PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Electron tubes

Book T9 1985

Photomultiplier tubes

Photo tubes

Channel electron multipliers

Elcoma – Philips Electronic Components and Materials Division – embraces a world-wide group of companies operating under the following names:

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ADEK

PHOTO AND ELECTRON MULTIPLIERS

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

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

The contents of each series are listed on pages iv to viii.

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

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:

T1	**Tubes for r.f. heating**
T2a	**Transmitting tubes for communications, glass types**
T2b	**Transmitting tubes for communications, ceramic types**
T3	**Klystrons, travelling-wave tubes, microwave diodes**
ET3	**Special Quality tubes, miscellaneous devices** (will not be reprinted)
T4	**Magnetrons for microwave heating**
T5	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	**Geiger-Müller tubes**
T7	**Gas-filled tubes** Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories
T8	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display
T9	**Photo and electron multipliers** Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates
T10	**Camera tubes and accessories**
T11	**Microwave semiconductors and components**
T12	**Vidicons and Newvicons**
T13	**Image intensifiers**
T14	**Infrared detectors**
T15	**Dry reed switches**
T16	**Monochrome tubes and deflection units** Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

T12–T15: Data collations on these subjects are available now. Data Handbooks will be published in 1985.

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S1 **Diodes**
Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes ($< 1,5$ W), voltage reference diodes, tuner diodes, rectifier diodes

S2a **Power diodes**

S2b **Thyristors and triacs**

S3 **Small-signal transistors**

S4a **Low-frequency power transistors and hybrid modules**

S4b **High-voltage and switching power transistors**

S5 **Field-effect transistors**

S6 **R.F. power transistors and modules**

S7 **Surface mounted semiconductors**

S8 **Devices for optoelectronics**
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.

S9 **Power MOS transistors**

S10 **Wideband transistors and wideband hybrid IC modules**

S11 **Microwave semiconductors** (to be published in 1985)

S12 **Surface acoustic wave devices**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXISTING SERIES

IC1 **Bipolar ICs for radio and audio equipment**

IC2 **Bipolar ICs for video equipment**

IC3 **ICs for digital systems in radio, audio and video equipment**

IC4 **Digital integrated circuits**
CMOS HE4000B family

IC5 **Digital integrated circuits – ECL**
ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs

IC6 **Professional analogue integrated circuits**

IC7 **Signetics bipolar memories**

IC8 **Signetics analogue circuits**

IC9 **Signetics TTL logic**

IC10 **Signetics Integrated Fuse Logic (IFL)**

IC11 **Microprocessors, microcomputers and peripheral circuitry**

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	
IC02N	**Video and associated systems** Bipolar, MOS	
IC03N	**Telephony equipment** Bipolar, MOS	
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family uncased integrated circuits** CMOS	(published 1984)
IC06N	**PC54/74HC/HCU/HCT logic families** HCMOS	
IC07N	**PC54/74HC/HCU/HCT uncased integrated circuits** HCMOS	
IC08N	**10K and 100K logic family** ECL	(published 1984)
IC09N	**Logic series** TTL	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Analogue - industrial**	
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom integrated fuse logic** IFL series 20/24/28	
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	
IC15N	**Logic series** FAST TTL	(published 1984)

Note

Books available in the new series are shown with their date of publication.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1 **Programmable controller modules**
PLC modules, PC20 modules

C2 **Television tuners, video modulators, surface acoustic wave filters**

C3 **Loudspeakers**

C4 **Ferroxcube potcores, square cores and cross cores**

C5 **Ferroxcube for power, audio/video and accelerators**

C6 **Synchronous motors and gearboxes**

C7 **Variable capacitors**

C8 **Variable mains transformers**

C9 **Piezoelectric quartz devices**
Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements

C10 **Connectors**

C11 **Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)

C12 **Variable resistors and test switches**

C13 **Fixed resistors**

C14 **Electrolytic and solid capacitors**

C15 **Ceramic capacitors***

C16 **Permanent magnet materials**

C17 **Stepping motors and associated electronics**

C18 **D.C. motors**

C19 **Piezoelectric ceramics**

C20 **Wire-wound components for TVs and monitors**

C21 **Assemblies for industrial use**
HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices

* Film capacitors are included in Data Handbook C22 which will be published in 1985. The September 1982 edition of C15 should be retained until C22 is issued.

PHOTOMULTIPLIER TUBES

RATING SYSTEM

(in accordance with IEC Publication 134)

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply 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.

SURVEY OF TYPES

photocathode	useful dia mm	type	number of stages	photocathode spectral sensitivity, $sk_{e(\lambda)}$ mA/W	λ (nm)	anode sensitivity 1) A/lm 2) A/lmF 3) kA/W 4) gain	at total voltage V	rise time ns	anode pulse linearity mA	page
bialkaline SbKCs on quartz window	44	XP2020Q	12	80	400	4) 3×10^7	2200	1,5	280	77
bialkaline SbRbCs on quartz window	32	XP2018B	10	75	440	3) 60	1350	2,5	200	69
bialkaline SbKCs on UV-glass window	10	XP2041	14	85	400	4) 3×10^7	2200	2,0	280	97
bialkaline SbKCs	23	XP2962	8	75	400	2) 1	1100	1,8	80	237
	23	XP2972 +	10	75	400	2) 10	1300	1,9	80	253
	23	XP2982	11	75	400	2) 30	1350	1,9	80	261
	32	XP2012*	10	90	400	3) 60	1350	2,5	200	61
	44	XP2020	12	85	400	4) 3×10^7	2200	1,5	280	77
	44	XP2102*+	10VB	85	400	2) 1,5	1250	10	10	123
	44	XP2202*	10	75	400	3) 60	1400	3,5	200	131
	44	XP2212*+	12	75	400	4) 3×10^7	1900	4,0	250	147
	44	XP2230*	12	85	400	4) 3×10^7	2300	1,6	280	155
	44	XP2242B	6	80	400	4) 10^4	1100	1,6	350	175
	44	XP2252*	12	80	400	4) 3×10^7	1850	2,0	250	183
	44	XP2262*	12	80	400	4) 3×10^7	1850	2,0	250	203
	44	XP3102*+	8	90	400	2) 1,5	950	3,0	100	269
	44	XP3202*+	8	75	400	2) 1,5	950	3,0	100	277
	56	XP2432*+	10VB	90	400	2) 1,5	1250	10	10	229
	56H	XP3422*+	8	95	400	2) 1,5	950	3,0	100	285
	68	XP2312*	12	85	400	4) 3×10^7	2000	2,5	250	213
	70	XP2412*+	10VB	105	400	2) 1,5	1250	11	10	221
	110	XP2050	10VB	95	400	3) 12	1270	16	10	107
bialkaline SbRbCs	14	XP1911	10	80	440	2) 10	1200	2,3	80	35
	32	XP2011*	10	85	440	2) 7,5	1300	2,5	200	53
	32	XP2061*	10	85	440	2) 7,5	1300	2,5	200	115
trialkaline SbNaKCs (S20)	14	XP1117 +	9	13	700	1) 30	1520	3,5	30	27
	23	XP2963	8	20	700	1) 6	1120	1,8	80	245
	32	XP2023B	8	20	700	1) 6	1120	2,5	200	89
	44	XP2203B	10	16	700	1) 60	1350	3,5	200	139
	44	XP2233B	12	15	700	4) 3×10^7	2050	2,0	250	167
trialkaline SbNaKCs on quartz window	44	XP2254B	12	15	700	4) 3×10^7	2700	1,5	280	193
trialkaline SbNaKCs (S20R)	32	XP1017	10	6,5	860	1) 60	1470	3,5	100	19
bialkaline SbRbCs	20	AV29	diode	80	440	C_{ak} = 6 pF	1-1000	3,0	15×10^{-3}	295
SbCs (S11)	30	150 AV	diode	60	440	C_{ak} = 13 pF	1-90	14	–	299

H = hexagonal shape, dimensions between flats; for other hexagonal tubes please contact us.

VB = venetian blind multiplier

* = also available with plastic base by adding B to the type number

\+ = can be supplied with standard or customized integral PC-board voltage divider.

REPLACEMENT LIST

The previous type reference PM (as e.g. in PM2412) has been replaced by XP (so: XP2412), due to a change in the type number system.
A number of photomultiplier tubes are no longer available and relevant device data are not given in this book any more.
The list below gives possible replacements. In case of doubt, please contact your supplier.

old type	replaced by
PM1980	XP2972
PM1982	XP2982
XP1000	XP2202B
XP1001	XP2202B
XP1002	XP2203B
XP1003	XP2254B
XP1006	XP2202B
XP1010	XP2012B
XP1016	XP2023B
XP1020	XP2020
XP1021	XP2020
XP1023	XP2020Q
XP1030	XP2412B or XP2312B
XP1031	XP2412B or XP2312B
XP1034	XP2412B or XP2312B
XP1040	XP2041
XP1041	XP2041
XP1110	XP1911
XP1113	XP1920

old type	replaced by
XP1180	XP2972
XP1910	XP1911
XP2000	XP2102B or XP3102B
XP2000UB	XP2102 or XP3102
XP2030	XP2412B
XP2030UB	XP2412
XP2040	XP2041
XP2232	XP2262 or XP2252
XP2232B	XP2262B or XP2252B
54AVP	XP2050
54DVP	XP2050
56AVP*	XP2262B or XP2252B
56DUVP*	XP2020Q
56DVP*	XP2262B or XP2252B
56TUVP*	XP2254B
56TVP*	XP2233B
56UVP*	XP2020Q
58AVP	XP2041
58DVP	XP2041
58UVP	XP2041Q

* See also page 18, obsolete types 56 AVP family.

LIST OF SYMBOLS

		*
Photocathode	k	
Secondary emission electrode (dynode) n	S_n	dn
Anode	a	
Accelerating electrode	acc	g
Grid	g	
Cathode luminous sensitivity	N_k	sk_v
Cathode spectral sensitivity	N_{kr}	$sk_{e(\lambda)}$
Anode luminous sensitivity	N_a	sa_v
Anode spectral sensitivity	N_{ar}	$sa_{e(\lambda)}$
Anode blue sensitivity		sa_F
Current amplification (gain)	G	
Total supply voltage	V_b	V_{ht}
Anode current	I_a	
Anode dark current	I_{ao}	i_{da}
Cathode current	I_k	
Wavelength	λ	
Internal connection (do not use)	i.c.	
Non-connected pin (may be used)	n.c.	
External conductive coating	m	

* The symbols in the left-hand column are gradually being replaced by those in the right-hand column.

GENERAL OPERATIONAL RECOMMENDATIONS
PHOTOMULTIPLIER TUBES

1. GENERAL *

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

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

a. the opaque photocathode;

b. the semi-transparent photocathode.

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

1.3 The **photoelectron optical collection system** (electron-optical input system) is that part of the photomultiplier tube which focuses the photoelectrons onto the first dynode. The quality of the inputs optics can be measured by the spread in the electron transit times, and by the collection efficiency, i.e. the percentage of electrons emitted by the photocathode that land on the first dynode.

In most tubes the electron-optical input system consists of the photocathode itself and a focusing electrode, connected internally to the first dynode or externally to a suitable voltage between those of the photocathode and the first dynode. In some photomultiplier tubes, such as XP2020, XP2041, XP2254B, an improvement in time characteristics has been obtained by using additional electrodes.

1.4 Several **dynode system constructions** are possible such as linear focused or venetian blind structures.
The materials used for dynodes is CuBe, which offers a good stability.
Assuming that all dynodes have the same secondary emission factor, δ the amplification of the tube is given by:

$$G = \delta^n$$

where n is the number of dynodes.

* Where applicable reference is made to IEC Publication 306.

1.5 **Spectral response**

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

1.5.1 The S11 (type A) and Super A type tubes formerly made were equipped with a semi-transparent caesium antimony photocathode on a MnO_2 layer, evaporated on the inside of the glass window. Their maximum sensitivity was at 420 nm with a slightly higher green response than tubes with the bialkali type D (SbKCs) cathode. Recently the S11 and Super A have been replaced by the bialkali SbRbCs photocathode.

1.5.2 The bialkali SbKCs (type D) cathode is evaporated on the inside of a glass window. This photocathode has a high quantum efficiency in the blue region of the spectrum an a low thermionic emission. The maximum sensitivity is approximately 400 nm.

1.5.3 The bialkali SbKCs(type DU) evaporated on the inside of a fused silica window offers extended response into the ultraviolet region of the spectrum.

1.5.4 The bialkali SbRbCs cathode is evaporated on the inside of a glass window. This photocathode has a high quantum efficiency in the blue region of the spectrum with a higher green response than the bialkali SbKCs types.

1.5.5 The bialkali SbRbCs cathode can also be evaporated on the inside of a fused silica window to reach extended response in the ultraviolet region of the spectrum.

1.5.6 The S20 (type T) tubes have a trialkali SbNaKCs semi-transparent photocathode evaporated on the inside of a glass window. This cathode has a good sensitivity in the visible and near infrared region of the spectrum with a maximum sensitivity at approximately 420 nm.

1.5.7 S20R tubes have a thicker trialkali SbNaKCs cathode evaporated on the inside of a glass window. The sensitivity extends from the visible into the near infrared region of the spectrum with a maximum sensitivity at approximately 550 nm.

1.5.8 The type TU tubes have the same trialkali SbNaKCs cathode as the S20 tubes but evaporated on the inside of a fused silica window extending the sensitivity into the ultraviolet region of the spectrum.

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

2. INTERPRETATION OF CHARACTERISTICS

In general the characteristics given in the data sheets are typical values. The "typical value" of a parameter is the median of the grequency distribution of the parameter measured on a large number of tubes.

In some cases maximum or minimum values are stated. These values are defined on test-limits carried out on each tube. Approximate values are given when these values are obtained from batch sample data.

Each tube is accompanied by a test card stating its test results.

The more important parameters are discussed below.

2.1 **Cathode luminous sensitivity**

The cathode luminous sensitivity is defined (IEC) as the quotient of the photocurrent of the cathode by the incident luminous flux, expressed in amperes per lumen.
For this measurement the photomultiplier tube is connected as a diode. The cathode current, I_k, (corrected for dark current) is about 100 nA.
The voltage used should be sufficient to ensure saturation.

The sensitivity is given by: $sk_v = \frac{I_k}{\phi}$

where ϕ is the luminous flux, in lumen, of a tungsten filament lamp having a colour temperature of 2856 K.

2.2 **Cathode spectral sensitivity**

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

2.3 **Absolute spectral sensitivity**

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

2.4 **Quantum efficiency**

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

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

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

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

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

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

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

Anode luminous sensitivity

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

$$sa_v = G \cdot sk_v \text{ (A/lm)}.$$

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

2.6 Dark current and noise

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

type of cathode		dark current emission at 20°C (electrons . s^{-1} . cm^{-2})	activation energy (eV)	lowest useful temperature (°C)
AgOCs	(S1)	5.10^6	1	−100
SbNaKCs	(S20R)	10^3	1,3	−40
SbNaKCs	(S20)	300	1,3	−40
SbCs	(S11)	100	1,3	−20
SbKCs	(D)	10	1,2	0
SbRbCs		30	1,3	−20

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

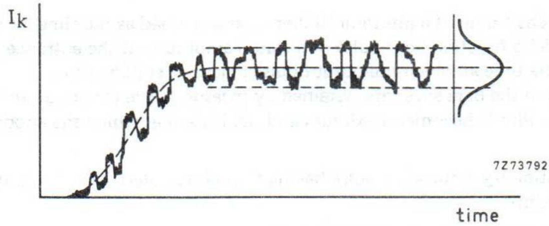
At very low supply voltage (V_{ht}) the major component of the dark current is the - ohmic - leakage current between the pins; this component is proportional to the voltage and increases with dust and high relative humidity.

2.6.2 **Shot noise or Schottky effect**

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

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

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



Noise in photomultipliers.

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

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

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

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

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

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

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

2.7 Linearity and saturation

The cathode and dynode currents should always be in the region of saturation, i.e. all electrons emitted by an electrode are collected by the next one, so as to guarantee the proportionality between the current and the cathode illumination over the whole operating range. When the tube is operated with a voltage $V_{d1/k}$ within the limiting values, saturation of the cathode is generally assured for cathode currents in the range of 10^{-8} A at room temperature.
Nevertheless for type -D photocathodes, departure from linearity can be observed for cathode currents in the range of 10^{-10} A, especially when operating at low temperatures.
The saturation current of the dynodes is generally reached under normal operating conditions even at the highest permissible luminous flux.
The saturation of the anode is different. The anode current causes a voltage drop across the load resistor. If the anode voltage decreases below a certain value this results in a non-linearity Moreover, the current may be limited by space charge effects at the highest permissible anode currents.
That limit is reached for anode currents of 10 to 300 mA depending on the type of photomultiplier and on the voltage divider. The electrode mean currents should never be so high as to be detrimental to the tube's life, or cause excessive fatigue or ageing.

2.8 Time characteristics (IEC)

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

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

2.8.2 The **anode pulse rise time** of a photomultiplier tube is defined as the time required for the amplitude to rise from a stated low percentage to a stated higher percentage of maximum value when the photocathode receives a delta function light pulse. Normally the 10% and 90% levels are considered.

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

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

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

2.8.6 **Note**: Rise time, pulse duration, and transit time vary as a function of high-tension supply voltage, V_{ht}, approximately as $V_{ht}^{-½}$.

2.9 Stability

The concept of stability refers to different behaviour of the gain of photomultipliers which may change as a function of current, voltage, time, temperature, and history. For anode currents between 10 μA and absolute limiting value - which ranges from 100 to 500 μA - slow. Irreversible changes of gain are observed. As an indication, for an anode current of 30 μA, a change of gain by a factor of 2 can be observed after about 5000 h for most tube types.
In the specific case of the S1 photocathode there is also a decrease in cathode sensitivity due to caesium desorption effect in the last stages, which requires a lower mean anode current. For anode currents below 1 μA, only reversible changes of gain are generally observed, but these changes may exhibit hysteresis effects with time constants ranging from some seconds to some hours, depending on the anode current. A change of gain in applications such as scintillation counting is very cumbersome because it is associated by a shift of the total absorption peak, strongly degrading the resolution.
According to ANSI-N42-9-1972 of IEEE there are two types of pulse amplitude (height) stability tests:

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

In the time stability test, a pulse amplitude analyser, a ^{137}Cs source, and an NaI (Tl) crystal are employed to measure the pulse amplitude. The ^{137}Cs source is located along the major axis of the tube and crystal so that a count rate of about 10^4 Hz is obtained. The entire system is allowed to warm up under operating conditions for a period of 30 minutes to one hour before readings are recorded. Following this period of stabilization, the pulse amplitude is recorded at 1 h intervals for a period of 16 h.

The drift rate, D_g, is then calculated, in % as the mean gain deviation, MGD, of the series of pulse amplitude measurements as follows:

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

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

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

3. OPERATING NOTES

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

$$\frac{dG}{G} = 0{,}75\,n.\frac{dV_{ht}}{V_{ht}}.$$

The percentage change in gain is approximately ten times the percentage change in supply voltage. Thus to hold the gain stable within 1%, the power supply must be stabilized to within approximately 0,1%.
When the radiant flux to be measured causes high anode currents, it is possible to replace the resistors of the last 3 or 4 stages in the voltage divider by voltage regulator diodes.

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

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

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

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

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

$$\overline{I_a} = I_a \,.N.t_w$$

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

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

$$Q_a = \int I_a dt.$$

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

$$C_{n+1} = \frac{Q_c}{V_{dn}} = \frac{100 Q_a}{V_{dn}} = \frac{100}{V_{dn}} \int I_a dt.$$

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

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

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

3.3 **General remarks**

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

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

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

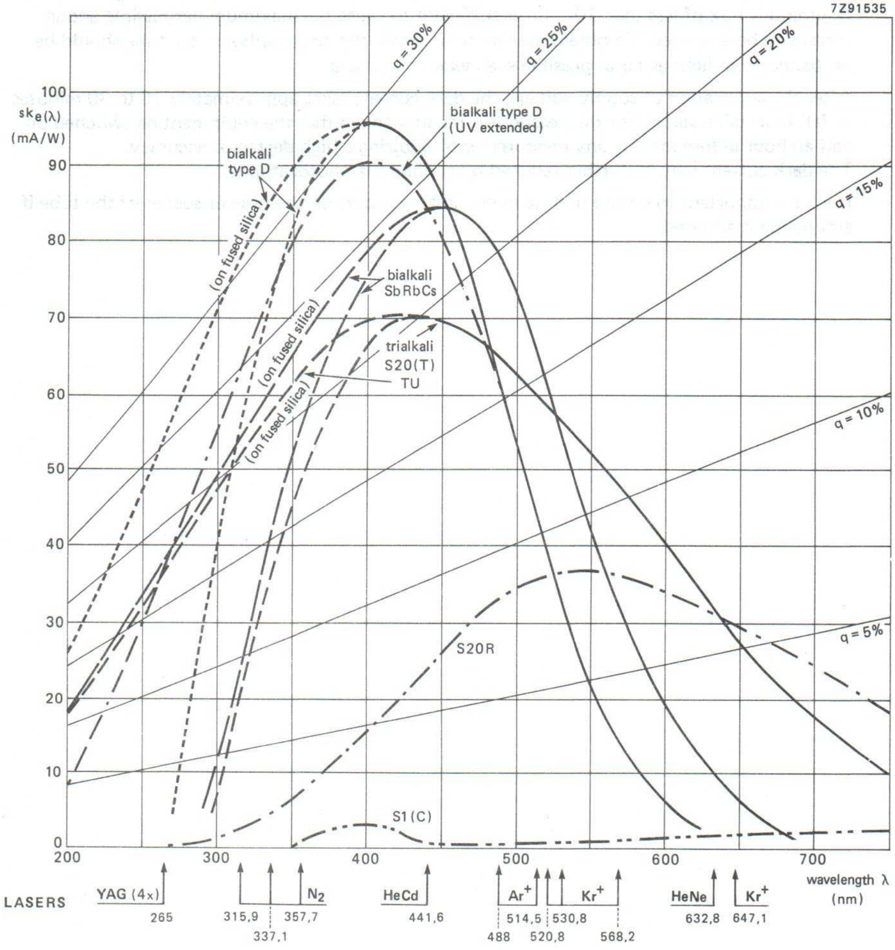


Fig. 1a Typical spectral sensitivity characteristics. The specific curve for each tube is given in the relevant device data.

$$sk_{e(\lambda)}\ (\text{mA/W}) = q\ (\%)\ \frac{\lambda(\text{nm})}{124}$$

q = quantum efficiency

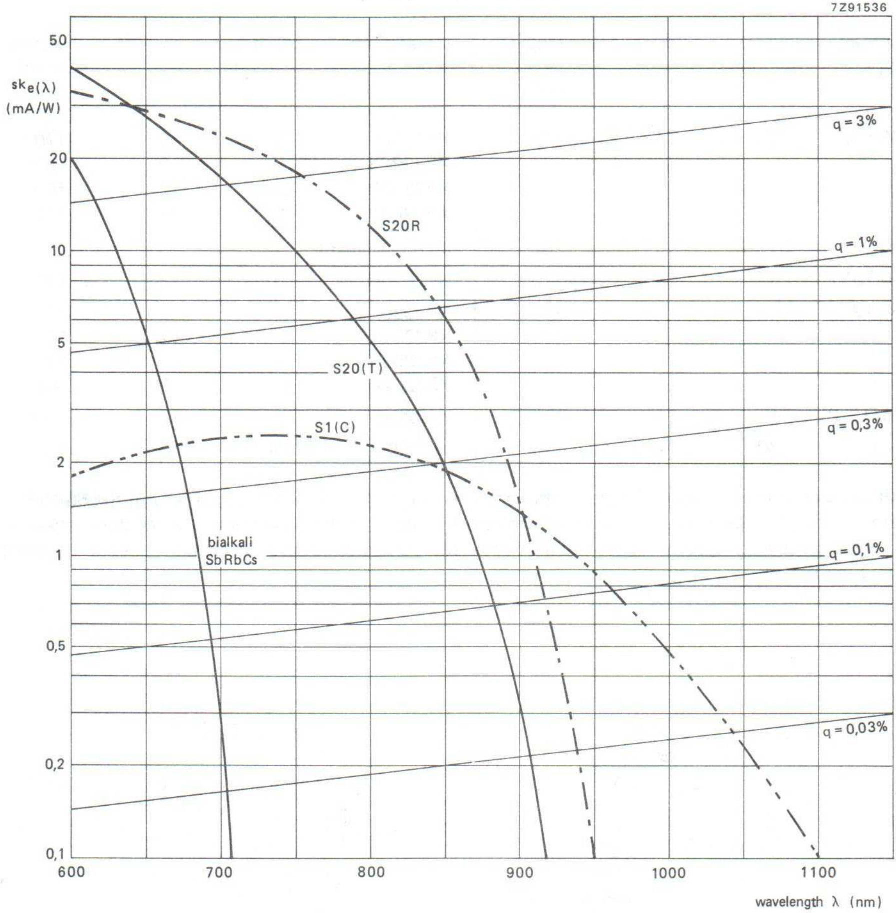


Fig. 1b Typical spectral sensitivity characteristics. The specific curve for each tube is given in the relevant device data.

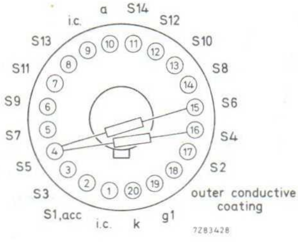
$$sk_{e(\lambda)}\ (\text{mA/W}) = q\ (\%)\ \frac{\lambda(\text{nm})}{124}$$

q = quantum efficiency

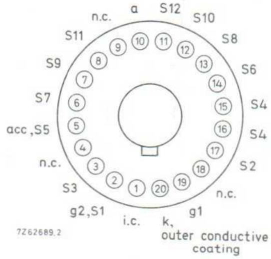
Our well known 56AVP family photomultiplier tubes with 44 mm photocathode diameter are replaced by more modern tubes with improved characteristics.

obsolete type	photo-cathode	dynodes	seated length mm	replacement type	photo-cathode	dynodes	seated length mm
56AVP	S11 (A)	14	170	XP2020	D	12	170
				XP2230B	D	12	152
				XP2252B	D	12	152
				XP2262B	D	12	145
56CVP	S1 (C)	10	152	no replacement			
56DUVP	DU	14	170	XP2020Q	DU	12	170
56DVP	D	14	170	XP2020	D	12	170
				XP2230B	D	12	152
				XP2252B	D	12	152
				XP2262B	D	12	145
56TUVP	TU	14	170	XP2254B	TU	12	170
56TVP	S20 (T)	14	170	XP2233B	S20 (T)	12	145

All replacement types have 12-stage multipliers and are unilaterally interchangeable with the 56AVP family tubes. By connection of dynode S_4 to pins 15 and 16 of the plastic base, the resistors between S_4-S_5 and between S_5-S_6 are short-circuited in bleeders wired for the 56AVP family tubes as indicated in figures below.



14-stage.



12-stage.

10-STAGE PHOTOMULTIPLIER TUBE

- 32 mm useful diameter head-on type
- Flat window
- Semi-transparent tri-alkaline S20R extended red photocathode
- For in the red and near-infrared part of the spectrum

QUICK REFERENCE DATA

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

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on

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

Electron optical input system

This system consists of: the photocathode (k), a metallized part of the glass envelope, internally connected to the photocathode and the accelerating electrode (g), internally connected to d1.

Multiplier system

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

Magnetic field

When the photocathode is uniformly illuminated the anode current is halved (at V_{ht} = 1200 V, voltage divider A) at a magnetic flux density of:
– 0,25 mT perpendicular to axis a (Fig. 1);
– 0,15 mT parallel with axis a.

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

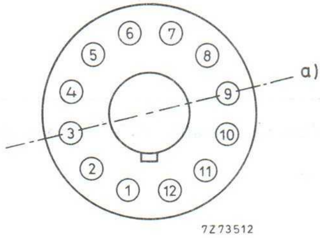


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

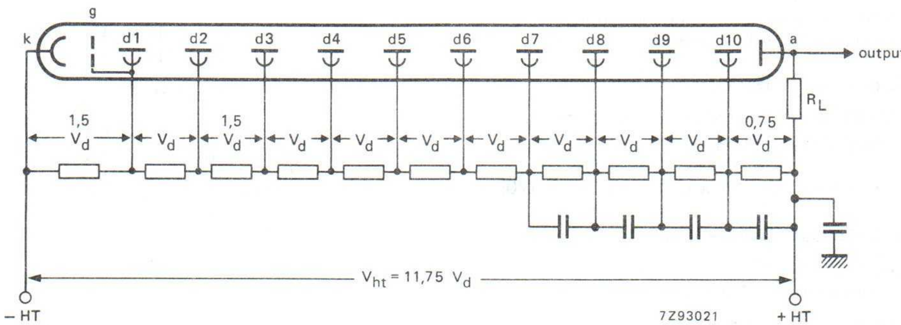


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

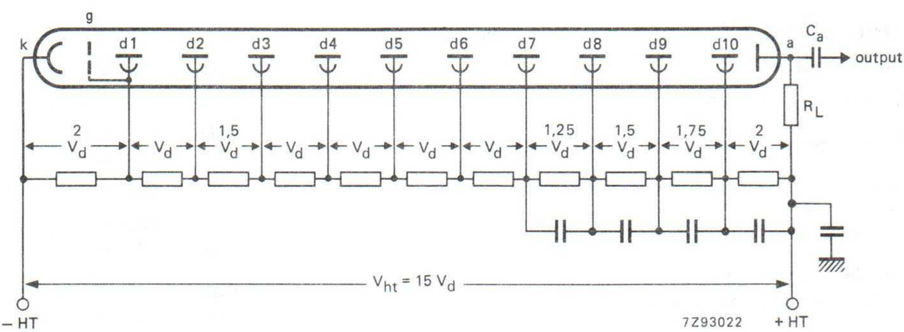


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)

				notes
Supply voltage for an anode luminous sensitivity of 60 A/lmF, (Fig. 6)	<	1650	V	
	typ.	1470	V	
Gain at V_{ht} = 1800 V	≈	1×10^6		
Anode dark current at an anode luminous sensitivity of 60 A/lmF	<	50	nA	2, 3
	typ.	2	nA	
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈	30	mA	

With voltage divider B (Fig. 3) 1

Supply voltage for an anode luminous sensitivity at 60 A/lmF	≈	1730	V	
Anode pulse rise time at V_{ht} = 1700 V	≈	3,5	ns	4
Anode pulse duration at half height at V_{ht} = 1700 V	≈	6	ns	4
Signal transit time at V_{ht} = 1700 V	≈	34	ns	4
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈	100	mA	

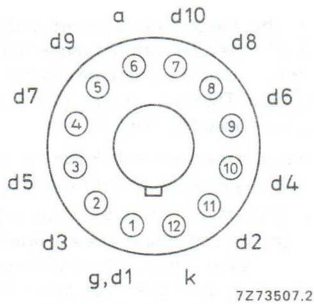
LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1900	V	5
Continuous anode current	max.	0,2	mA	9
Voltage between first dynode and photocathode	max.	500	V	6
	min.	120	V	
Voltage between consecutive dynodes	max.	300	V	
Voltage between anode and final dynode	max.	300	V	7
	min.	30	V	
Ambient temperature range operational (for short periods of time)	max.	+80	°C	8
	min.	−30	°C	
continuous operation and storage	max.	+50	°C	
	min.	−30	°C	

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
4. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
5. Total HT supply voltage, or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm whichever is lower.
6. Minimum value to obtain good collection in the input optics.
7. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
8. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplied should be consulted.
9. A value of $< 10\ \mu A$ is recommended for applications requiring high stability.

MECHANICAL DATA



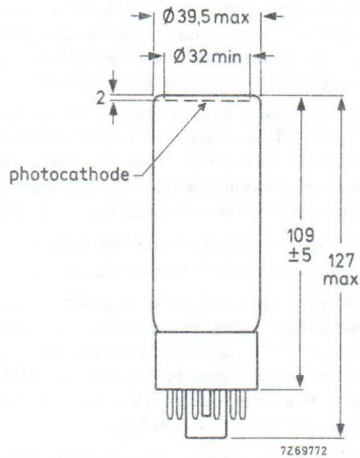


Fig. 4.

