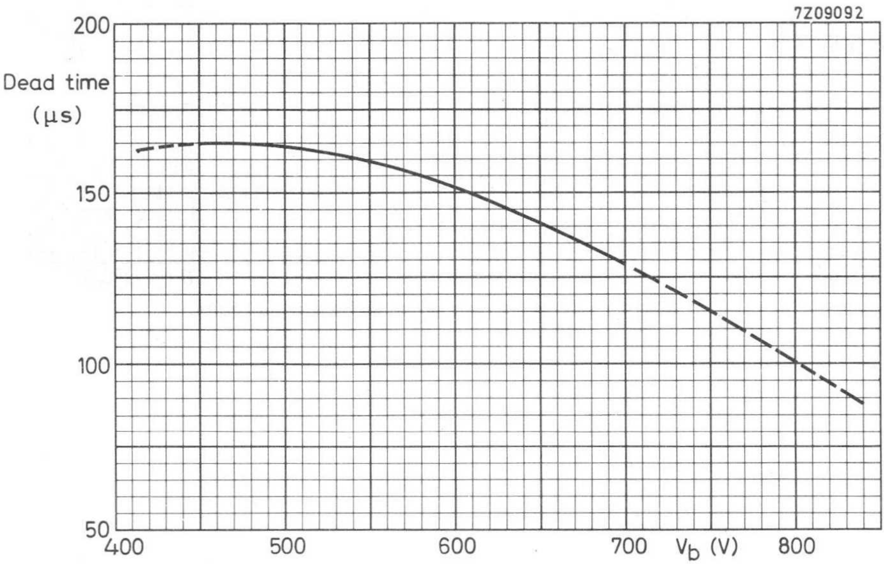


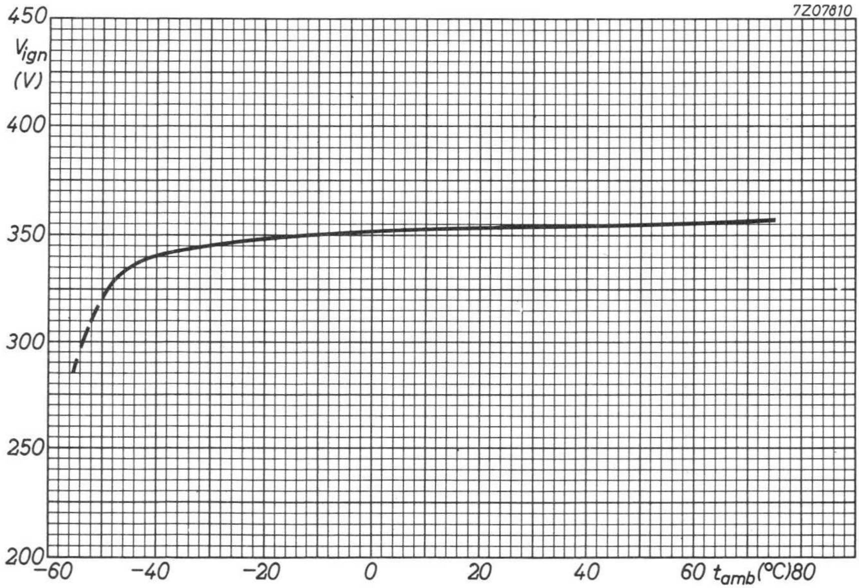
Fig.1



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

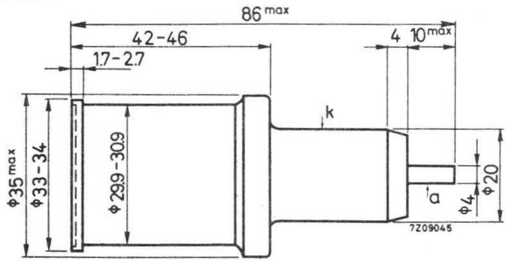
ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

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

LIFE EXPECTANCY

5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

$R_1 C_{stray} = R_2 C_2$

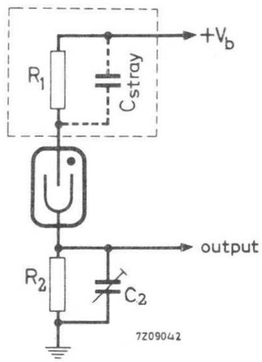
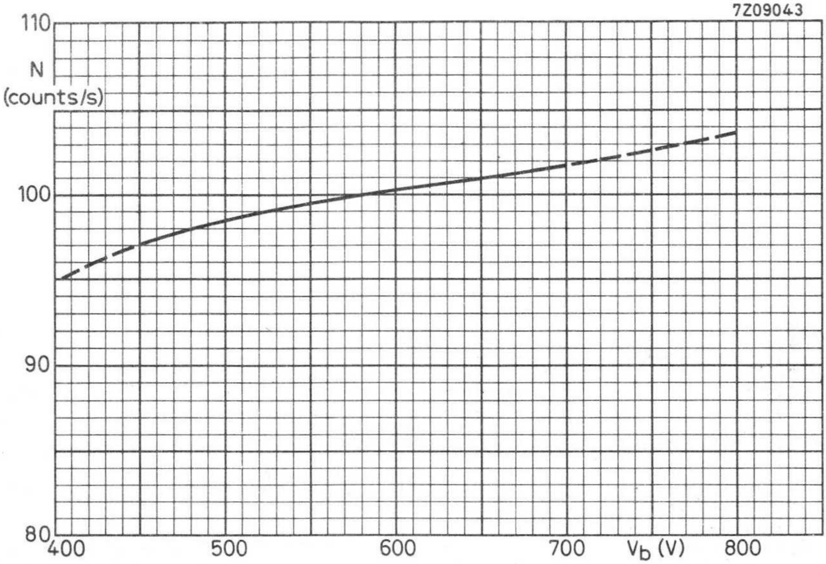
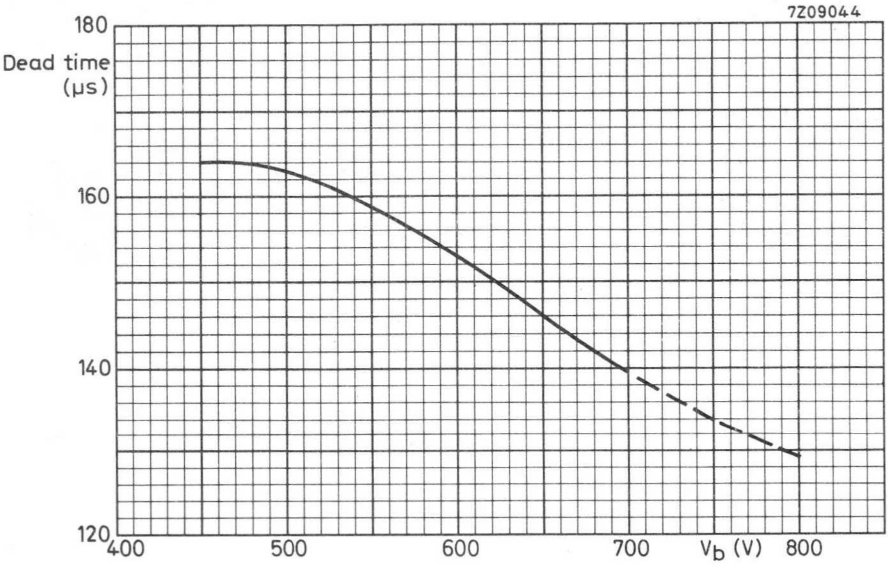


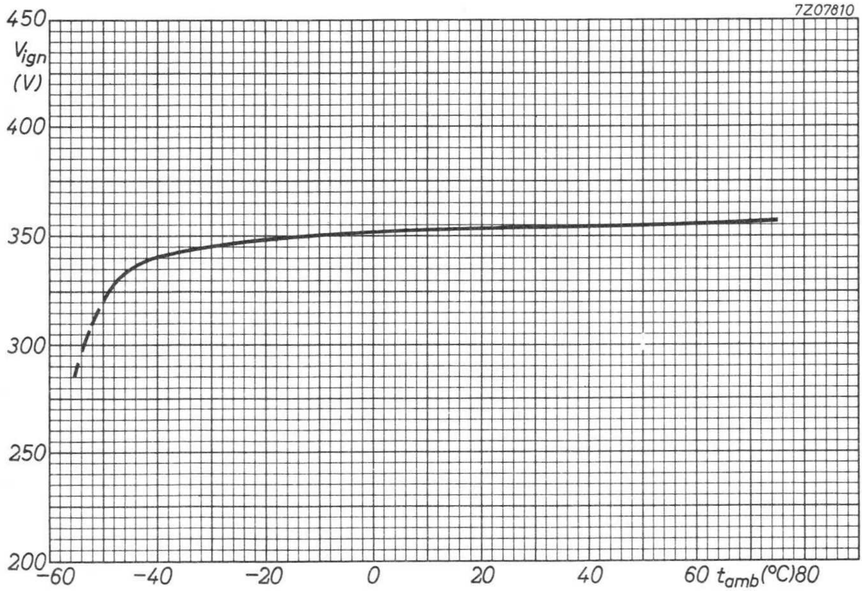
Fig. 1



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

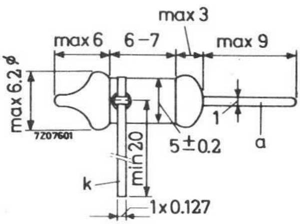
BETA AND GAMMA RADIATION COUNTER TUBE

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

LIFE EXPECTANCY

Life expectancy 10^{10} counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 47 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

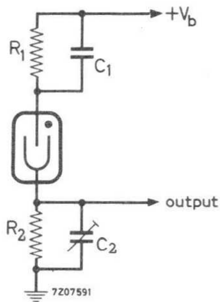
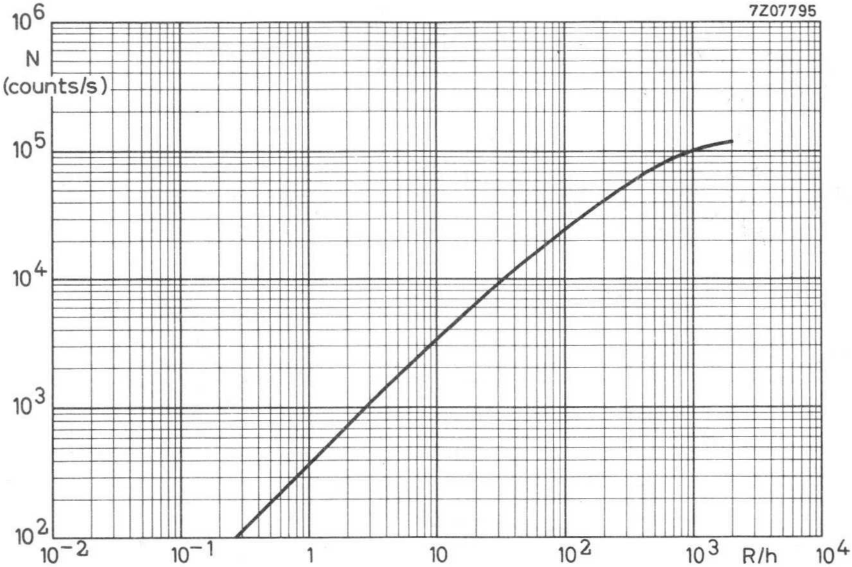
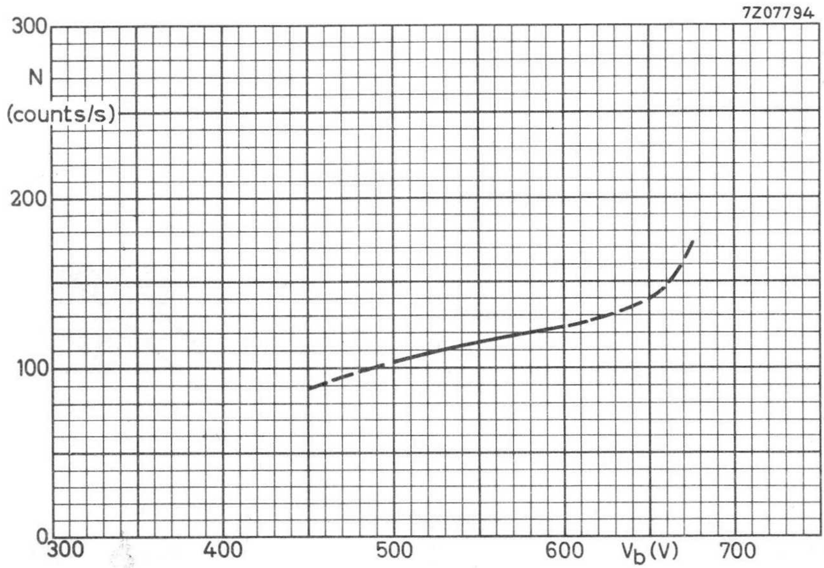


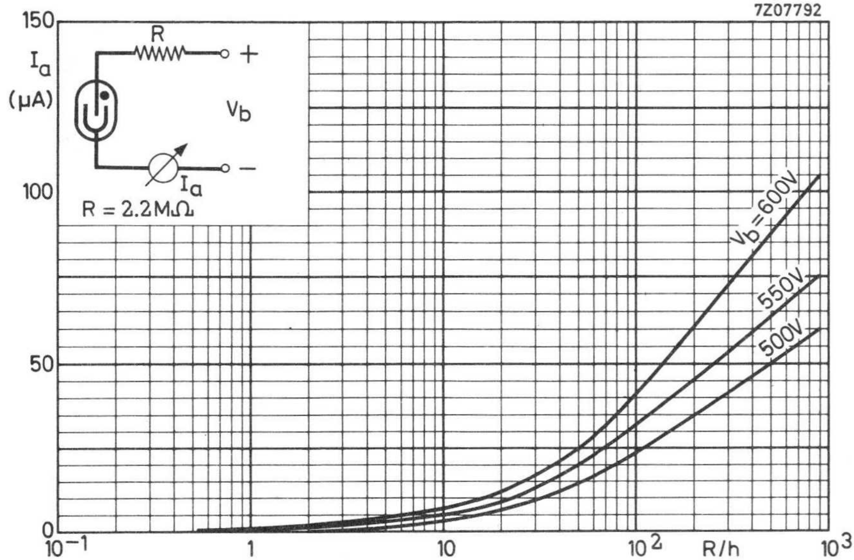
Fig.1



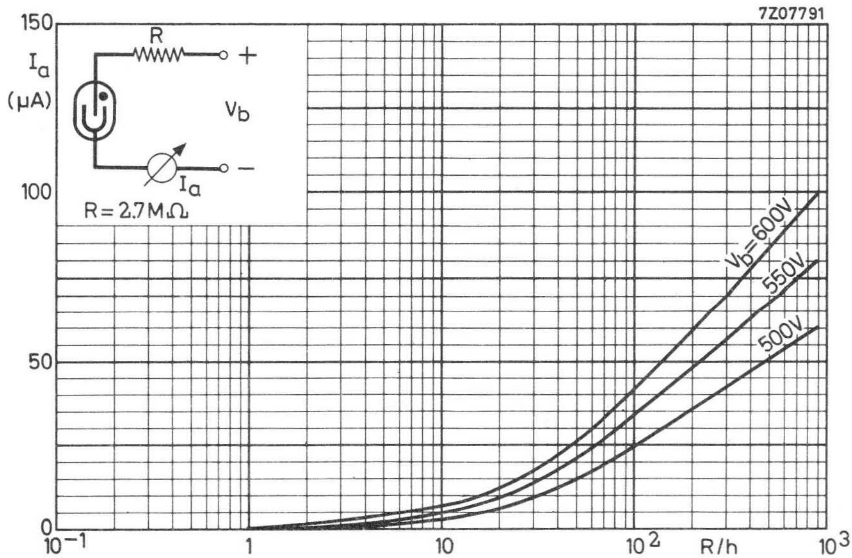
Count rate as function of dose rate



Plateau curve



Current as function of dose rate



Current as function of dose rate

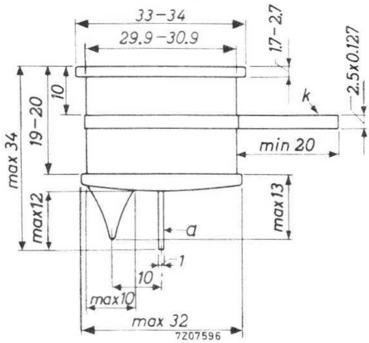
ALPHA AND BETA RADIATION COUNTER TUBE

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

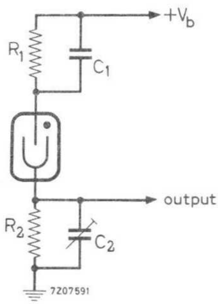
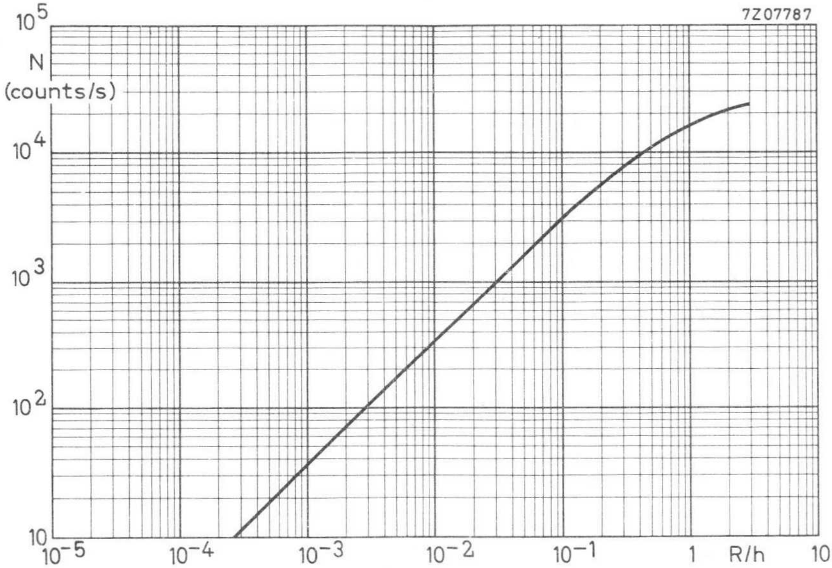
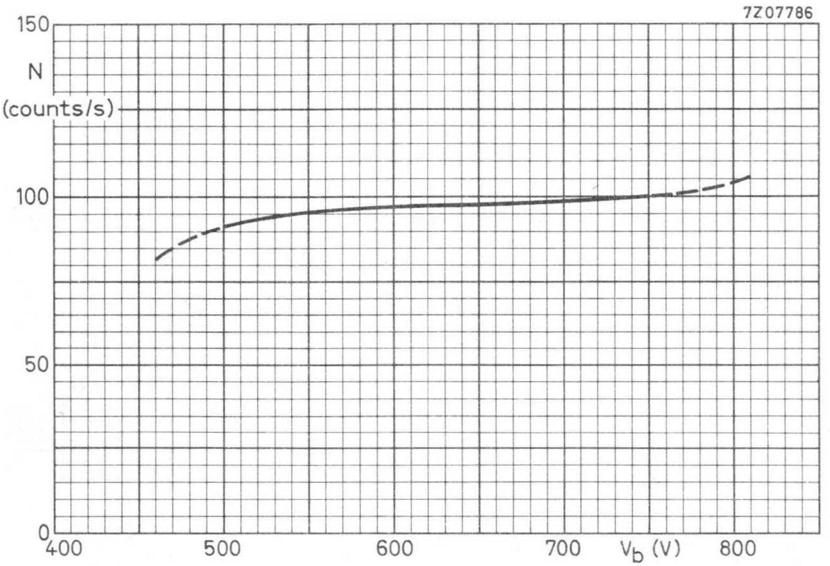