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

ACCESSORIES

Socket	type FE1012

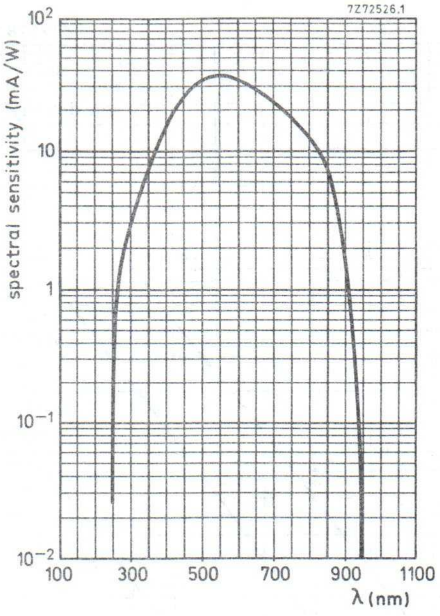


Fig. 5 Spectral sensitivity characteristic.

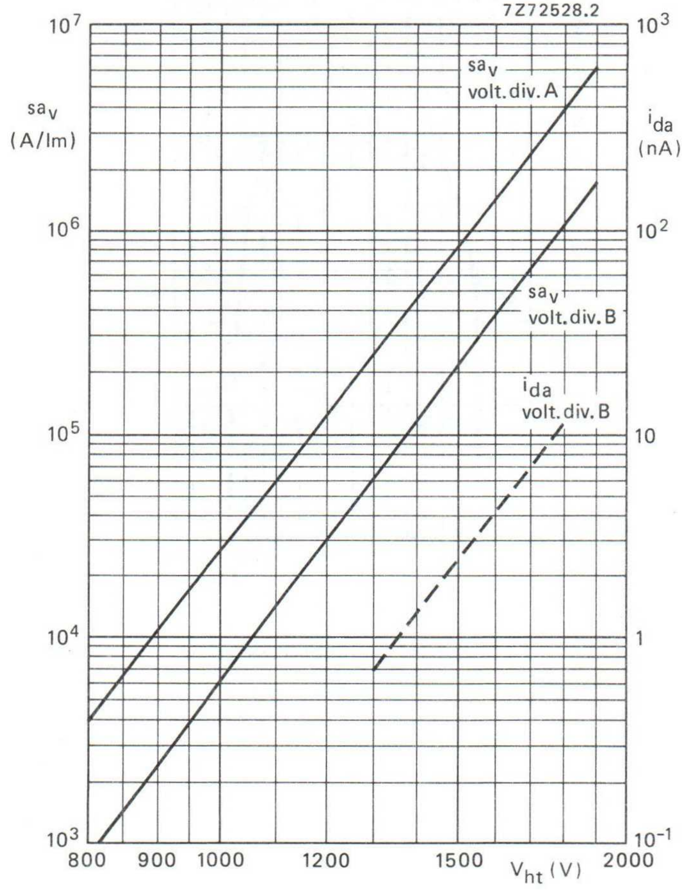


Fig. 6 Anode luminous sensitivity and anode dark current i_{da} as a function of the supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

9-STAGE PHOTOMULTIPLIER TUBE

- 14 mm useful diameter head-on type
- Flat window
- Semi-transparent S20 type T photocathode
- For optical measurements in the entire visible spectrum; industrial applications
- Rugged construction

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S20, type T
Useful diameter of the photocathode	> 14 mm
Spectral sensitivity of the photocathode at 700 nm	13 mA/W
Supply voltage for anode luminous sensitivity = 30 A/lm	1520 V
Anode pulse rise time (with voltage divider B)	≈ 3,5 ns
Linearity	
with voltage divider A (Fig. 2)	up to ≈ 10 mA
with voltage divider B (Fig. 3)	up to ≈ 30 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	borosilicate	
Shape	plano-concave	
Refractive index at 550 nm	1,48	
Photocathode		
Semi-transparent, head-on		
Material	Sb Na K Cs	
Useful diameter	> 14 mm	
Spectral sensitivity characteristic (Fig. 6)	S20, type T	
Maximum spectral sensitivity	420 ± 30 nm	
Luminous sensitivity	typ. 140 μA/lm > 100 μA/m	1
Spectral sensitivity at 700 nm	13 mA/W	2

Multiplier system

Number of stages	9
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 1,9 pF
anode to all	≈ 3 pF

Magnetic field

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

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

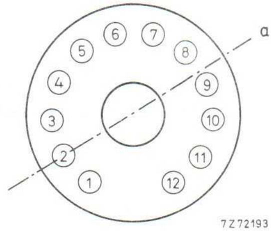


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

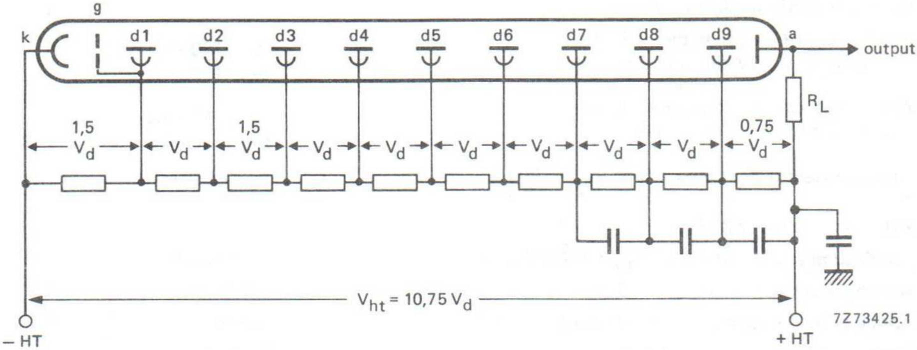


Fig. 2 Voltage divider A.

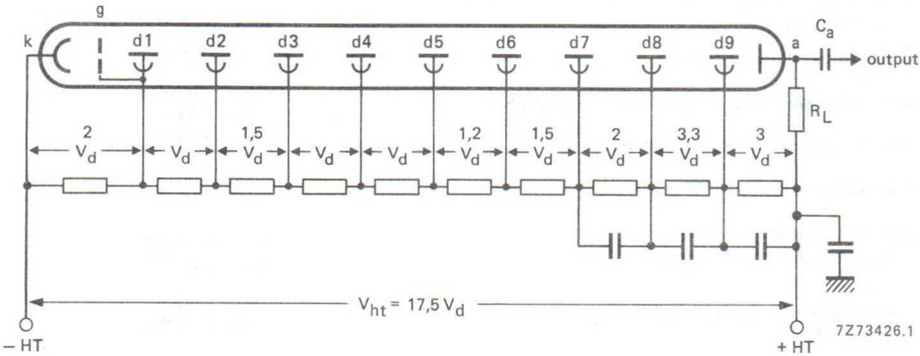


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
dn = dynode

a = anode
R_L = load resistor
Typical value of capacitors : 10 nF

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		1
Supply voltage for an anode luminous sensitivity of 30 A/lm (Fig. 8)	$<$ 1800 V typ. 1520 V	
Anode dark current at an anode luminous sensitivity of 30 A/lm (Fig. 8)	$<$ 100 nA typ. 10 nA	2, 3
Anode current linear within 2% at V_{ht} = 1800 V	up to ≈ 10 mA	
With voltage divider B (Fig. 3)		1
Anode luminous sensitivity at V_{ht} = 1800 V (Fig. 8)	≈ 15 A/lm	
Anode pulse rise time at V_{ht} = 1800 V	≈ 3,5 ns	4
Anode pulse duration at half height at V_{ht} = 1800 V	≈ 6 ns	4
Signal transit time at V_{ht} = 1800 V	≈ 28 ns	4
Anode current linear within 2% at V_{ht} = 1800 V	up to ≈ 30 mA	

LIMITING VALUES (Absolute maximum rating system)

		notes
Supply voltage	max. 1900 V	5
Continuous anode current	max. 0,2 mA	8
Voltage between first dynode and photocathode	max. 350 V min. 100 V	6
Voltage between consecutive dynodes	max. 200 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	7
Ambient temperature range operational (for short periods of time)	max. + 70 °C min. −50 °C	
continuous operation and storage	max. + 50 °C min. −50 °C	

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\,\Omega$.
3. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 15 min.
4. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
5. Total HT supply voltage, or the voltage at which the tube has an anode sensitivity of 500 A/lm whichever is lower.
6. Minimum value to obtain good collection in the input optics.
7. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
8. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.

MECHANICAL DATA

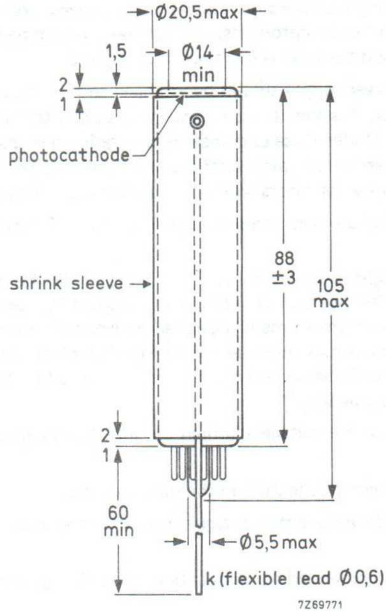


Fig. 4.

PIN CONNECTIONS

Base 12-pin all-glass

Net mass 25 g

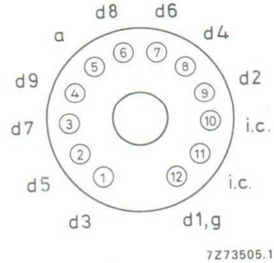


Fig. 5.

ACCESSORIES

Socket: type FE1004

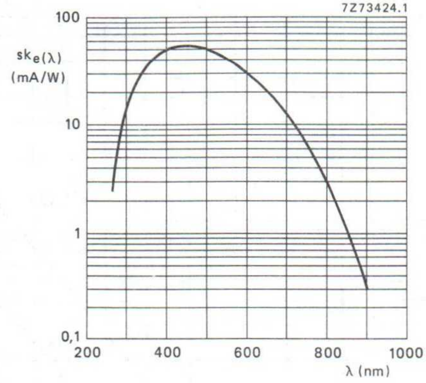


Fig. 6 Spectral sensitivity characteristic.

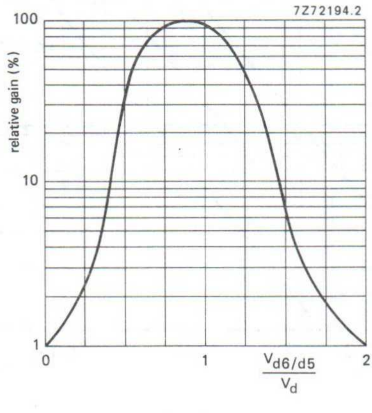


Fig. 7 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

Note: Gain regulation by changing the voltage between d6 and d5 may cause a degradation of other parameters such as stability and linearity.

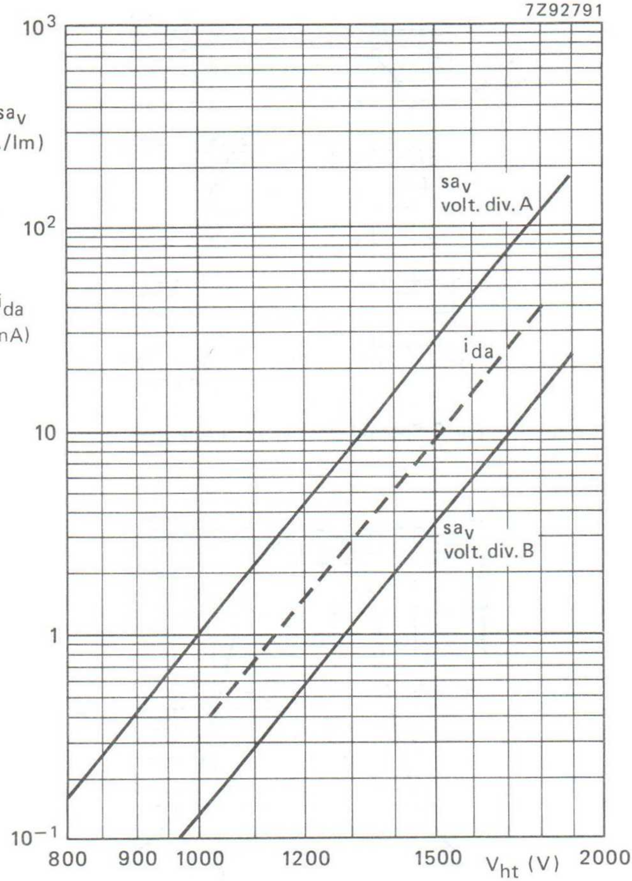


Fig. 8.

Anode luminous sensitivity, sa_v, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

10-STAGE PHOTOMULTIPLIER TUBE

- 14 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- For high-energy physics, scintillation counting under limited dimensional conditions.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 14 mm
Cathode blue sensitivity	10 μA/lmF
Supply voltage for anode blue sensitivity = 10 A/lmF	1200 V
Anode pulse rise time (with voltage divider B)	≈ 2,4 ns
Linearity	
with voltage divider A (Fig. 2)	≈ 20 mA
with voltage divider B (Fig. 3)	≈ 80 mA

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

GENERAL CHARACTERISTICS

Window

Material	lime glass	
Shape	plano-concave	
Refractive index at 400 nm	1,54	

Photocathode (note 2)

Semi-transparent, head-on

Material	Sb Rb Cs	
Useful diameter	> 14 mm	
Spectral sensitivity characteristic (Fig. 5)	type D	
Maximum spectral sensitivity	440 ± 30 nm	
Luminous sensitivity	≈ 85 μA/lm	note 3
Blue sensitivity	typ. 10 μA/lmF	
	> 8,0 μA/lmF	note 1
Spectral sensitivity at 440 nm	≈ 80 mA/W	note 4

Multiplier system

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

Magnetic field

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

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

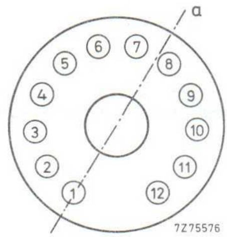


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

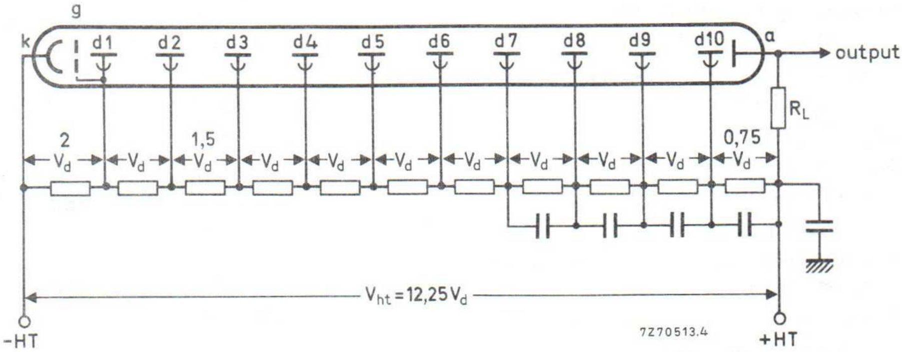


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

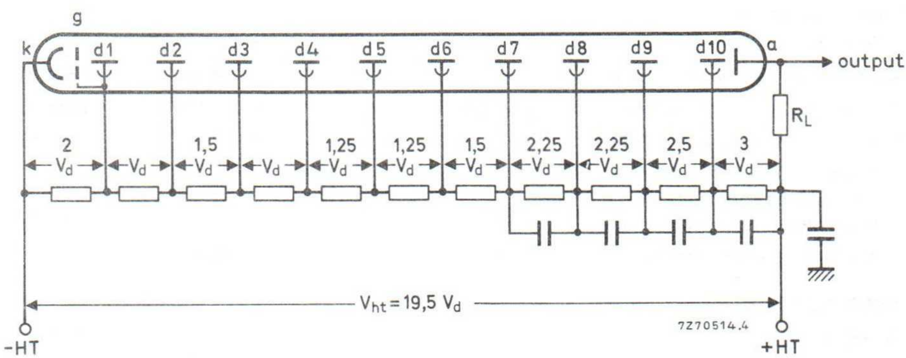


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)

Supply voltage for an anode blue sensitivity of 10 A/lmF	< 1500 V typ. 1200 V	notes 1,5
Anode radiant sensitivity at 440 nm and V_{ht} = 1200 V	≈ 80 kA/W	
Gain at V_{ht} = 1200 V (Fig. 7)	≈ 1 x 10^6	
Anode dark current at an anode blue sensitivity of 10 A/lmF	< 10 nA typ. 2 nA	notes 1,6,7
after 30 min. of stabilization	≈ 0,3 nA	
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 10 A/lmF	≈ 7,5 %	notes 1,8
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 20 mA	
Mean anode sensitivity deviation long term (16 h)	≈ 1,5 %	note 9
after change of count rate	≈ 1,5 %	
Anode pulse rise time at V_{ht} = 1500 V	≈ 2,3 ns	note 10
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 3,5 ns	note 10
Signal transit time at V_{ht} = 1500 V	≈ 22 ns	note 10

With voltage divider B (Fig. 3)

Gain at V_{ht} = 1700 V (Fig. 7)	≈ 4,5 x 10^6	
Anode pulse rise time at V_{ht} = 1700 V	≈ 2,4 ns	note 10
Anode pulse duration at half height at V_{ht} = 1700 V	≈ 3,8 ns	note 10
Signal transit time at V_{ht} = 1700 V	≈ 22 ns	note 10
Signal transit time difference between the centre of the photocathode and 7 mm from the centre at V_{ht} = 1700 V	≈ 1,5 ns	
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈ 80 mA	

LIMITING VALUES (Absolute maximum rating system)

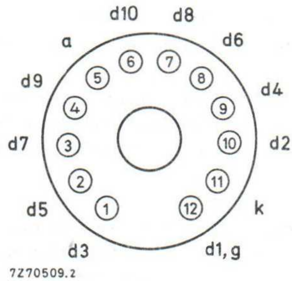
Supply voltage	max. 1900 V	note 11
Continuous anode current	max. 0,2 mA	note 12
Voltage between first dynode and photocathode	max. 350 V min. 100 V	note 13
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	note 14
Ambient temperature range operational (for short periods of time)	max. +80 °C min. −30 °C	
continuous operation and storage	max. +50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 440 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 8×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
7. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
8. Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 1118 or equivalent) with a diameter of 12 mm and a height of 12 mm. The count rate used is $\approx 10^4$ c/s.
9. The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an anode current of ≈ 300 nA.

   Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an anode current of ≈ 1 μA and $\approx 0{,}1$ μA respectively.
   Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. Total HT supply voltage, or the voltage at which the tube has a gain of 1×10^7, whichever is lower.
12. A value of < 10 μA is recommended for applications requiring high stability.
13. Minimum value to obtain good collection in the input optics.
14. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA



Pin positions equal to those of tubes XP1910 and PM1911.

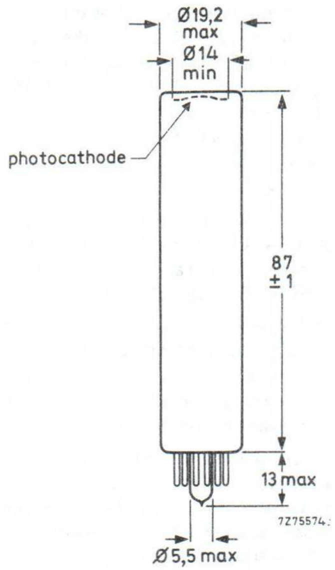


Fig. 4.

Base	12-pin all glass
Net mass	21 g

ACCESSORIES

Socket	type FE1004

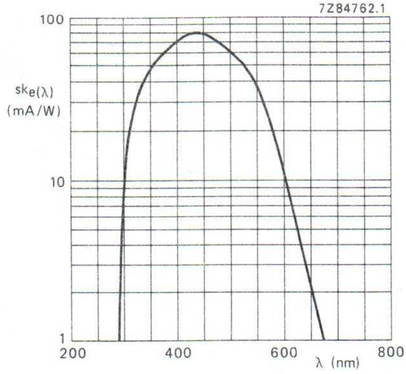


Fig. 5 Spectral sensitivity characteristic.

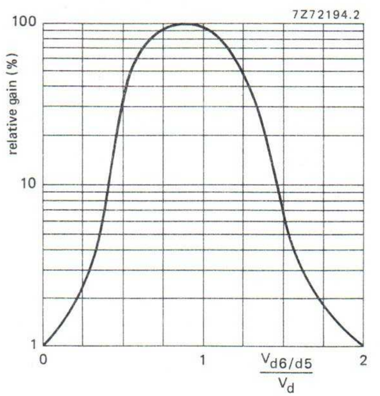


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

Note: Gain regulation by changing the voltage between d6 and d5 may cause a degradation of other parameters such as stability and linearity.

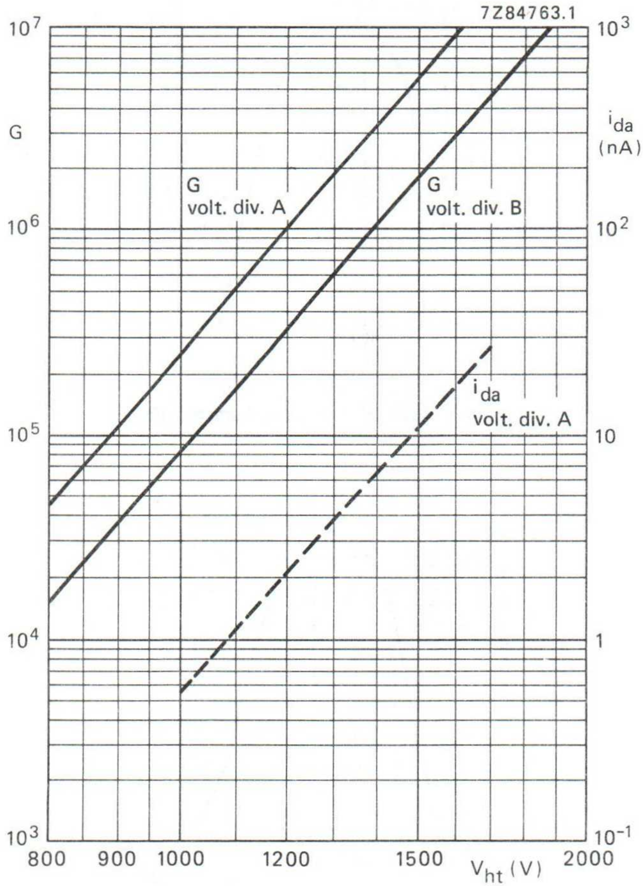


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

replaced by XP2011
XP2011B

10-STAGE PHOTOMULTIPLIER TUBES

The XP2008 and XP2008UB are 32 mm useful diameter head-on photomultiplier tubes with a flat window and a semi-transparent Super A photocathode. The tubes are intended for use in applications such as scintillation counting, laboratory and industrial photometry and large volume calorimeter experiments. Their CuBe dynode system offers a high stability. The XP2008 is provided with a 12-pin plastic base; the XP2008UB has a 14-pin all-glass base.

QUICK REFERENCE DATA

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

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

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

For BBQ light the typical integral quantum efficiency is 13% and can be measured on request.

Electron optical input system

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

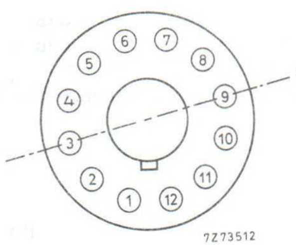
Multiplier system

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

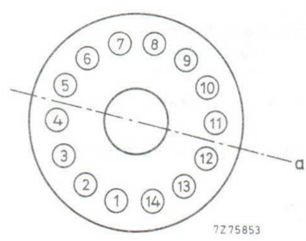
Magnetic field

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

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



XP2008



XP2008UB

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

RECOMMENDED CIRCUITS

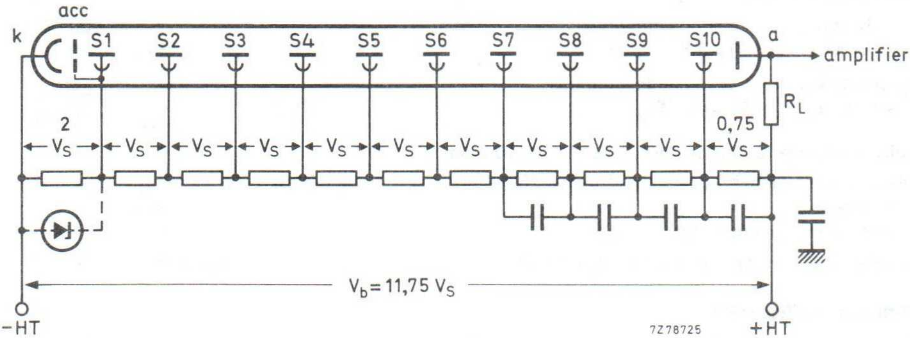


Fig. 1 Voltage divider A.

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

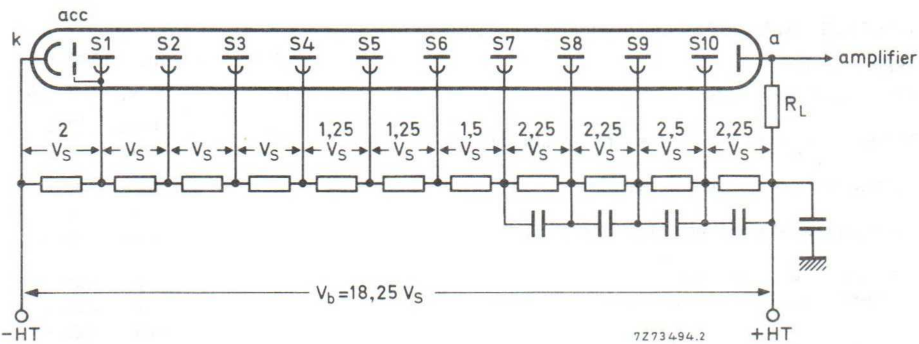


Fig. 2 Voltage divider B.

k = cathode

acc = accelerating electrode

S_n = dynode no. n

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

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

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	7	max.	1800 V
Continuous anode current	11	max.	0,2 mA
Voltage between first dynode and photocathode	8	max. min.	500 V 150 V
Voltage between consecutive dynodes		max.	300 V
Voltage between anode and final dynode	9	max. min.	300 V 30 V
Ambient temperature range			
Operational (for short periods of time)	10	max. min.	+80 °C −30 °C
Continuous operating and storage		max. min.	+50 °C −30 °C

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.

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

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

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

5. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the scintillator count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA.
Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu A$ and $\approx 0{,}1\ \mu A$ respectively.
Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.

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

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

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

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

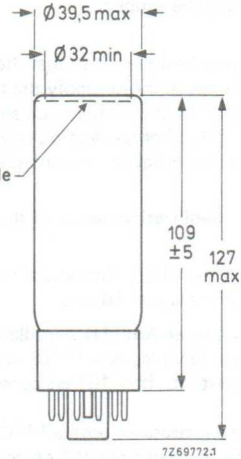
10. For type XP2008 this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

11. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.

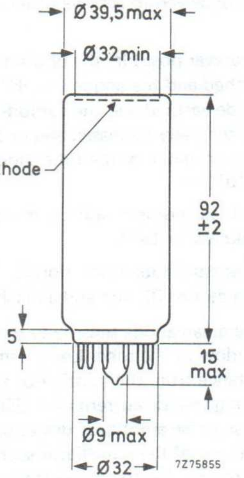
MECHANICAL DATA

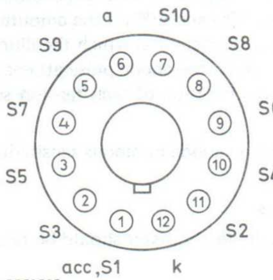
Dimensions in mm

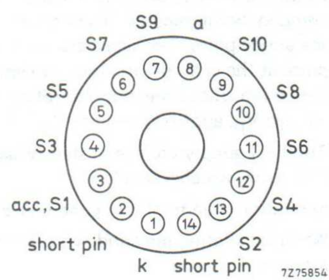
XP2008



XP2008UB







Base: 12-pin (JEDEC B12-43)

Net mass: 72 g

Base: 14-pin all-glass

Net mass: 54 g

ACCESSORIES

Socket:
- for XP2008 type FE1012
- for XP2008UB type FE1112

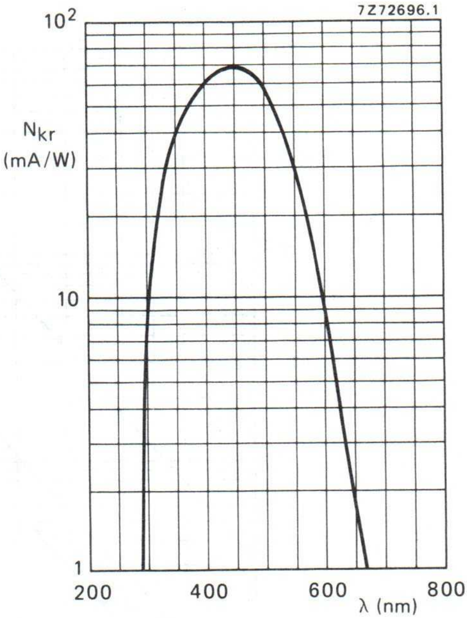


Fig. 3 Spectral sensitivity characteristic.

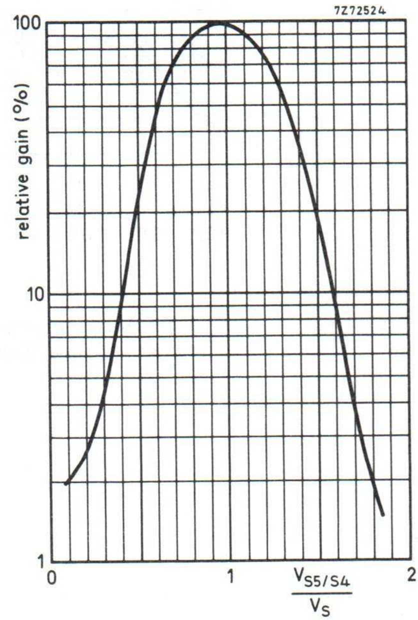


Fig. 4 Relative gain as a function of the voltage between S5 and S4, normalized to V_S. $V_{S6/S4}$ constant.

Note: Gain regulation by changing the voltage between S5 and S4 may cause a degradation of other parameters such as stability and linearity.

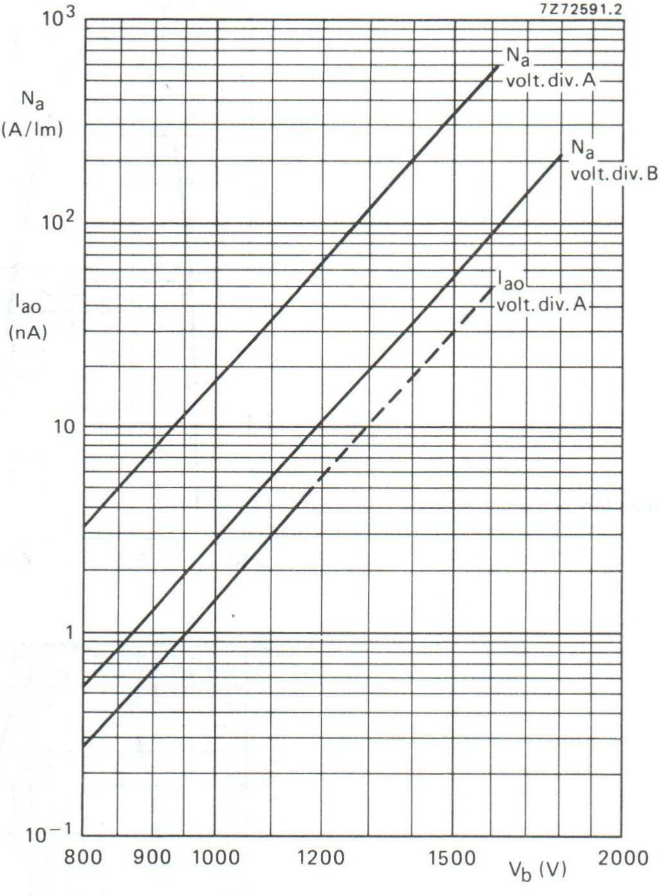


Fig. 5 Anode luminous sensitivity, N_a, and anode dark current, I_{ao}, as a function of supply voltage V_b.