Fig.1

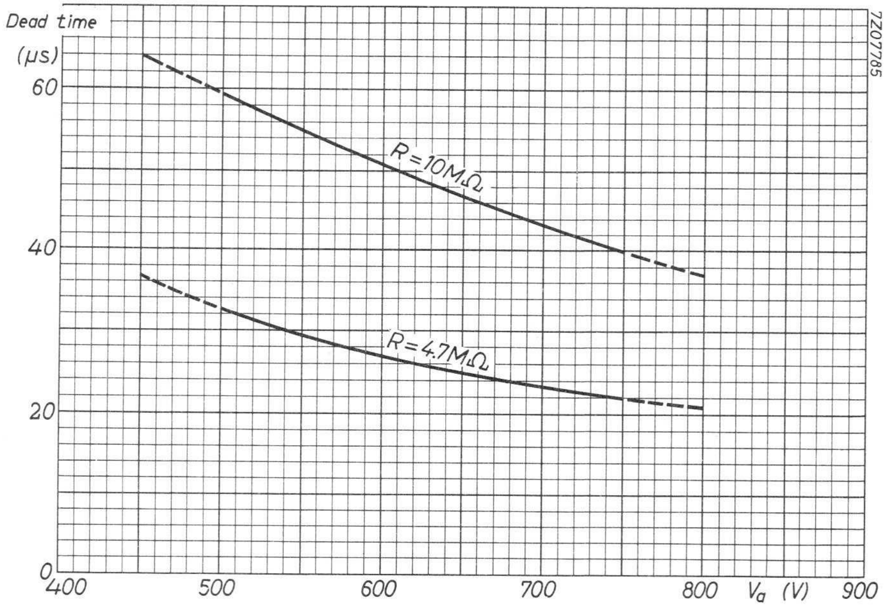
[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V



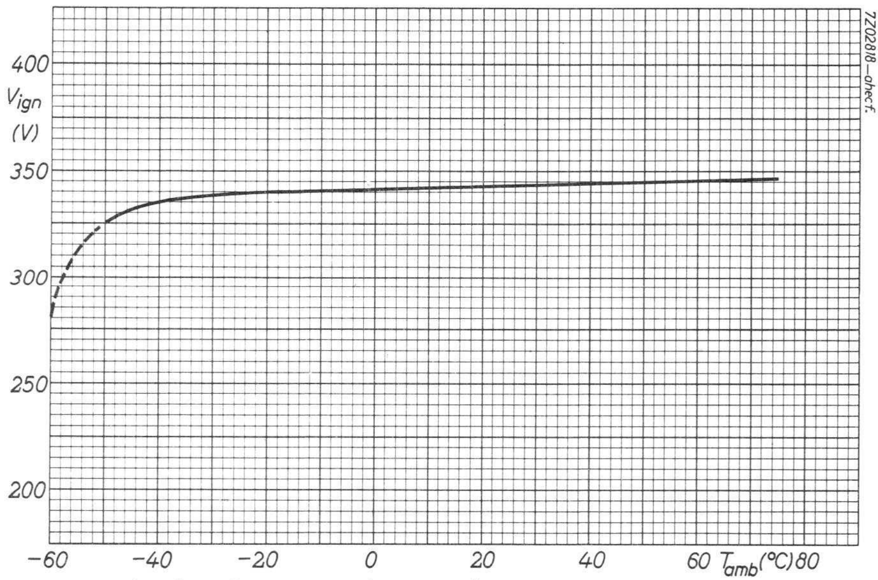
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

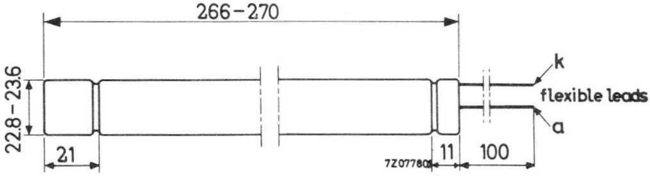
GAMMA RADIATION COUNTER TUBE

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.7 MΩ

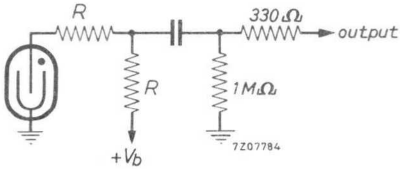
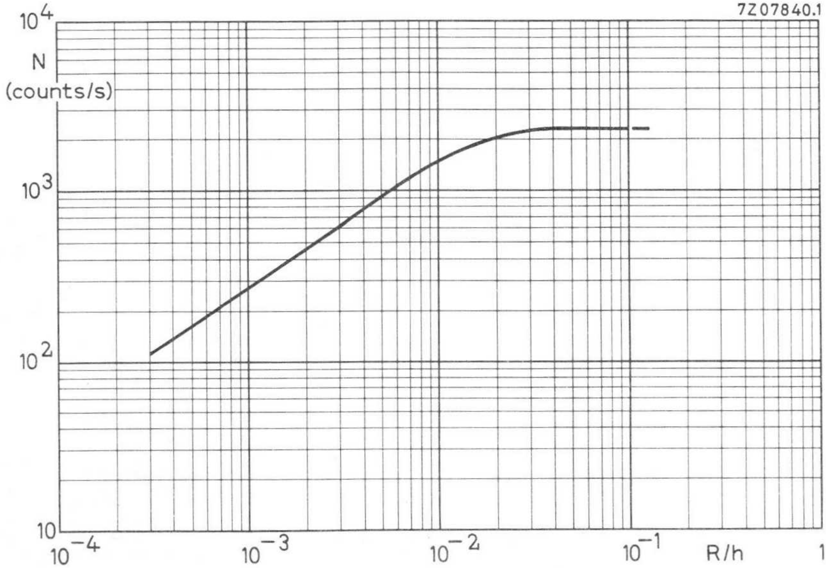
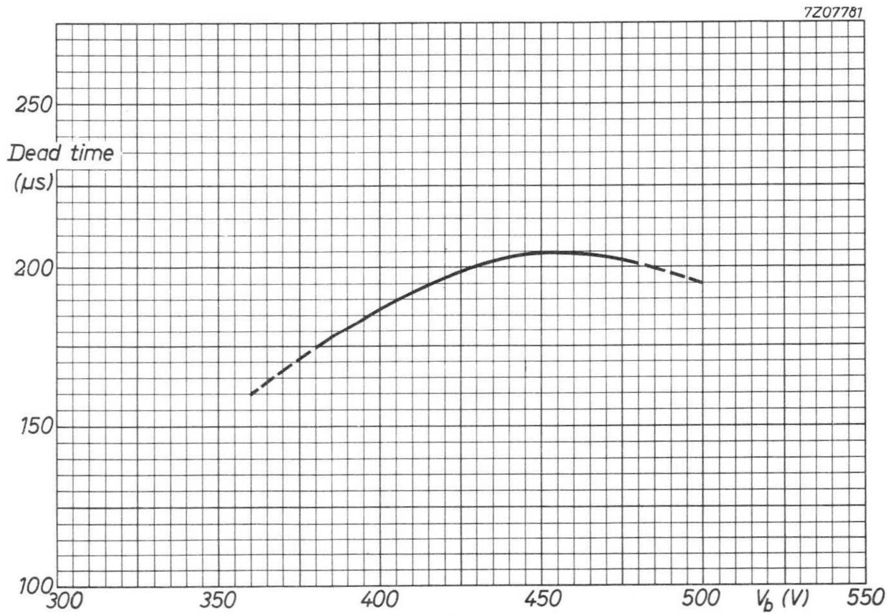


Fig.1



Count rate as function of dose rate

Plateau curve



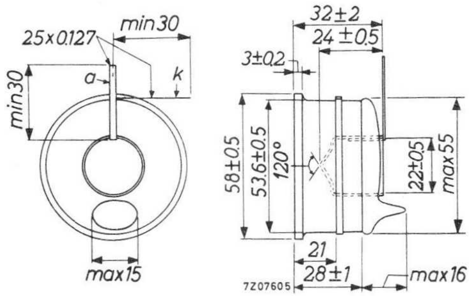
Dead time curve

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 4.7 MΩ

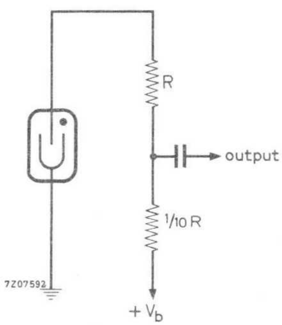
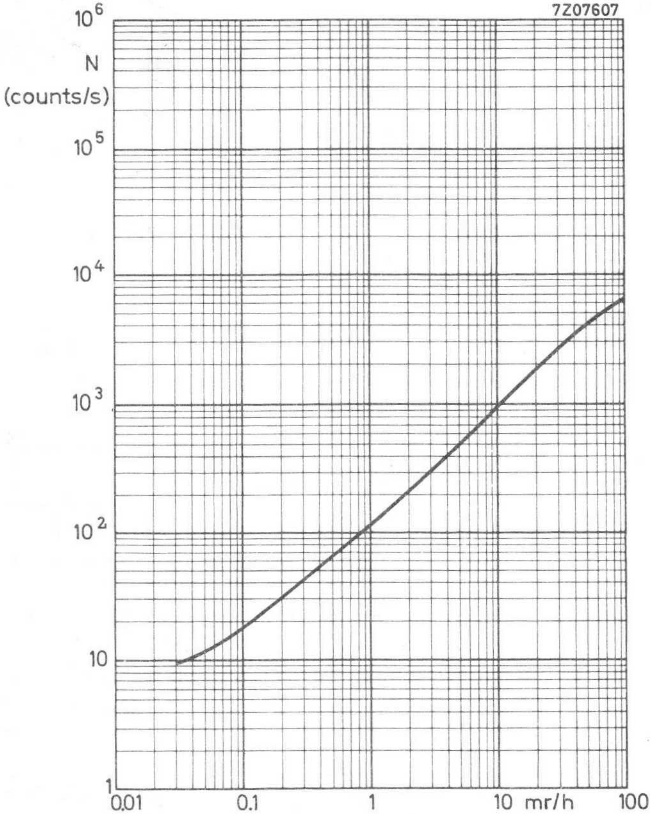
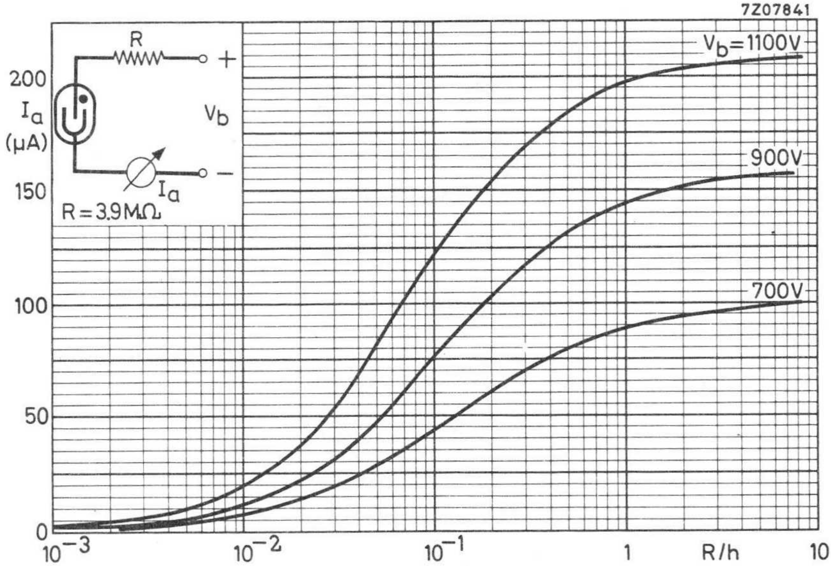


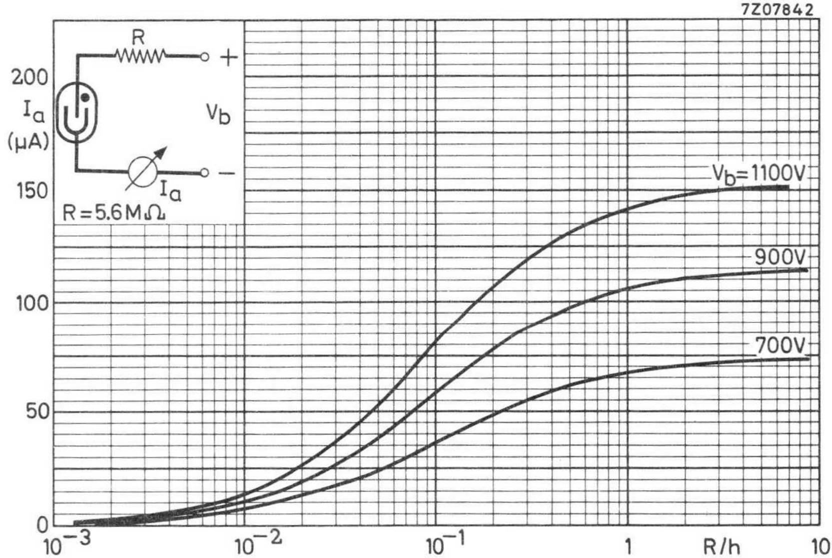
Fig.1



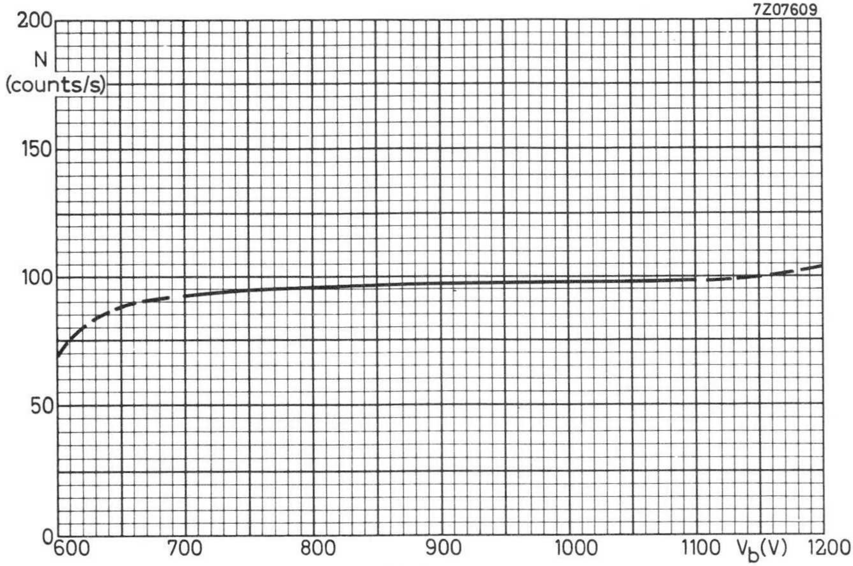
Count rate as function of dose rate



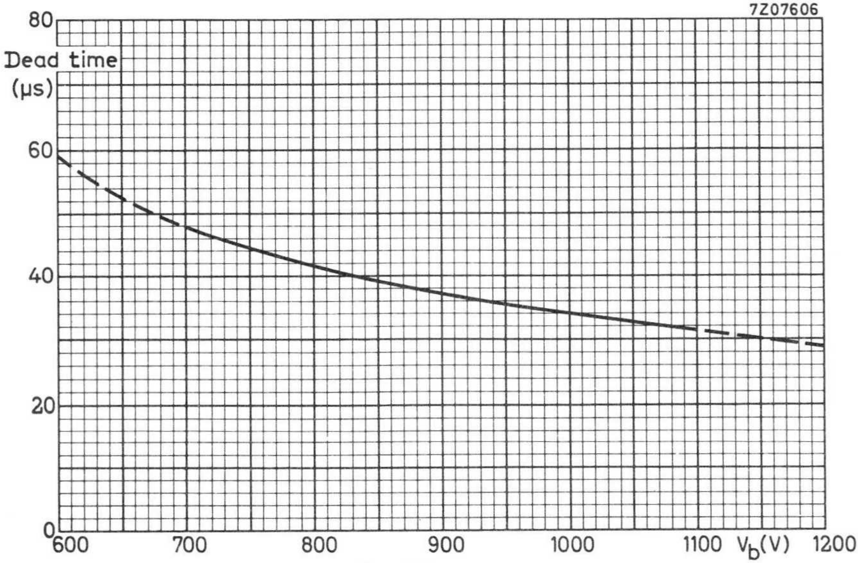
Current as function of dose rate



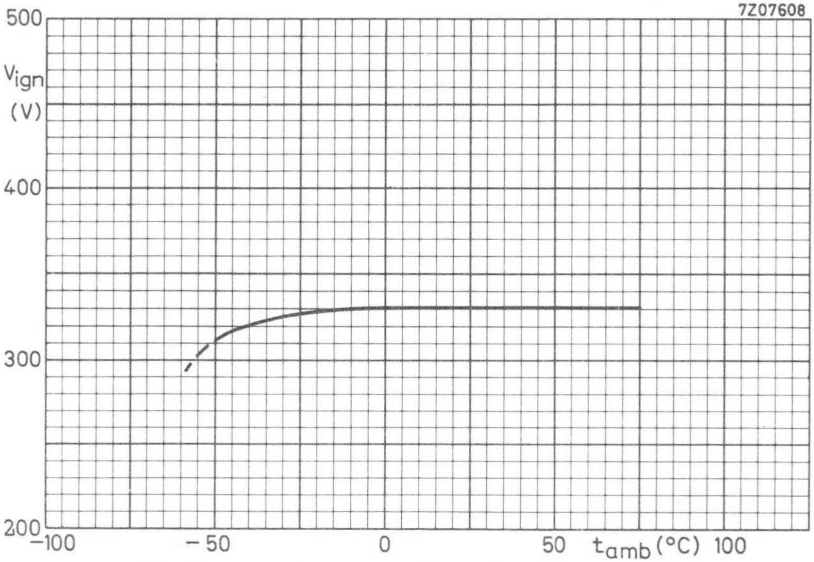
Current as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