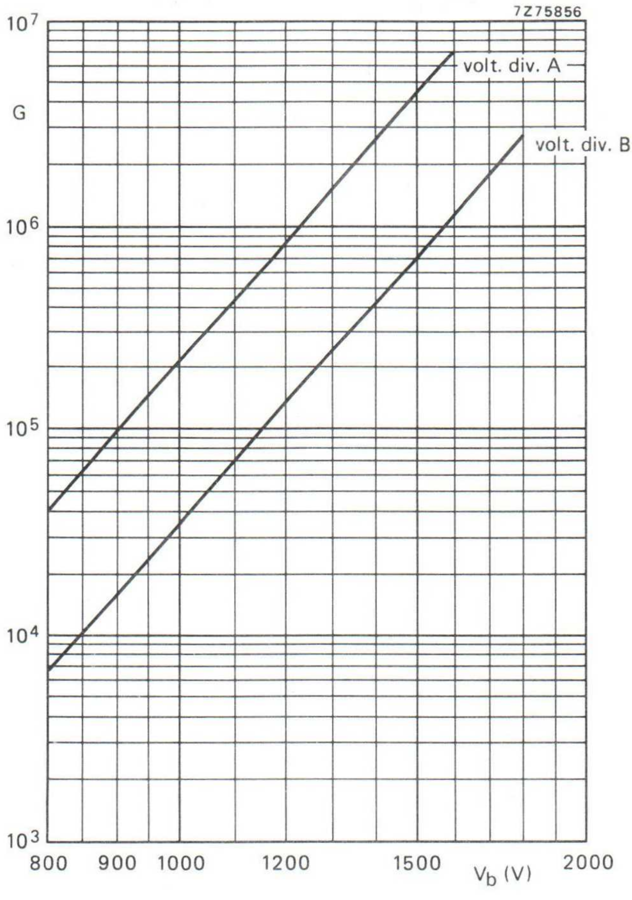


Fig. 6 Gain G as a function of supply voltage V_b.

XP2011 replaces XP2008UB
XP2011B replaces XP2008

10-STAGE PHOTOMULTIPLIER TUBE

- 32 mm useful diameter head-on type
- flat window
- semi-transparent bi-alkaline photocathode
- high stability
- good linearity
- for high-energy physics experiments, scintillation counting, laboratory and industrial photometry
- XP2011B has a 12-pin plastic base; XP2011 has a 14-pin all-glass base

QUICK REFERENCE DATA

Spectral sensitivity characteristic		Fig. 6		
Useful diameter of the photocathode		>	32	mm
Cathode blue sensitivity			11	μA/lmF
Supply voltage for anode blue sensitivity = 7,5 A/lmF			1300	V
Pulse amplitude resolution for ^{137}Cs		≈	7,2	%
Pulse amplitude resolution for ^{55}Fe		≈	43	%
Mean anode sensitivity deviation		≈	1	%
Anode pulse rise time		≈	2,5	ns
Linearity (with voltage divider B)	up to	≈	200	mA

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

GENERAL CHARACTERISTICS

Window

Material	lime glass			
Shape	plano-plano			
Refractive index at 400 nm		1,54		

Photocathode

Semi-transparent, head-on

Material	SbRbCs			
Useful diameter	>	32	mm	
Spectral sensitivity characteristic	see Fig. 6			
Maximum spectral sensitivity		440 ± 30	nm	
Luminous sensitivity		110	μA/lm	2
Blue sensitivity	typ.	11	μA/lmF	1
	>	8,5	μA/lmF	
Spectral sensitivity at 440 nm	≈	85	mA/W	3

Electron optical input system

This system consists of: the photocathode (k), a metallized part of the glass envelope, internally connected to the photocathode and the accelerating electrode (g), internally connected to d1.

Multiplier system

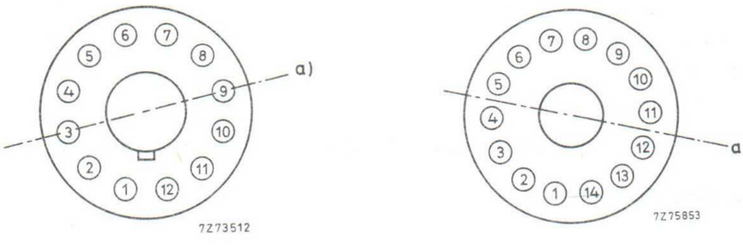
Number of stages	10
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

Magnetic field

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

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

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



XP2011B XP2011

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

RECOMMENDED CIRCUITS

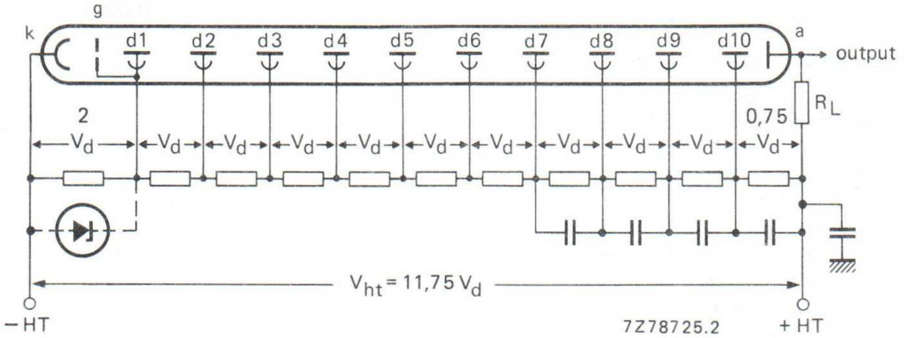


Fig. 2 Voltage divider A*.

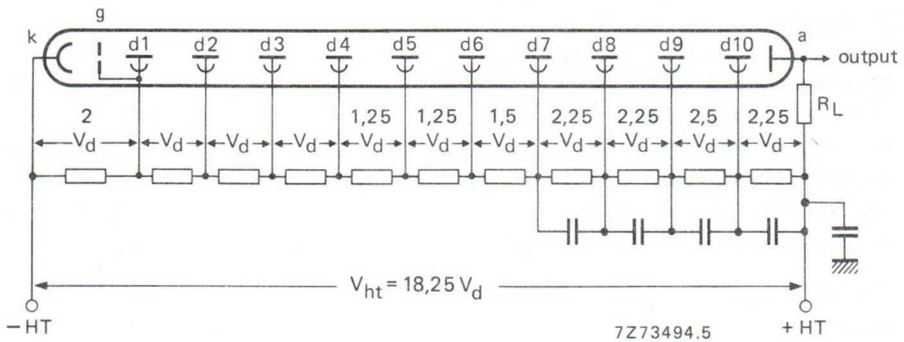


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

k = cathode;

g = accelerating electrode;

dn = dynode no.;

a = anode;

R_L = load resistor.

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

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				4
Supply voltage for an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		< typ.	1600 V 1300 V	1
Gain at V_{ht} = 1300 V (Fig. 9)		≈	7×10^5	
Anode dark current at an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		< typ.	20 nA 1,5 nA	5,6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF		≈	7,2 %	7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		≈	43 %	8
Peak-to-valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		≈	34	
Mean anode sensitivity deviation				9
long term (16 h)		≈	1 %	
after change of count rate		≈	1 %	
Anode pulse rise time at V_{ht} = 1300 V		≈	2,5 ns	10
Anode pulse duration at half height at V_{ht} = 1300 V		≈	6 ns	10
Signal transit time at V_{ht} = 1300 V		≈	30 ns	10
Anode current linear within 2% at V_{ht} = 1300 V	up to	≈	40 mA	
With voltage divider B (Fig. 3)				4
Gain at V_{ht} = 1700 V (Fig. 9)		≈	7×10^5	
Anode pulse rise time at V_{ht} = 1700 V		≈	2,5 ns	10
Anode pulse duration at half height at V_{ht} = 1700 V		≈	6 ns	10
Signal transit time at V_{ht} = 1700 V		≈	26 ns	10
Anode current linear within 2% at V_{ht} = 1700 V	up to	≈	200 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1800 V	11
Continuous anode current	max.	0,2 mA	12
Voltage between first dynode and photocathode	max. min.	500 V 150 V	13
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max. min.	300 V 30 V	14
Ambient temperature range			
Operational (for short periods of time)	max. min.	+80 °C −30 °C	15
Continuous operating and storage	max. min.	+50 °C −30 °C	

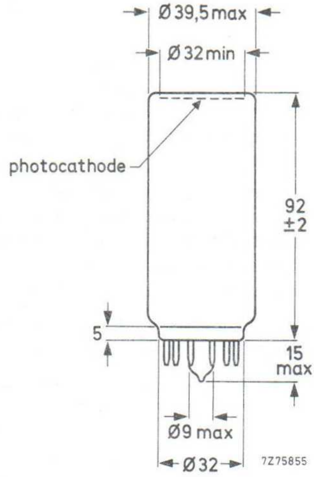
NOTES

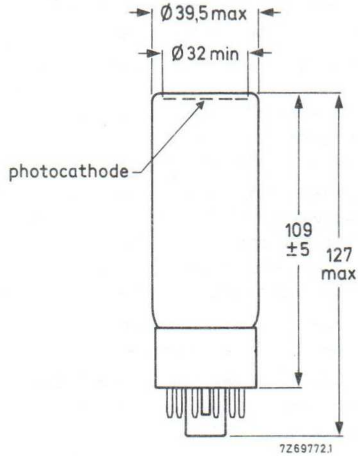
1. Blue sensitivity, expressed in $\mu A/lmF$, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K.
3. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 440 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
4. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode, voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\,\Omega$.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 2470 or equivalent) with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of ≈ 300 nA.
   Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu A$ and $\approx 0{,}1\ \mu A$ respectively.
   Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. Total HT supply voltage or the voltage at which the tube has an anode blue sensitivity of 75 A/lmF (voltage given on test certificate for an anode blue sensitivity of 7,5 A/lmF, multiplied by 1,4), whichever is lower.
12. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
13. Minimum value to obtain good collection in the input optics.

NOTES (continued)

14. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
15. For type XP2011B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA





Base	14-pin all glass		Base	12-pin (JEDEC B12-43)
Net mass	54 g		Net mass	72 g

PIN CONNECTIONS

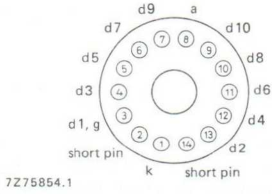


Fig. 4 XP2011.

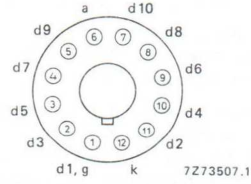


Fig. 5 XP2011B.

ACCESSORIES

Socket:
for XP2011 : FE1112
for XP2011B : FE1012

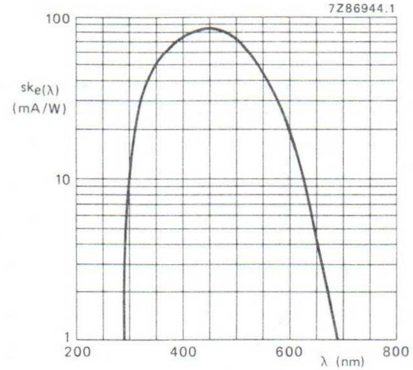


Fig. 6 Spectral sensitivity characteristic.

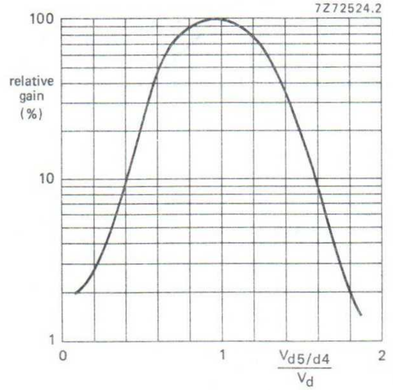


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

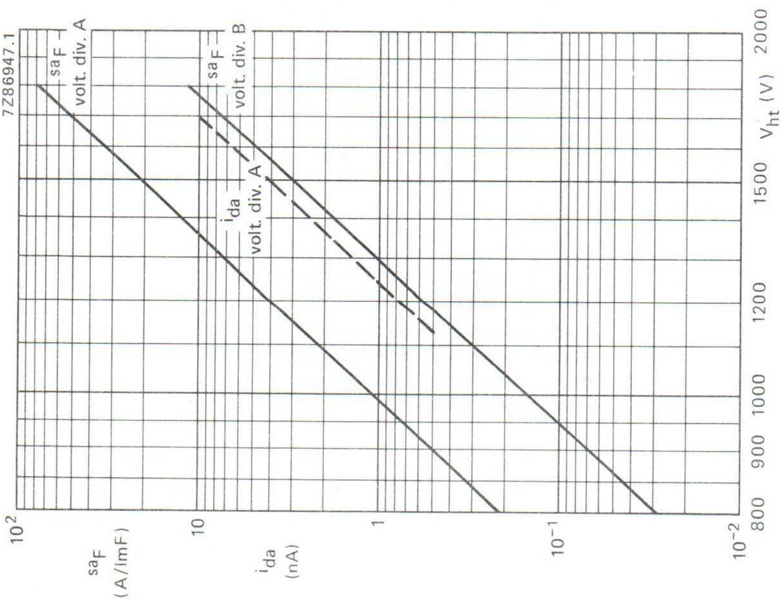


Fig. 8 Anode blue sensitivity, sa_F, and anode dark current i_{da}, as a function of supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

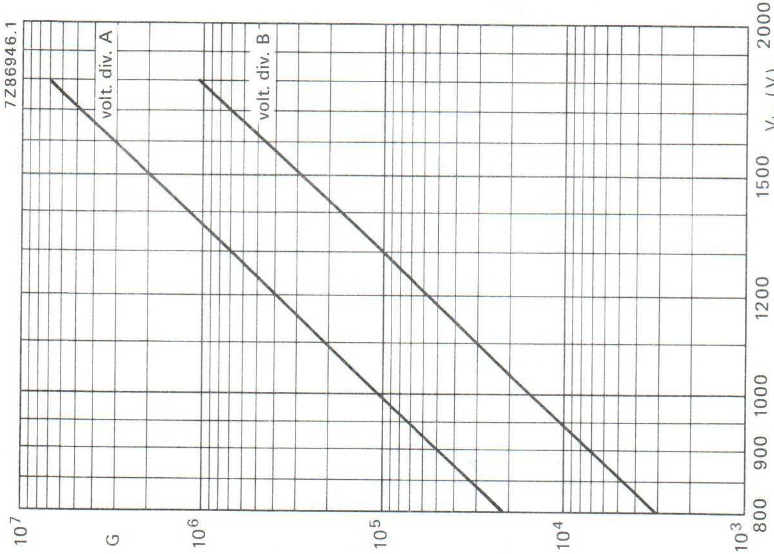


Fig. 9 Gain G as a function of supply voltage V_{ht}.

XP2012B replaces XP2010

10-STAGE PHOTOMULTIPLIER TUBES

The XP2012 and XP2012B are 32 mm useful diameter head-on photomultiplier tubes with a flat window and a semitransparent bialkaline type D photocathode. The tubes are intended for use in X-ray and γ-spectrometry and for all applications requiring a low background noise and/or dark current. Their Cu-Be dynode system offers a high stability. The XP2012 has a 14-pin all-glass base; the XP2012B is provided with a 12-pin plastic base.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	32	mm
Spectral sensitivity of the photocathode at 400 nm			90	mA/W
Supply voltage for an anode spectral sensitivity = 60 kA/W			1350	V
Pulse amplitude resolution				
for ^{57}Co at sa_V = 10 kA/W		≈	11,2	%
for ^{55}Fe at sa_V = 60 kA/W		≈	42	%
Peak-to-valley ratio for ^{55}Fe at sa_V = 60 kA/W		≈	34	
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Mean anode sensitivity deviation		≈	1	%
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	200	mA

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

GENERAL CHARACTERISTICS

Window

Shape	plano-plano		
Material	lime glass		
Refractive index at 400 nm		1,54	

Photocathode (note 1)

Semi-transparant, head-on	SbKCs		
Useful diameter	>	32	mm
Spectral sensitivity characteristic (Fig. 6)	type D		
Maximum sensitivity at		400 ± 30	nm
Spectral sensitivity at 400 nm	typ.	90	mA/W
	>	60	mA/W

Multiplier system

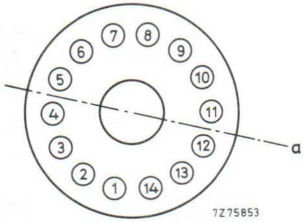
Number of stages		10
Dynode structure		linear focused
Dynode material		Cu Be
Capacitances		
Anode to all	≈	5 pF
Anode to final dynode	≈	3 pF

Magnetic field

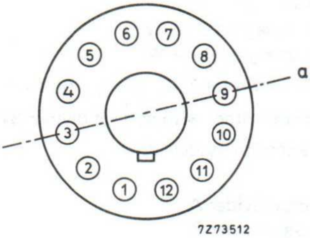
When the photocathode is illuminated uniformly the anode current is halved (at V_{ht} = 1200 V, voltage divider A):

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

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



XP2012



XP2012B

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

RECOMMENDED CIRCUITS

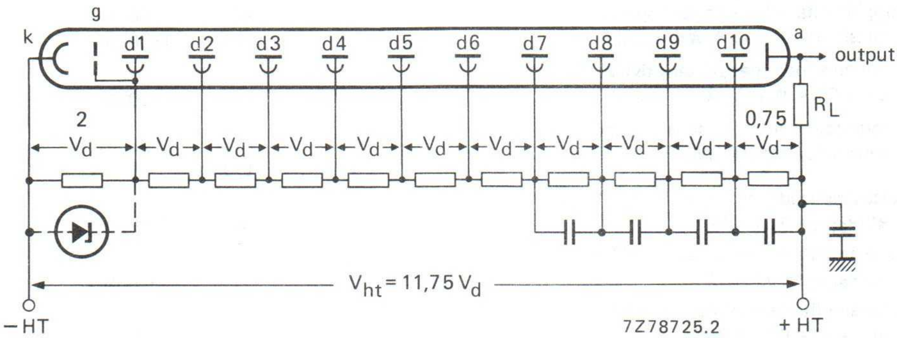


Fig. 2 Voltage divider A.

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

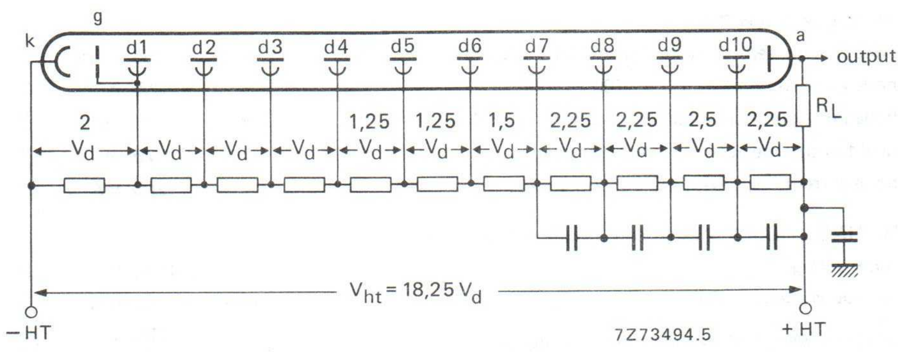


Fig. 3 Voltage divider B.

k = cathode

g = accelerating electrode

dn = dynode no

a = anode

R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS *

				notes
With voltage divider A (Fig. 2)				2
Supply voltage for an anode spectral sensitivity of 60 kA/W (Fig. 8)		< typ.	1600 V 1350 V	
for an anode spectral sensitivity of 300 kA/W (Fig. 8)		≈	1650 V	
Anode dark current at an anode spectral sensitivity of 60 kA/W (Fig. 8)		< typ.	20 nA 1 nA	3,4
Pulse amplitude resolution for ^{137}Cs at $sa_{e(\lambda)}$ = 10 kA/W		≈	7,2 %	5
Pulse amplitude resolution for ^{57}Co at $sa_{e(\lambda)}$ = 10 kA/W		≈	11,2 %	5
Pulse amplitude resolution for ^{55}Fe at $sa_{e(\lambda)}$ = 60 kA/W		≈	42 %	6
Peak-to-valley ratio for ^{55}Fe at $sa_{e(\lambda)}$ = 60 kA/W		≈	34	6
Anode current linear within 2% at V_{ht} = 1700 V	up to	≈	100 mA	
Mean anode sensitivity deviation				13
long term (16 h)		≈	1 %	
after change of count rate		≈	1 %	
versus temperature between 0 and + 40 °C at 450 nm		≈	0,2 %/K	
With voltage divider B (Fig. 2)				2
Anode spectral sensitivity at V_{ht} = 1700 V (Fig. 8)		≈	50 kA/W	
Anode pulse rise time at V_{ht} = 1700 V		≈	2,5 ns	7
Anode pulse duration at half-height at V_{ht} = 1700 V		≈	6 ns	7
Signal transit time at V_{ht} = 1700 V		≈	26 ns	7
Anode current linear within 2% at V_{ht} = 1700 V	up to	≈	200 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1800 V	8
Continuous anode current	max.	0,2 mA	9
Voltage between first dynode and photocathode	max. min.	500 V 150 V	10
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max. min.	300 V 30 V	11
Ambient temperature range			
Operational (for short periods of time)	max. min.	+80 °C −30 °C	12
Continuous operation and storage	max. min.	+50 °C −30 °C	

* All spectral sensitivities refer to a wavelength of 400 nm.

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at –30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at –HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators having an insulation resistance of $> 10^{15}\ \Omega$.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ ¼ h).
5. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is ≈ 10^3 c/s.
6. Pulse amplitude resolution for ^{55}Fe is measured with an NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is 2 x 10^3 c/s.
7. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
8. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.
9. A value of < 10 µA is recommended for applications requiring high stability.
10. Minimum value to obtain good collection in the input optics.
11. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
12. For type XP2012B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
13. The mean pulse amplitude deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 c/s corresponding to an anode current of ≈ 300 nA.
    Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an anode current of ≈ 1 µA and ≈ 0,1 µA respectively.
    Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.

MECHANICAL DATA

Dimensions in mm

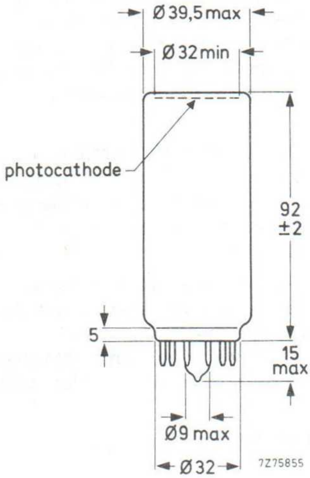
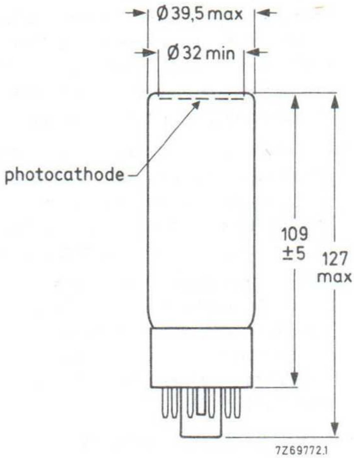


Fig. 4 XP2012



XP2012B

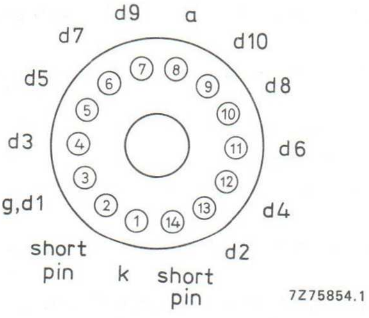
Base: 14-pin all-glass

Net mass: 54 g

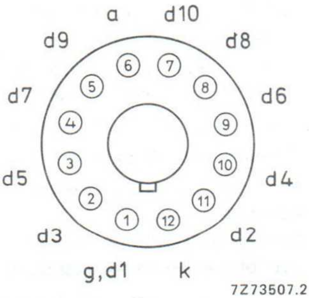
Base: 12-pin (JEDEC B12-43)

Net mass: 72 g

PIN CONNECTIONS



XP2012



XP2012B

ACCESSORIES

Socket:
- for XP2012 type FE1112
- for XP2012B type FE1012

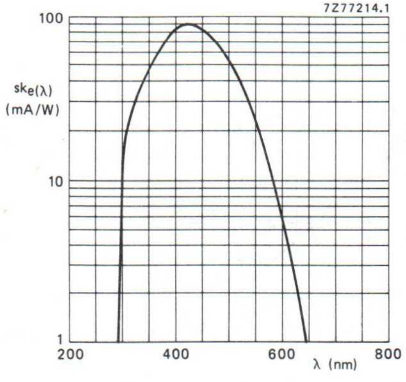


Fig. 6 Spectral sensitivity characteristic.

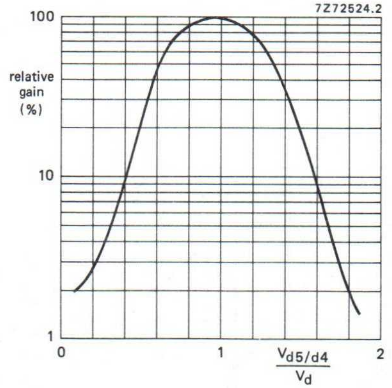


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

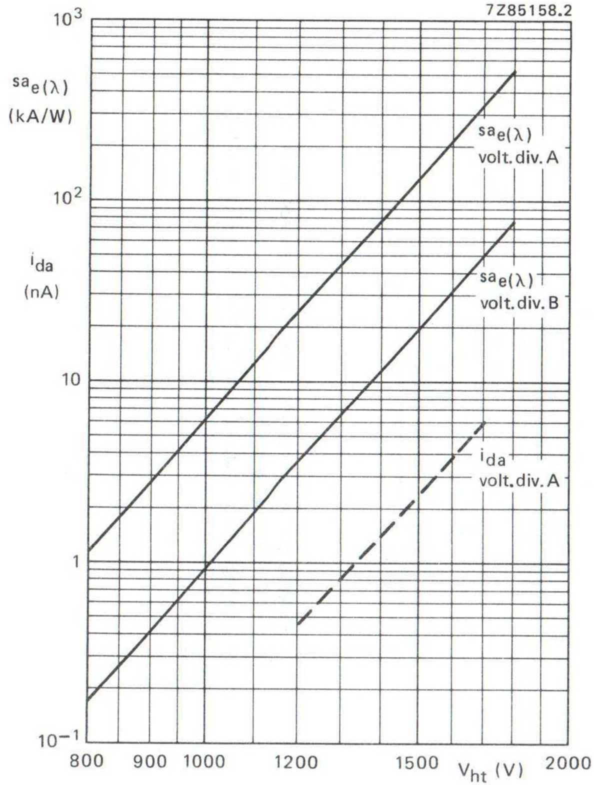


Fig. 8 Anode spectral sensitivity, $sa_{e(\lambda)}$, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

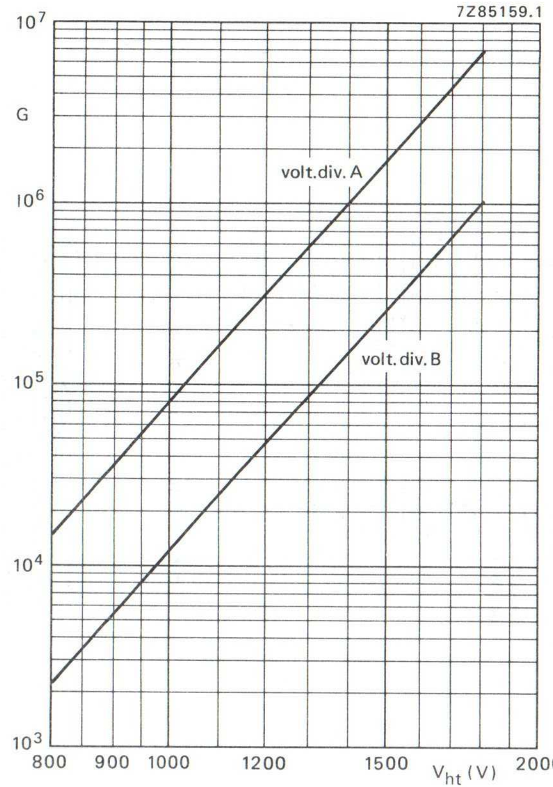


Fig. 9 Gain G as a function of supply voltage V_{ht}.

10-STAGE PHOTOMULTIPLIER TUBE

The XP2018 B is a 32 mm useful diameter head-on photomultiplier tube with a flat window and a semi-transparent S13 (type U) photocathode. The tube is intended for use in applications where a high sensitivity in the ultraviolet region of the spectrum is required, such as spectrophotometry.

QUICK REFERENCE DATA

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

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on			
Material			Sb Rb Cs
Useful diameter		>	32 mm
Spectral sensitivity characteristic	See fig. 5		
Maximum spectral sensitivity at			400 ± 30 nm
Spectral sensitivity at 440 nm		typ.	75 mA/W
		>	40 mA/W
Luminous sensitivity		≈	85 μA/lm

Multiplier system

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

Magnetic field

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

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

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

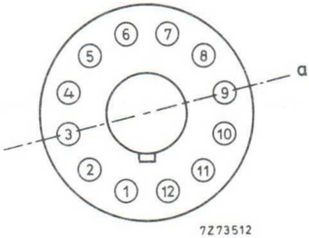


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

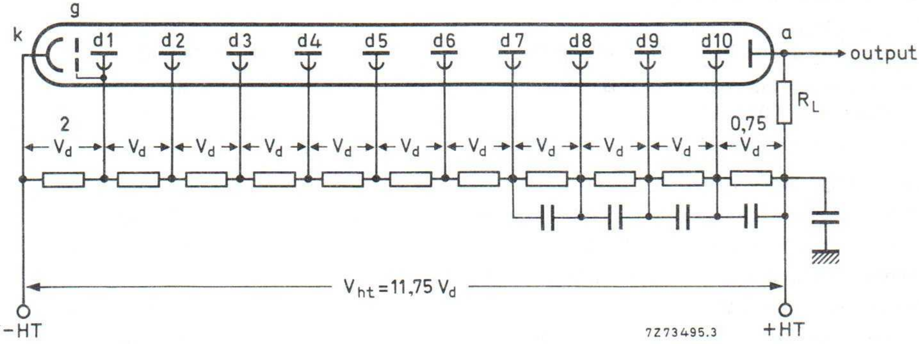


Fig. 2 Voltage divider A. Typical value of capacitors: 10 nF, k = cathode, g = accelerating electrode, dn = dynode no., a = anode, R_L = load resistor.

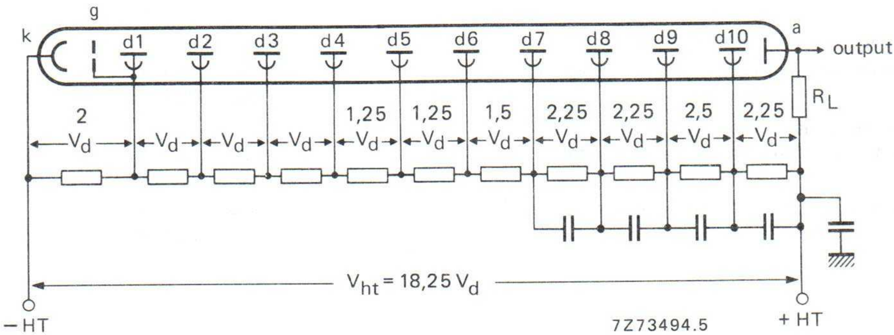


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF, k = cathode, g = accelerating electrode, dn = dynode no., a = anode, R_L = load resistor.

TYPICAL CHARACTERISTICS

				notes
With voltage divider A Fig. 2)				1
Supply voltage for an anode spectral sensitivity of 60 kA/W at 440 nm (Fig. 7)	< typ.	1600 1350	V V	
Anode dark current at an anode spectral sensitivity of 60 kA/W	< typ.	50 5	nA nA	2,3
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈	100	mA	
With voltage divider B (Fig. 3)				1
Anode spectral sensitivity at V_{ht} = 1700 V (Fig. 7)	≈	50	kA/W	
Anode pulse rise time at V_{ht} = 1700 V	≈	2,5	ns	4
Anode pulse duration at half-height at V_{ht} = 1700 V	≈	6	ns	4
Signal transit time at V_{ht} = 1700 V	≈	26	ns	4
Anode current linear within 2% at V_{ht} = 1700 V	up to≈	200	mA	

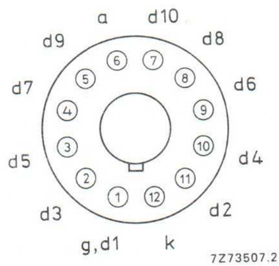
LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	1800	V	5
Continuous anode current	max.	0,2	mA	9
Voltage between first dynode and photocathode	max. min.	500 150	V V	6
Voltage between consecutive dynodes	max.	300	V	
Voltage between anode and final dynode	max. min.	300 30	V V	7
Ambient temperature range				
operational (for short periods of time)	max. min.	+80 −30	°C °C	8
continuous operation and storage	max. min.	+50 −30	°C °C	

Notes

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

MECHANICAL DATA



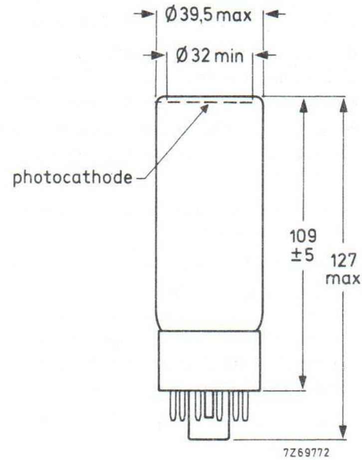


Fig. 4.

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

ACCESSORIES

Socket	type FE1012

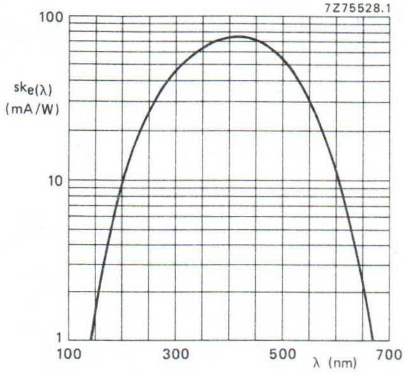


Fig. 5 Spectral sensitivity characteristic.

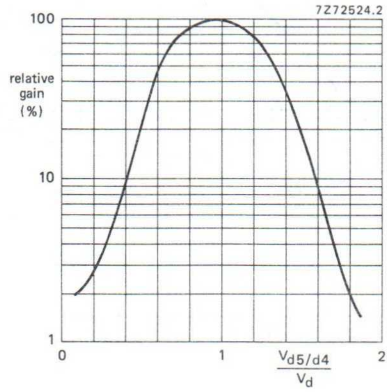


Fig. 6 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

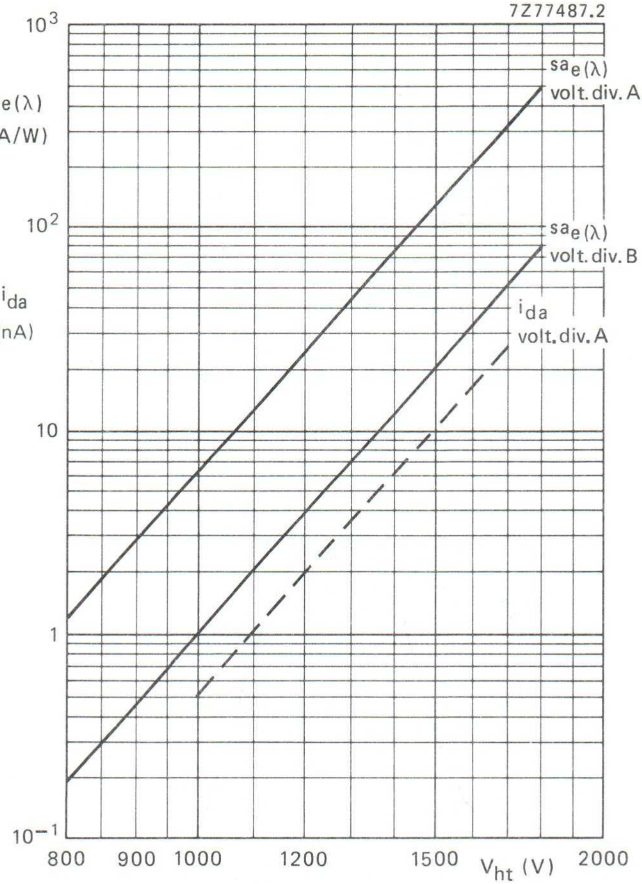


Fig. 7 Anode spectral sensitivity $sa_{e(\lambda)}$, and anode dark current i_{da} as a function of the supply voltage V_{ht}.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2020 and XP2020Q are 44 mm useful diameter head-on photomultiplier tubes with a plano-concave window and a semi-transparent type D photocathode. The tubes are intended for use in nuclear physics where the number of photons to be detected is very low. The tubes feature a high cathode sensitivity and a good linearity combined with very low background noise and extremely good time characteristics. They are especially useful in high-energy physics experiments where ultimate time characteristics are needed, such as coincidence measurements, Cerenkov detection, etc. The XP2020Q has a fused silica window enabling transmission at a wavelength of 160 nm and higher.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	XP2020 XP2020Q	type D type DU		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 400 nm				
XP2020			26	%
XP2020Q			25	%
Spectral sensitivity of the photocathode at 400 nm				
XP2020			85	mA/W
XP2020Q			80	mA/W
Supply voltage for a gain of 3×10^7			2200	V
Pulse amplitude resolution for ^{137}Cs		≈	7,5	%
Anode pulse rise time (with voltage divider B′)		≈	1,5	ns
Linearity, with voltage divider B	up to	≈	280	mA
Signal transit time distribution	σ	≈	0,25	ns

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

GENERAL CHARACTERISTICS

Window

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

Photocathode (note 1)

Semi-transparent, head-on			
Material	SbKCs		
Useful diameter	>	44	mm

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

Multiplier system

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

Magnetic field

See Fig. 13.

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

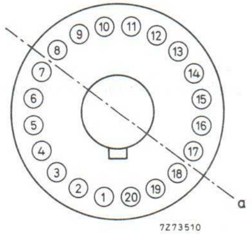


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

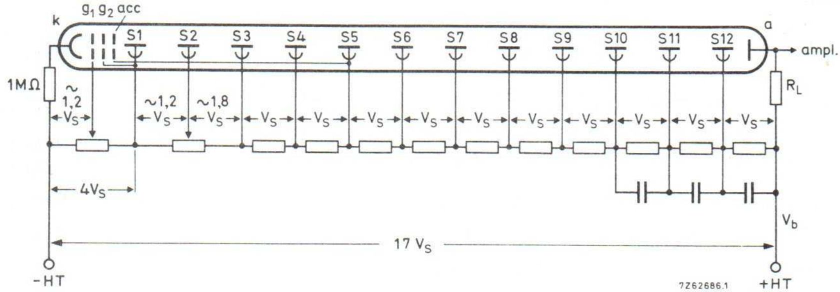


Fig. 2 Voltage divider type A.

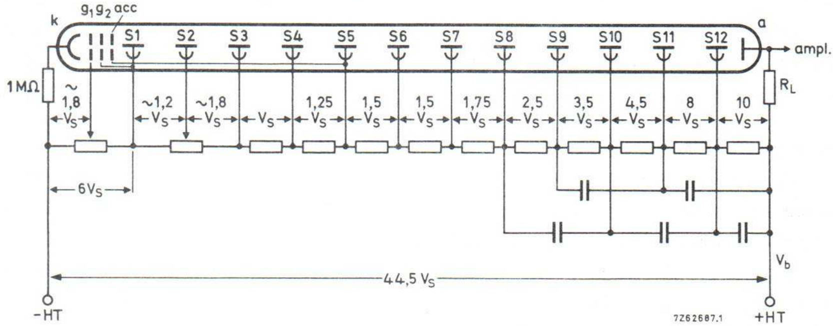


Fig. 3 Voltage divider type B.

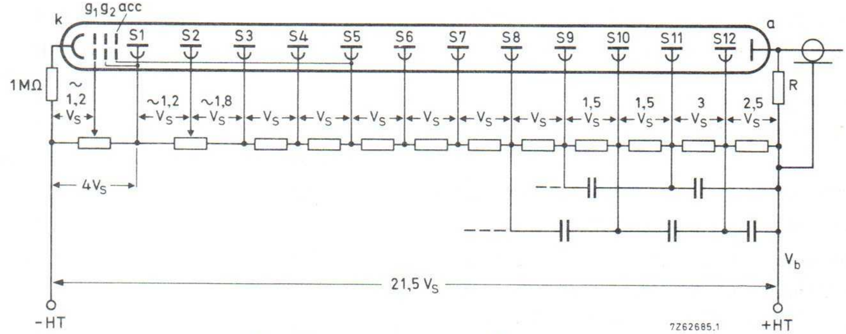


Fig. 4 Voltage divider type B'.

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

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

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

Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

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

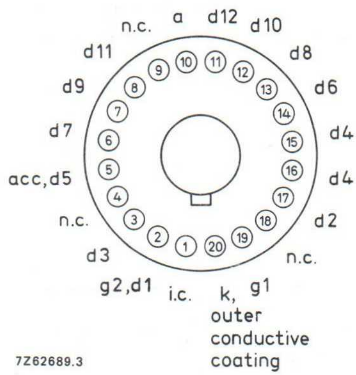
LIMITING VALUES (Absolute maximum rating system)	note		
Supply voltage	8	max.	3000 V
Continuous anode current	14	max.	0,2 mA
Voltage between focusing electrode, g_1 and photocathode		max.	300 V
Voltage between first dynode and photocathode	9	max. min.	800 V 300 V
Voltage between consecutive dynodes (except S_{11} and S_{12})		max.	400 V
Voltage between dynodes S_{11} and S_{12}	13	max.	600 V
Voltage between anode and final dynode	10	max. min.	700 V 80 V
Ambient temperature range	11		
operational (for short periods of time)		max. min.	+80 °C −30 °C
continuous operation and storage		max. min.	+50 °C −30 °C

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B′ are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this should be kept at cathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
5. After having been stored with its protective hood, the tube is placed in darkness with V_b set to a value to give a gain of 3×10^7. After a 30 min. stabilization period noise pulses with a threshold of $4{,}25 \times 10^{-13}$ C (corresponding to 0,1 photoelectron) are recorded (Fig. 9).
6. Pulse amplitude resolution for ^{55}Fe is measured with a NaI (Tl) cylindrical scintillator with a diameter of 19 mm and a height of 3 mm. The count rate is $\approx 10^3$ c/s. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator with a diameter of 44 mm and a height of 50 mm. The count rate is $\approx 10^4$ c/s.
7. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$.
8. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.
12. Transit time fluctuations of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation σ.
13. Non-inductive resistors of 51 Ω are incorporated in the base connected to S_{11} and S_{12}. See also *General Operational Recommendations Photomultiplier Tubes.*
14. A value of $< 10\ \mu$A is recommended for applications requiring good stability.

MECHANICAL DATA

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode.
Care should be taken to avoid electric shock.



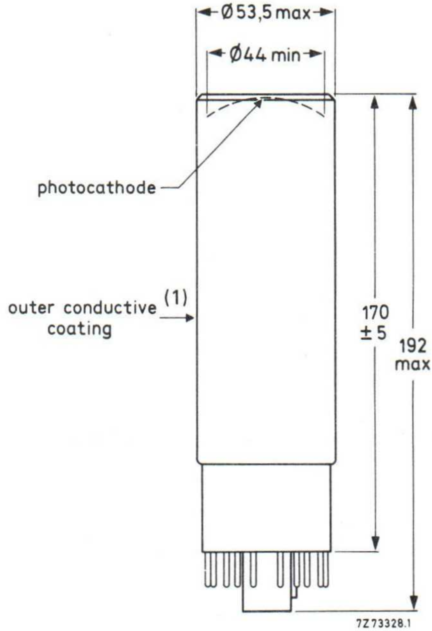


Fig. 5.

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

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

ACCESSORIES

Socket	type FE1020

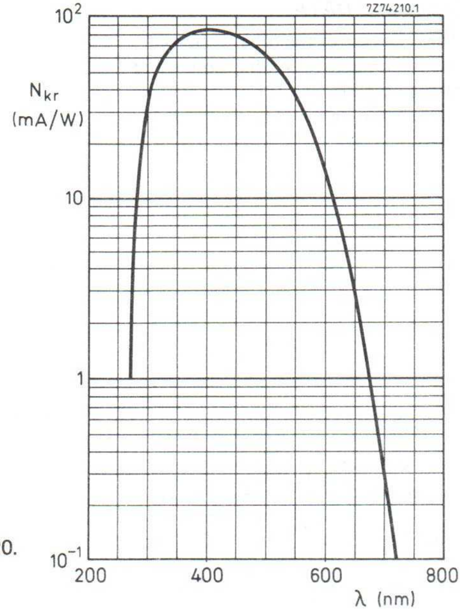


Fig. 6 Spectral sensitivity characteristic XP2020.

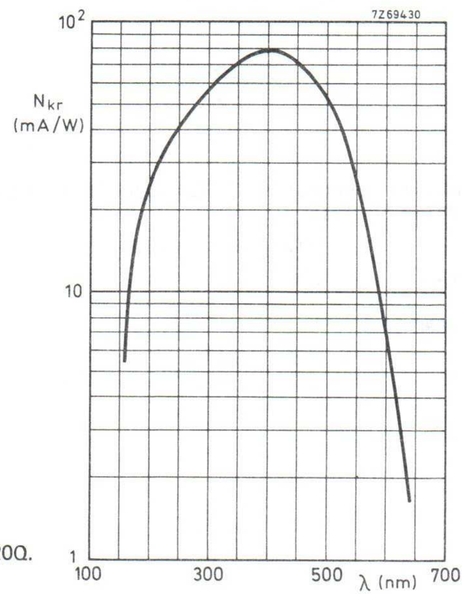


Fig. 7 Spectral sensitivity characteristic XP2020Q.

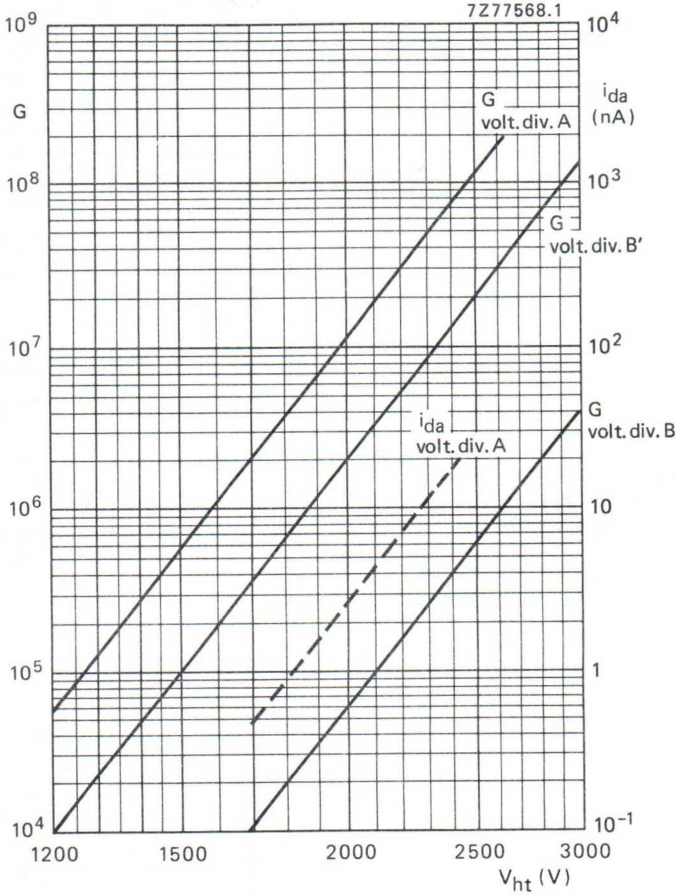


Fig. 8 Gain, G, and anode dark current, i_{da}, as a function of supply voltage V_b.

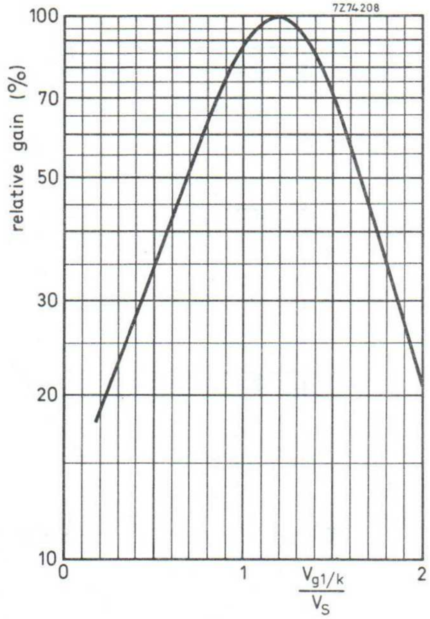


Fig. 9 Relative gain as a function of the voltage between grid 1 and cathode, normalized to V_S. $V_{S1/k}$ constant.

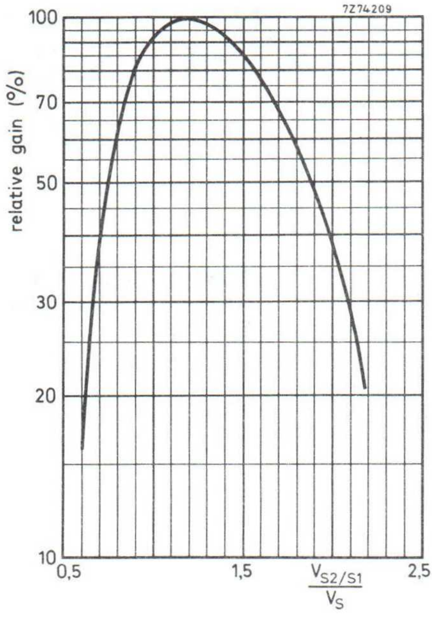


Fig. 10 Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S. $V_{S3/S1}$ constant.

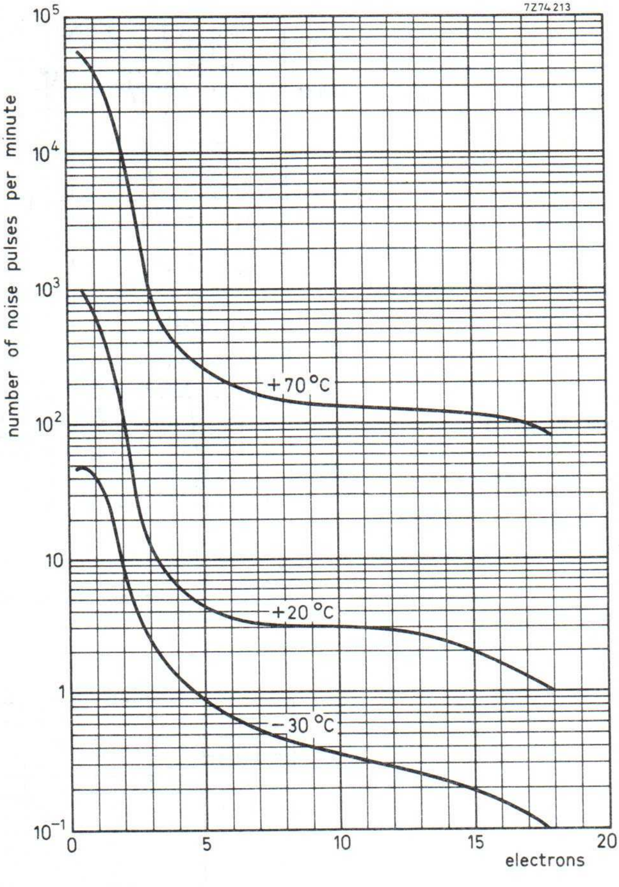


Fig. 11 Typical background spectrum from 0,1 to 18 equivalent photoelectrons, at a gain of 3×10^7 with voltage divider A.

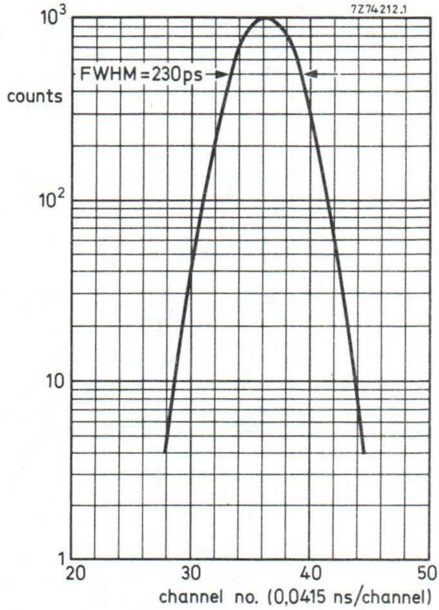


Fig. 12 Time resolution for 2 tubes XP2020 in coincidence. Measuring conditions:
Number of photoelectrons ≈ 1500
Supply voltage 2500 V
Constant fraction operation
Dynamic energy region 20%.

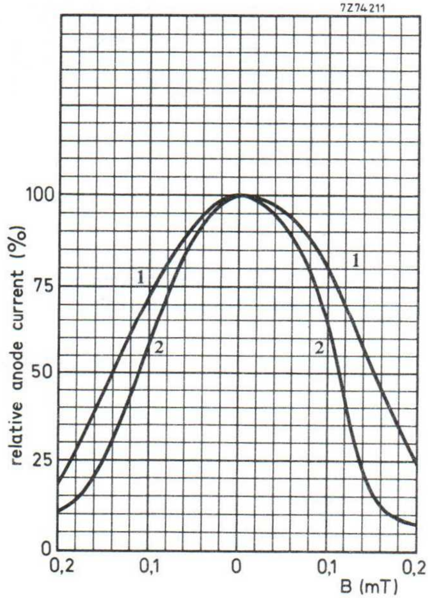


Fig. 13 Relative anode current as a function of the magnetic flux density B.
1. ⊥ axis a
2. // axis a

8-STAGE PHOTOMULTIPLIER TUBE

- 32 mm useful diameter head-on type
- Flat window
- Semi-transparent tri-alkaline S20 (type T) photocathode
- Good time characteristics
- Good linearity
- For industrial applications, e.g. laser reading

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S20 (type T)
Useful diameter of the photocathode	> 32 mm
Cathode spectral sensitivity at 700 nm	20 mA/W
Supply voltage for anode luminous sensitivity of 6 A/lm	1120 V
Anode pulse rise time (with voltage divider B)	≈ 2,5 ns
Linearity, with voltage divider B	up to ≈ 200 mA

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

GENERAL CHARACTERISTICS

Window (frosted)

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

Photocathode

Semi-transparent, head-on		
Material	SbNaKCs	
Useful diameter	> 32 mm	
Spectral sensitivity characteristic (Fig. 5)	S20 (type T)	
Maximum spectral sensitivity	420 ± 30 nm	
Luminous sensitivity	≈ 200 μA/lm	note 1
Spectral sensitivity at 700 nm	typ. 20 mA/W > 10 mA/W	note 2
Spectral sensitivity at 630 nm	≈ 40 mA/W	note 2

Mulitplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

Magnetic field

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

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

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

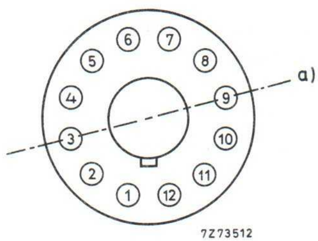


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

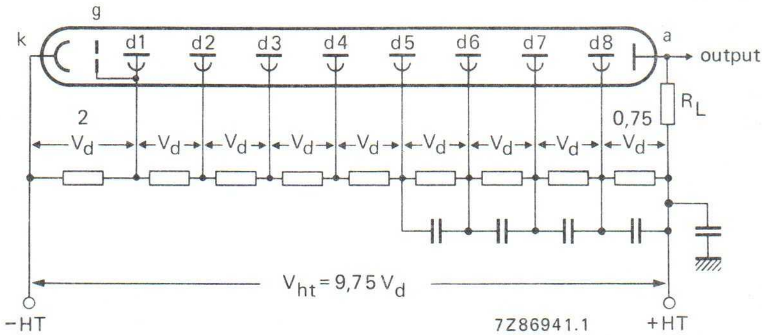


Fig. 2 Voltage divider A.

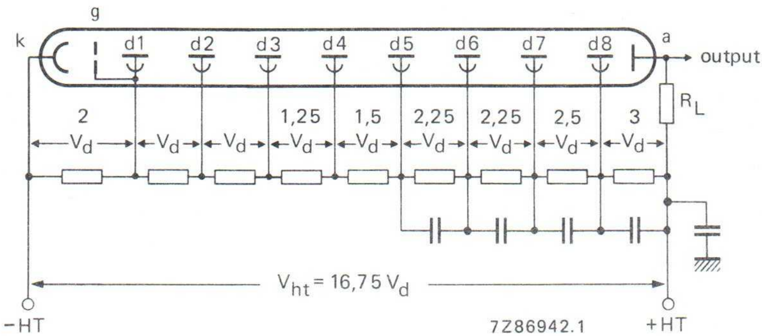


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2) — note 3

Supply voltage for an anode luminous sensitivity of 6 A/lm (Fig. 7)	typ. <	1120 1300	V V	note 1
Anode dark current at an anode luminous sensitivity of 6 A/lm (Fig. 7)	typ. <	1 5	nA nA	notes 4, 5
Mean anode sensitivity deviation at V_{ht} = 1000 V, long term (16 h)	≈	1	%	note 6
Anode current linear within 2% at V_{ht} = 1300 V	up to ≈	80	mA	

With voltage divider B (Fig. 3) — note 3

Anode luminous sensitivity at V_{ht} = 1500 V (Fig. 7)	≈	7	A/lm	
Anode pulse rise time at V_{ht} = 1500 V	≈	2,5	ns	note 7
Anode pulse duration at half height at V_{ht} = 1500 V	≈	6	ns	note 7
Signal transit time at V_{ht} = 1500 V	≈	24	ns	note 7
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈	200	mA	

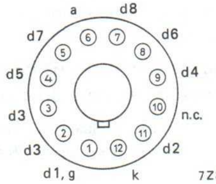
LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1800	V	note 8
Continuous anode current	max.	0,2	mA	note 9
Voltage between first dynode and photocathode	max. min.	500 150	V V	note 10
Voltage between consecutive dynodes	max.	300	V	
Voltage between anode and final dynode	max. min.	350 30	V V	note 11
Ambient temperature range operational (for short periods of time)	max. min.	+ 80 −30	°C °C	note 12
continuous operation and storage	max. min.	+ 50 −30	°C °C	

NOTES

1. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
2. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter.
3. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
4. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators having an insulation resistance of $> 10^{15}\,\Omega$.
5. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
6. The mean anode sensitivity deviation measurement is carried out with light pulses at a count rate of $\approx 10^4$ c/s, resulting in an average anode current of 0,3 μA. See also *General Operational Recommendations Photomultiplier Tubes.*
7. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns: the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
8. Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of $\approx$ 120 A/lm (test certificate voltage multiplied by 1,65), whichever is lower.
9. A value of < 10 μA is recommended for applications requiring good stability.
10. Minimum value to obtain good collection in the input optics.
11. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
12. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb.

MECHANICAL DATA



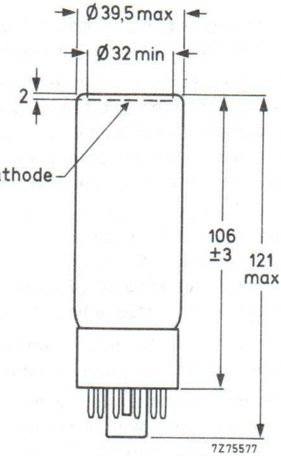


Fig. 4.

Base	12-pin (JEDEC B12-43)
Net mass	75 g
Socket*	FE1012

Note: To improve the anode sensitivity over the entire cathode area the external surface of the window has been frosted.

* To be ordered separately.

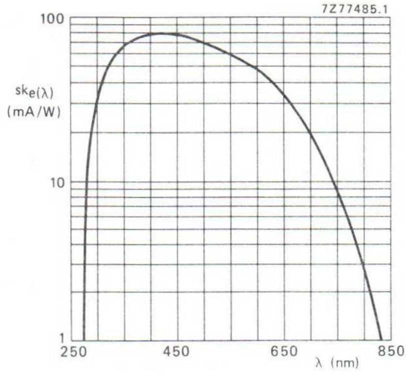


Fig. 5 Spectral sensitivity characteristic.

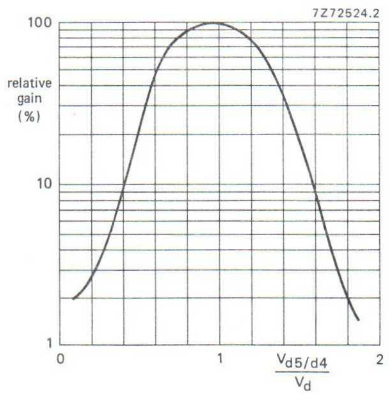


Fig. 6 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

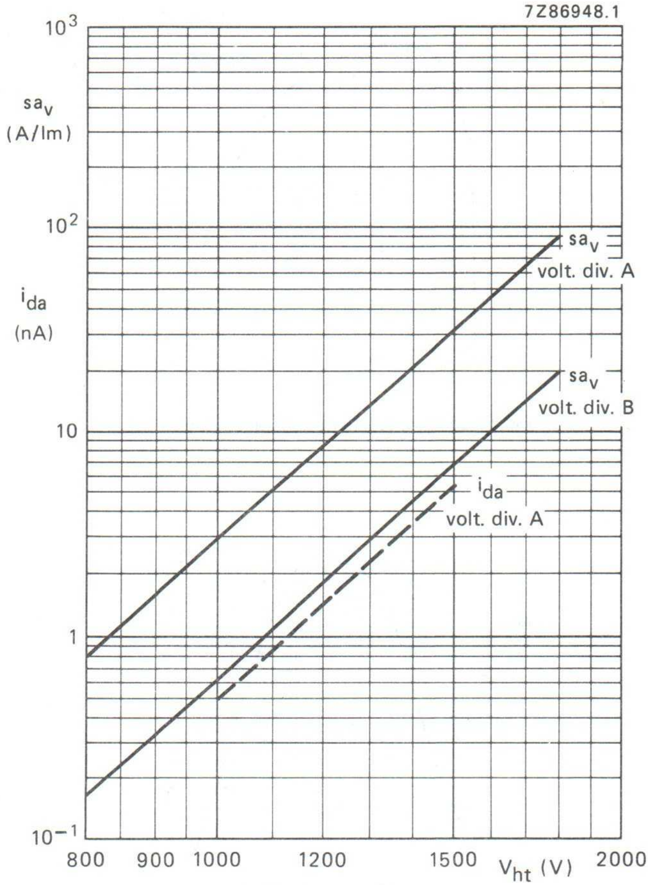


Fig. 7 Anode luminous sensitivity sa_v and anode dark current i_{da} as a function of the supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

XP2041 replaces XP2040
XP2041Q replaces XP2040Q

14-STAGE PHOTOMULTIPLIER TUBES

- 110 mm useful diameter head-on type
- Concave-convex window
- Semi-transparent bi-alkaline type D photocathode
- For nuclear physics where the number of photons to be detected is very low, c.q. where very good time characteristics are required, e.g. coincidence measurements and Cerenkov light detection
- XP2041 is supplied with a plano-concave plastic adapter (300 nm and up)
- XP2041Q is supplied with a plano-concave fused silica adapter (200 nm and up)

QUICK REFERENCE DATA

Spectral sensitivity characteristic			type D, extended ultra violet	
Useful diameter of the photocathode		>	110	mm
Quantum efficiency at 400 nm			26	%
Cathode spectral sensitivity at 400 nm			85	mA/W
Supply voltage for a gain of 3×10^7			2200	V
Anode pulse rise time (with voltage divider B)		≈	2	ns
Linearity				
with voltage divider A (Fig. 2)	up to	≈	30	mA
with voltage divider B (Fig. 3)	up to	≈	220	mA
with voltage divider B' (Fig. 4)	up to	≈	80	mA

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

GENERAL CHARACTERISTICS

Window *

Material	u.v. transmitting glass
Shape	concave-convex
Radius of curvature	183 ± 5 mm
Refractive index at 550 nm	1,48

* This glass window (type Schott 8337 or equivalent) must be protected from humidity.