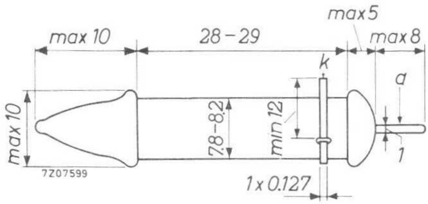
BETA AND GAMMA RADIATION COUNTER TUBE

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 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUITS

R_1 = 4.7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

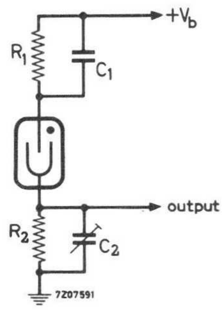
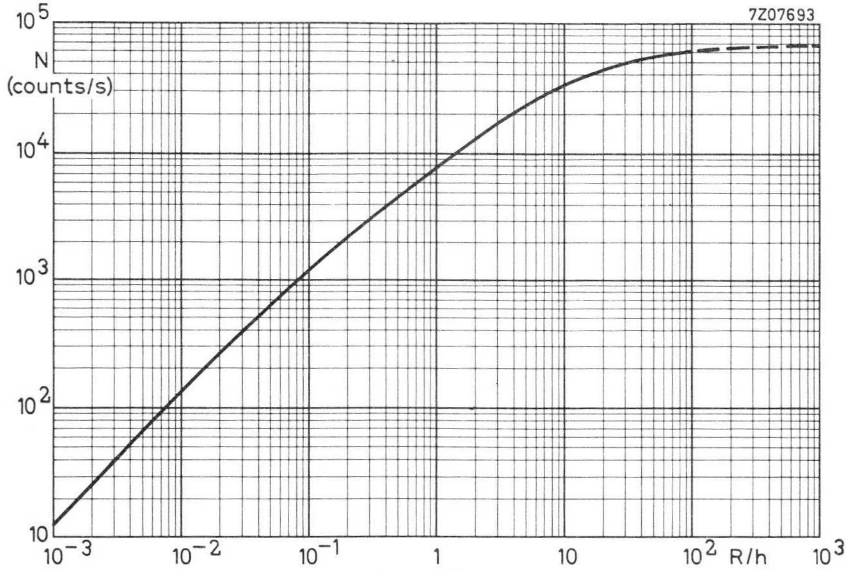
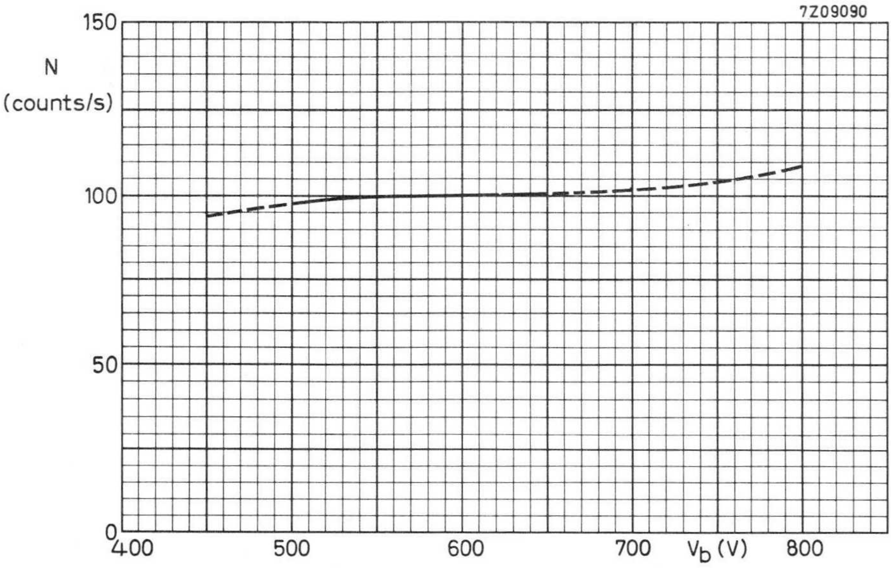


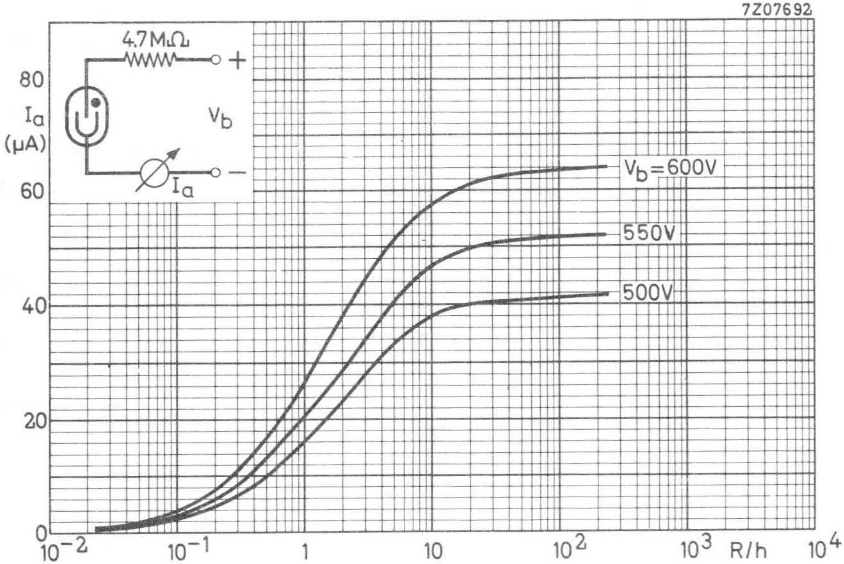
Fig.1



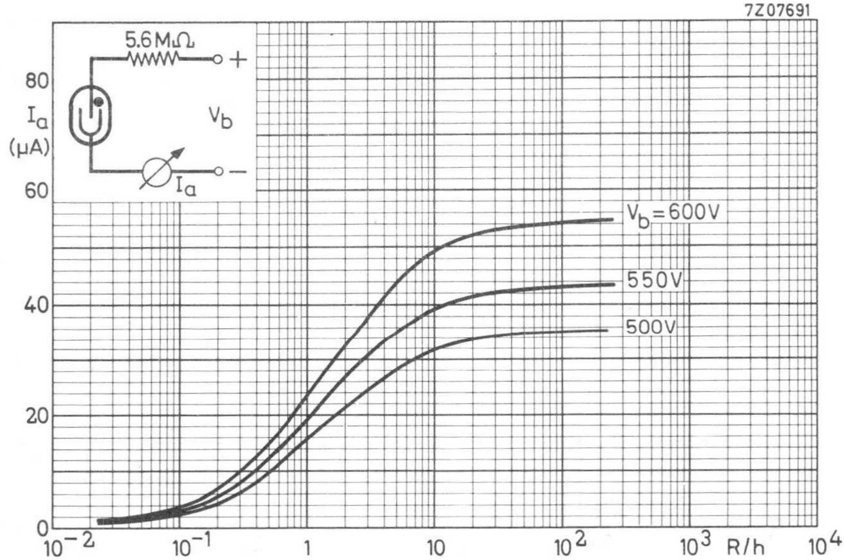
Count rate as function of dose rate



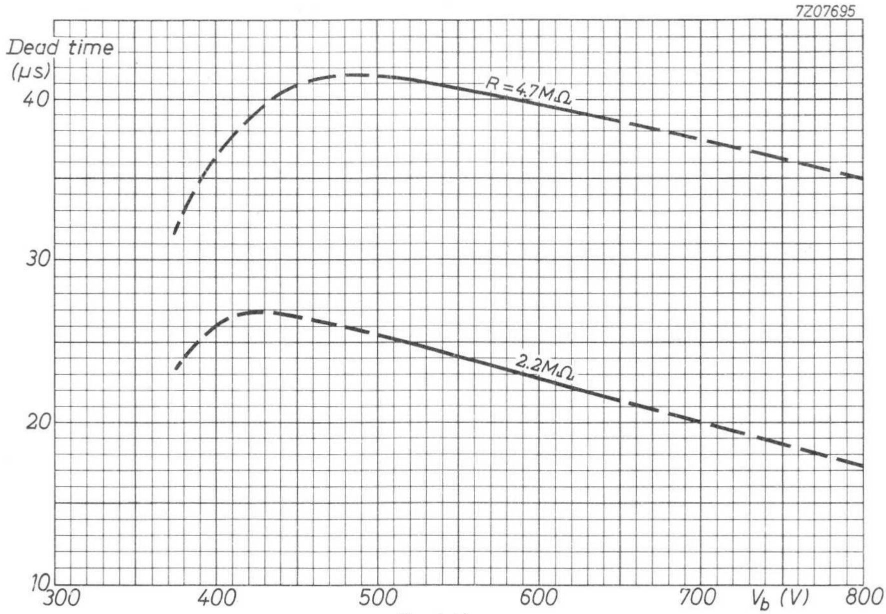
Plateau curve



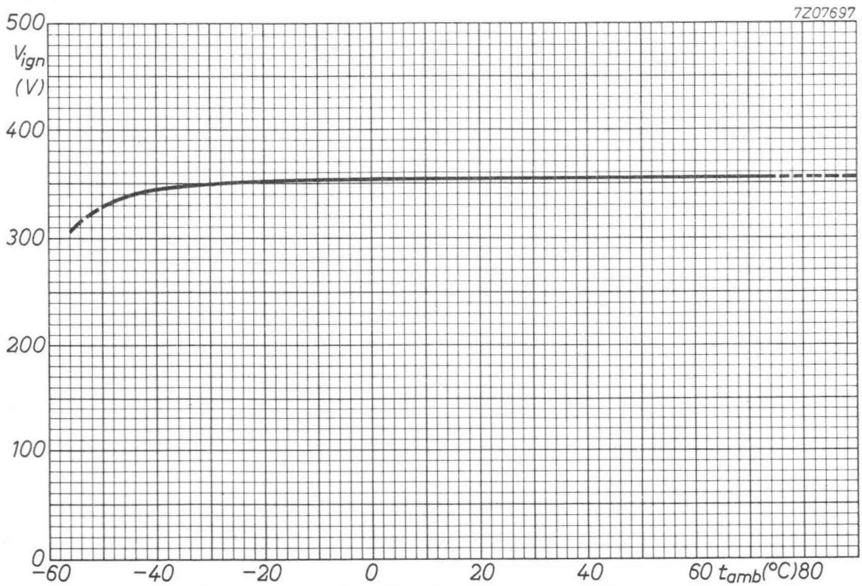
Current as function of dose rate



Current as function of dose rate



Dead time curve



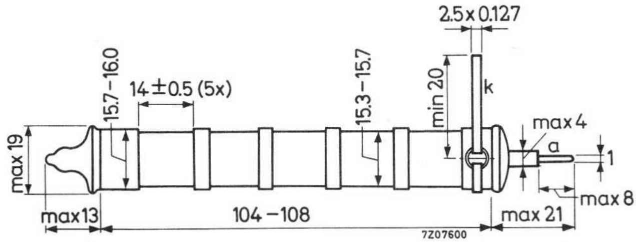
Starting voltage as function of ambient temperature

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^{-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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

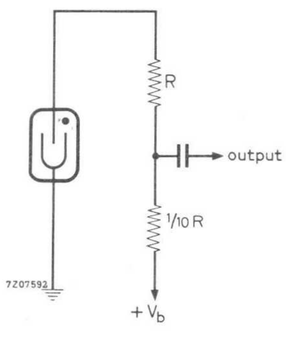
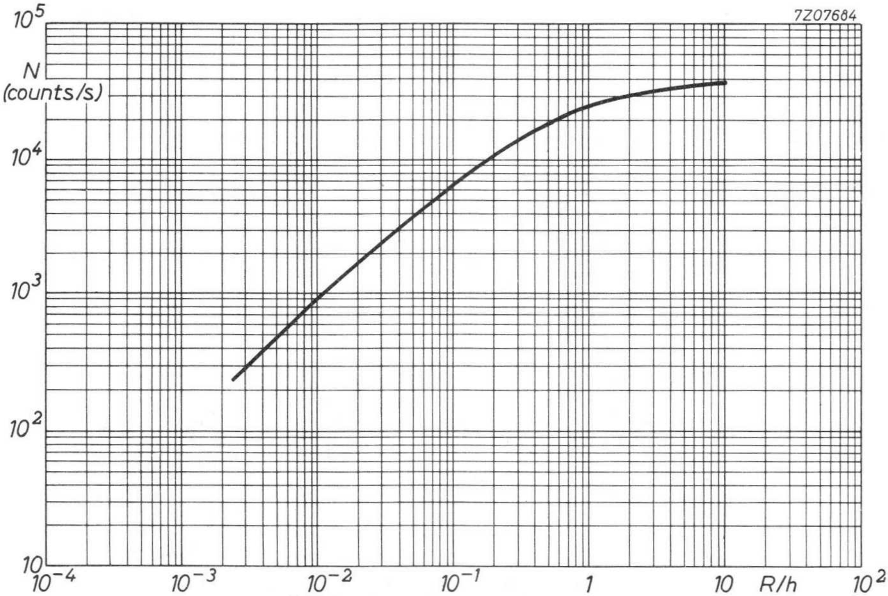
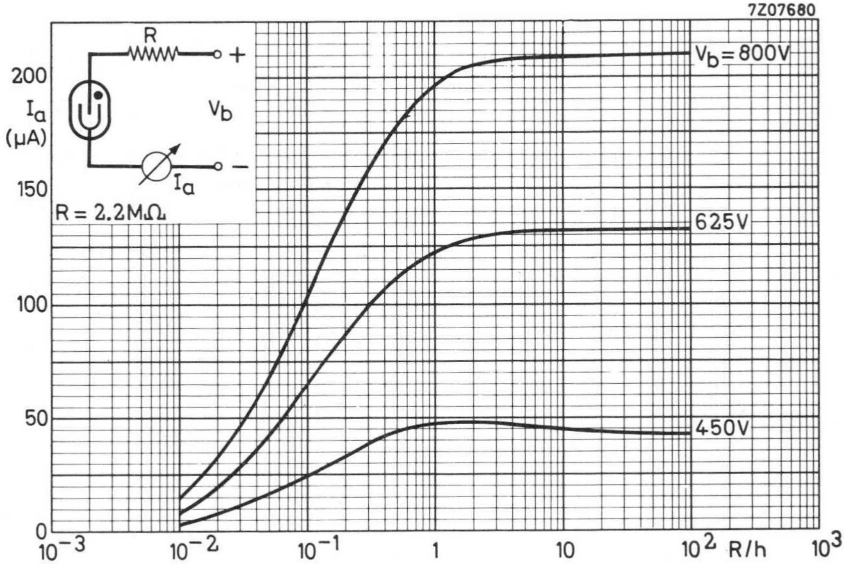