Photocathode

Semi-transparent, head-on	
Material	Sb K Cs
Useful diameter	> 110 mm
Spectral sensitivity characteristic (Fig. 6)	type D, extended ultraviolet
Maximum spectral sensitivity	400 ± 30 nm
Quantum efficiency at 400 nm	26 %
Spectral sensitivity at 400 nm	typ. 85 mA/W
	> 65 mA/W

Multiplier system

Number of stages	14
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 5 pF
anode to all	≈ 7 pF
grid1 to k + grid2 + grid3 + d1	≈ 70 pF

Magnetic field

When the photocathode is illuminated uniformly the anode current is halved (at V_{ht} = 1900 V, voltage divider A) at a magnetic flux density of:

0,15 mT in the direction of the longitudinal axis;
0,13 mT perpendicular to axis a (see Fig. 1);
0,05 mT parallel to axis a.

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

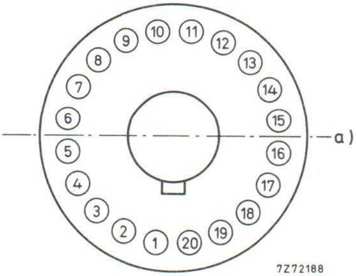


Fig. 1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

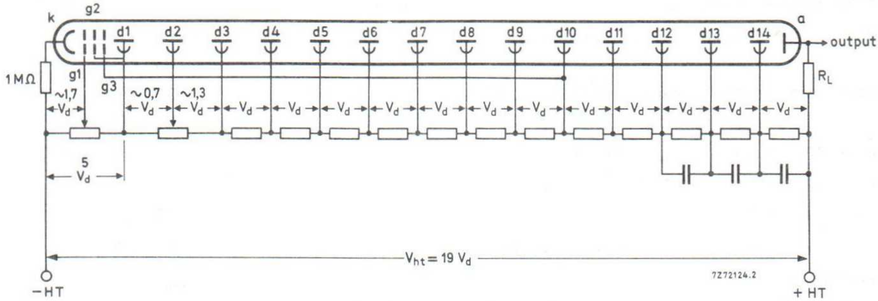


Fig. 2 Voltage divider A.

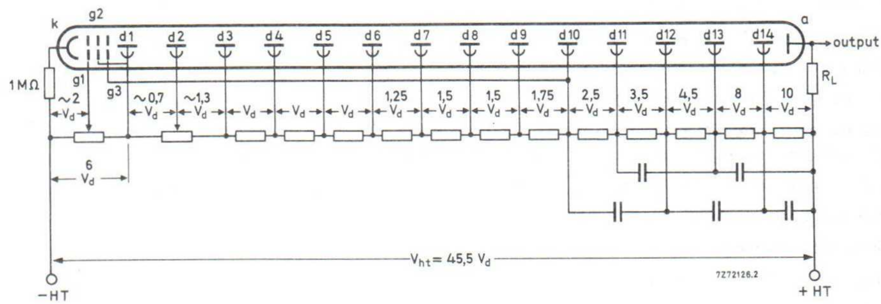


Fig. 3 Voltage divider B.

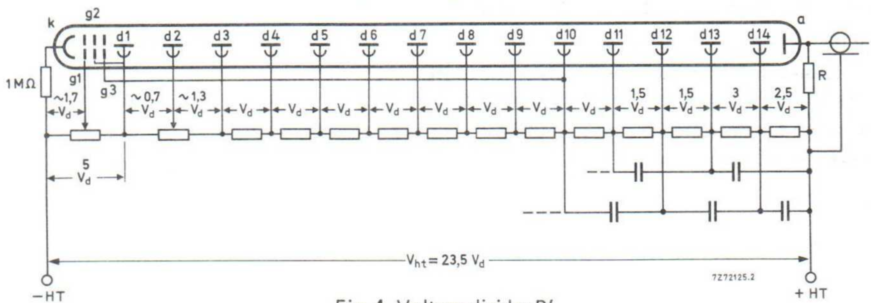


Fig. 4 Voltage divider B′.

k = cathode; g1, g2 = focusing electrodes; g3 = accelerating electrode; dn = dynode no.; a = anode
R_L = load resistor. The voltage between k and g1 should be adjusted at about 1,7 V_d for voltage dividers A and B′ or about 2 V_d for voltage divider B.
R = This resistor serves to connect the anode when the output cable is not terminated. Recommended value: 10 kΩ. The cathode resistor of 1 MΩ limits the current in case of unintentional contact between the conductive coating and earth when the anode is earthed. The voltage between d1 and d2 should be adjusted at about 0,7 V_d. Typical value of capacitors: 1 nF.

TYPICAL CHARACTERISTICS

			notes
With voltage divider A (Fig. 2)			
Supply voltage for a gain of 3×10^7 (Fig. 10)	typ.	2200 V	1
	<	2700 V	
Anode dark current at a gain of 3×10^7 (Fig. 10)	typ.	30 nA	1, 2
	<	600 nA	
Anode pulse rise time at V_{ht} = 2200 V	≈	2,5 ns	3, 4
Anode pulse duration at half height at V_{ht} = 2200 V	≈	5 ns	3
Signal transit time at V_{ht} = 2200 V	≈	46 ns	3
Anode current linear within 2% at V_{ht} = 2200 V	up to ≈	30 mA	
Obtainable peak anode current	≈	200 mA	
With voltage divider B (Fig. 3)	≈		5
Gain at V_{ht} = 2800 V (Fig. 10)	≈	4×10^6	
Anode pulse rise time at V_{ht} = 2800 V	≈	2,1 ns	3, 4
Anode pulse duration at half height at V_{ht} = 2800 V	≈	3 ns	3
Signal transmit time at V_{ht} = 2800 V	≈	49 ns	3
Signal transmit time difference between the centre of the photocathode and 50 mm from the centre at V_{ht} = 2800 V	≈	1 ns	
Anode current linear within 2% at V_{ht} = 2800 V	up to ≈	280 mA	
Obtainable peak anode current	≈	0,5 to 1 A	
With voltage divider B' (Fig. 4)	≈		5
Gain at V_{ht} = 2500 V (Fig. 10)	≈	2×10^7	
Anode pulse rise time at V_{ht} =2500 V	≈	2 ns	3, 4
Anode pulse duration at half height at V_{ht} =2500 V	≈	3 ns	3
Signal transit time at V_{ht} =2500 V	≈	46 ns	3
Signal transit time difference between the centre of the photocathode and 50 mm from the centre at V_{ht} =2500 V	≈	1 ns	
Anode current linear within 2% at V_{ht} = 2500 V	up to ≈	20 mA	
Obtainable peak anode current	≈	500 mA	

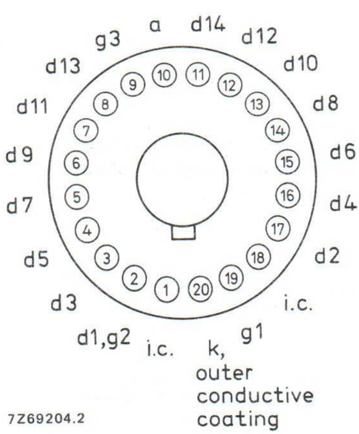
LIMITING VALUES (Absolute maximum rating system)

				notes
Supply voltage	max.	3000	V	6
Continuous anode current	max.	0,2	mA	7
Voltage between focusing electrode, g1 and photocathode	max.	300	V	
Voltage between first dynode and photocathode	max.	800	V	8
	min.	400	V	
Voltage between accelerating electrode and photocathode	max.	18	V_d	
	min.	14	V_d	
Voltage between consecutive dynodes	max.	500	V	
Voltage between anode and final dynode	max.	500	V	9
	min.	80	V	
Ambient temperature range				
operational (for short periods of time)	max.	+80	°C	10
	min.	−30	°C	
continuous operation and storage	max.	+50	°C	
	min.	−30	°C	

Notes

1. Wherever possible, the photomultiplier power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended to keep the metal envelope at cathode potential. This implies safety precautions to protect the user.
2. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ 15 min).
3. Measured with a pulsed light source with a pulse duration of < 1 ns; the cathode being completely illuminated.
   The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
   The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of the HT supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
4. A non-inductive resistor of 51 Ω is incorporated in the base, connected to d14.
   See also *"General Operational Recommendations Photomultiplier tubes".*
5. Divider circuits B and B′ are examples of "progressive dividers", each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally advisable to keep the increase in voltage between one stage and the next to less than a factor 2.
6. Total HT supply voltage, or the voltage at which the tube circuited in voltage divider "A" has a gain of 3×10^8, whichever is lower.
7. For applications requiring a high stability a value of $<10 \mu A$ is recommended.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
10. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
    Where lower temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA



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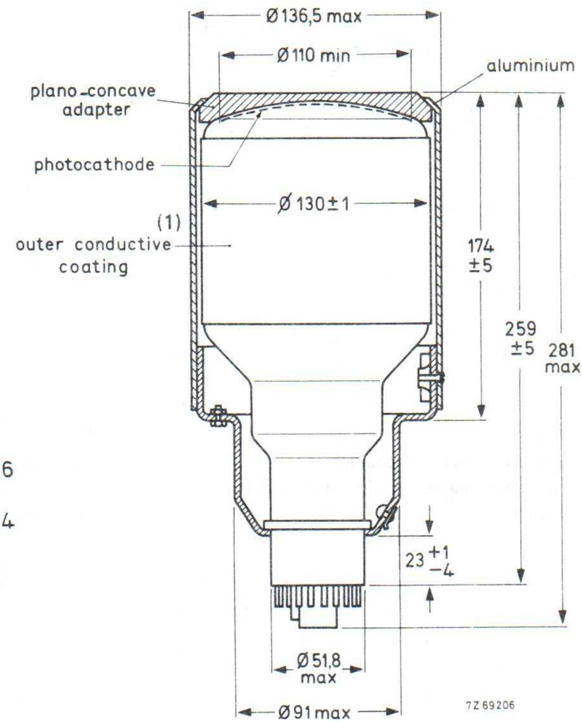


7Z69206

Fig. 5 Care should be taken in handling this larger diameter tube because of the risk of implosion.

Base: 20-pin (JEDEC B20-102)

Net mass: 1340 g

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

ACCESSORIES

Socket type FE1020

The XP2041 may be used with the base assembly S563, see separate data sheet.

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. Take care to avoid electric shock. See also note 1.

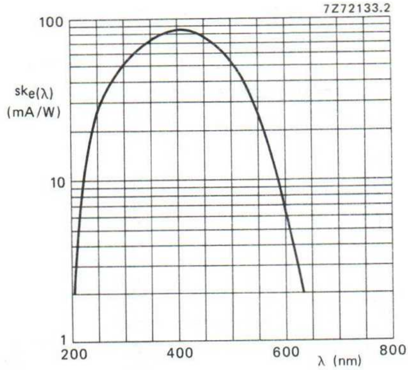


Fig. 6

Spectral sensitivity characteristic (without adapter or with fused silica adapter).

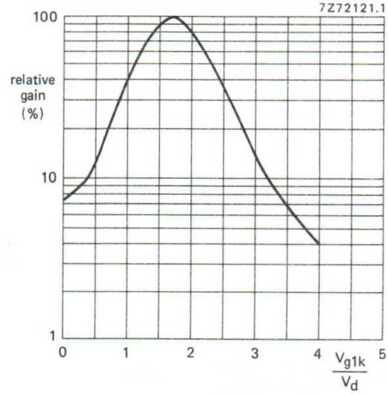


Fig. 7

Relative gain as a function of the voltage between focusing electrode g1 and photocathode, normalized to V_d.

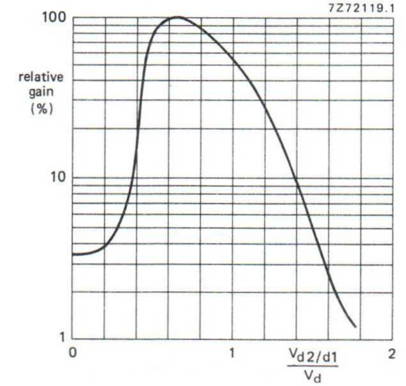


Fig. 8

Relative gain as a function of the voltage between d2 and d1, normalized to V_d.

$V_{d3/d1}$ constant.

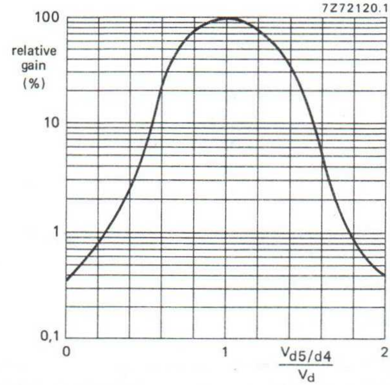


Fig. 9

Relative gain as a function of the voltage between d5 and d4, normalized to V_d ; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

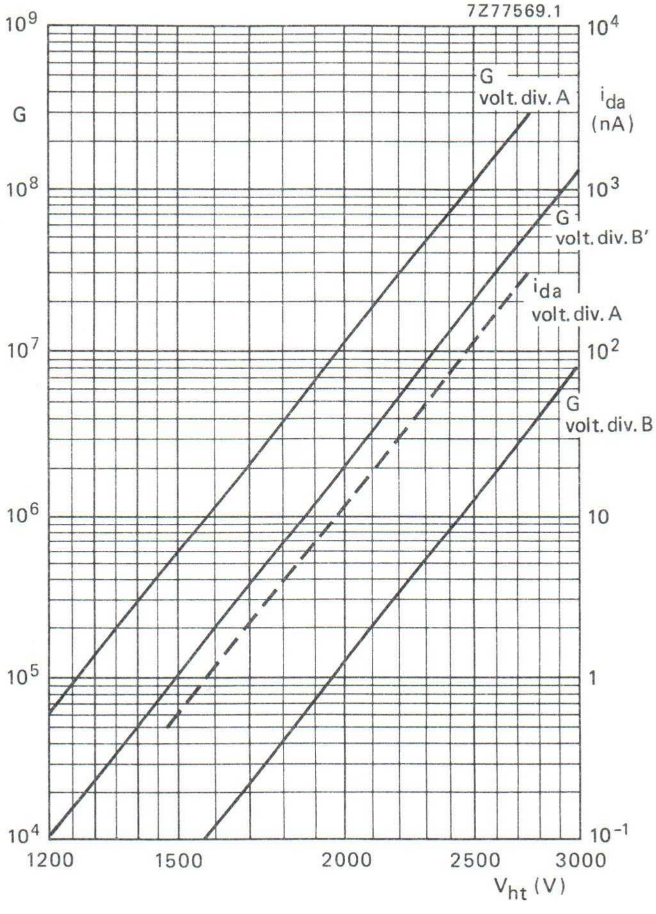


Fig. 10.

Gain, G, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

- 110 mm useful diameter head-on type
- flat window
- semi-transparent bialkaline type D photocathode
- for high-energy physics, e.g. large dimensional Cerenkov counters, leadglass walls, etc.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D
Useful diameter of the photocathode	>	110 mm
Quantum efficiency at 400 nm		95 mA/W
Supply voltage for an anode spectral sensitivity of 12 kA/W at 400 nm		1270 V
Pulse amplitude resolution (^{137}Cs)	≈	7,5 %
Mean anode sensitivity deviation	≈	1 %

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

GENERAL CHARACTERISTICS

Window

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

Photocathode *

Semi-transparent, head-on

Material	Sb K Cs
Useful diameter	> 110 mm
Spectral sensitivity characteristic (Fig. 4)	type D
Maximum spectral sensitivity at	400 ± 30 nm
Quantum efficiency at 400 nm	29 %
Spectral sensitivity at 400 nm	typ. 95 mA/W > 65 mA/W

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

Multiplier system

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

Magnetic field

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

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

RECOMMENDED CIRCUITS

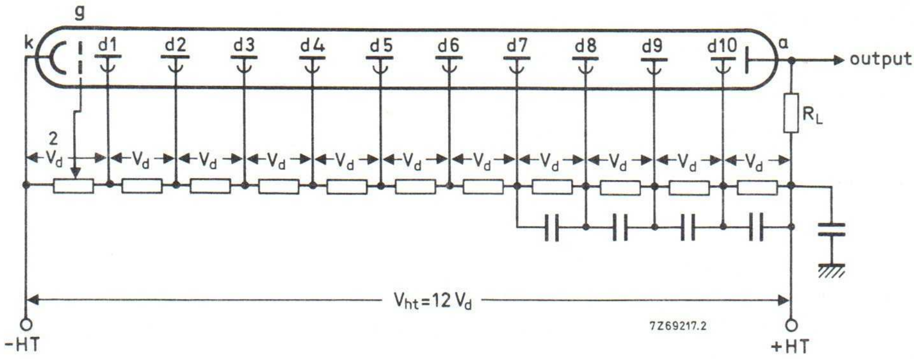


Fig. 1 Voltage divider A.

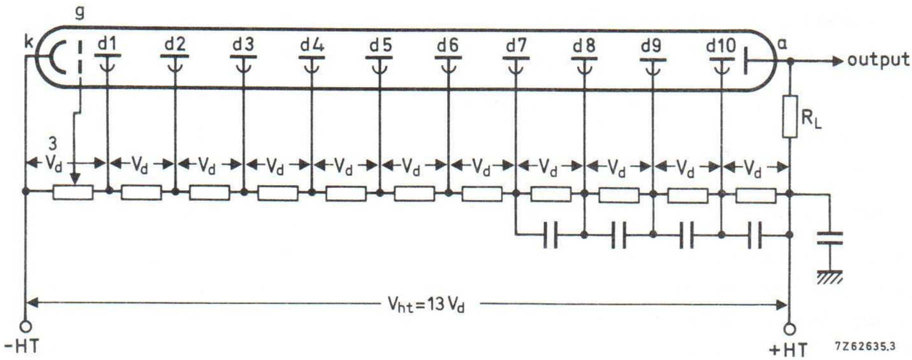


Fig. 2 Voltage divider A_1.

Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; d_n = dynode no.; a = anode; R_L = load resistor.

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

TYPICAL CHARACTERISTICS

Note: All spectral sensitivities refer to a wavelength of 400 nm.

				notes
With voltage divider A (Fig. 1)				1
Supply voltage for an anode spectral sensitivity of 12 kA/W (Fig. 7)		< typ.	1500 V 1270 V	
Anode spectral sensitivity at V_{ht} = 1500 V		≈	35 kA/W	
Anode dark current at an anode spectral sensitivity of 12 kA/W		< typ.	5 nA 0,5 nA	2
Anode current linear within 2 % at V_{ht} = 1500 V	up to	≈	10 mA	
With voltage divider A_1 (Fig. 2)				
Anode spectral sensitivity at V_{ht} = 1500 V (Fig. 7)		≈	25 kA/W	
Pulse amplitude resolution for ^{137}Cs at 12 kA/W		≈	7,5 %	3
Anode current linear within 2% at V_{ht} = 1500 V	up to	≈	10 mA	
Mean anode sensitivity deviation				4
long term (16 h)		≈	1 %	
after change of count rate		≈	1 %	
Anode pulse rise time at V_{ht} = 1500 V		≈	16 ns	5
Anode pulse width at half height at V_{ht} = 1500 V		≈	40 ns	5
Signal transit time at V_{ht} = 1500 V		≈	90 ns	5

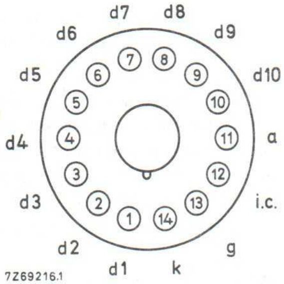
LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2000 V	6
Continuous anode current	max.	0,2 mA	10
Voltage between first dynode and photocathode	max. min.	500 V 150 V	7
Voltage between accelerating electrode and photocathode	max.	500 V	
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max.	300 V	8
Ambient temperature range			9
operational (for short periods of time)	max. min.	+80 °C −30 °C	
continuous operation and storage	max. min.	+50 °C −30 °C	

Notes

1. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators having an insulation resistance of $> 10^{15}$ ohm.
2. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
3. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 4170 or equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is $\approx 10^4$ c/s.
4. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long-term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s, corresponding to an anode current of $\approx$ 300 nA. Mean anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance from the scintillator such that the count rate can be changed from $\approx 10^4$ c/s to $\approx 10^3$ c/s, corresponding to anode currents of $\approx 1\ \mu A$ and $\approx 0{,}1\ \mu A$ respectively. Both tests are carried out according to ANSI-N42-9-1972 of IEEE recommendations.
5. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode spectral sensitivity of $\approx$ 300 kA/W, whichever is lower.
7. Minimum value to obtain good collection in the input optics.
8. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
9. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.
10. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.

MECHANICAL DATA



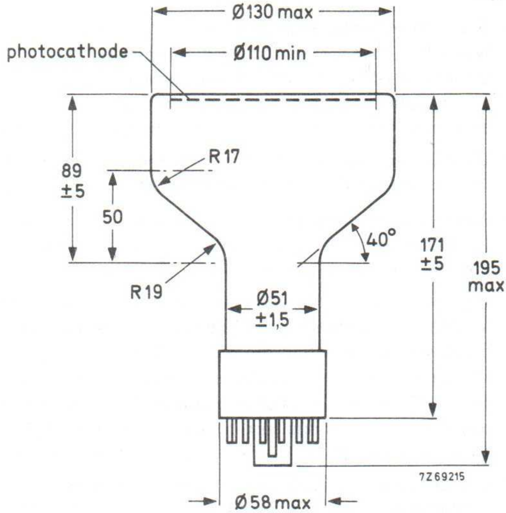


Fig. 3.

Base: IEC 67–1–16a (Jedec B14–38)

Net mass: 460 g

ACCESSORIES

Socket type FE1014

Care should be taken in handling this larger diameter tube because of the risk of implosion.

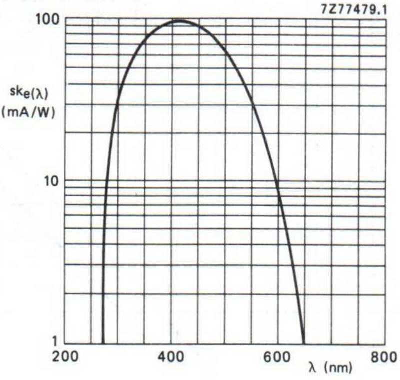


Fig. 4 Spectral sensitivity characteristic.

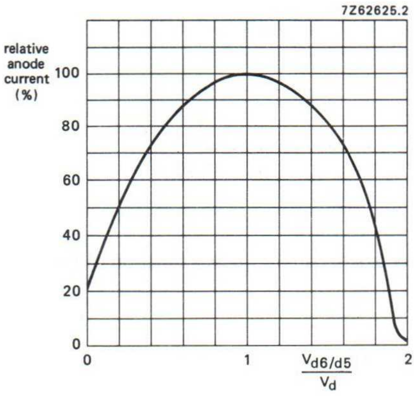


Fig. 5 Relative gain as a function of the voltage between d6 and d5 normalized to V_d · $V_{d7/d5}$ constant. V_d = 90 V.

Note: Gain regulation by changing the voltage between d6 and d5 may cause a degradation of other parameters such as stability and linearity.

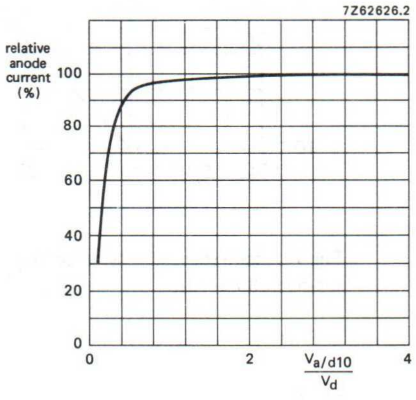


Fig. 6 Relative anode current as a function of the voltage between anode and final dynode. V_d = 90 V.

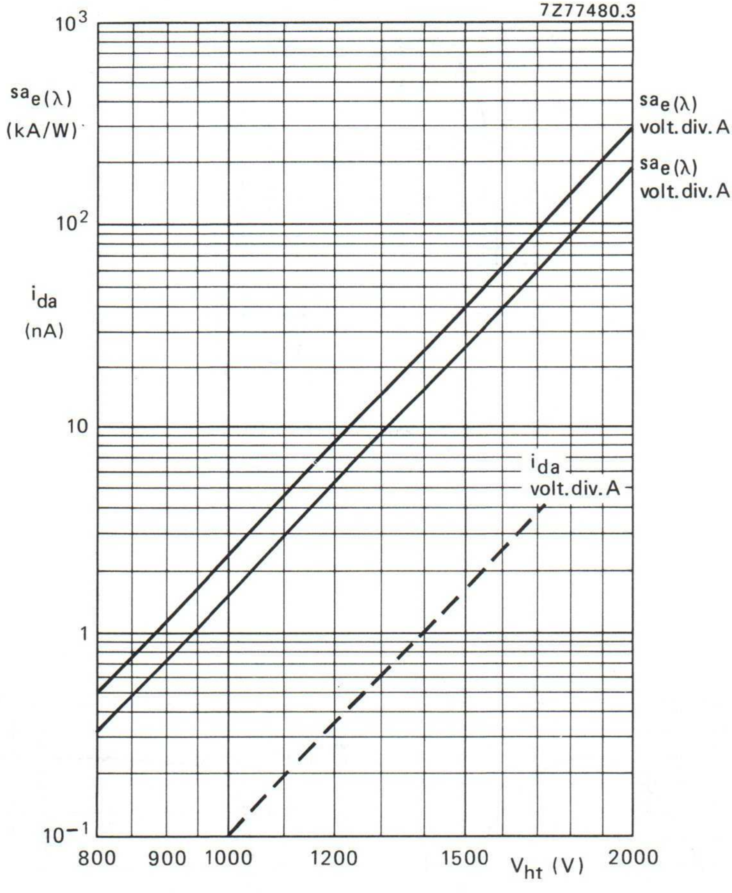


Fig. 7 Anode spectral sensitivity $sa_{e(\lambda)}$ and anode dark current i_{da} as a function of the supply voltage V_{ht}.

XP2061 replaces XP2060
XP2061B replaces XP2060B

10-STAGE PHOTOMULTIPLIER TUBE

- 32 mm useful diameter head-on type
- flat window
- semi-transparent bi-alkaline photocathode
- high stability
- good linearity
- for high-energy physics experiments, scintillation counting, laboratory and industrial photometry
- XP2061B has a 12-pin plastic base; XP2061 has a 14-pin all-glass base

QUICK REFERENCE DATA

Spectral sensitivity characteristic	Fig. 6
Useful diameter of the photocathode	> 32 mm
Cathode blue sensitivity	11 μA/lmF
Supply voltage for anode blue sensitivity = 7,5 A/lmF	1300 V
Pulse amplitude resolution for ^{137}Cs	≈ 7,2%
Pulse amplitude resolution for ^{55}Fe	≈ 43%
Mean anode sensitivity deviation	≈ 1%
Anode pulse rise time (with voltage divider B)	≈ 2,5 ns
Linearity (with voltage divider B)	up to ≈ 200 mA

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

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-plano
Refractive index at 400 nm	1,54

Photocathode

Semi-transparent, head-on		
Material	SbRbCs	
Useful diameter	> 32 mm	
Spectral sensitivity characteristic	see Fig. 6	
Maximum spectral sensitivity	440 ± 30 nm	
Luminous sensitivity	110 μA/lm	note 2
Blue sensitivity	typ. 11 μA/lmF > 8,5 μA/lmF	note 1
Spectral sensitivity at 440 nm	≈ 85 mA/W	note 3

Electron optical input system

This system consists of: the photocathode (k), a metallized part of the glass envelope, internally connected to the photocathode and the accelerating electrode (g), internally connected to d1.

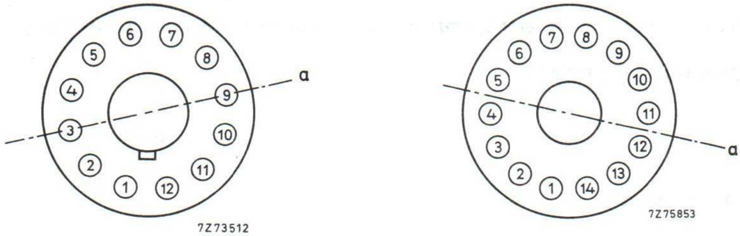
Multiplier system

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

Magnetic field

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

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



XP2061B XP2061

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

RECOMMENDED CIRCUITS

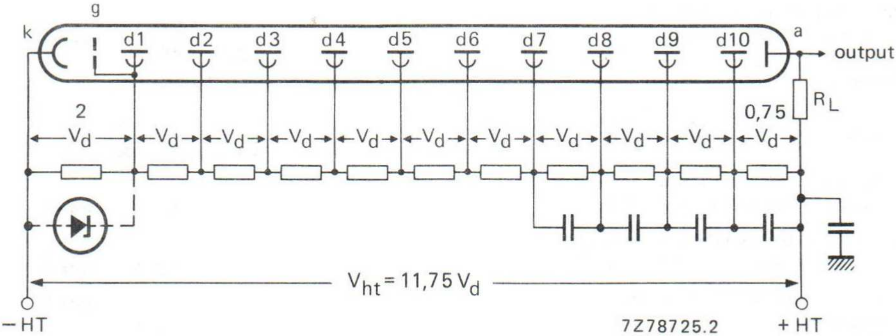


Fig. 2 Voltage divider A*.

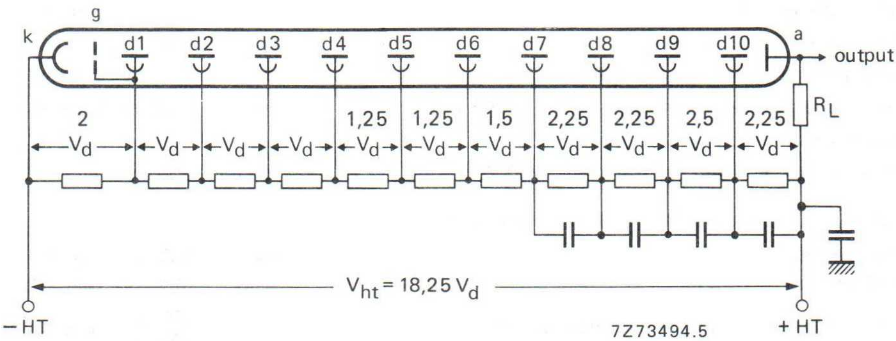


Fig. 3 Voltage divider B.

k = cathode;
g = accelerating electrode;
dn = dynode no.;
a = anode;
R_L = load resistor.

Typical values of capacitors: 10 nF

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

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)			note 4
Supply voltage for an anode blue sensitivity of 7,5 A/lmF (Fig. 8)	< typ.	1600 V 1300 V	note 1
Gain at V_{ht} = 1300 V (Fig. 9)	≈	7×10^5	
Anode dark current at an anode blue sensitivity of 7,5 A/lmF (Fig. 8)	< typ.	20 nA 1,5 nA	notes 5, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈	7,2 %	note 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈	43 %	note 8
Mean anode sensitivity deviation			note 9
long term	≈	1 %	
after change of count rate	≈	1 %	
Anode current linear within 2% at V_{ht} = 1300 V	up to ≈	40 mA	
With voltage divider B (Fig. 3)			note 4
Gain at V_{ht} = 1700 V (Fig. 9)	≈	7×10^5	
Anode pulse rise time at V_{ht} = 1700 V	≈	2,5 ns	note 10
Anode pulse duration at half height at V_{ht} = 1700 V	≈	6 ns	note 10
Signal transit time at V_{ht} = 1700 V	≈	26 ns	note 10
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈	200 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1800 V	note 11
Continuous anode current	max.	0,2 mA	note 12
Voltage between first dynode and photocathode	max. min.	500 V 150 V	note 13
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max. min.	300 V 30 V	note 14
Ambient temperature range			
Operational (for short periods of time)	max. min.	+80 °C −30 °C	note 15
Continuous operating and storage	max. min.	+50 °C −30 °C	

NOTES

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
3. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 440 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube. ←
4. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\,\Omega$.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 15 min.
7. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 2470 or equivalent) with a diameter of 32 mm and a height of 32 mm. The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s
9. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA.
   Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of ≈ 1 μA and $\approx 0{,}1$ μA respectively.
   Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. Total HT supply voltage or the voltage at which the tube has an anode blue sensitivity of 75 A/lmF (voltage given on test certificate for an anode blue sensitivity of 7,5 A/lmF, multiplied by 1,4), whichever is lower.
12. A value of < 10 μA is recommended for applications requiring good stability.
13. Minimum value to obtain good collection in the input optics.