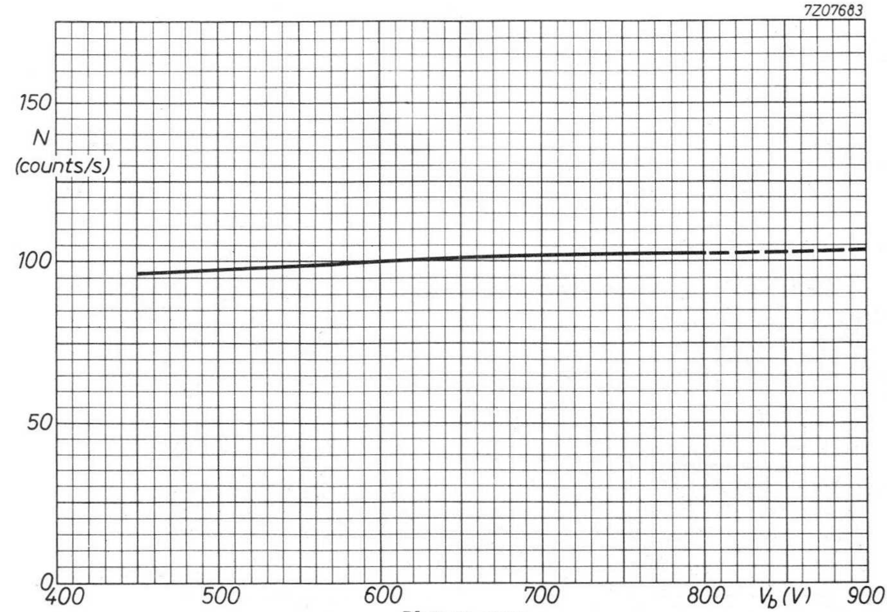
Fig.1



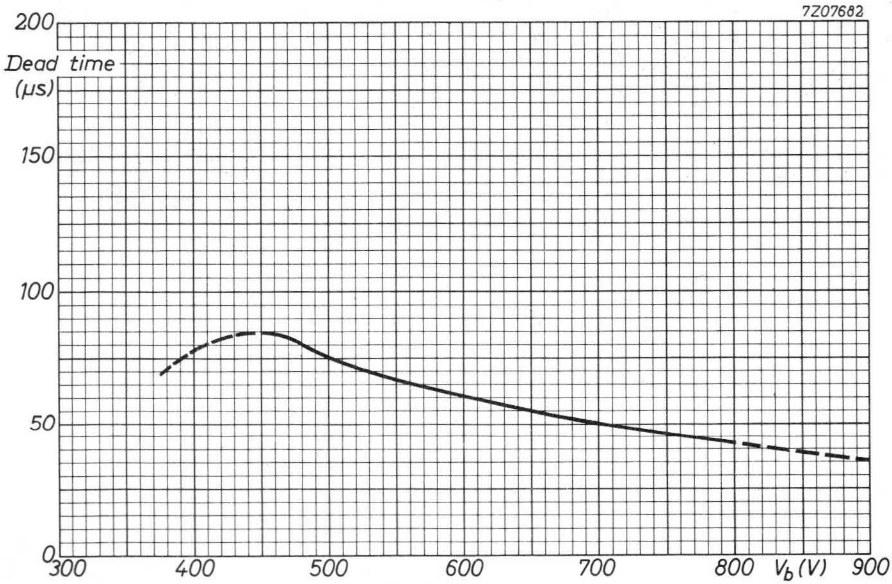
Count rate as function of dose rate



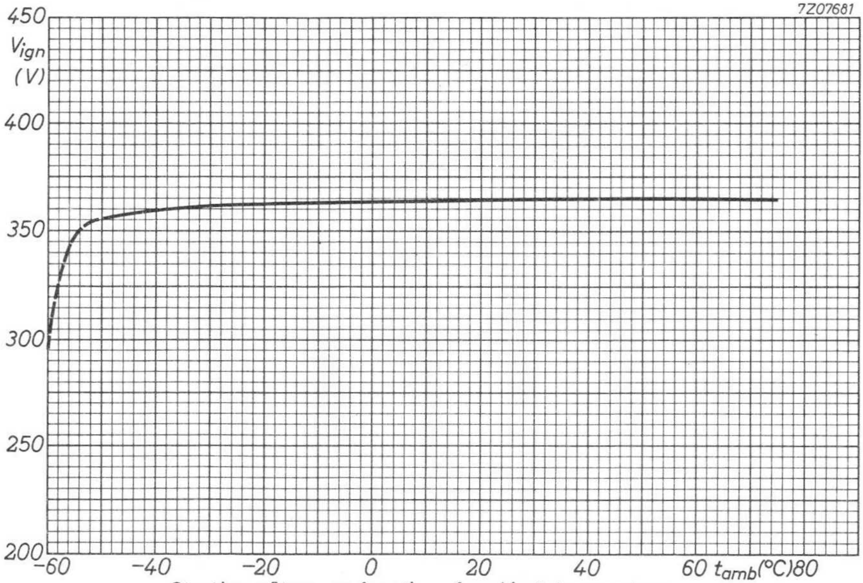
Current as function of dose rate



Plateau curve



Dead time curve



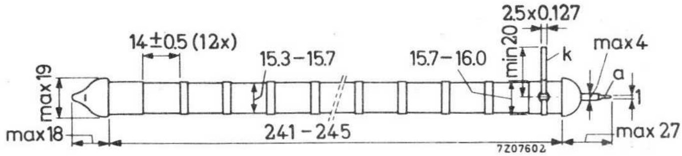
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (>0.3 MeV) and γ radiation counter tube

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

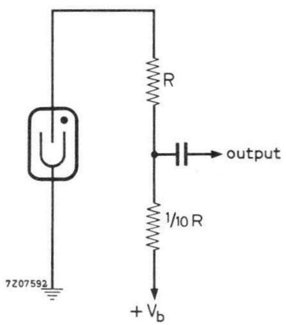
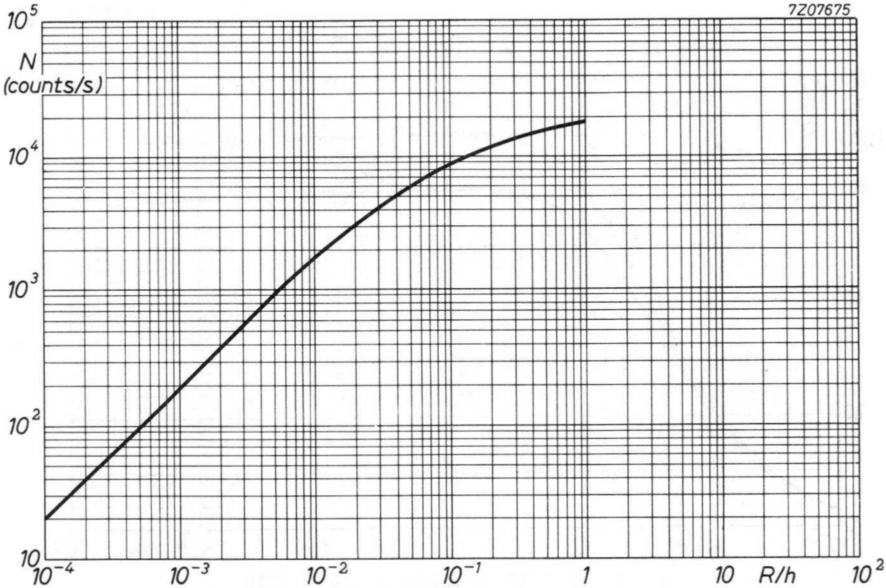
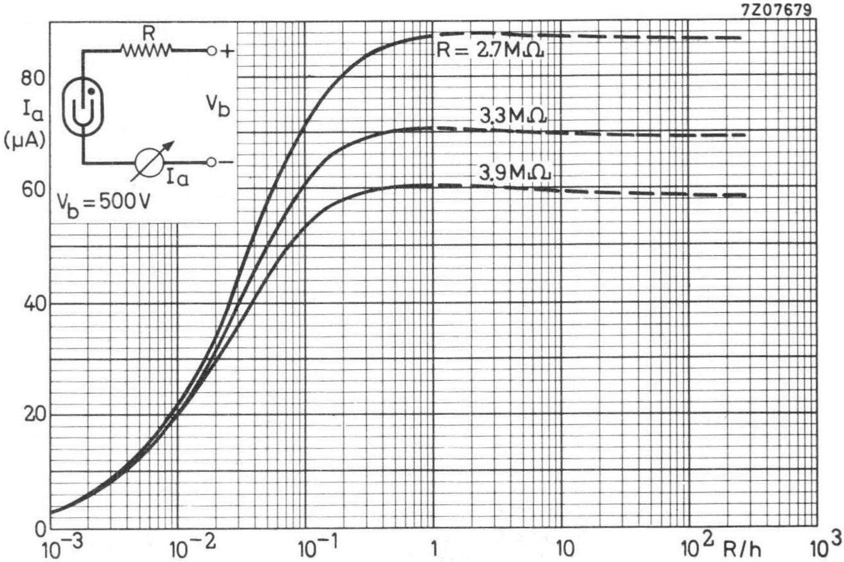


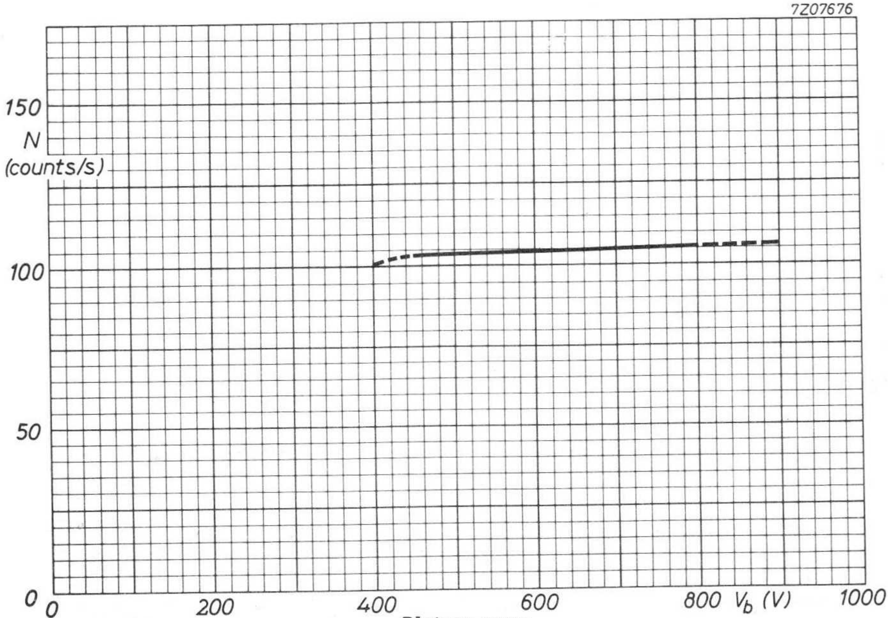
Fig.1



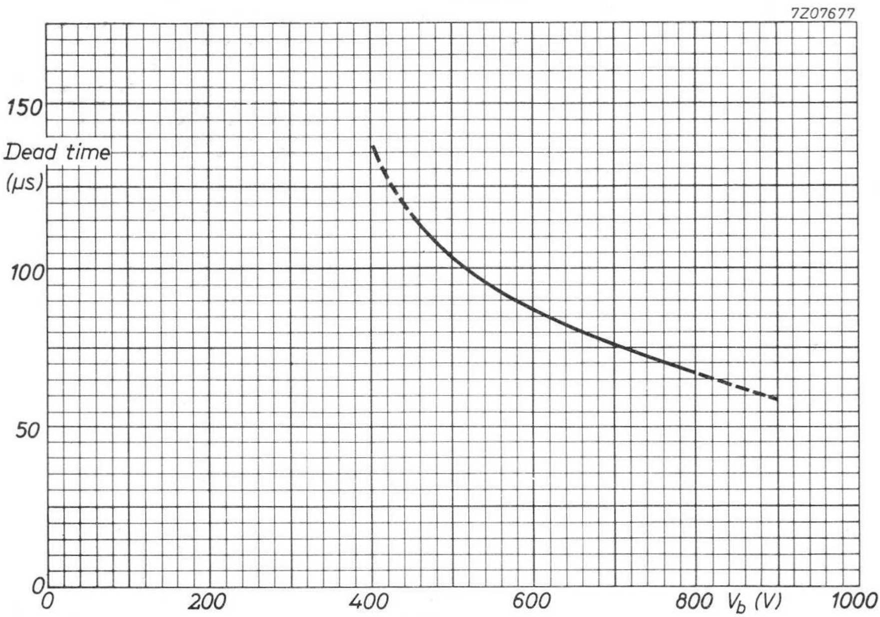
Count rate as function of dose rate



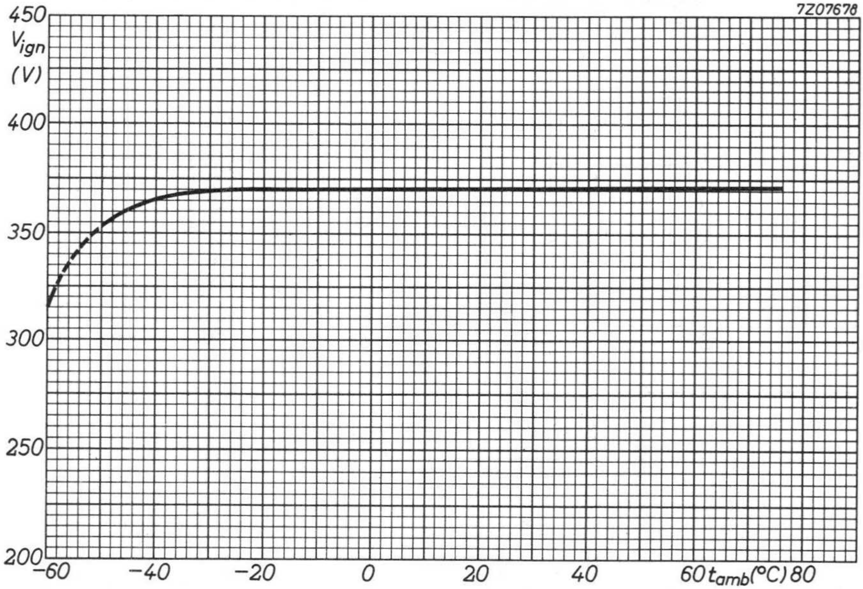
Current as function of dose rate



Plateau curve



Dead time curve



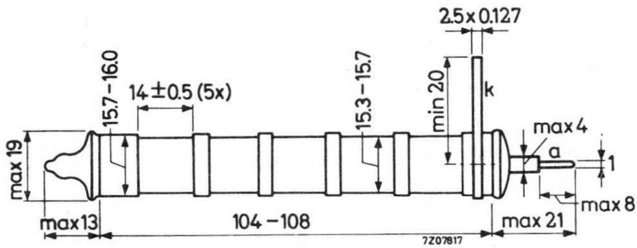
Starting voltage as function of ambient temperature

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 ^oC) 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	^oC
		max.	+75	^oC

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

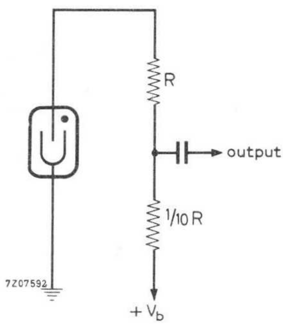
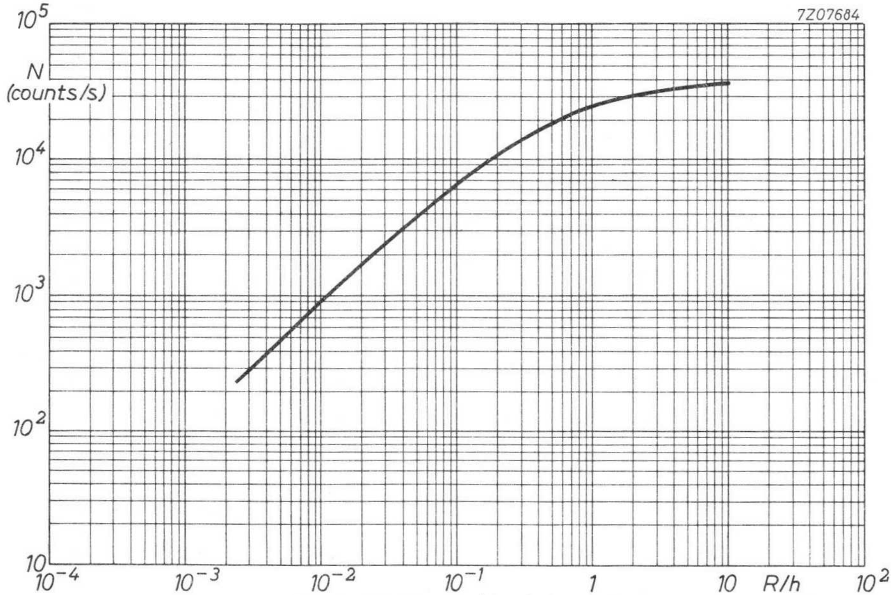


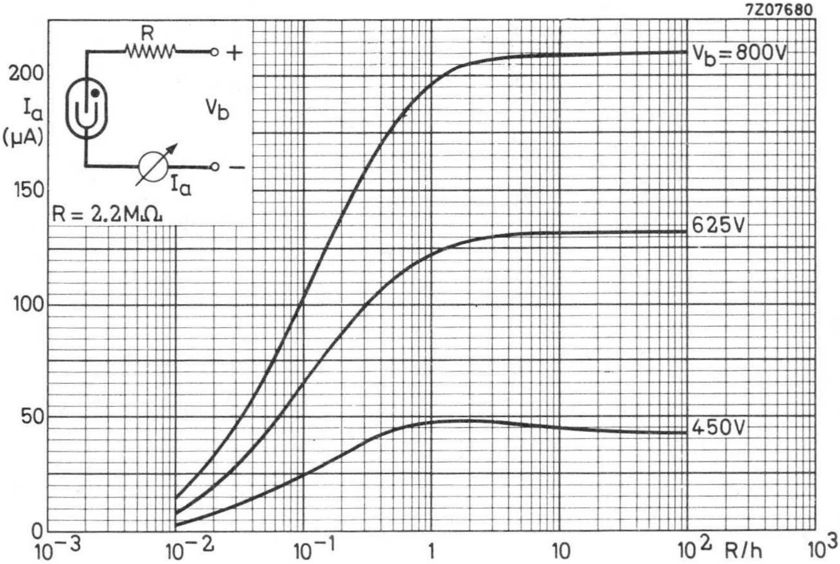
Fig.1

REMARK

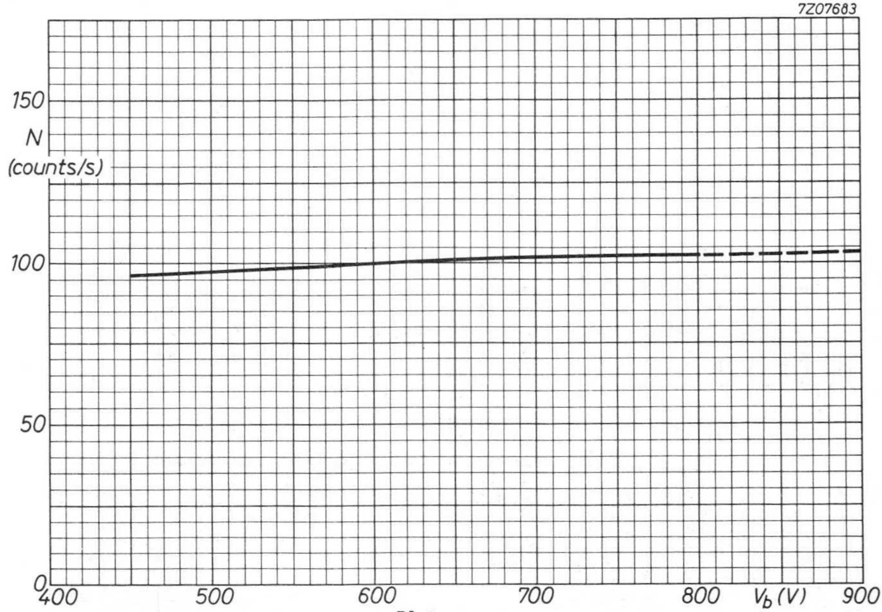
The cathode is covered with a corrosion resistive coating of lacquer, fulfilling the conditions of salt spray testing according to ASTM B117-49T and PNX41-002.



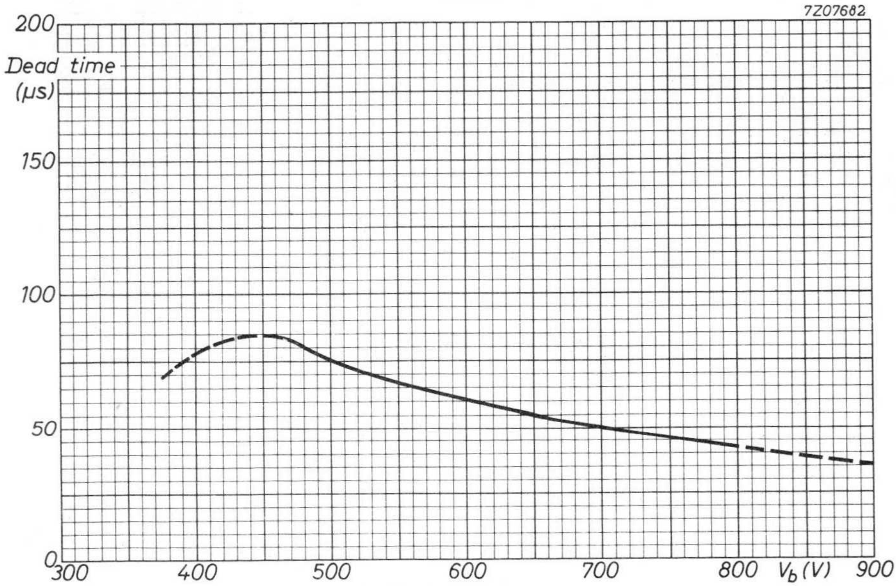
Count rate as function of dose rate



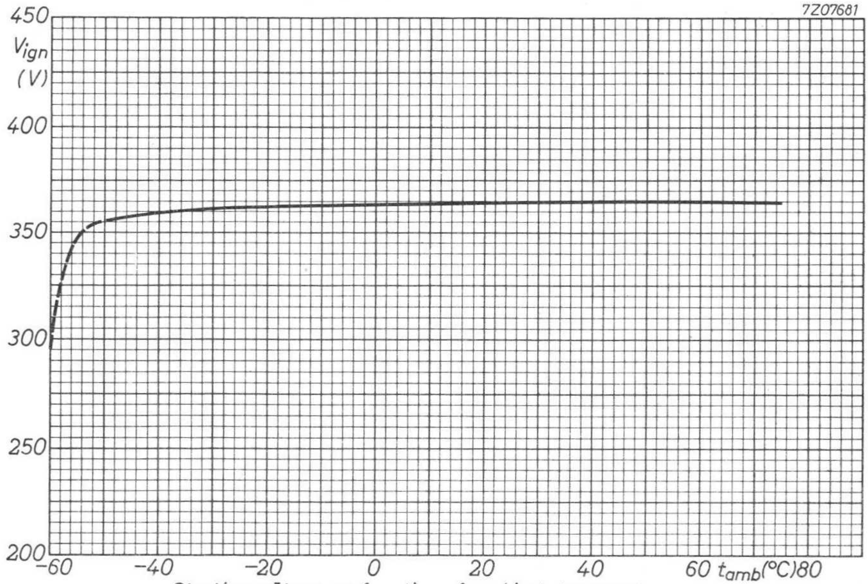
Current as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

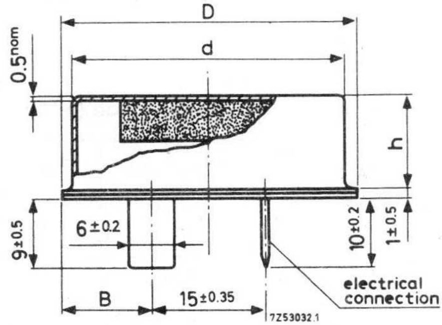
Semiconductor radiation detectors

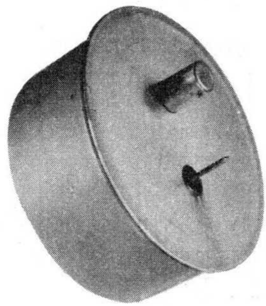
LITHIUM DRIFTED GERMANIUM DETECTORS

Planar detectors intended for measurement of gamma-radiation and X-rays, used at cryogenic temperatures.

MECHANICAL DATA

Dimensions in mm





Available sizes

envelope number	d	D	h	B
31/12	31	34	12	9.5
31/16	31	34	16	9.5
31/21	31	34	21	9.5
36/12	36	39	12	12
36/16	36	39	16	12
36/21	36	39	21	12
46/12	46	49	12	17
46/16	46	49	16	17
46/21	46	49	21	17

MOUNT

To prevent surface contamination and to reduce surface leakage, detectors are supplied in an evacuated envelope with an entrance window 0.50 mm thick. One connection is made via a feed-through connector, the can is grounded. Residual gas pressure in the envelope is less than 10^{-5} torr.

ENTRANCE WINDOW

The entrance window consists of:
- 0.5 mm Fe (envelope)
- about 500 μm Ge.

UNENCAPSULATED DETECTORS

For low energy measurement, we can supply detectors unencapsulated and mounted in one of the cryostat systems.

ACCESSORIES

Cryostat CRY 1 to CRY 4

CHARACTERISTICS

Basic type number	Active area (cm^2)	Depletion depth (mm)	Gamma energy resolution (1.33 MeV) (keV-FWHM) at 77 °K	Envelope number	Capacitance (pF) 1)	
					Envelope	Total
APY16	3	5	3.5	31/12	2.8	11.2
		8	3.5	31/16	2.8	8.1
		10	4.0	31/21	2.8	7.0
		12	4.0	31/21	3.0	6.5
APY17	5	5	3.5	36/12	3.3	17.3
		8	3.5	36/16	3.3	12.1
		10	4.0	36/21	3.3	10.3
		12	4.0	36/21	4.5	10.4
APY18	8	5	3.5	46/12	3.8	26.2
		8	4.0	46/12	3.8	17.8
		10	4.0	46/21	3.5	14.7
		12	4.0	46/21	4.3	13.7
APY19	10	5	3.5	46/12	4.8	32.8
		8	4.0	46/16	4.8	22.3
		10	4.0	46/21	4.0	18.0
		12	4.0	46/21	5.0	16.7

COMPOSITION OF TYPE NUMBER

APY18-8

basic type number — depletion depth

1) These values are approximate as the thickness of the germanium slice differs slightly for a given depletion depth.

Resolution

System gamma resolution at least as good as stated in the accompanying table is guaranteed. It is measured at 77 ^{o}K with ^{60}Co (1.33 MeV) at a low count rate with main amplifier differentiating and integrating time constants of 3.2 μs.

Bias voltage

Detectors will withstand a bias of 2000 V, thus permitting the most efficient charge collection.

Leakage current

Leakage is less than 1 nA, measured at operating voltage and at the temperature of liquid nitrogen.

Storage

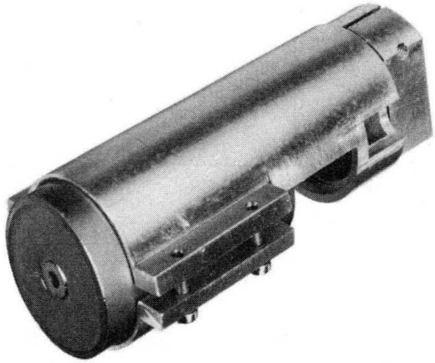
Encapsulated detectors are delivered packed in dry ice and must be stored at a temperature below -80 ^{o}C.

Test certificate

Certified test data accompanying all detectors include:
System gamma resolution at FWHM and at FW 0.1 M, for several energies,
Effective thickness,
Detector capacitance,
Photo-peak to Compton ratio,
Relative photo-peak efficiency,
Bias voltage - with polarity.

LITHIUM DRIFTED GERMANIUM DETECTORS

Coaxial detectors intended for measurement of gamma-radiation and X-rays, used at cryogenic temperatures.



MECHANICAL DATA

Shape and size

Detectors are right circular cylinders, active volumes range from 10 cm^3 to 60 cm^3; depletion depths are up to 12 mm.

Cryostat system

These detectors are unencapsulated so they can only be supplied in one of the cryostat systems.

ACCESSORIES

Cryostat — cry 2 to cry 4

CHARACTERISTICS

Basic type number	Effective active volume (cm^3)	Depletion depth	Gamma energy resolution (1.33 MeV) at 77 °K (keV-FWHM)
APY20	10	up to 12 mm	better than 4 keV typically 3 to 3.5 keV
APY21	20		
APY22	25		
APY23	30		
APY24	35		
APY25	40		
APY26	45		
APY27	50		
APY28	55		
APY29	60		

COMPOSITION OF TYPE NUMBER

APY 28-8

Basic type number — APY 28; -8 — depletion depth

Resolution

Gamma energy resolution is quaranteed to be better than 4 keV (typically 3 keV to 3.5 keV) for ^{60}Co (1.33 MeV), measured with the detector in a cryostat and with the pre-amplifier at room temperature.

Bias-voltage

The detectors will withstand a bias of 2000 V, thus permitting the most efficient charge collection.

Leakage current

Less than 1 nA, measured at operating voltage and at the temperature of liquid nitrogen.

Storage

Detectors must be stored in vacuum at a temperature below -80 °C.

Test Certificate

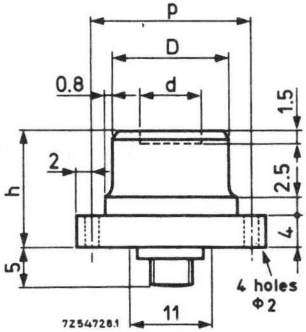
Certified test data accompanying all detectors include:
System gamma resolution at FWHM and FW 0.1 M, for several energies,
Dimensions,
Detector capacitance,
Photo-peak to Compton ratio,
Relative photo-peak efficiency,
Bias voltage-with polarity.

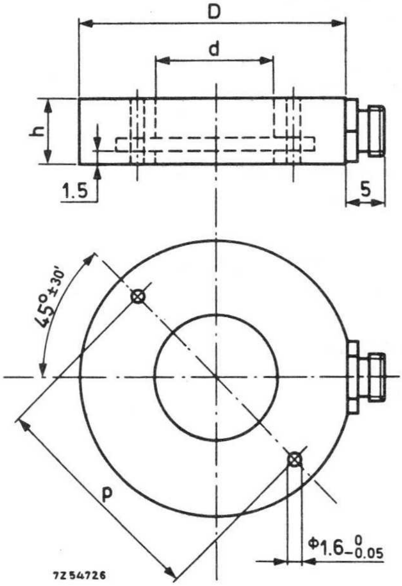
LITHIUM DRIFTED SILICON DETECTORS

Detectors intended for measurement of alpha- and beta- radiation and particles as well as particle identification (standard series), measurement of low energy gamma radiation and X-rays (low temperature series).

MECHANICAL DATA

Dimensions in mm





Standard mount
h = 15 mm (for depletion depth ≤ 3 mm)
h = 17 mm (for depletion depth of 5 mm)

Transmission mount, type T
h = 8.5 mm for depletion depth ≤ 3 mm
h = 10.5 mm for depletion depth of 5 mm

Basic type number	Standard mount			Transmission mount		
	d	D	p	d	D	p
BPX10	5.6	13.6	19.6	5.6	21.5	15.0
BPX12	11.3	19.3	25.3	11.3	31.6	25.0
BPX13	16.0	25.6	31.6	16.0	36.5	30.0
BPX14	20.0	31.6	37.6	20.0	36.5	30.0

MECHANICAL DATA (continued)

Standard series

Mount

The following gold plated mounts are available:
Standard - with rear female connector Microdot 33-36 for mating socket 32-11 or 32-17.
Transmission - type T with side female connector Microdot 33-36 for mating socket 32-11 or 32-17.

Entrance and rear window

The entrance window is a layer of deposited gold less than 60 $\mu g/cm^2$. The rear window is silicon less than 200 μm thick.

Low temperature series

Mount

Detectors are supplied in standard mount fitted with rear female connector Microdot 33-36 for mating socket 32-11 or 32-17.

Entrance window

The entrance window is a layer of deposited gold less than 60 $\mu g/cm^2$.

ACCESSORIES

Cryostat	CRY 1 to CRY 4

CHARACTERISTICS

		Standard series				Low temperature series	
			Maximum resolution (keV-FWHM)				Maximum beta resolution (keV-FWHM)
			alpha	beta			
Basic type number	Active area (mm^2)	Depletion depth (mm)	20 °C	20 °C	-30 °C	Depletion depth (mm)	77 °K
BPX10	25	2	25	12	5	3 [1]	4
		3	30	15	6		
		5	50	17	8		
BPX12	100	2	40	17	6	3	4
		3	50	20	7		
		5	70	22	9		
BPX13	200	2	50	18	7	—	—
		3	70	22	9		
		5	90	25	11		
BPX14	300	2	60	21	8	—	—
		3	80	25	10		
		5	100	30	12		

COMPOSITION OF TYPE NUMBER

BPX12 - 3/K

basic type number ← BPX12

depletion depth ← 3

K → suffix

- no suffix for standard series, standard mount
- suffix T for standard series, transmission mount
- suffix K for low temperature series, standard mount

[1] Available on request

CHARACTERISTICS (continued)

Standard series

Resolution

Alpha resolution is measured at 20 °C, in total darkness, at a pressure of 10^{-3} torr, with a non-collimated ^{241}Am source (5.48 MeV) approximately 3 cm from the entrance window. Beta resolution is measured in the same way but with a ^{207}Bi source (976 keV) at 20 °C and at −30 °C.

Temperature

Detectors are for use between −60 °C and +25 °C.

Storage

We advise storing at about −40 °C, but detectors may be stored for a limited time at room temperature in darkness. In either case they are ready for immediate use.

Test certificate

Certified test date accompany all detectors. Depletion depth is stated to an accuracy of ± 10%.

Low temperature series:

Resolution

Beta resolution is measured at 77 °K, in total darkness, at a pressure of 10^{-3} torr, with a non-collimated ^{207}Bi source (976 keV) approximately 3 cm from the entrance window. Beta resolution is better than 4 keV, but typically 3 keV to 3.5 keV.

Temperature

Detectors are for use at 77 °K.

Storage

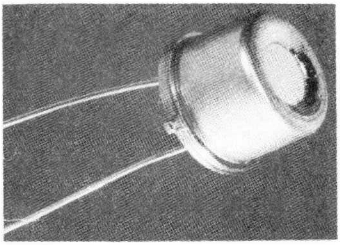
We advise storing at about −40 °C, but detectors may be stored for a limited time at room temperature in darkness. In either case they are ready for immediate use.

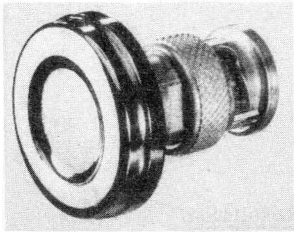
Test certificate

Certified test date accompany all detectors. Depletion depth is stated to an accuracy of ± 10%.

DIFFUSED SILICON DETECTORS

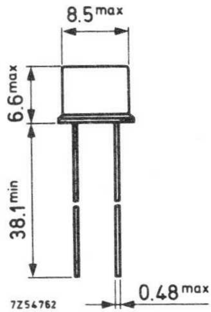
Detectors intended for measurement of particles and for health physics applications.

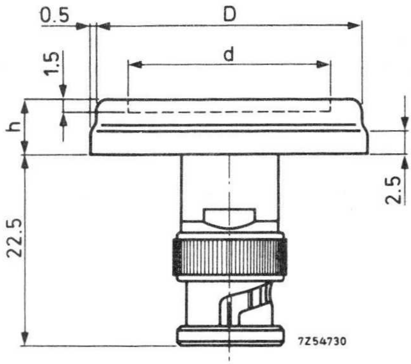




MECHANICAL DATA

Dimensions in mm





Basic type number	d	D	h
BPY22	11.8	17	6
BPY23	16.5	23	6

Mount

BPY20 is supplied in TO-5 envelope with open front.
BPY22 and BPY23 are supplied in brass mount with male connector UG589/U for mating socket UG89/U.

Entrance window

The detector is opaque. The entrance window is a layer of silicon of less than 120 $\mu g/cm^2$.

CHARACTERISTICS

Depletion depth

Depletion depth is > 50 μm for all types

Basic type number	Active area (mm^2)
BPY20	12
BPY22	100
BPY23	200

Resolution

Alpha resolution is better than 100 keV (FWHM) at 20 °C for ^{241}Am (5.48 MeV).

Storage

Detectors can be stored at any temperature between +80 °C and −50 °C. They are ready for immediate use.

Test certificate

Certified test data accompany all detectors.

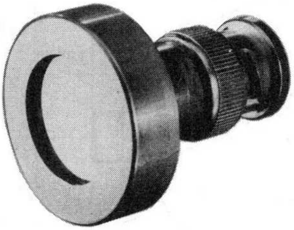
PARTIALLY DEPLETED SILICON SURFACE BARRIER DETECTORS

Detectors intended for measurement of alpha- and low energy beta-radiation, particles and fission products.
In conjunction with totally depleted detectors they can be used for particle identification purposes.

MECHANICAL DATA

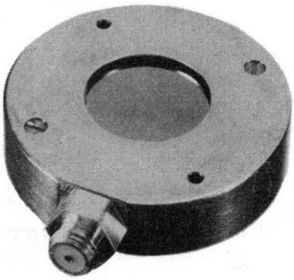
Versions

Detectors are available in two versions:

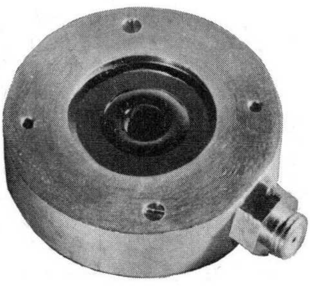


Circular with a choice of mounts:
- standard, silver plated brass with male connector BNC31-304 for mating socket UG89/U.
- planar, silver plated brass with female connector Microdot 33-36 for mating socket 32-11 or 32-17.