NOTES (continued)

14. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
15. For type XP2061B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

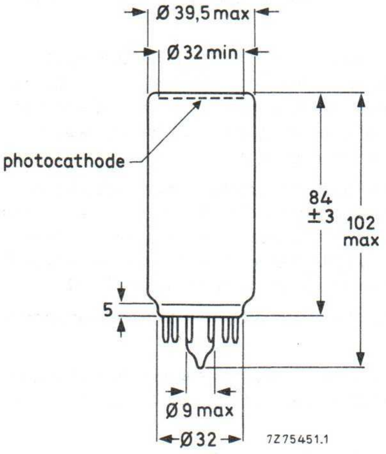


Fig. 4 XP2061.

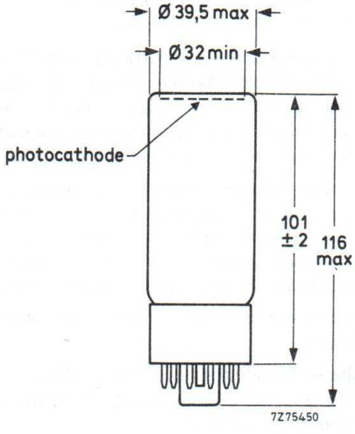
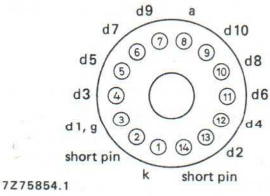


Fig. 5 XP2061B.

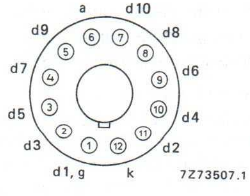
Base	14-pin all glass
Net mass	51 g

Base	12-pin (JEDEC B12-43)
Net mass	69 g

PIN CONNECTIONS



XP2061



XP2061B

ACCESSORIES

Socket

for XP2061	type FE1112
for XP2061B	type FE1012

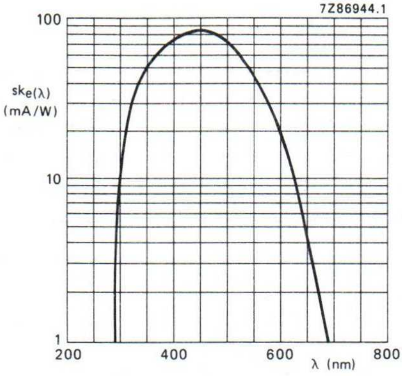


Fig. 6 Spectral sensitivity characteristic.

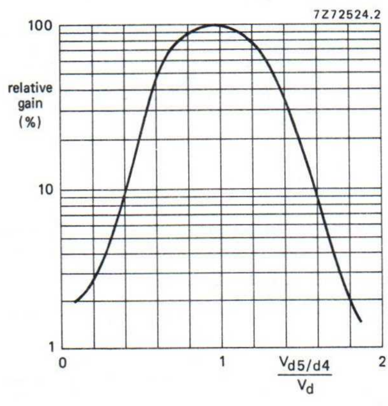


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

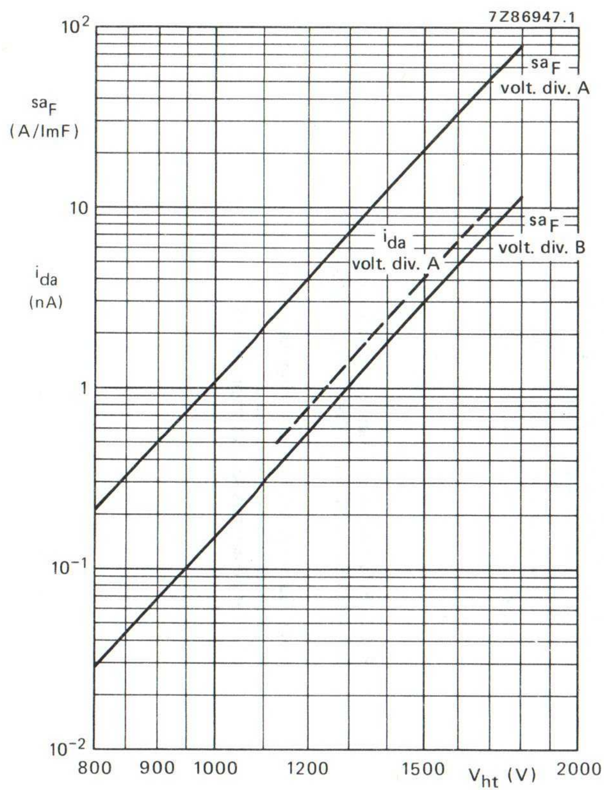


Fig. 8 Anode blue sensitivity, sa_F, and anode dark current i_{da}, as a function of supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

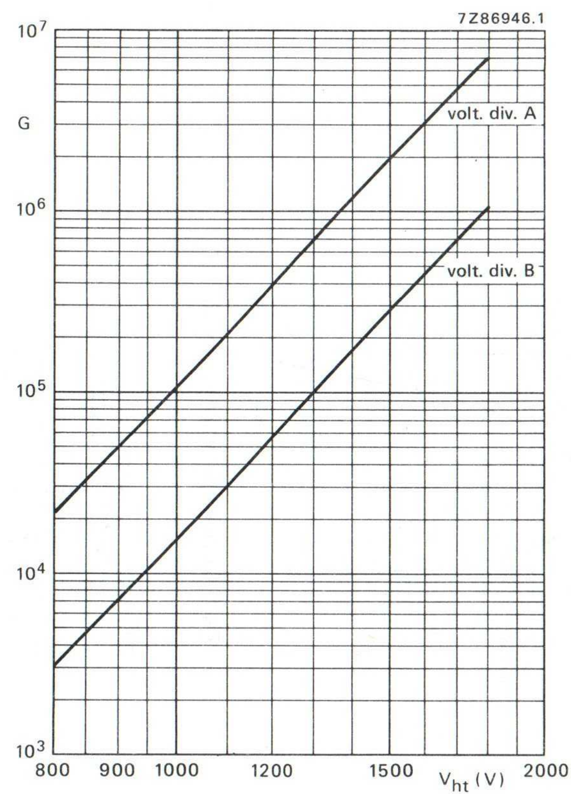


Fig. 9 Gain G as a function of supply voltage V_{ht}.

XP2102 replaces XP2000UB
XP2102B replaces XP2000

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBES

- 46 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Very good pulse amplitude resolution
- Very low dark current
- Very good stability
- For scintillation detection applications, e.g. gamma cameras, high energy physics experiments

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 46 mm
Cathode blue sensitivity	11,5 µA/lmF
Supply voltage for anode blue sensitivity = 1,5 A/lmF	1250 V
Anode dark current at anode blue sensitivity = 1,5 A/lmF	0,5 nA
Pulse amplitude resolution (^{57}Co)	≈ 9,5%
Mean anode sensitivity deviation (30 days)	≈ 1%

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 46 mm	
Spectral sensitivity characteristic (Fig. 2)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 µA/lm	3
Blue sensitivity	typ. 11,5 µA/lmF > 9,0 µA/lmF	1
Spectral sensitivity at 400 nm	≈ 85 mA/W	4

Multiplier system

Number of stages	10
Dynode structure	venetian blind
Dynode material	CuBe
Capacitances	
anode to final dynode	$\approx$ 7 pF
anode to all	$\approx$ 8,5 pF

Magnetic field

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

A mu-metal shield extending more than 15 mm beyond the cathode is recommended for magnetic screening.

RECOMMENDED CIRCUIT

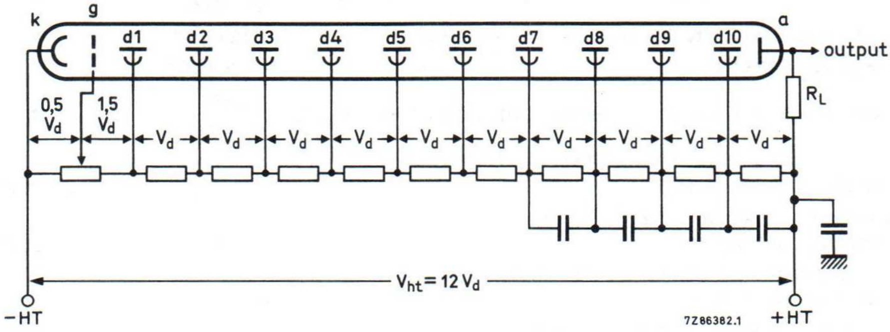


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

Note

For optimum pulse amplitude resolution, the accelerating-electrode potential should be between the cathode and first dynode potentials. If the tube is used in a socket wired for the XP2000UB or XP2000 with the accelerating electrode connected to the first dynode, the pulse amplitude resolution for ^{57}Co is about 9,7%.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

		notes
		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig. 5)	< 1450 V typ. 1250 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1250 V	≈ 12 kA/W	
Gain at V_{ht} = 1250 V	≈ 1,3 x 10^5	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 5)	< 5 nA typ. 0,5 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF	≈ 9,5%	1, 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 38%	1, 8
Peak-to-valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 40	1, 8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 0,5%	
long term (30 days)	≈ 1%	
after change of count rate	≈ 0,8%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,1% per K	
Anode pulse rise time at V_{ht} = 1500 V	≈ 10 ns	10
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 20 ns	10
Signal transit time at V_{ht} = 1500 V	≈ 46 ns	10
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 10 mA	11

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max. 2000 V	12
Continuous anode current	max. 0,2 mA	13
Voltage between first dynode and photocathode	max. 500 V min. 150 V	14
Voltage between accelerating electrode and photocathode	max. 500 V	
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V	15
Ambient temperature range operational (for short periods)	max. + 80 °C min. −30 °C	16
continuous operation and storage	max. + 50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7,7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4856 or equivalent) with a diameter of 50 mm and a height of 50 mm (2" x 2"). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 1 μA and $\approx$ 0,1 μA respectively. Both tests are carried out according to ANSI−N42−9−1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of $<$ 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, whichever is lower.
13. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the input optics.
15. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
16. For type XP2102B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

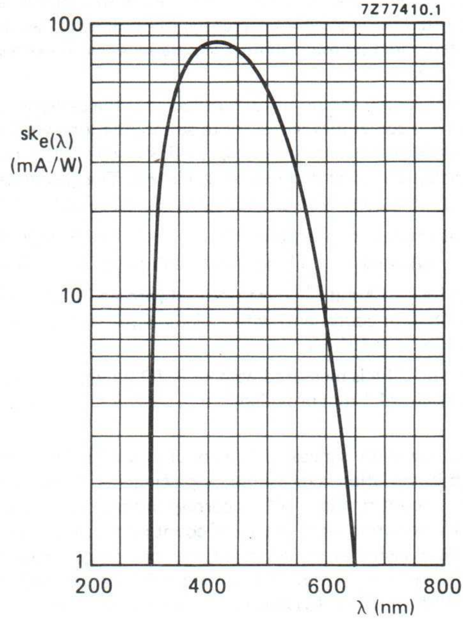


Fig. 2 Spectral sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm

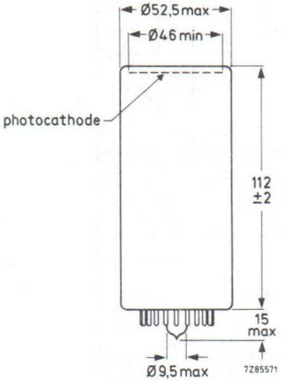


Fig. 3 XP2102.

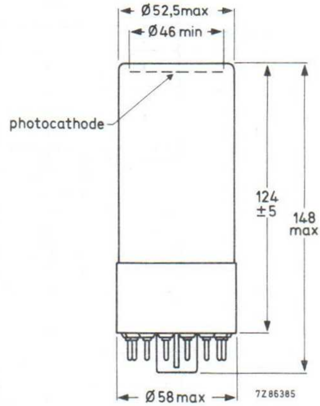
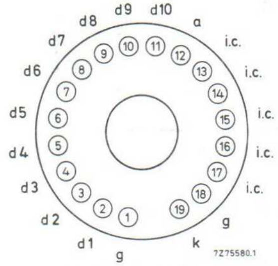


Fig. 4 XP2102B.

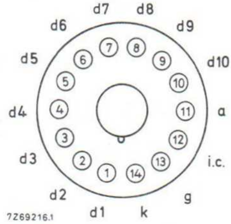
Base	19-pin all-glass
Net mass	120 g

Base	14-pin IEC67-1-16a (JEDEC B14-38)
Net mass	163 g

PIN CONNECTIONS



XP2102



XP2102B

ACCESSORIES

Socket
- for XP2102 — type FE2019
- for XP2102B — type FE1014

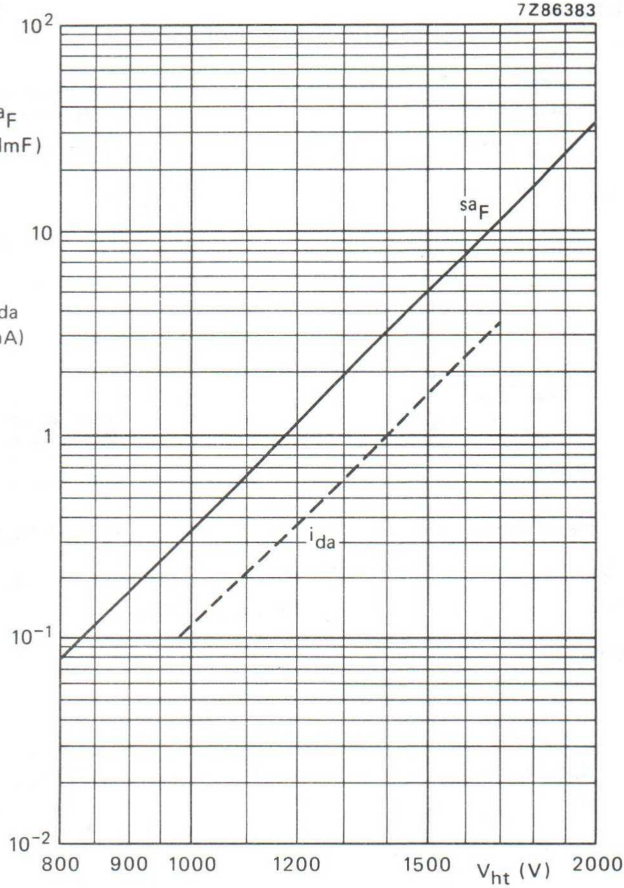


Fig. 5 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

See also XP3202
XP3202B

10-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-plano window
- semi-transparent bi-alkaline type D photocathode
- high stability
- tubes, from serial number 9500 onwards, are provided with high gain first dynode
- for scintillation counting, laboratory and industrial photometry
- XP2202 has a 19-pin all-glass base; XP2202B has a 14-pin plastic base.

QUICK REFERENCE DATA

spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Cathode spectral sensitivity at 400 nm			75	mA/W
Supply voltage for an anode spectral sensitivity of 60 kA/W at 400 nm			1400	V
Anode pulse rise time		≈	3,5	ns
Pulse amplitude resolution (^{137}Cs)		≈	7,2	%
Pulse amplitude resolution (^{55}Fe)		≈	42	%
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	200	mA

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

GENERAL CHARACTERISTICS

				note
Window				
Material	lime-glass			
Shape	plano-plano			
Refractive index at 400 nm		1,54		
Photocathode (note 1)				
Semi-transparent, head-on				
Material	Sb K Cs			
Useful diameter	>	44	mm	
Spectral sensitivity characteristic (Fig. 6)	type D			
Maximum spectral sensitivity		400 ± 30	nm	
Spectral sensitivity at 400 nm	typ. >	75 60	mA/W mA/W	2

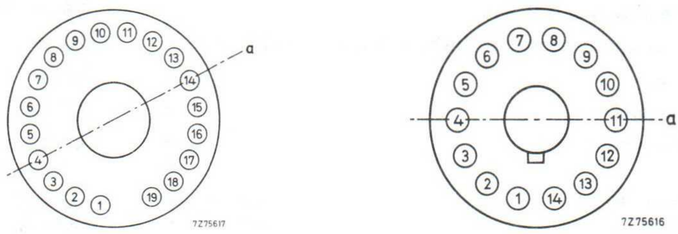
Multiplier system

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

Magnetic field

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

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



XP2202 XP2202B

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

RECOMMENDED CIRCUITS

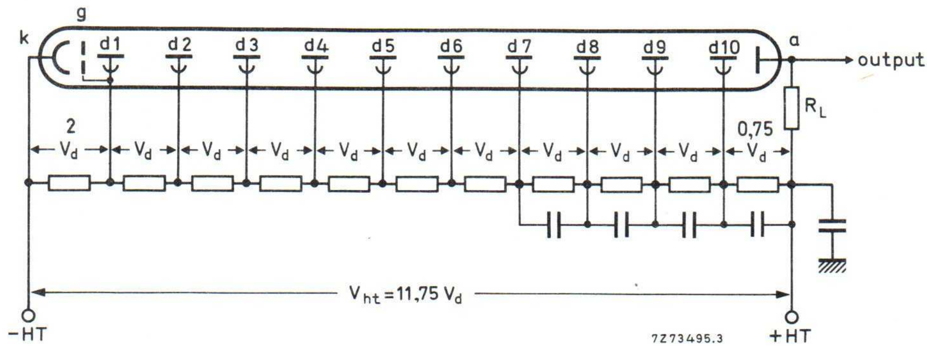


Fig. 2 Voltage divider A.

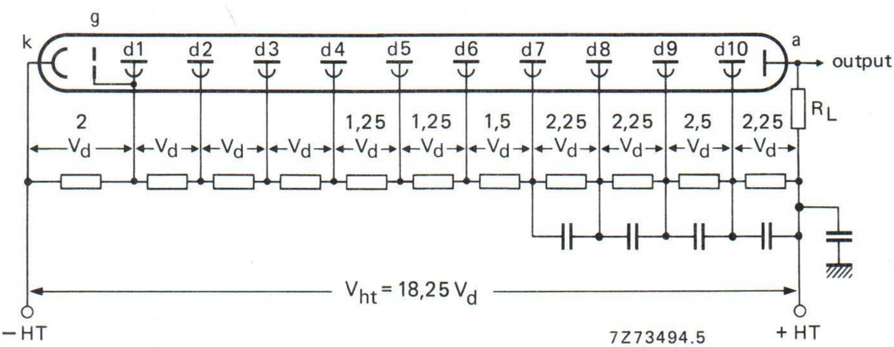


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

k = cathode

g = accelerating electrode (internally connected to d1)

dn = dynode no.

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

Note: All spectral sensitivities refer to a wavelength of 400 nm.

				notes
With voltage divider A (Fig. 2)				3
Supply voltage for an anode spectral sensitivity of 60 kA/W (Fig. 8)		<	1700 V	
		typ.	1400 V	
Anode dark current at an anode spectral sensitivity of 60 kA/W (Fig. 8)		<	30 nA	4,5
		typ.	3 nA	
Pulse amplitude resolution for ^{137}Cs at an anode spectral sensitivity of 12 kA/W		≈	7,2 %	6
Pulse amplitude resolution for ^{55}Fe at an anode spectral sensitivity of 70 kA/W		≈	42 %	7
Mean anode sensitivity deviation				8
long term (16 h)		≈	1 %	
after change of count rate		≈	1 %	
versus temperature between 0 and +40 °C at 450 nm		≈	0,2 %/K	
Anode current linear within 2% at V_{ht} = 1700 V	up to	≈	100 mA	
With voltage divider B (Fig. 3)				3
Anode spectral sensitivity at V_{ht} = 1700 V (Fig. 8)		≈	60 kA/W	
Anode pulse rise time at V_{ht} = 1700 V		≈	3,5 ns	9
Anode pulse duration at half-height at V_{ht} = 1700 V		≈	7 ns	9
Signal transit time at V_{ht} = 1700 V		≈	35 ns	9
Anode current linear within 2% at V_{ht} = 1700 V	up to	≈	200 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1800 V	10
Continuous anode current	max.	0,2 mA	11
Voltage between first dynode and photocathode	max.	600 V	12
	min.	150 V	
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max.	300 V	13
	min.	30 V	
Ambient temperature range			
operational (for short periods of time)	max.	+80 °C	14
	min.	−30 °C	
continuous operation and storage	max.	+50 °C	
	min.	−30 °C	

Notes

1. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.

Notes (continued)

2. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter.
3. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.
4. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
5. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
6. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no. 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count rate used is $\approx 10^4$ c/s.
7. Pulse amplitude resolution for ^{55}Fe is measured with a NaI (Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm, provided with a beryllium window. The count-rate used is 2×10^3 c/s.
8. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of ≈ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu$A and $\approx 0{,}1\ \mu$A respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
9. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
10. Total HT supply voltage or the voltage at which the tube has an anode spectral sensitivity of 600 kA/W, whichever is lower.
11. A value of $< 10\ \mu$A is recommended for application requiring good stability.
12. Minimum value to obtain good collection in the input optics.
13. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
14. For type XP2202B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

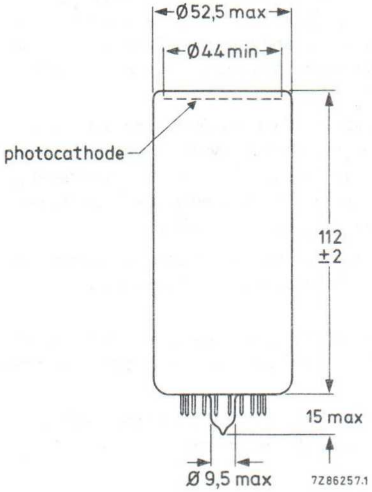


Fig. 4 XP2202.

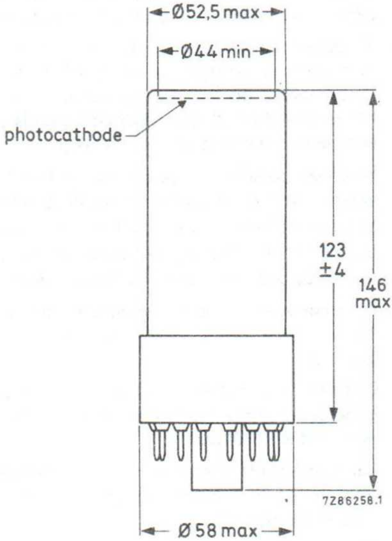
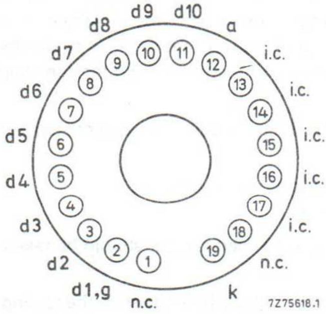


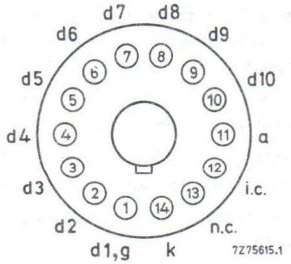
Fig. 5 XP2202B.

Base 19-pin all-glass
Net mass 110 g

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

PIN CONNECTIONS





ACCESSORIES

Socket:
for XP2202 type FE2019
for XP2202B type FE1014

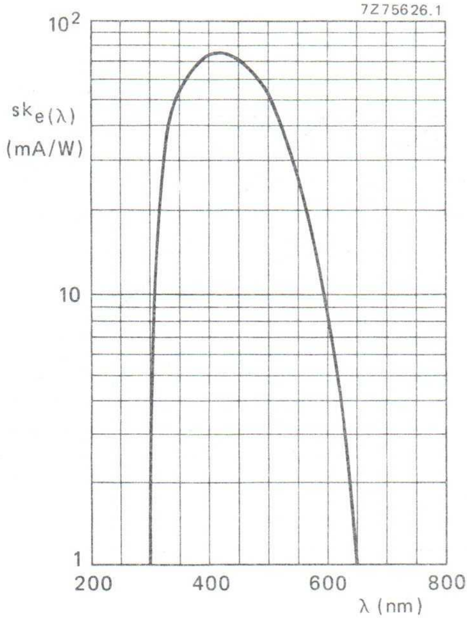


Fig. 6 Spectral sensitivity characteristic.

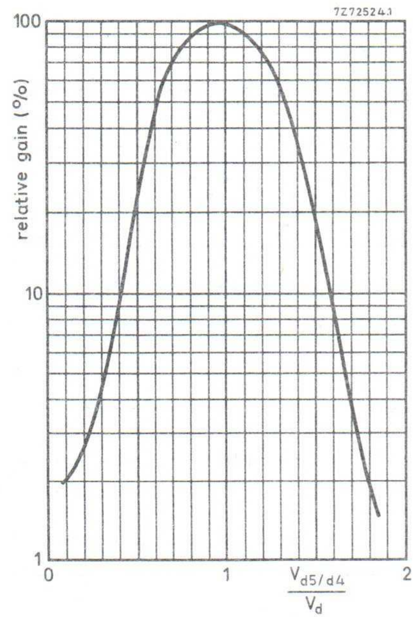


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

Note: gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

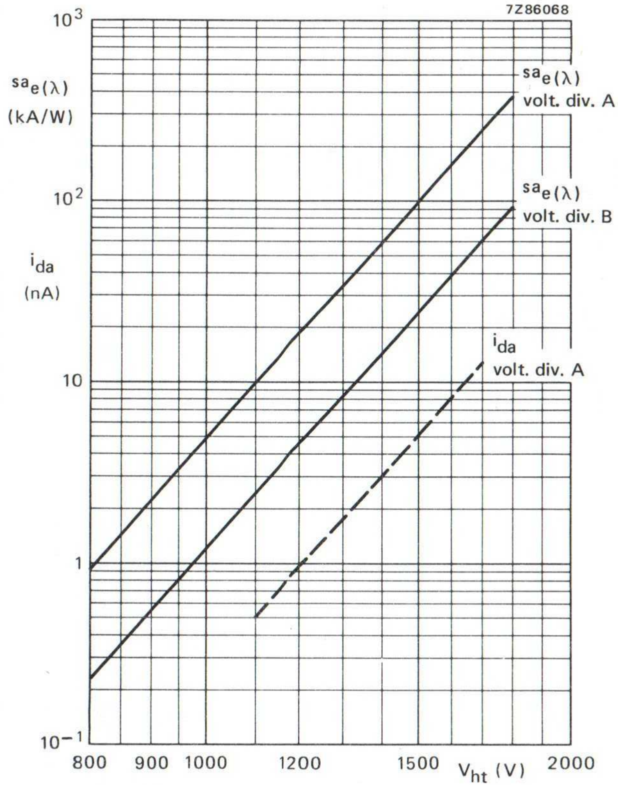


Fig. 8 Anode spectral sensitivity $sa_{e(\lambda)}$ at λ = 400 nm, and anode dark current i_{da} as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

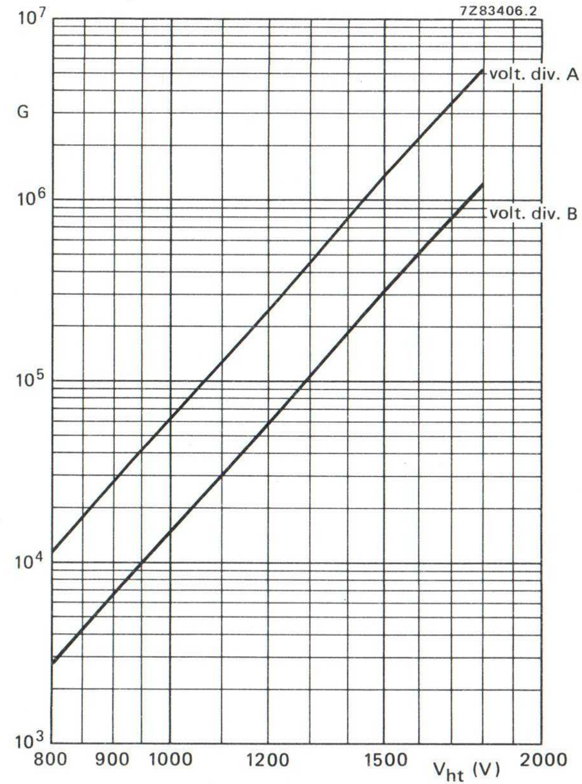


Fig. 9 Gain G as a function of supply voltage V_{ht}.

10-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-plano window
- semi-transparent tri-alkaline S20 (type T) photocathode
- high stability
- for industrial applications, e.g. lasers and flying spot scanners
- unilaterally interchangeable with XP1002

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S20 (type T)
Useful diameter of the photocathode	$>$ 44 mm
Spectral sensitivity of the photocathode at 700 nm	16 mA/W
Supply voltage for an anode luminous sensitivity = 60 A/lm	1350 V
Anode pulse rise time (with voltage divider B)	$\approx$ 3,5 ns
Linearity	
with voltage divider A	up to $\approx$ 100 mA
with voltage divider B	up to $\approx$ 200 mA

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on	
Material	Sb Na K Cs
Useful diameter	$>$ 44 mm
Spectral sensitivity characteristic (Fig. 5)	S20 (type T)
Maximum spectral sensitivity	420 ± 30 nm
Luminous sensitivity	$\approx$ 165 μA/lm
Spectral sensitivity	
at 700 nm	typ. 16 mA/W
	$>$ 7 mA/W
at 630 nm	$\approx$ 30 mA/W

Multiplier system

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

Magnetic field

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

0,2 mT perpendicular to axis a (see Fig. 1);

0,1 mT parallel with axis a.

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

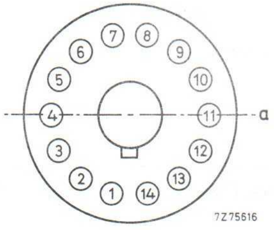


Fig. 1 Axis a with respect to base pins (botton view).

RECOMMENDED CIRCUITS

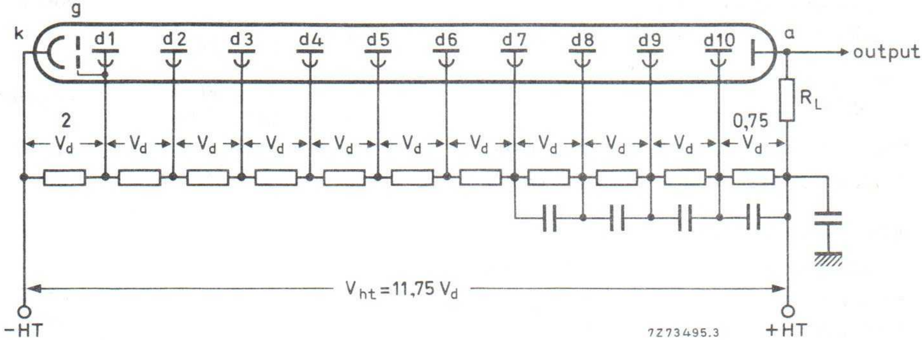


Fig. 2 Voltage divider A.