(Types BPY51 to BPY55)



Annular - in a silver plated brass transmission mount (open front and back) with female connector Microdot 33-36 for mating socket 32-11 or 32-17.
(Types BPY58 and BPY59)

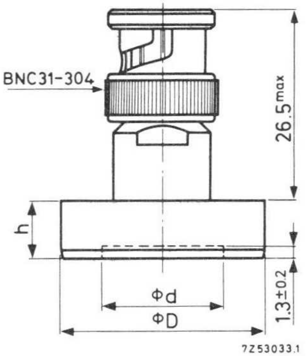


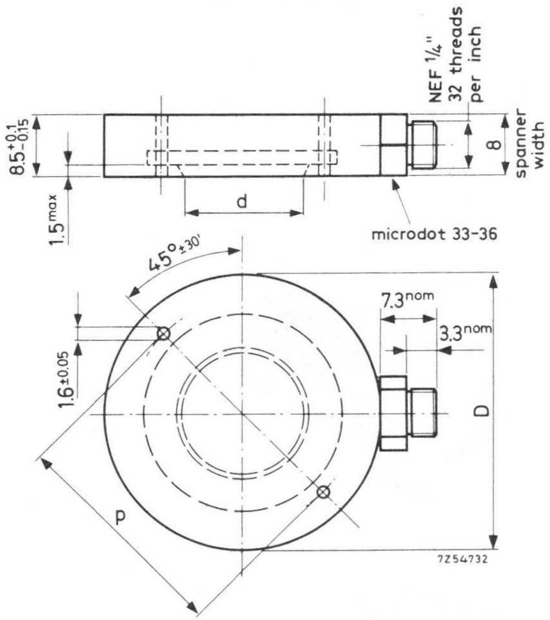
Entrance window

The entrance window is a layer of deposited gold 40 $\mu g/cm^2$.

MECHANICAL DATA (continued) Dimensions in mm

CIRCULAR DETECTORS





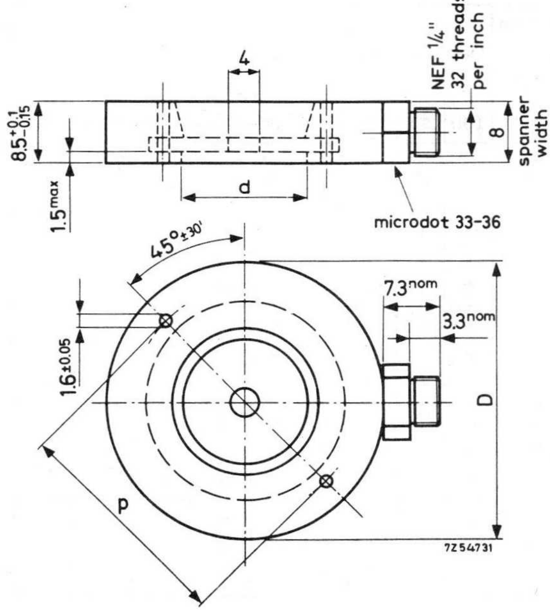
Standard mount
h = 7.5 mm for depletion depth ≤ 1000 μm
h = 10 mm for depletion depth > 1000 μm

Planar mount
(type S)

Basic type number	Kind of mount	Depletion depth ≤ 1000 μm			Depletion depth > 1000 μm		
		d	D	p	d	D	p
BPY51	standard	5.6	16.0	–	5.6	22.0	–
	planar	5.6	22.0	15.0	5.6	32.0	25.0
BPY53	standard	11.5	22.0	–	11.5	26.5	–
	planar	11.5	32.0	25.0	11.5	37.0	30.0
BPY54	standard	16.0	26.5	–	16.0	30.0	–
	planar	16.0	37.0	30.0	16.0	37.0	30.0
BPY55	standard	19.6	30.0	–	–	–	–
	planar	19.6	37.0	30.0	–	–	–

MECHANICAL DATA (continued) Dimensions in mm

ANNULAR DETECTORS



Standard hole diameter is 4 mm, but they can be supplied with holes up to 10 mm, if required.

Standard hole diameter is 4 mm, but they can be supplied with holes up to 10 mm, if required.

Transmission mount

Basic type number	Kind of mount	Depletion depth ≤ 1000 μm			Depletion depth > 1000 μm		
		d	D	p	d	D	p
BPY58	transmission	16.0	32.0	25.0	16.0	37.0	30.0
BPY59	transmission	19.6	37.0	30.0	19.6	37.0	30.0

CHARACTERISTICS

+ Available types.

Basic type number	Active area (mm^2)	Quality class	Max. resolution at 20 °C (keV-FWHM)		Depletion depth (μm)								
			alpha	beta	100	200	350	500	700	1000	1500	2000	2500
CIRCULAR DETECTORS													
BPY51	25	SQ	15	12	+	+	+	+	+	+			
		A	18	13	+	+	+	+	+	+	+	+	+
		B	25	20	+	+	+	+	+	+	+	+	+
BPY53	100	SQ	18	13	+	+	+	+	+	+			
		A	20	15	+	+	+	+	+	+	+	+	+
		B	25	20	+	+	+	+	+	+	+	+	+
BPY54	200	SQ	20	15	+	+	+	+	+	+			
		A	25	20	+	+	+	+	+	+	+	+	+
		B	30	25	+	+	+	+	+	+	+	+	+
BPY55	300	SQ	20	15	+	+	+	+	+	+			
		A	25	20	+	+	+	+	+	+			
		B	30	25	+	+	+	+	+	+			
ANNULAR DETECTORS													
BPY58	100		30	25	+	+	+	+	+	+	+	+	
BPY59	200		40	35	+	+	+	+	+	+	+	+	

COMPOSITION OF TYPE NUMBER

BPY54 - 350/A/S

- BPY54: basic type number
- 350: depletion depth
- A: quality class (SQ, A or B)
- S: S for planar mount; No indication for other mounts
- A/S: for circular detectors only

CHARACTERISTICS (continued)

Resolution

Alpha resolution is measured at 20 °C, in total darkness, at a pressure of 10^{-3} torr, with a non-collimated ^{244}Cm source (5.806 MeV) 6 cm to 8 cm from the entrance window. Beta resolution is measured under the same conditions but with $^{137}Ba^{m}$ conversion electrons.

Stability under vacuum

Detector stability is unaffected by vacuum as high as 10^{-6} torr.

Shock and vibration

Detectors can withstand the following conditions:
severe shock - acceleration up to 1 000 g;
vibration - acceleration up to 10 g in the range 20 Hz to 2 000 Hz.

Storage

Detectors can be stored indefinitely at room temperature and be ready for immediate use.

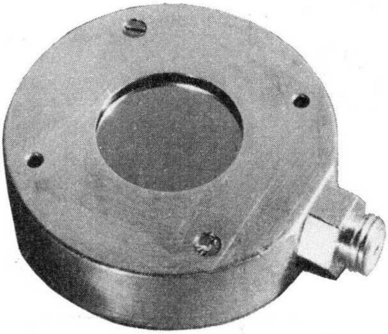
Test certificate

Certified test data accompany all detectors. Depletion depth is stated to an accuracy of ± 10%.

TOTALLY DEPLETED SILICON SURFACE BARRIER DETECTORS

Detectors for measurement of alpha-radiation and particles. They can be stacked with a partially depleted silicon surface barrier detector or with a lithium drifted silicon detector.

MECHANICAL DATA



Versions

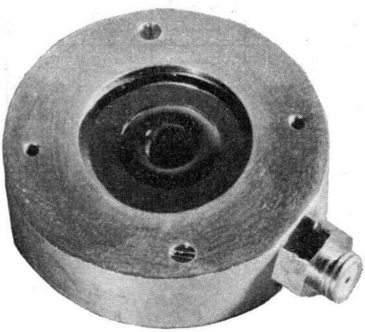
Detectors are available in two versions:

Circular - in a silver plated brass transmission mount (open front and back) with female connector Microdot 33-36 for mating socket 32-11 or 32-17.

(Types BPY81 to BPY85)

Annular - in the same transmission mount.

(Types BPY88 and BPY89)



Annular - in the same transmission mount.

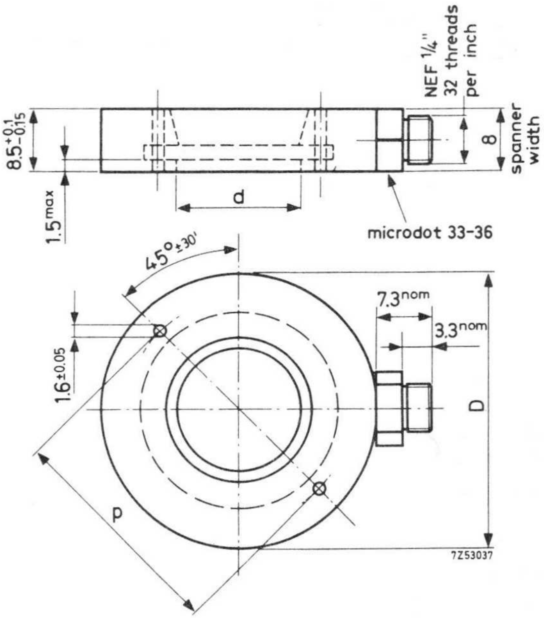
(Types BPY88 and BPY89)

Entrance window

The entrance window is a layer of deposited gold 40 $\mu g/cm^2$

MECHANICAL DATA (continued) Dimensions in mm

CIRCULAR DETECTORS

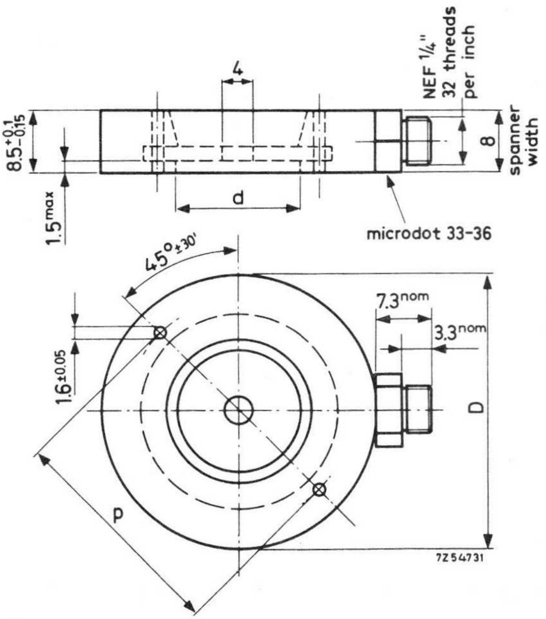


Basic type number	Depletion depth ≤ 1000 μm			Depletion depth > 1000 μm		
	d	D	p	d	D	p
BPY81	5.6	22.0	15.0	5.6	32.0	25.0
BPY83	11.5	32.0	25.0	11.5	37.0	30.0
BPY84	16.0	37.0	30.0	16.0	37.0	30.0
BPY85	19.6	37.0	30.0	–	–	–

MECHANICAL DATA (continued)

Dimensions in mm

ANNULAR DETECTORS

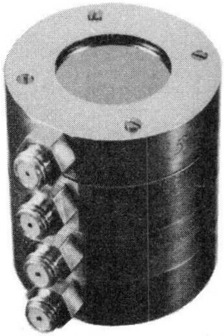


Standard hole diameter is 4 mm, but they can be supplied with holes up to 10 mm, if required

Basic type number	Depletion depth ≤ 1000 μm			Depletion depth > 1000 μm		
	d	D	p	d	D	p
BPY88	16.0	32.0	25.0	16.0	37.0	30.0
BPY89	19.6	37.0	30.0	19.6	37.0	30.0

MECHANICAL DATA (continued)

Dimensions in mm



Note

Detectors that are to be stacked must have the same diameter mount. If necessary we will fit totally depleted detectors in a larger than normal transmission mount to match the planar mount of a specific partially depleted detector.

CHARACTERISTICS

Basic type number	Active area (mm^2)	Quality class	Max. resolution at 20 °C (keV-FWHM)	
			alpha	beta
CIRCULAR DETECTORS				
BPY81	25	A B	20 25	15 20
BPY83	100	A B	20 25	15 20
BPY84	200	A B	25 30	20 25
BPY85	300	A B	25 30	20 25
ANNULAR DETECTORS				
BPY88	100	–	30	25
BPY89	200	–	40	35

CHARACTERISTICS (continued)

• Circular detectors available in one quality class only.
Instead of the maximum resolution we guarantee a noise < 20 keV.
\+ Available types. In the case of circular detectors, available in both quality classes A and B.

<table>
<tr><th rowspan="2">Basic type number</th><th colspan="14">Depletion depth (µm)</th></tr>
<tr><th>3 to 7</th><th>7 to 12</th><th>12 to 17</th><th>17 to 22</th><th>22 to 30</th><th>50</th><th>100</th><th>200</th><th>350</th><th>500</th><th>700</th><th>1000</th><th>1500</th><th>2000</th></tr>
<tr><td colspan="15">CIRCULAR DETECTORS</td></tr>
<tr><td rowspan="2">BPY81</td><td>±0.25 µm</td><td colspan="4">±0.5 µm</td><td colspan="5">±1 µm</td><td colspan="4">±2 µm</td></tr>
<tr><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td rowspan="2">BPY83</td><td rowspan="2"></td><td rowspan="2"></td><td colspan="8">±1 µm</td><td colspan="4">±2 µm</td></tr>
<tr><td>•</td><td>•</td><td>•</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td rowspan="2">BPY84</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td colspan="10">±2 µm</td></tr>
<tr><td>•</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td rowspan="2">BPY85</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td colspan="7">±2 µm</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td colspan="15">ANNULAR DETECTORS</td></tr>
<tr><td>BPY88</td><td></td><td></td><td></td><td></td><td></td><td></td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>BPY89</td><td></td><td></td><td></td><td></td><td></td><td></td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
</table>

COMPOSITION OF TYPE NUMBER

BPY84-350/A

- BPY84 — basic type number
- 350 — depletion depth [1]
- / — for circular detectors with depletion depth ≥ 50 µm only
- A — quality class (A or B)

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[1] For 3-7, 7-12, etc. use 7, 12, etc. The true value of the depletion depth is stated in the test certificate. The tolerance on the true value is shown in the table.

CHARACTERISTICS (continued)

Resolution

Alpha resolution is measured at 20 °C, in total darkness, at a pressure of 10^{-3} torr, with a non-collimated ^{244}Cm source (5.806 MeV) 6 cm to 8 cm from the entrance window. Beta resolution is measured under the same conditions but with ^{137}Ba^{m} conversion electrons.

Crystal regularity

The wafers are specially cut to prevent particles being channelled along the crystal axes thus obviating asymmetric output pulses.

Stability under vacuum

Detector stability is unaffected by vacuum as high as 10^{-6} torr.

Shock and vibration

Detectors can withstand the following conditions:
severe shock - acceleration up to 1000 g,
vibration - acceleration up to 10 g in the range 20 Hz to 2000 Hz.

Storage

Detectors can be stored indefinitely at room temperature and be ready for immediate use.

Test certificate

Certified test data accompany all detectors.

CRYOSTAT

CRY1 : vertical cryostat supplied without dewar.
CRY2 : cryostat CRY1 supplied with a 25 litre dewar.
CRY3 : right-angle cryostat mounted on top of the dewar.
CRY4 : right-angle cryostat mounted below the dewar.

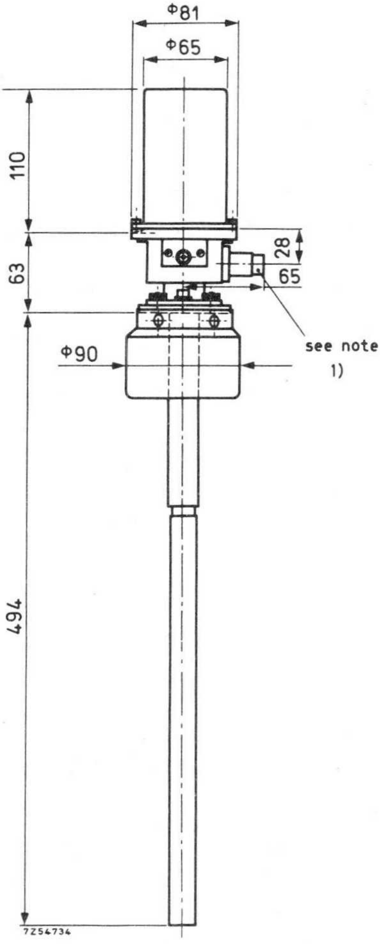
NOTES - For X-ray and low energy gamma ray spectrometry the cryostats can be fitted with a special beryllium window.
- An additional connector (Amphenol 17-20090) is fitted if the first stage of the pre-amplifier is mounted in the cryostat.
- The horizontal arms of CRY3 and CRY4 are normally 46 cm long, but if requested they can be of any length up to 60 cm.
- Types CRY3 and CRY4 are provided with an additional pumping connection, suitable for a 1 litre per second ion pump.

SPECIFICATIONS

Consumption of cryostat and dewar per 24 hours:
CRY2 : 0.9 litres
CRY3 : 1.5 litres
CRY4 : 2.6 litres
Holding time for one charge:
CRY2 : 24 days
CRY3 : 14 days
CRY4 : 10 days

Min. liquid nitrogen level (recharging level)	CRY2 and 3: 50 mm
Getter	Zeolite; type 13X (Union Carbide)
Reactivation of zeolite	
- reactivating intervals	approx. 6 to 12 months
- temperature	min. 180 °C; max. 200 °C
- vacuum	max. 10^{-2} torr
- reconditioning time	min. 2 hours
Pre-vacuum (before immersion into liquid nitrogen)	10^{-3} ($< 10^{-2}$) torr
Vacuum (cryostat, during operation)	10^{-5} ($< 10^{-4}$) torr
Total capacitance of electrical connection	4 ± 0.5 pF
Electrical connection	modified version MHV UG932/U
Number of adaptors available (aluminium)	9 models
Hood (aluminium)	
- entrance window	diameter 40 mm thickness 0.75 mm
- cylindrical wall	thickness 0.50 mm

DIMENSIONS in mm

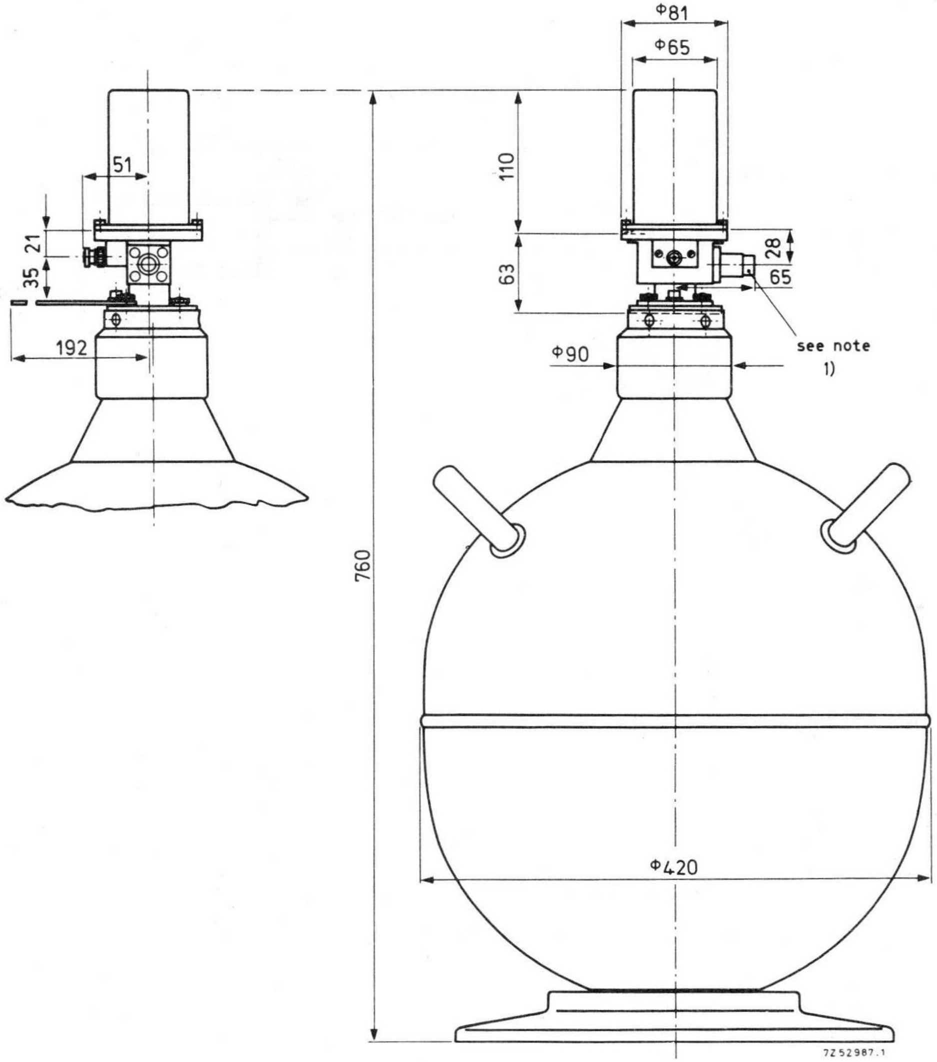


CRY1 : A standard vertical cryostat supplied without dewar

Net weight: 2.2 kg

1) Relief valve and connection for pumping.

DIMENSIONS in mm



CRY2 : As CRY1, but supplied with 25 litre dewar

Net weight: empty : 9 kg
filled with 25 litres liquid nitrogen: 30 kg

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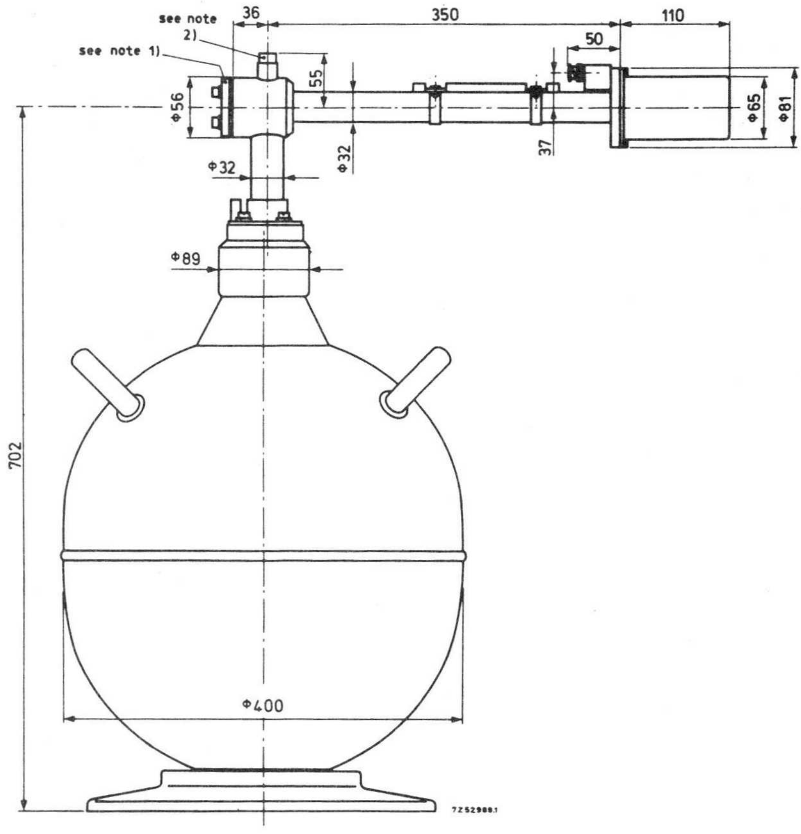
1) Relief valve and connection for pumping.

DIMENSIONS in mm

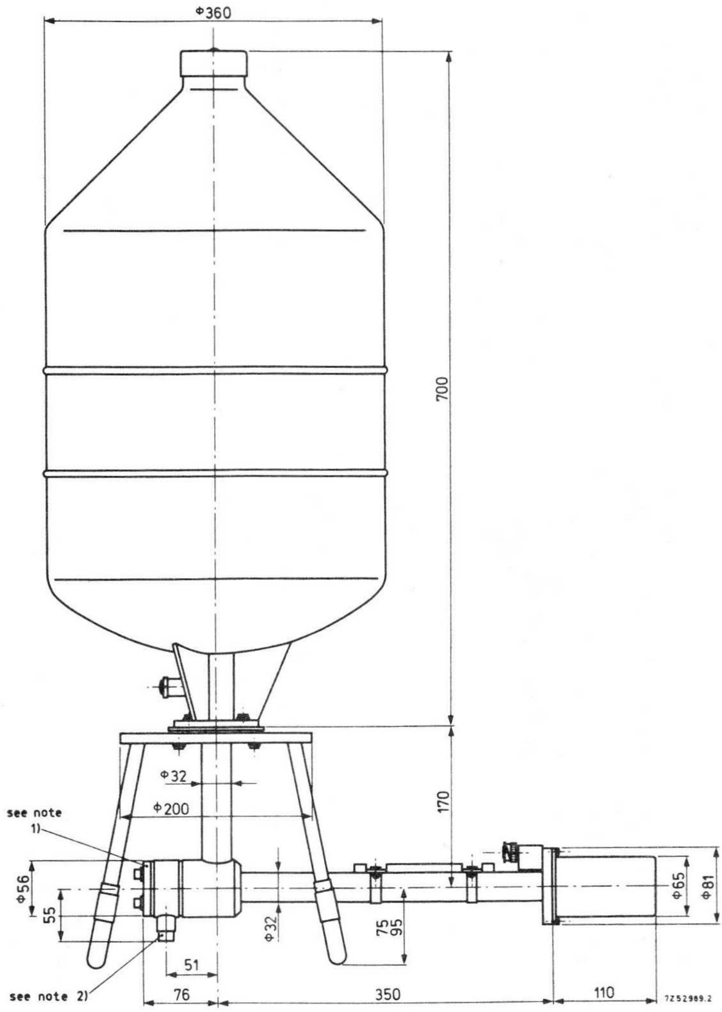


CRY3 : A right angle cryostat mounted on top of a dewar

Net weight: empty : 12.5 kg
filled with 25 litres liquid nitrogen: 33 kg

1) Additional pumping connection, suitable for a 1 litre per second ion pump.
2) Relief valve and connection for pumping.

DIMENSIONS in mm



CRY4 : A right angle cryostat mounted below a dewar

Net weight: empty : 16 kg
filled with 25 litres liquid nitrogen: 36 kg

1) Additional pumping connection, suitable for a 1 litre per second ion pump.
2) Relief valve and connection for pumping.

ADAPTORS

Dimensions in mm

A series of nine aluminium adaptors is available to match the various detector envelopes to the cryostat.

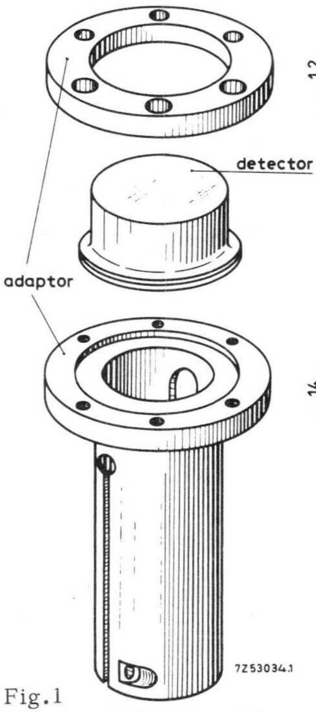


Fig.1
Relation of detector and adaptor.

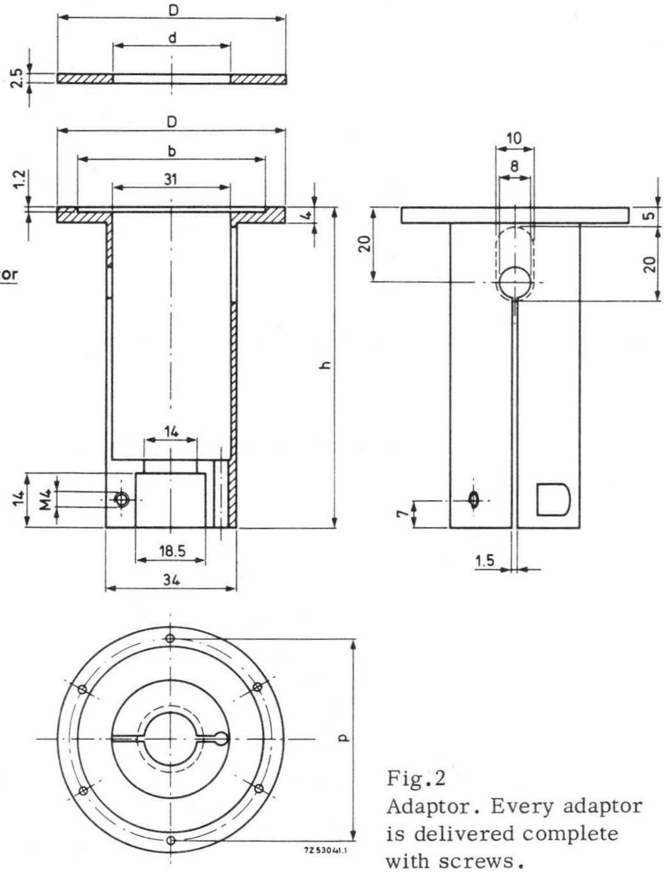


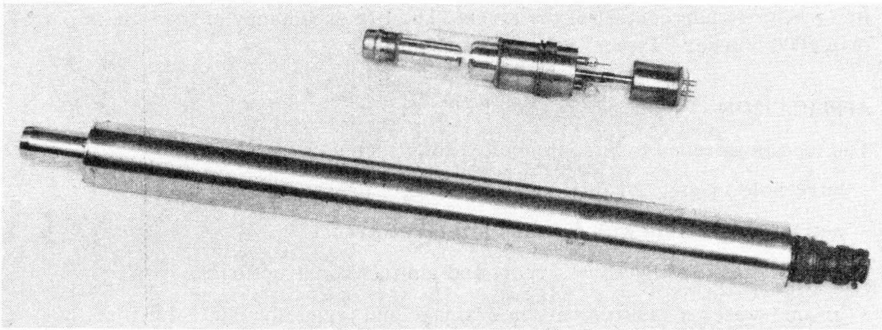
Fig.2
Adaptor. Every adaptor is delivered complete with screws.

Adaptor	Envelope	D	d	b	h	p
A31/12	31/12	45	32	34.5	88	39.0
A31/16	31/16	45	32	34.5	84	39.0
A31/21	31/21	45	32	34.5	80	39.0
A36/12	36/12	50	37	39.5	88	44.0
A36/16	36/16	50	37	39.5	84	44.0
A36/21	36/21	50	37	39.5	80	44.0
A46/12	46/12	60	47	49.5	88	54.0
A46/16	46/16	60	47	49.5	84	54.0
A46/21	46/21	60	47	49.5	80	54.0

Neutron generator tubes

NEUTRON GENERATOR TUBE

Sealed-off neutron generator tube for continuous and pulsed operation.



DESCRIPTION

The 18601 is a compact and sturdy type of sealed-off accelerating tube that makes use of the T (d, n) ^{4}He reaction to generate 14 MeV neutrons, thus forming a mono-energetic continuous or pulsed neutron source without accompanying γ radiation. The tube operates at a high voltage of −125 kV. It produces in continuous operation over 10^8 neutrons per second, in pulsed operation up to 2.10^{11} neutrons per second (typical) during the pulse.
The tube contains a Penning ion source, which 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 (replenisher) and can be measured by a built in ionization gauge. The beam of accelerated deuterium-and tritium ions strikes and replenishes the titanium-tritium target ensuring a tube life that is not limited by the tritium content of the target. The life expectancy of the tube is more than 1000 h under "Typical operation" conditions.

APPLICATION

The tube is intended for use in applications such as:

- bore-hole logging for oil, coal and mineral prospecting;
- activation analysis with fast or thermal neutrons;
- soil studies for highway, airport and similar constructions;
- ground-water measurements in drainage and irrigation control projects;
- subcritical reactor research;
- fast reactor control;
- fundamental nuclear research;
- radiobiology;
- radiochemistry;
- production of radioisotopes;
- training and education;
- different applications in industry:

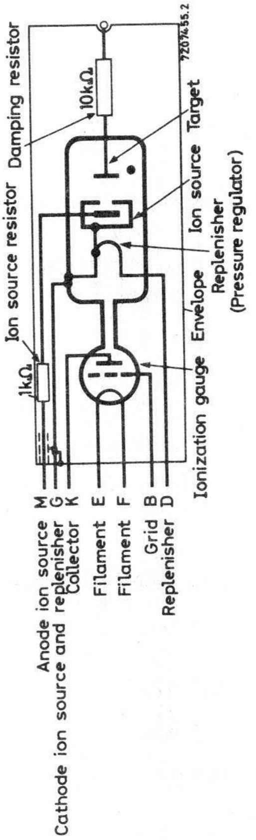
  labelling of items for tracer work;

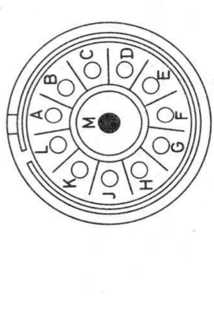
  moisture control of foundry sand;

  inventory of large stockpiles of coal and grain.

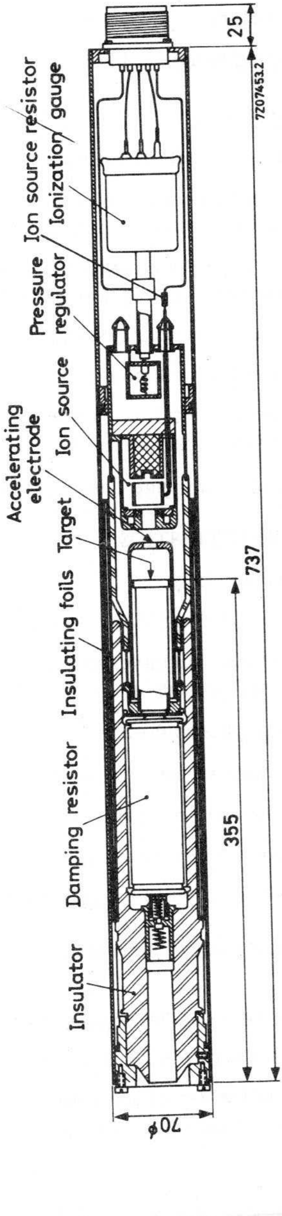
MECHANICAL DATA

Dimensions in mm





plug connections



Mounting position: any

Weight

Net weight 6 kg

Shipping weight 11.5 kg

Accessories

a) Supplied with the tube:

- Tube filled with silicone grease X01805 or equivalent (e.g. Dow Corning DC4) for high tension connector
- 12 pin female connector plug Amphenol with cable clamp AN3057-16 (or equivalent) — type MS3106A28-18S See page 3

b) Optional at extra costs:

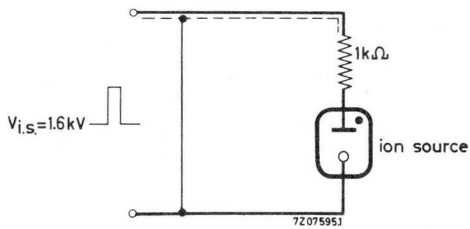
- HT cable with connectors (length 6.5 m) — type 56066
- Supply cable for ion source /ionization gauge/ pressure regulator — on request.
- Ionization gauge control unit — type WPS-3-NL/NG

CHARACTERISTICS

Neutron energy	approx. 14 MeV (DT-reaction)
Neutron yield at V_t = −125 kV, I_t = 100 μA	
continuous and average during pulsed operation	min. 10^8 n/s
during pulse max. yield	> 10^{11} n/s
Pulse duration at a yield of 10^{11} n/s	5 to 1000 μs
Neutron yield n = f (target voltage V_t)	See page 7
Maxium duty cycle = f (gas pressure p)	See page 8
Peak neutron yield n_{peak} = f (gas pressure p)	See page 9
Peak ion source current $I_{i.s.peak}$ = f (gas pressure p)	See page 10
Peak target current I_{tpeak} = f (gas pressure p)	See page 11
Gas pressure p = f (replenisher current $I_{repl.}$)	See page 12
Build-up time τ of ion source current pulse = f (gas pressure p)	See page 13

TYPICAL OPERATION

	Continuous operation	Pulsed operation	
Neutron output	2.10^8	2.10^{11}	n/s
Pulse duration	-	5 to 1000	μs [1])
Target voltage	-125	-125	kV
Target current	100	mean value 100	μA
Ion source supply voltage	2	1.6	kV
Ion source current	10^{-4}	peak value 1	A
Replenisher current	3	4.2	A
Gas pressure	3.10^{-5}	8.10^{-3}	torr
Ambient temperature	25	25	°C
Ionization gauge:			
emission current	10		μA
cathode voltage	33		V
grid-filament voltage	150		V
collector-filament voltage	-28		V
filament voltage	approx. 2		V



Ion source circuit

[1]) At lower yields longer pulses are permissible, however, the maximum target dissipation should be observed.