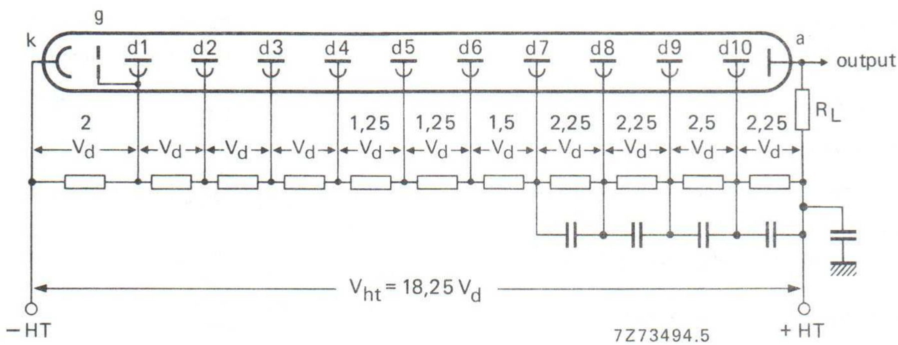


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode (internally connected to d1)
dn = dynode no.
a = anode
R_L = load resistor

Typical values of capacitors: 10 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)		note 1
Supply voltage for an anode luminous sensitivity = 60 A/lm (Fig. 7)	< 1550 V typ. 1350 V	
Anode dark current at an anode luminous sensitivity = 60 A/lm (Fig. 7)	< 50 nA typ. 3 nA	notes 2,3
Mean anode sensitivity deviation at V_{ht} = 1200 V, long term (16 h)	≈ 1%	note 4
Anode current linear within 2% at V_{ht} = 1700 V	up to 100 mA	
With voltage divider B (Fig. 3)		note 1
Anode luminous sensitivity at V_{ht} = 1700 V (Fig. 7)	≈ 55 A/lm	
Anode pulse rise time at V_{ht} = 1700 V	≈ 3,5 ns	note 5
Anode pulse duration at half height at V_{ht} = 1700 V	≈ 7 ns	note 5
Signal transit time at V_{ht} = 1700 V	≈ 35 ns	note 5
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈ 200 mA	

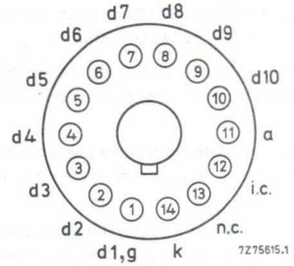
LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max. 1800 V	note 6
Continuous anode current	max. 0,2 mA	note 7
Voltage between first dynode and photocathode	max. 600 V min. 150 V	note 8
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	note 9
Ambient temperature range operational (for short periods of time)	max. +80 °C min. −30 °C	note 10
continuous operation and storage	max. +50 °C min. −30 °C	

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
3. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
4. The mean anode sensitivity deviation measurement is carried out with light pulses at a count rate of 10^4 c/s resulting in an average anode current of 0,5 μA. See also *General Operational Recommendations Photomultiplier Tubes.*
5. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
6. Total HT supply voltage, or the voltage at which the tube has an anode luminous sensitivity of 600 A/lm, whichever is lower.
7. A value of < 10 μA is recommended for applications requiring good stability.
8. Minimum value to obtain good collection in the input optics.
9. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
10. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA



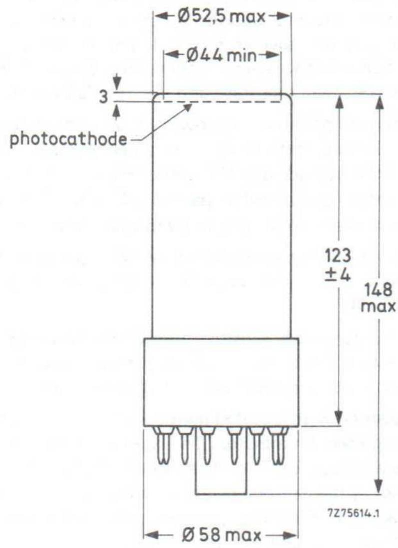


Fig. 4.

Base	14-pin (JEDEC B14-38)
Net mass	144 g

ACCESSORIES

Socket	type FE1014

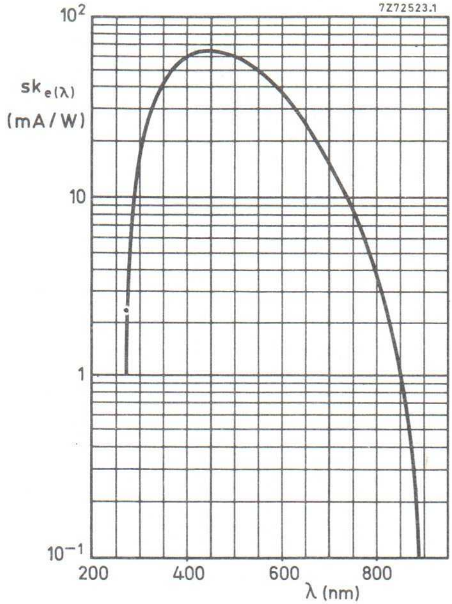


Fig. 5 Spectral sensitivity characteristic.

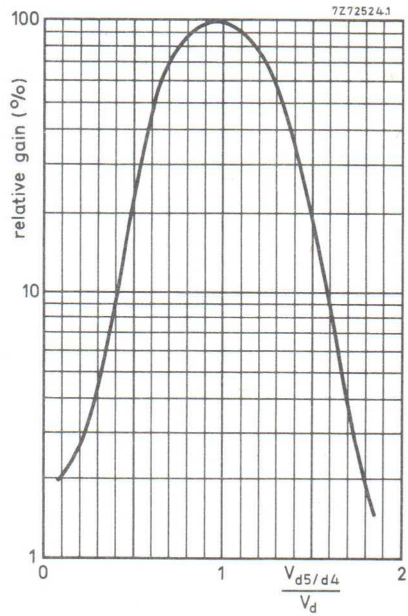


Fig. 6 Relative gain as a function of the voltage between d5 and d4 normalized to V_d; $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

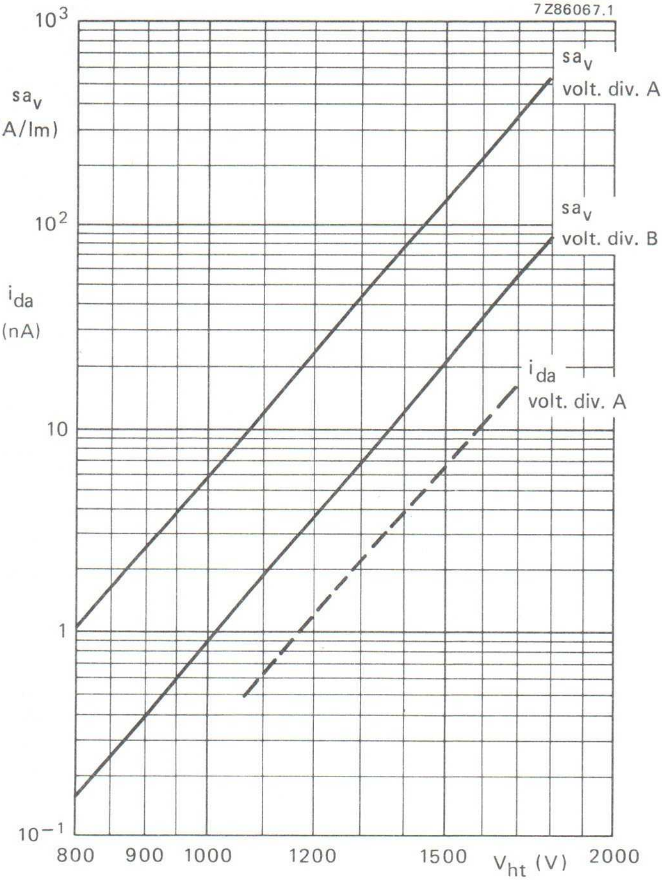


Fig. 7 Anode luminous sensitivity, sa_v, and anode dark current i_{da} as a function of supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

12-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on types
- plano-plano window
- semi-transparent bi-alkaline type D photocathode
- high gain and very good pulse linearity
- good single electron spectrum resolution, for tubes with high gain first dynode (from serial number 7000 onwards)
- For high energy physics experiments and industrial applications.
- XP2212 (with 19-pin base) is pin-compatible with XP2232 and XP2262;
  XP2212B (with 20-pin base) is pin-compatible with XP2232B and XP2262B, and unilaterally pin-compatible with 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 400 nm			23	%
Cathode spectral sensitivity at 400 nm			75	mA/W
Supply voltage for a gain of 3×10^7			1900	V
Pulse amplitude resolution for ^{137}Cs		≈	7,2	%
Anode pulse rise time (with voltage divider B)		≈	4	ns
Linearity				
with voltage divider A (Fig. 2)	up to	≈	100	mA
with voltage divider B (Fig. 3)	up to	≈	250	mA

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

GENERAL CHARACTERISTICS

				notes
Window				
Material	lime glass			
Shape	plano-plano			
Refractive index at 400 nm		1,54		
Photocathode				1
Semi-transparent, head-on				
Material	Sb K Cs			
Useful diameter	>	44	mm	
Spectral sensitivity characteristic (Fig. 4)	type D			
Maximum spectral sensitivity		400 ± 30	nm	
Quantum efficiency at 400 nm		23	%	
Spectral sensitivity at 400 nm	typ. >	75 60	mA/W mA/W	2

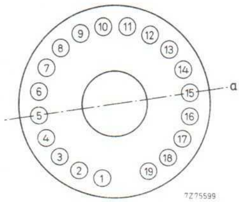
Multiplier system

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

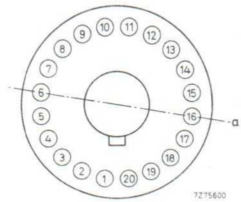
Magnetic field

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

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



XP2212



XP2212B

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

RECOMMENDED CIRCUITS

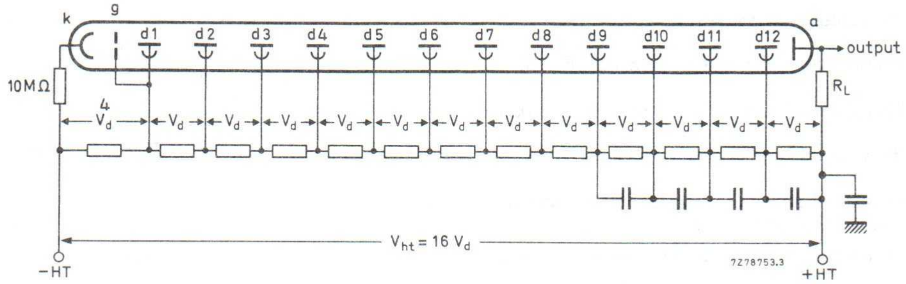


Fig. 2 Voltage divider A.

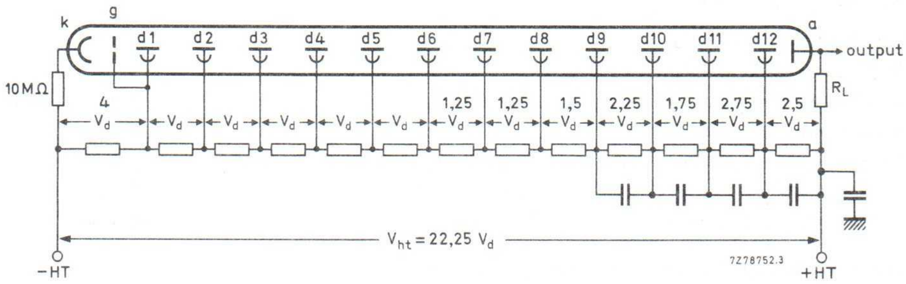


Fig. 3 Voltage divider B.

Typical values of capacitors: 1 nF

k = cathode

g = accelerating electrode (internally connected to d1 in XP2212B).

dn = dynode no.

a = anode

R_L = load resistor

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.

TYPICAL CHARACTERISTICS

Note: All spectral sensitivities refer to a wavelength of 400 nm.

				notes
With voltage divider A (Fig. 2)				3
Supply voltage for a gain of 3×10^7 (Fig. 8)		$<$ typ.	2400 V 1900 V	
Anode dark current at a gain of 3×10^7 (Fig. 8)		$\approx$	15 nA	4
Background noise at a gain of 3×10^7		typ. $<$	1500 c/s 10^4 c/s	4,5
Pulse amplitude resolution for ^{137}Cs at an anode spectral sensitivity of 70 kA/W		$\approx$	7,2 %	6
Anode current linear within 2% at V_{ht} = 1900 V	up to	$\approx$	100 mA	
Mean anode sensitivity deviation				7
long term (16 h)		$\approx$	1 %	
after change of count rate		$\approx$	1 %	
versus temperature between 0 and + 40 °C at 450 nm		$\approx$	0,2 %/K	
Single electron spectrum, peak to valley ratio, at a gain of 3×10^7		$\approx$	2	8
With voltage divider B (Fig. 3)				3
Gain at V_{ht} = 2000 V (Fig. 8)		$\approx$	7×10^6	
Anode pulse rise time at V_{ht} = 2000 V		$\approx$	4 ns	9
Anode pulse duration at half height at V_{ht} = 2000 V		$\approx$	8 ns	9
Signal transit time at V_{ht} = 2000 V		$\approx$	36 ns	9
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2000 V		$\approx$	5 ns	
Anode current linear within 2% at V_{ht} = 2000 V	up to	$\approx$	250 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	2500 V	10
Continuous anode current	max.	0,2 mA	11
Voltage between first dynode and photocathode	max. min.	800 V 300 V	12
Voltage between consecutive dynodes	max.	400 V	
Voltage between anode and final dynode	max. min.	600 V 80 V	13
Ambient temperature range			
operational (for short periods of time)	max. min.	+80 °C −30 °C	14
continuous operation and storage	max. min.	+50 °C −30 °C	

Notes

1. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.
2. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter.
3. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages propressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
4. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used this be kept at photocathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
5. Noise is measured at ambient temperature. After having been stored with its protective hood, the tube is placed in darkness with V_{ht} set to a value to give a gain of 3×10^7. After a 5 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0,2 photoelectron) are recorded. Lower values can be obtained after a longer stabilization period.
6. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no.: 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count-rate used is $\approx 10^4$ c/s.
7. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu$A and $\approx 0{,}1\ \mu$A respectively. Both tests are carried out according to ANSI−N42−9−1972 of IEEE recommendations.
8. Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.
9. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
   Non-inductive resistors of 51 Ω are connected in the base of type XP2212B to d11 and d12. See also *General Operational Recommendations Photomultiplier Tubes.*
10. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
11. A value of < 10 μA is recommended for applications requiring good stability.
12. Minimum value to obtain good collection in the input optics.

Notes (continued)

13. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
14. For type XP2212B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

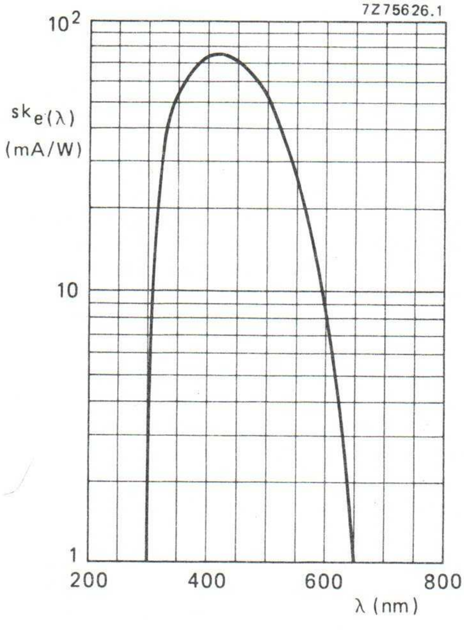


Fig. 4 Spectral sensitivity characteristic.

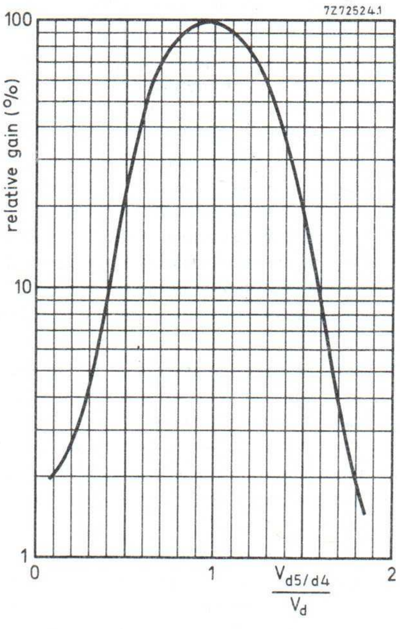


Fig. 5 Relative gain as a function of the voltage between d5 and d4 normalized to V_d. $V_{d6/d4}$ constant.

Note: Gain regulation by changing the voltage between d5 and d4 may cause a degradation of other parameters such as stability and linearity.

MECHANICAL DATA

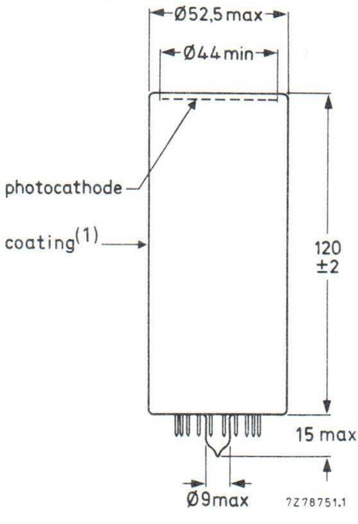


Fig. 6 XP2212.

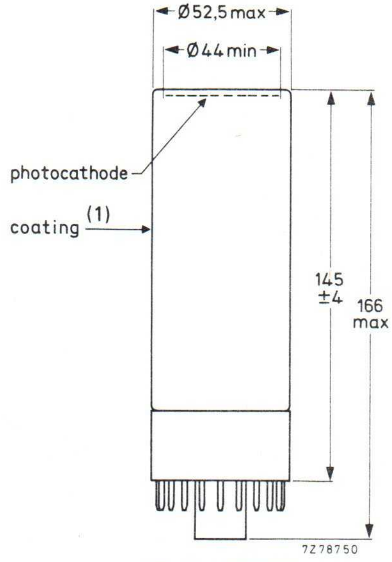
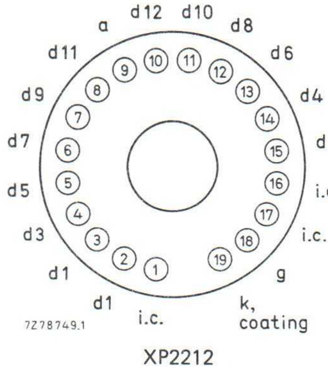


Fig. 7 XP2212B.

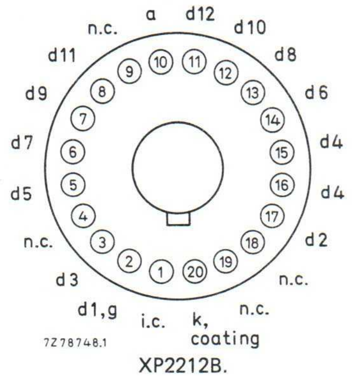
Base	19-pin all glass
Net mass	111 g

Base	20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass	148 g

PIN CONNECTIONS



XP2212



XP2212B.

ACCESSORIES

Socket: for XP2212 type FE2019
for XP2212B type FE1020

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. On top of this a black paint is applied which is neither guaranteed to be light tight nor isolating. Care should be taken to avoid electric shock.

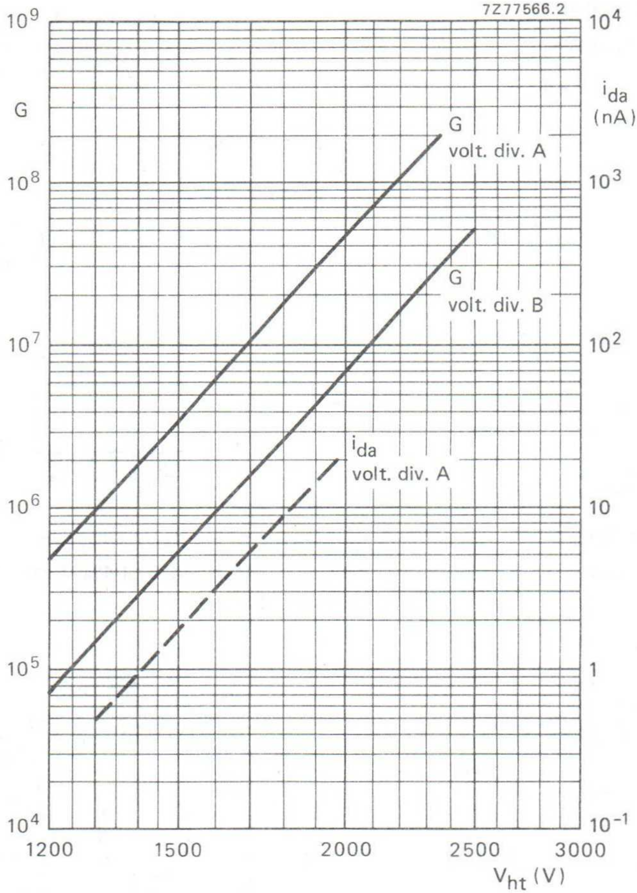


Fig. 8 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

replaced by XP2252
XP2252B

12-STAGE PHOTOMULTIPLIER TUBE

The XP2230 and XP2230B are 44 mm useful diameter head-on photomultiplier tubes with a plano-concave window and a semi-transparent bialkaline type D photocathode.
The tubes are intended for use in nuclear physics where the number of photons to be detected is very low. The tubes feature a high cathode sensitivity and a good linearity combined with very low background noise and very good time characteristics. They are especially useful in high-energy physics experiments such as coincidence measurements, Cerenkov detection etc. The XP2230 has a 21-pin all-glass base.

The XP2230B is provided with a 20-pin plastic base. This version is unilaterally interchangeable with the 56AVP-family tubes.

QUICK REFERENCE DATA				
Spectral sensitivity characteristic			type D	
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 401 nm			28	%
Spectral sensitivity of the photocathode at 401 nm			85	mA/W
Supply voltage for a gain $G = 3 \times 10^7$			2300	V
Background noise		≈	600	c/s
Pulse amplitude resolution for ^{137}Cs		≈	7,5	%
Anode pulse rise time (with voltage divider B')		≈	1,6	ns
Linearity (with voltage divider B)	up to	≈	280	mA
Signal transit time distribution at V_b = 2500 V	σ	≈	0,35	ns

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

GENERAL CHARACTERISTICS

Window

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

Photocathode [1]

Semi-transparent, head-on

Material	Sb K Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 4)	type D		
Maximum spectral sensitivity at		400 ± 30	nm
Quantum efficiency at 401 nm		28	%
Spectral sensitivity at 401 ± 3 nm [2]	typ.	85	mA/W
	>	65	mA/W

Electron optical input system

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

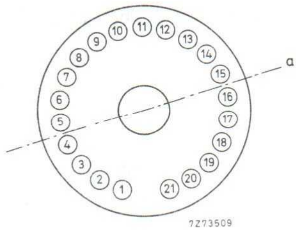
Multiplier system

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

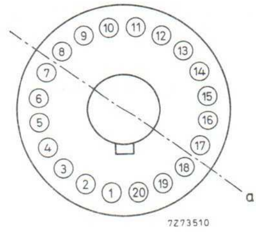
Magnetic field

See Fig. 9

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



XP2230



XP2230B

Axis a with respect to base pins (bottom view)

RECOMMENDED CIRCUITS

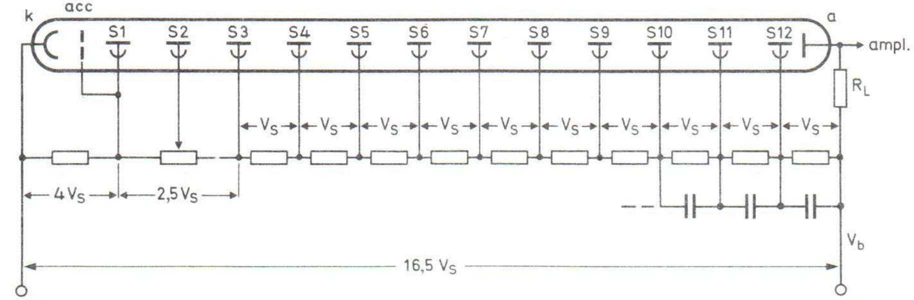


Fig. 1 Voltage divider A

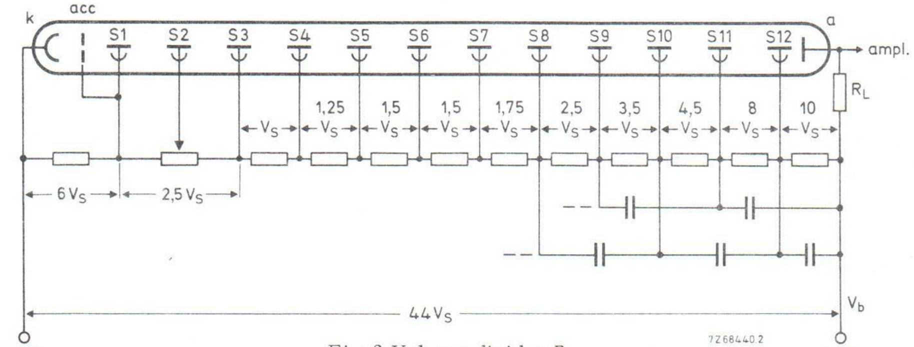


Fig. 2 Voltage divider B

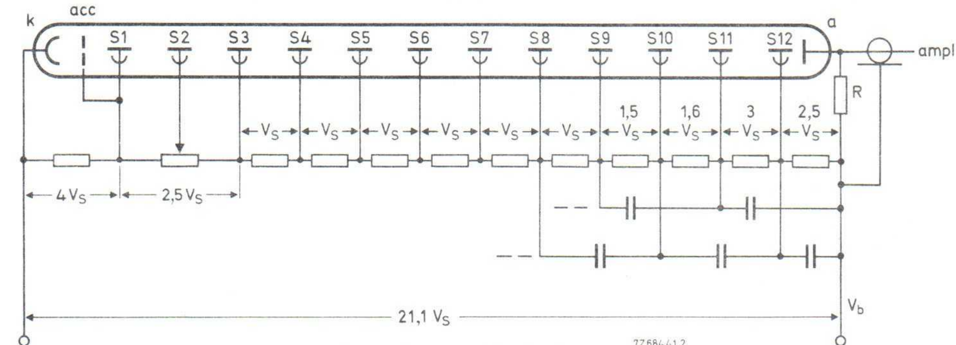


Fig. 3 Voltage divider B'

k = cathode

acc = accelerating electrode

S_n = dynode no. n

R_L = load resistor

a = anode

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

Typical value of capacitors : 1 nF

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)	3)				
Supply voltage for a gain $G = 3 \times 10^7$ (Fig. 6)			typ. <	2300 2600	V V
Anode dark current at $G = 3 \times 10^7$ (Fig. 6)	4) 5)		typ. <	7 25	nA nA
Background noise at $G = 3 \times 10^7$ (Fig. 5)	6)		≈	600	c/s
Pulse amplitude resolution for ^{137}Cs at $V_b = 1200$ V	7)		≈	7,5	%
Anode pulse rise time at $V_b = 2000$ V	8)		≈	1,8	ns
Anode pulse duration at half height at $V_b = 2000$ V	8)		≈	3,8	ns
Signal transit time at $V_b = 2000$ V	8)		≈	28	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2000$ V	8)		≈	0,6	ns
Anode current linear within 2% at $V_b = 2000$ V up to			≈	25	mA
Obtainable peak anode current			≈	100	mA
With voltage divider B (Fig. 2)	3)				
Gain G at $V_b = 3000$ V (Fig. 6)			≈	5×10^6	
Anode pulse rise time at $V_b = 3000$ V	8)		≈	1,6	ns
Anode pulse duration at half height at $V_b = 3000$ V	8)		≈	3	ns
Signal transit time at $V_b = 3000$ V	8)		≈	31	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 3000$ V	8)		≈	0,65	ns
Anode current linear within 2% at $V_b = 3000$ V up to			≈	280	mA
Obtainable peak anode current			≈	0,5 to 1	A
With voltage divider B' (Fig. 3)	3)				
Gain G at $V_b = 2500$ V (Fig. 6)			≈	2×10^7	
Anode pulse rise time at $V_b = 2500$ V	8)		≈	1,6	ns
Anode pulse duration at half height at $V_b = 2500$ V	8)		≈	2,7	ns
Signal transit time at $V_b = 2500$ V	8)		≈	28	ns
Signal transit time distribution at $V_b = 2500$ V	9)	σ	≈	0,35	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at $V_b = 2500$ V	8)		≈	0,6	ns

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

---

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

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

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

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

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

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

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

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

9) Transit time fluctuations of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation σ.

LIMITING VALUES (Absolute max. rating system)

Supply voltage	1)	max.	3000	V
Continuous anode current	2)	max.	0,2	mA
Voltage between first dynode and photocathode	3)	max.	800	V
		min.	300	V
Voltage between consecutive dynodes (except S12 and S11)		max.	400	V
Voltage between dynode S12 and dynode S11		max.	600	V
Voltage between anode and final dynode	4)	max.	700	V
		min.	80	V
Ambient temperature range				
XP2230				
Operational (for short periods of time)		max.	+80	°C
		min.	−80	°C
Continuous operation and storage		max.	+50	°C
		min.	−80	°C
XP2230B				
Operational (for short periods of time)	5)	max.	+80	°C
		min.	−30	°C
Continuous operation and storage		max.	+50	°C
		min.	−30	°C

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

2) A value of < 10 μA is recommended for applications requiring good stability.

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

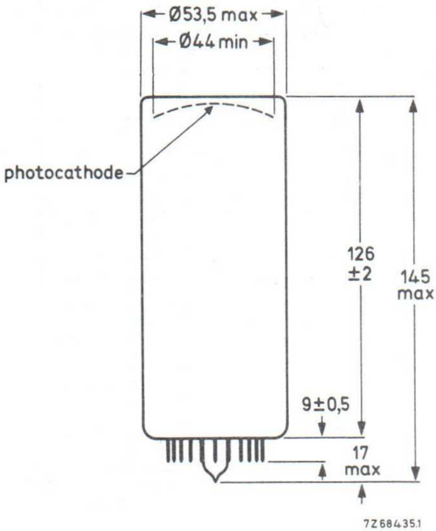
4) When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

5) For type XP2230B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.
When low temperature operation is contemplated, the supplier should be consulted.

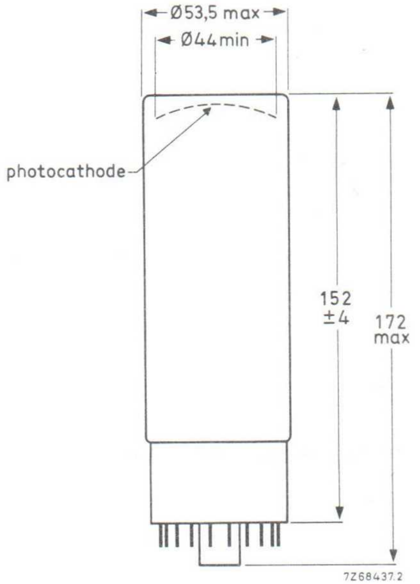
MECHANICAL DATA

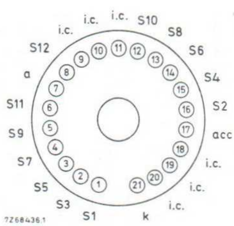
Dimensions in mm

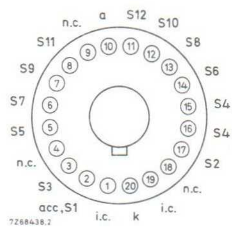
XP2230



XP2230B







Base	21-pin all-glass	Base: 20-pin (IEC 67-I-42a, JEDEC B20-102)
Net mass	160 g	190 g

ACCESSORIES

Socket	for XP2230 type FE2021	for XP2230B type FE1020

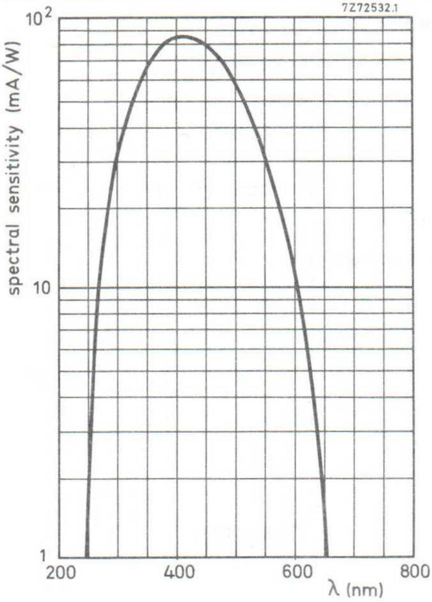


Fig. 4 Spectral sensitivity characteristic.