LIMITING VALUES (Absolute max. rating system)

Target voltage (during continuous operation)	min.	−30	kV
(during high output mode)	min.	−80	kV
Target voltage	max.	−130	kV
Target dissipation (continuous)	max.	12.5	W
Target dissipation (T_{av} = max 5 s)	max.	15	W
Target current (during continuous operation)	max.	100	μA
(T_{av} = max. 5s)	max.	120	μA
(during pulse), peak	max.	300	mA
, average	max.	100	μA
Ion source supply voltage	max.	3	kV
Replenisher current	max.	6	A
Gas pressure	max.	10^{-2}	torr
Ambient temperature	min.	−25	°C
	max.	70	°C

LIFE EXPECTANCY

The life expectancy of the tube is > 1000 h under "Typical operation" conditions.

WARNINGS

1. The tube contains 9.5 Curie titanium-bound tritium.
2. It is necessary to protect the user against the neutron radiation and the secondary γ radiation.

OPERATIONAL CONSIDERATION

For satisfactory operation of the tube the recommendations given in the "Instructions for operation" packed with each tube should be observed.

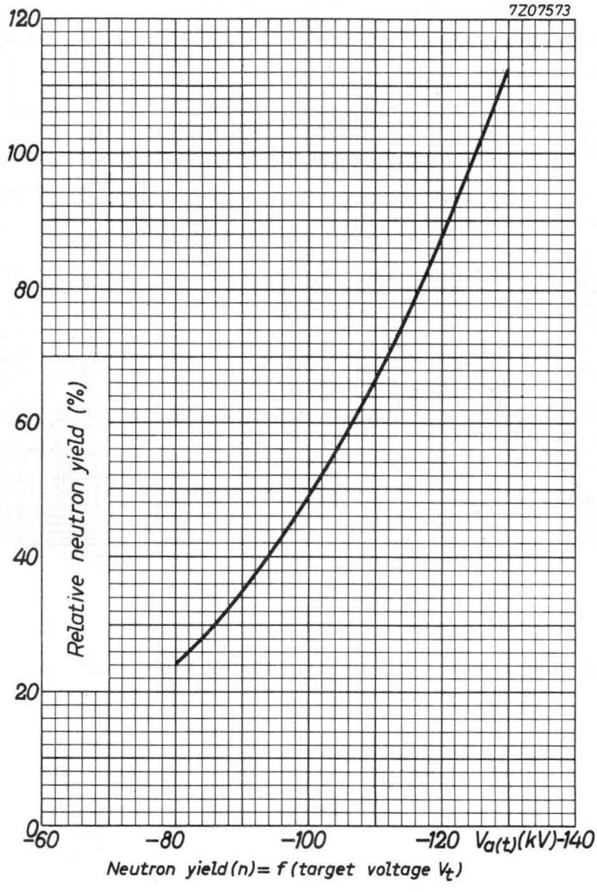

7Z07573
120
100
80
60
40
20
0
Relative neutron yield (%)
-60
-80
-100
-120
$V_{a(t)}$(kV)
-140
Neutron yield (n) = f (target voltage V_t)

Fig. 1

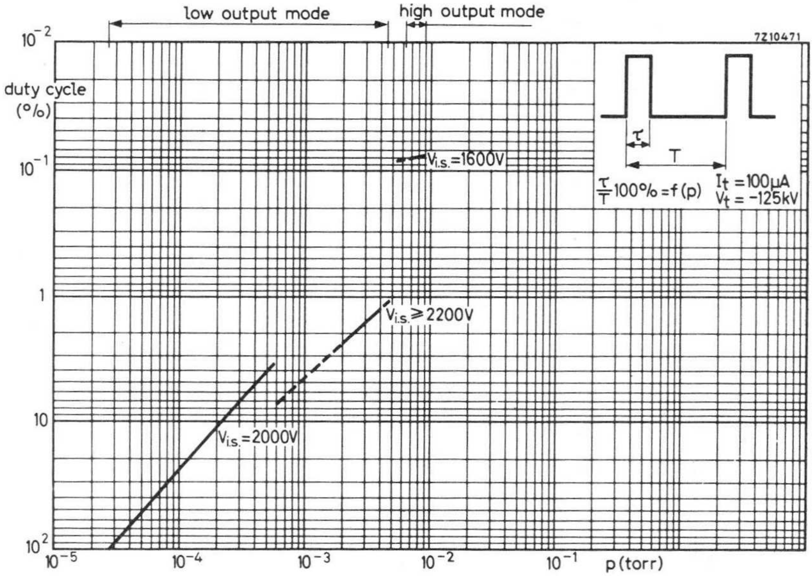


Fig.2

Maximum duty cycle as a function of gaspressure (p)

NOTES

- Operation in the region at the right of above given curve results in exceeding the limiting values and is therefore not permitted.
- In the dotted regions the ion source gives different types of discharge resulting in a variation in neutron output per pulse.

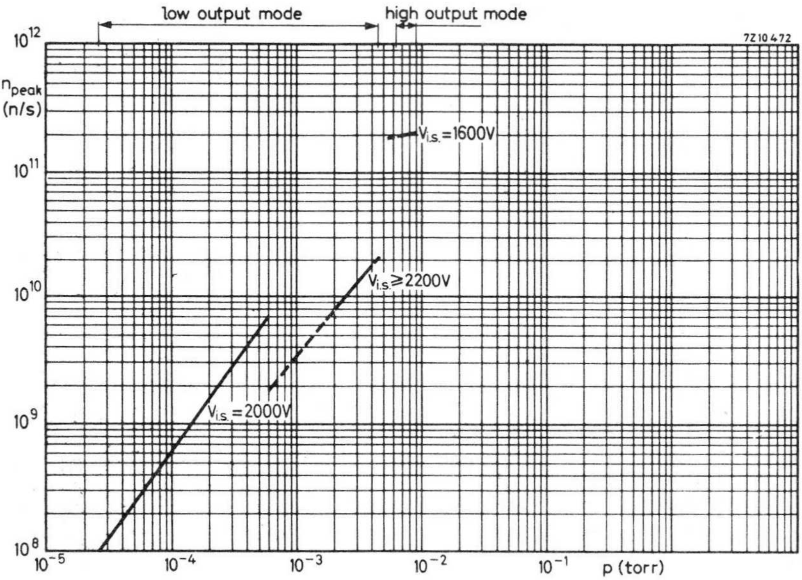


Fig.3

Peak neutron yield (n_{peak}) as a function of gaspressure (p)
Target dissipation = 12.5 W (I_t = 100 μA, V_t = −125 kV)

NOTES

- Operation in the region at the right of above given curve results in exceeding the limiting values and is therefore not permitted.
- In the dotted regions the ion source gives different types of discharge resulting in a variation in neutron output per pulse.

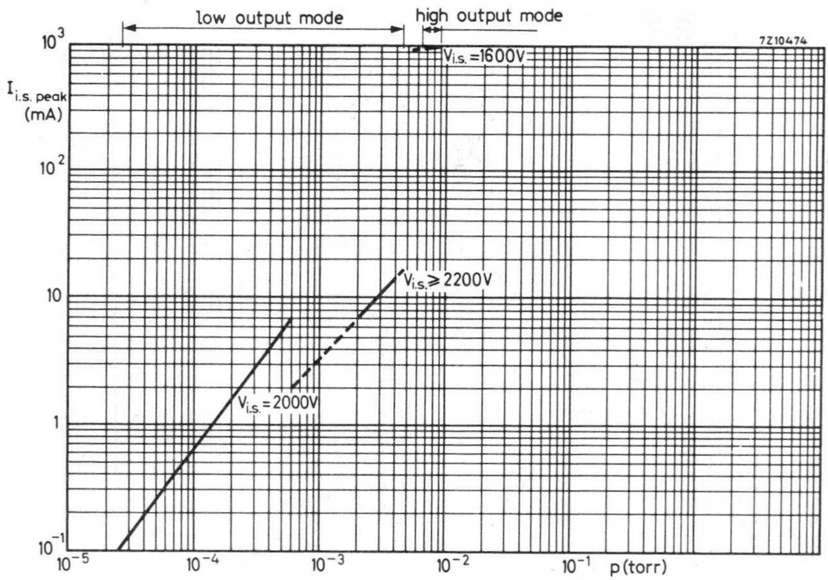


Fig.4

Peak ion source current ($I_{i.s.}$ peak) as a function of gas pressure (p)
Target dissipation = 12.5 W (I_t = 100 μA, V_t = -125 kV)

NOTES

- Operation in the region at the right of above given curve results in exceeding the limiting values and is therefore not permitted.
- In the dotted regions the ion source gives different types of discharge resulting in a variation in neutron output per pulse.

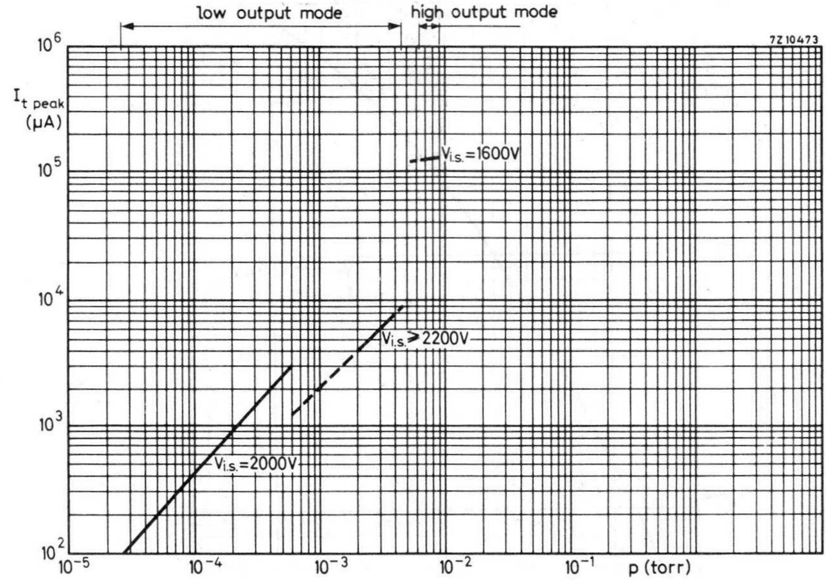
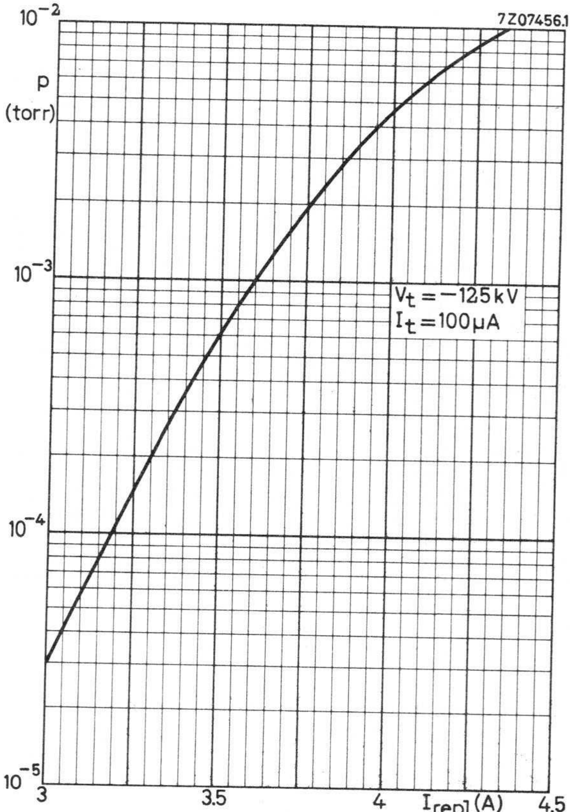


Fig.5

Peak target current ($I_{t\ peak}$) as a function of gas pressure (p)
Target dissipation = 12.5 W (I_t = 100 μA, V_t = 125 kV)

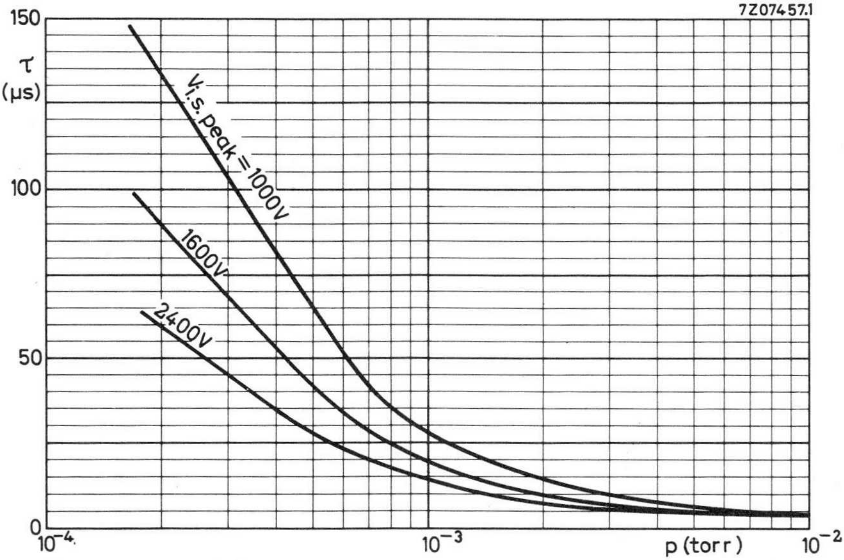
NOTES

- Operation in the region at the right of above given curve results in exceeding the limiting values and is therefore not permitted.
- In the dotted regions the ion source gives different types of discharge resulting in a variation in neutron output per pulse.



Gas pressure (p) as a function of replenisher current (I_{repl})

Fig.6

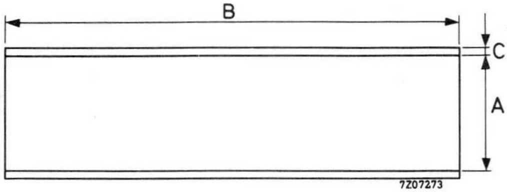


Build-up time (τ) of ion source current pulse as a function of gas pressure (p)

Fig. 7

Associated accessories

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

Type No.	Section	Type No.	Section	Type No.	Section
APY16 to 19	S.R.D.	S5600	Ph. Sc.	XP1052	Ph. Sc.
APY20 to 29	S.R.D.	XP1000	Pm. T.	XP1053	Ph. Sc.
BPX10 to 14	S.R.D.	XP1001	Pm. T.	XP1110	Pm. T.
BPY20 to 23	S.R.D.	XP1002	Pm. T.	XP1111	Pm. T.
BPY51 to 55	S.R.D.	XP1003	Pm. T.	XP1113	Pm. T.
BPY58, 59	S.R.D.	XP1004	Pm. T.	XP1114	Pm. T.
BPY81 to 85	S.R.D.	XP1005	Pm. T.	XP1115A	Pm. T.
BPY88,89	S.R.D.	XP1006	Pm. T.	XP1115B	Pm. T.
CRY1 to 4	S.R.D.	XP1010	Pm. T.	XP1116	Pm. T.
PS1010	Ph. Sc.	XP1011	Pm. T.	XP1117	Pm. T.
PS1011	Ph. Sc.	XP1015	Pm. T.	XP1118	Pm. T.
PS1012	Ph. Sc.	XP1015C	Pm. T.	XP1120	Pm. T.
PS1013	Ph. Sc.	XP1016	Pm. T.	XP1121	Pm. T.
PS1014	Ph. Sc.	XP1020	Pm. T.	XP1122	Pm. T.
PS1014SF	Ph. Sc.	XP1021	Pm. T.	XP1123	Pm. T.
PS1520	Ph. Sc.	XP1023	Pm. T.	XP1130	Pm. T.
PS1521	Ph. Sc.	XP1030	Pm. T.	XP1131	Pm. T.
PS1531	Ph. Sc.	XP1031	Pm. T.	XP1140	Pm. T.
PS5302	Ph. Sc.	XP1032	Pm. T.	XP1141	Pm. T.
PS5400	Ph. Sc.	XP1033	Pm. T.	XP1143	Pm. T.
PS5410	Ph. Sc.	XP1034	Pm. T.	XP1180	Pm. T.
SAM	Sc.	XP1040	Pm. T.	XP1190	Ph. Sc.
S1S	Sc.	XP1041	Pm. T.	XP1191	Ph. Sc.
SPF	Sc.	XP1050	Ph. Sc.	XP1192	Ph. Sc.
SPH	Sc.	XP1051	Ph. Sc.	XP1193	Ph. Sc.

Acc. = Accessories
N.G.T. = Neutron generator tubes
Ph. Sc. = Photoscintillators
Pm. T. = Photomultiplier tubes
R.C.T. = Radiation counter tubes
Sc = Scintillators
S.R.D. = Semiconductor radiation detectors

Type No.	Section
XP1200	Ph. Sc.
XP1210	Pm. T.
XP1220	Pm. T.
ZP1080	R.C.T.
ZP1081	R.C.T.
ZP1082	R.C.T.
ZP1083	R.C.T.
ZP1100	R.C.T.
53 AVP	Pm. T.
53 UVP	Pm. T.
54 AVP	Pm. T.
54 UVP	Pm. T.
56 AVP	Pm. T.
56 AVP/03	Pm. T.
56 AVP/05	Pm. T.
56 CVP	Pm. T.
56 DUVP	Pm. T.
56 DUVP/03	Pm. T.
56 DVP	Pm. T.
56 DVP/03	Pm. T.
56 TUVP	Pm. T.
56 TVP	Pm. T.
56 UVP	Pm. T.
57 AVP	Pm. T.
58 AVP	Pm. T.

Type No.	Section
58 DVP	Pm. T.
58 UVP	Pm. T.
60 AVP	Pm. T.
150 AVP	Pm. T.
150 CVP	Pm. T.
150 UVP	Pm. T.
153 AVP	Pm. T.
18503	R.C.T.
18504	R.C.T.
18505	R.C.T.
18506	R.C.T.
18507	R.C.T.
18509	R.C.T.
18511	R.C.T.
18515	R.C.T.
18516	R.C.T.
18517	R.C.T.
18518	R.C.T.
18520	R.C.T.
18522	R.C.T.
18526	R.C.T.
18527	R.C.T.
18529	R.C.T.
18536	R.C.T.
18545	R.C.T.

Type No.	Section
18546	R.C.T.
18550	R.C.T.
18552	R.C.T.
18553	R.C.T.
18555	R.C.T.
18601	N.G.T.
56127 to 56138	Acc.

Acc. = Accessories
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Photomultiplier tubes

Scintillators

Photoscintillators

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Neutron generator tubes

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Printed in The Netherlands

9399 241 07501