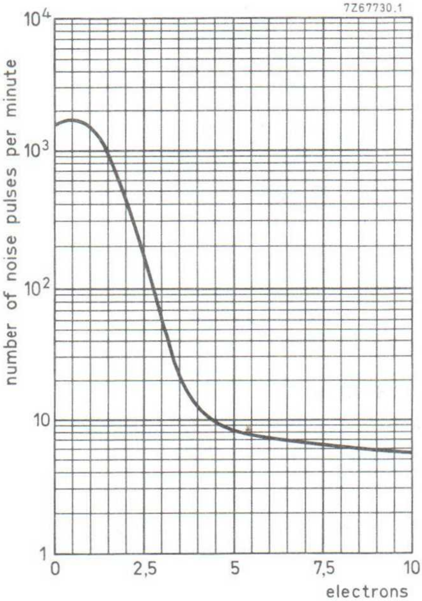


Fig. 5 Typical background spectrum from 0,1 to 10 equivalent photoelectrons, at a gain of 3×10^7, voltage divider A.

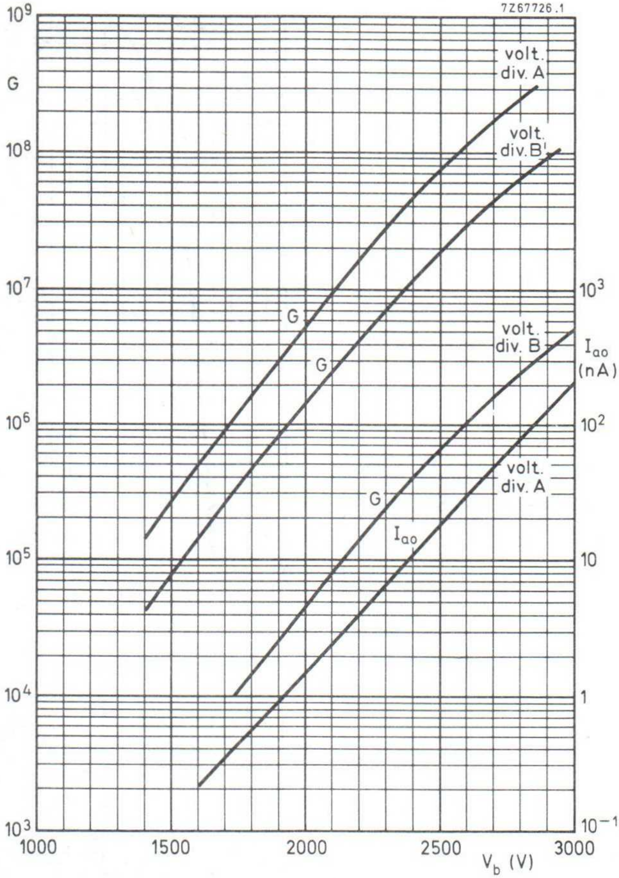


Fig. 6

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

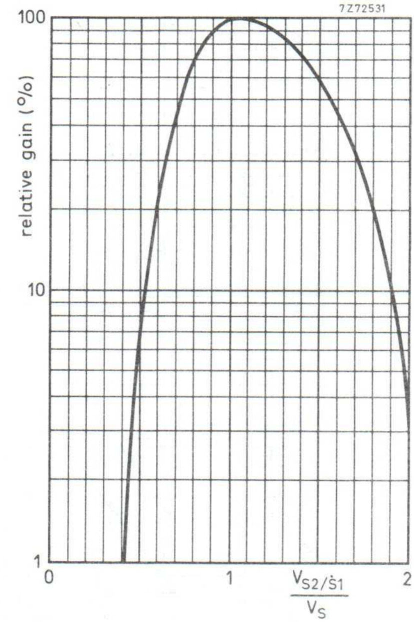


Fig. 7
Relative gain as a function of the voltage between dynodes S_2 and S_1, normalized to V_S.
$V_{S3/S1}$ constant.

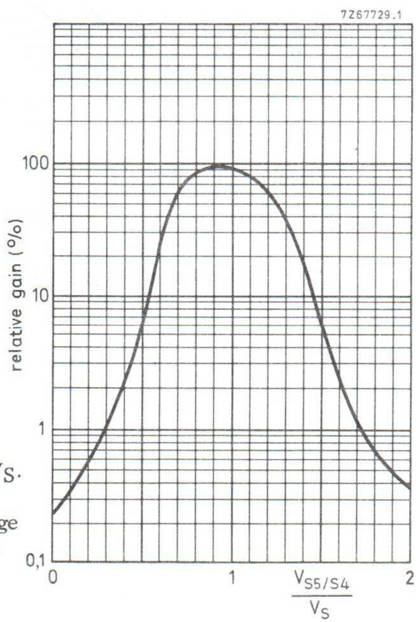


Fig. 8 Relative gain as a function of the voltage between S5 and S4, normalized to V_S.
$V_{S6/S4}$ constant.
Note: Gain regulation by changing the voltage between S_5 and S_4 may cause a degradation of other parameters such as stability and linearity.

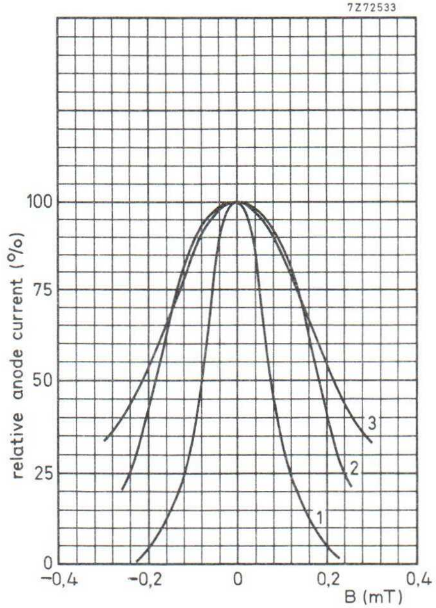


Fig. 9
Relative anode current as a function of the magnetic flux density B.
Voltage divider A, $V_b = 2300$ V.
1 B // axis a)
2 B ⊥ axis a)
3 B // tube axis

12-STAGE PHOTOMULTIPLIER TUBE

The **XP2233B** is a 44 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparent trialkaline S20 (type T) photocathode. The tube is intended for use in low light level physics experiments in the red and near infrared part of the spectrum such as laser detection, pollution monitoring, life time measurements. The tube also features good time characteristics.
The **XP2233B** is unilaterally interchangeable with 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		S20 (type T)		
Useful diameter of the photocathode		>	44	mm
Cathode spectral sensitivity at 698 nm			15	mA/W
Supply voltage for a gain of 3×10^7			2050	V
Anode pulse rise time (with voltage divider B)		≈	2,0	ns
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	250	mA

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on			
Material	Sb Na K Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 5)	S20 (type T)		
Maximum spectral sensitivity at		420 ± 30	nm
Spectral sensitivity			
at 698 ± 7 nm	typ.	15	mA/W
	>	7	mA/W
at 629 ± 3 nm	≈	30	mA/W
Luminous sensitivity	≈	150	μA/lm

Multiplier system

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

Magnetic field

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

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

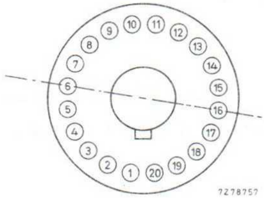


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

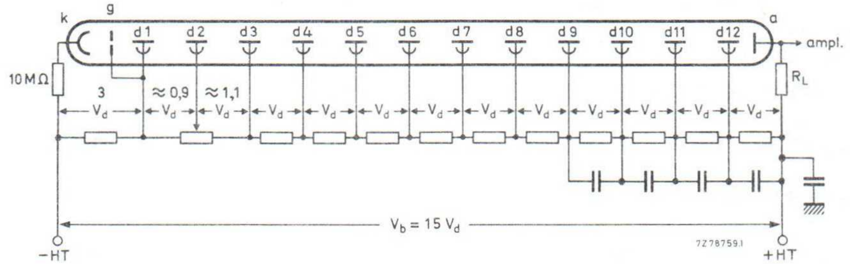


Fig. 2 Voltage divider A.

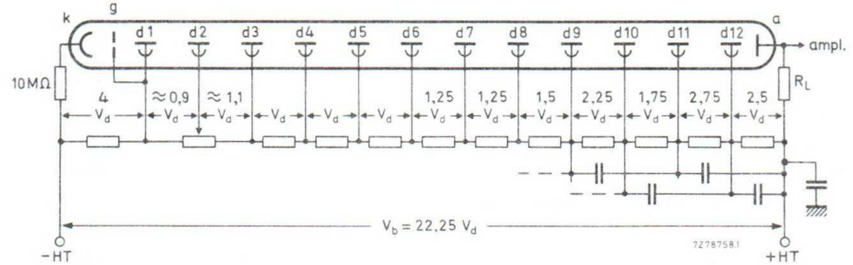


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
d_n = dynode no.:
R_L = load resistor
a • = anode

Typical values of capacitors 1 nF.

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.
The voltage, $V_{d2\text{-}d1}$, to be adjusted for maximum signal.

TYPICAL CHARACTERISTICS

	notes			
With voltage divider A (Fig. 2)	1			
Supply voltage for a gain of 3×10^7 (Fig. 7)			<	2500 V
			typ.	2050 V
Anode dark current at a gain of 3×10^7 (Fig. 7)	2,3		<	1500 nA
			typ.	60 nA
Anode pulse rise time at V_b = 2050 V	4		≈	2,2 ns
Anode pulse duration at half-height at V_b = 2050 V	4		≈	3,6 ns
Signal transit time at V_b = 2050 V	4		≈	30 ns
Anode current linear within 2% at V_b = 2050 V		up to	≈	100 mA
With voltage divider B (Fig. 3)	1			
Gain at V_b = 2400 V (Fig. 7)			≈	2×10^7
Anode pulse rise time at V_b = 2400 V	4		≈	2,0 ns
Anode pulse duration at half-height at V_b = 2400 V	4		≈	3,2 ns
Signal transit time at V_b = 2400 V	4		≈	30 ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2400 V	4		≈	0,7 ns
Anode current linear within 2% at V_b = 2400 V		up to	≈	250 mA

LIMITING VALUES (absolute maximum rating system)

	notes		
Supply voltage	5	max.	2500 V
Continuous anode current	9	max.	0,2 mA
Voltage between accelerating electrode, g, and photocathode		max.	800 V
Voltage between first dynode and photocathode	6	max.	800 V
		min.	300 V
Voltage between consecutive dynodes		max.	400 V
Voltage between anode and final dynode	7	max.	600 V
		min.	80 V
Ambient temperature range	8		
operational (for short periods of time)		max.	+80 °C
		min.	−30 °C
continuous operation and storage		max.	+50 °C
		min.	−30 °C

Notes

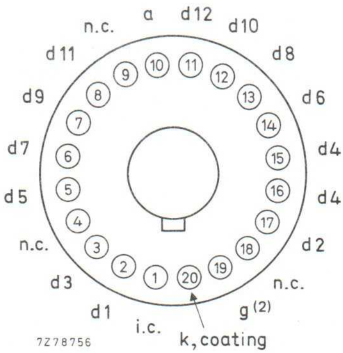
1. To obtain a peak pulse current greater than that obtainable with voltage divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuit B is an example of a "progressive" divider giving a compromise between gain, speed and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used this be kept at photocathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by isolators having an insulation resistance of $> 10^{15}\ \Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness ($\approx$ ¼ h).
4. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_b, approximately as $V_b^{-1/2}$. Non-inductive resistors of 51 Ω are connected in the base of the tube to d_{11} and d_{12}. See also General Operational Recommendations Photomultiplier Tubes.
5. Total high tension supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
6. Minimum value to obtain good collection in the input optics.
7. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
8. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.
9. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.

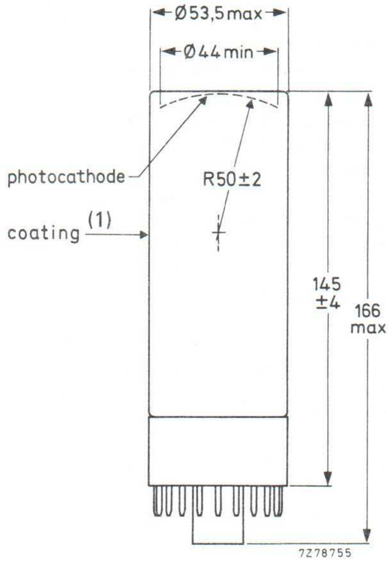
MECHANICAL DATA

Dimensions in mm

(1) **Warning:**

The envelope of the tube is covered with a conductive coating, connected to the cathode. On top of this a black paint is applied which is neither guaranteed to be light tight nor isolating.
Care should be taken to avoid hazard due to electric shock.





(2) Grid is connected to pin 19 starting from serial no. 1606.

Fig. 4.

Base	20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass	176 g

ACCESSORIES

Socket	type FE1020

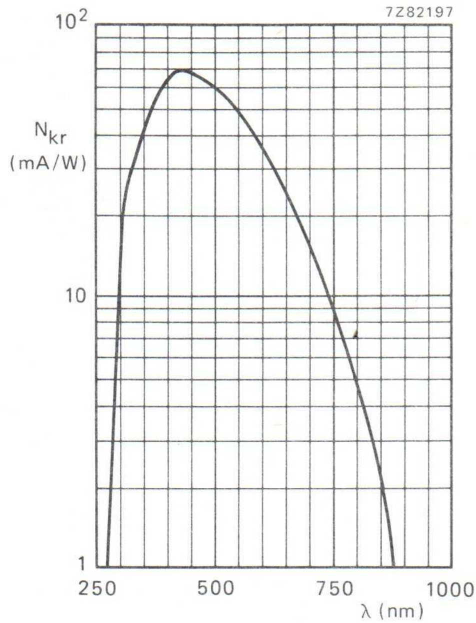


Fig. 5 Spectral sensitivity characteristic.

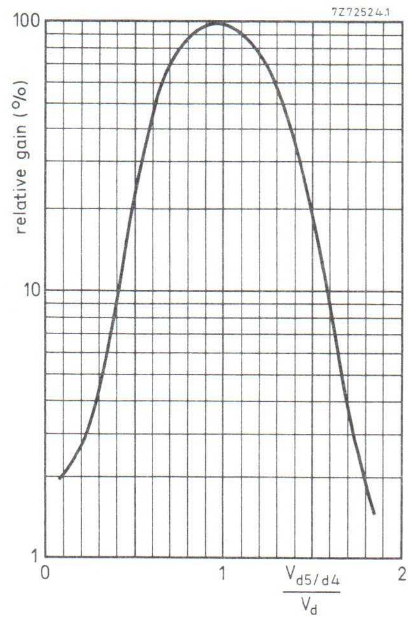


Fig. 6 Relative gain as a function of the voltage between S5 and S4, normalized to V_S. $V_{S6/S4}$ constant.

Note: Gain regulation by changing the voltage between S5 and S4 may cause a degradation of other parameters such as stability and linearity.

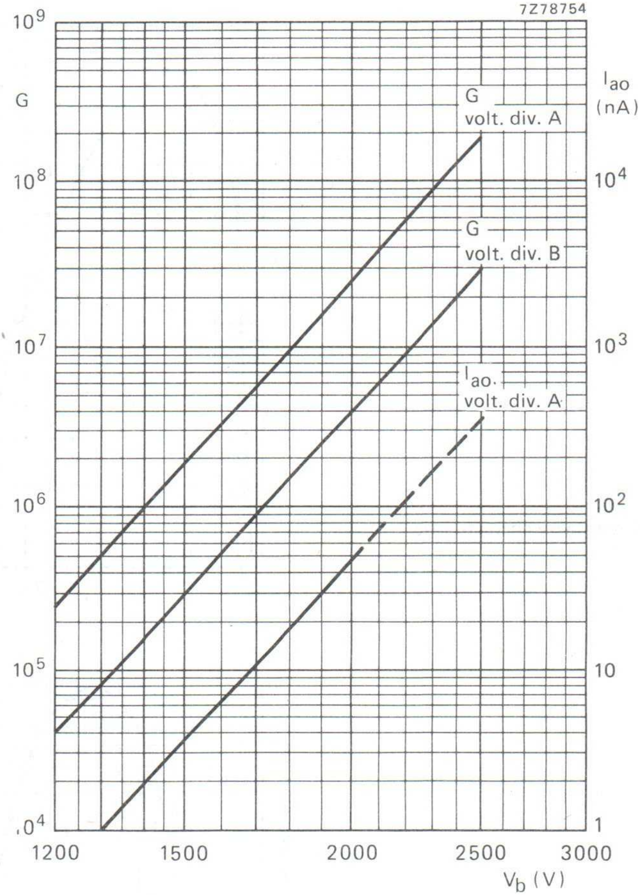


Fig. 7 Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b.

6-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-concave window
- semi-transparent bi-alkaline type D photocathode
- high cathode sensitivity
- low gain
- very good pulse linearity and time characteristics of high amplitude pulses at high count rates

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 400 nm			25	%
Cathode blue sensitivity			10,5	µA/lmF
Supply voltage for a gain of 2×10^4			2000	V
Anode pulse rise time (with voltage divider B)		≈	1,6	ns
Linearity (with voltage divider B)	up to		350	mA

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

GENERAL CHARACTERISTICS

				notes
Window				
Material	lime-glass			
Shape	plano-concave			
Refractive index at 400 nm		1,54		
Photocathode				2
Semi-transparent head-on				
Material	Sb K Cs			
Useful diameter	>	44	mm	
Spectral sensitivity characteristic (Fig. 5)	type D			
Maximum spectral sensitivity		400 ± 30	nm	
Luminous sensitivity	≈	70	µA/lm	3
Blue sensitivity	typ. >	10,5 8,0	µA/lmF µA/lmF	1
Spectral sensitivity at 400 nm	≈	80	mA/W	4
Quantum efficiency at 400 nm		25	%	

Multiplier system

Number of stages		6
Dynode structure		linear focused
Dynode material		Cu Be
Capacitances		
anode to final dynode	≈	3 pF
anode to all	≈	5 pF

Magnetic field

When the photocathode is illuminated uniformly, the anode current is halved at V_{ht} = 1100 V, voltage divider A, at a magnetic flux density of:
0,2 mT perpendicular to axis a (see Fig. 1);
0,1 mT parallel with axis a.

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

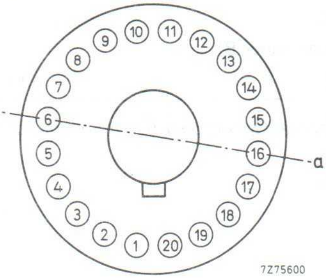


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

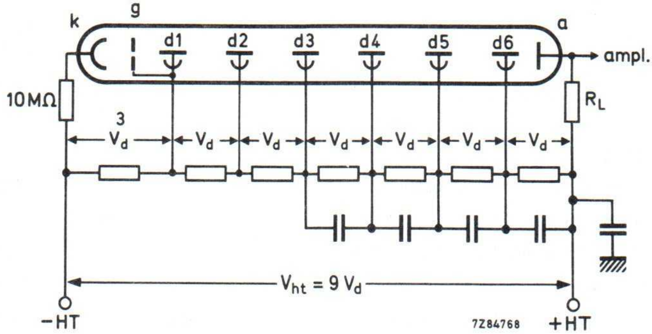


Fig. 2 Voltage divider A.

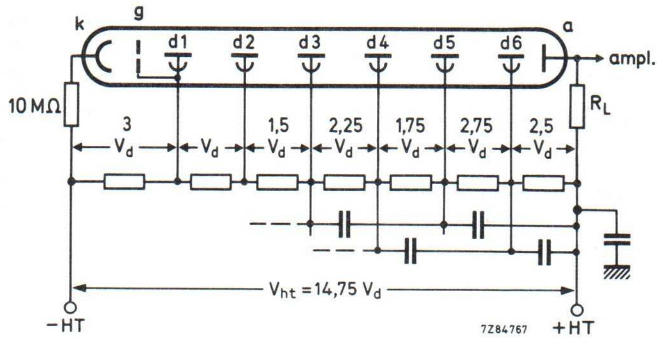


Fig. 3 Voltage divider B.

k = cathode;

g = accelerating electrode;

dn = dynode no.;

R_L = load resistor;

a = anode.

Typical values of capacitors 1 nF.

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				5
Supply voltage for a gain of 1×10^4 (Fig. 6)		<	1600 V	
		typ.	1100 V	
Anode dark current at a gain of 1×10^4 (Fig. 6)		<	5 nA	6,7
		typ.	1 nA	
With voltage divider B (Fig. 3)				5
Supply voltage for a gain of 2×10^4 (Fig. 6)		≈	2000 V	
Anode pulse rise time at V_{ht} = 2000 V		≈	1,6 ns	8
Anode pulse duration at half height at V_{ht} = 2000 V		≈	2,4 ns	8
Signal transit time at V_{ht} = 2000 V		≈	16,5 ns	8
Anode current linear within 2% at V_{ht} = 2000 V	up to	≈	350 mA	

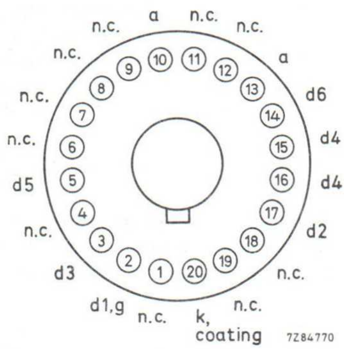
LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2200 V	
Continuous anode current	max.	0,2 mA	9
Voltage between first dynode and photocathode	max.	800 V	10
	min.	300 V	
Voltage between consecutive dynodes	max.	400 V	
Voltage between anode and final dynode	max.	600 V	11
	min.	80 V	
Ambient temperature range			
operational (for short periods of time)	max.	+80 °C	12
	min.	−30 °C	
continuous operation and storage	max.	+50 °C	
	min.	−30 °C	

NOTES

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 10 nA at room temperature or 0,1 nA at −100 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}6 \times 10^3$ for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used this be kept at photocathode potential. This implies safety precautions to protect the user. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
8. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
9. For applications which require good stability a value of < 10 μA is recommended. Use of high anode currents limits tube life; see also General Operational Recommendations Photomultiplier Tubes.
10. Minimum value to obtain good collection in the input optics.
11. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
12. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA



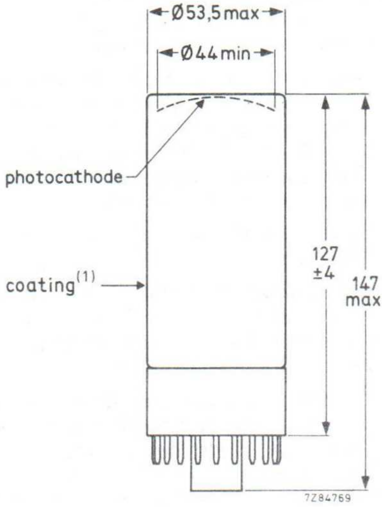


Fig. 4.

Note: Both anode contacts (pins 10 and 13) must be connected to prevent ringing of the anode pulse signal.

Base 20-pin (IEC67-1-42a, JEDEC B20-102)

Net mass 151 g

ACCESSORIES

socket type FE1020

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. On top of this a black paint is applied which is neither guaranteed to be light tight nor isolating. Care should be taken to avoid electric shock.

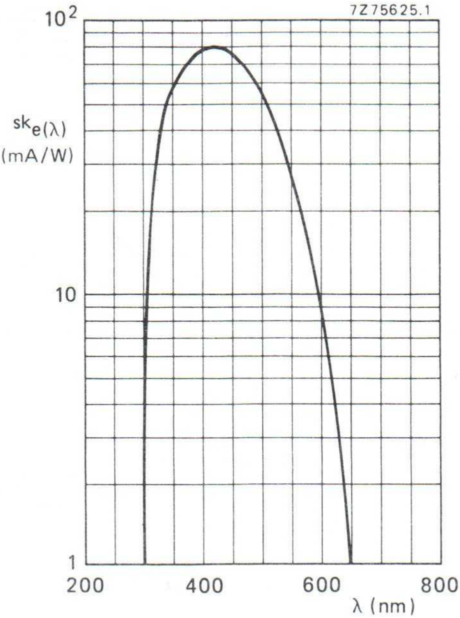


Fig. 5 Spectral sensitivity characteristic.

DEVELOPMENT SAMPLE DATA

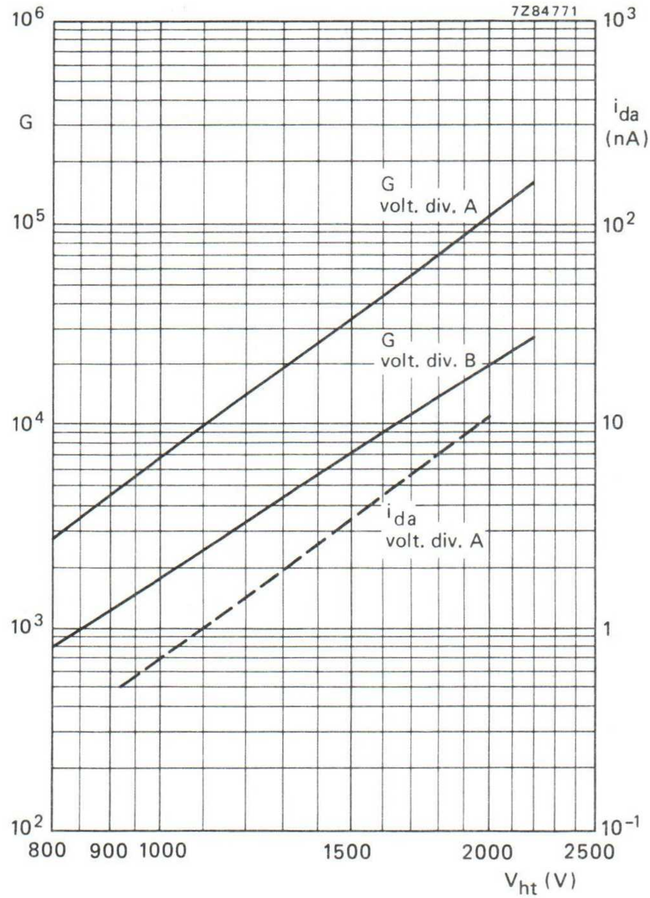


Fig. 6 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

The XP2252 replaces XP2230
The XP2252B replaces XP2230B

12-STAGE PHOTOMULTIPLIER TUBE

- 45 mm useful diameter head-on type
- plano-concave window
- semi-transparent bi-alkaline type D photocathode
- high cathode sensitivity
- very good linearity and time characteristics
- good single electron spectrum resolution
- for high-energy physics experiments
- XP2252 (with 21-pin base) is interchangeable with XP2230;
  XP2252B (with 20-pin base) is: interchangeable with XP2230B and XP2262B;
  pin-compatible with XP2020;
  unilaterally pin-compatible with 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic			type D	
Useful diameter of the photocathode		>	45	mm
Quantum efficiency at 400 nm			25	%
Cathode blue sensitivity			10,5	μA/lmF
Single electron spectrum resolution			70	%
Supply voltage for a gain of 3×10^7			1850	V
Pulse amplitude resolution for ^{137}Cs		≈	7,2	%
Anode pulse rise time (with voltage divider B)		≈	2,0	ns
Linearity				
with voltage divider A (Fig. 2)	up to	≈	100	mA
with voltage divider B (Fig. 3)	up to	≈	250	mA

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

GENERAL CHARACTERISTICS

Window

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

			notes
Photocathode			2
Semi-transparent, head-on			
Material	Sb K Cs		
Useful diameter	>	45 mm	
Spectral sensitivity characteristic (Fig. 4)	type D		
Maximum spectral sensitivity		400 ± 30 nm	
Luminous sensitivity	≈	70 μA/lm	3
Blue sensitivity	typ. >	10,5 μA/lmF 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈	80 mA/W	4
Quantum efficiency at 400 nm		25 %	

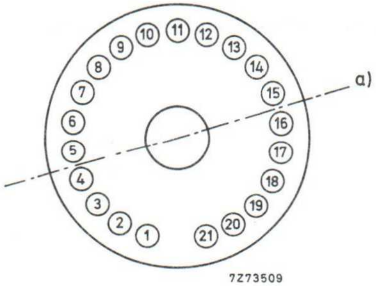
Multiplier system

Number of stages		12	
Dynode structure	linear focused		
Dynode material	CuBe		
Capacitance			
anode to final dynode	≈	3 pF	
anode to all	≈	5 pF	

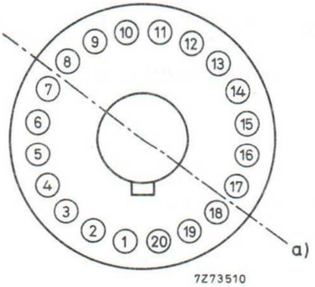
Magnetic field

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

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



XP2252



XP2252B

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

RECOMMENDED CIRCUITS

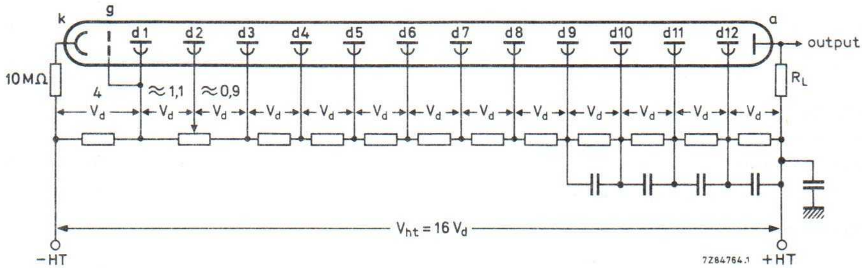


Fig. 2 Voltage divider A.

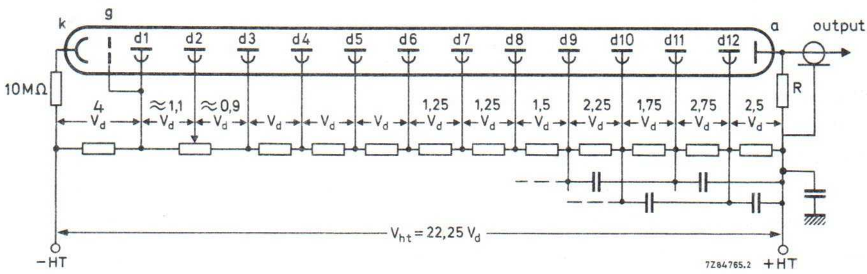


Fig. 3 Voltage divider B.

k = cathode;

g = accelerating electrode;

dn = dynode no.;

R_L = load resistor;

a = anode.

Typical values of capacitors 1 nF.

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.

The voltage, $V_{d2\text{-}d1}$, to be adjusted for maximum signal and optimum single electron spectrum resolution.

Resistor R (Fig. 3) connects the anode if the output cable is not terminated. Recommended value of R: 10 kΩ.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)

					notes
Supply voltage for a gain of 3×10^7 (Fig. 7)		< typ.	2400 1850	V V	5
Anode dark current at a gain of 3×10^7 (Fig. 7)		≈	10	nA	6
Background noise at a gain of 3×10^7		typ. <	1×10^3 6×10^3	c/s c/s	7
Single electron spectrum at a gain of 3×10^7 (Fig. 9)					
resolution		≈	70	%	8
peak to valley ratio		≈	3		9
Anode pulse rise time at V_{ht} = 1900 V		≈	2,3	ns	10
Anode pulse duration at half height at V_{ht} = 1900 V		≈	3,7	ns	10
Signal transit time at V_{ht} = 1900 V		≈	31	ns	10
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 10 A/lmF		≈	7,2	%	1,11
Anode current linear within 2% at V_{ht} = 1900 V	up to	≈	100	mA	
Mean anode sensitivity deviation					12
long term (16 h)		≈	1	%	
after change of count rate		≈	1	%	
versus temperature between 0 °C and 40 °C at 450 nm		≈	0,2	%/K	

With voltage divider B (Fig. 3) 5

Gain at V_{ht} = 2400 V (Fig. 7)		≈	6×10^7		
Anode pulse rise time at V_{ht} = 2200 V		≈	2,0	ns	10
Anode pulse duration at half height at V_{ht} = 2200 V		≈	3	ns	10
Signal transit time at V_{ht} = 2200 V		≈	30	ns	10
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2200 V		≈	0,7	ns	
Anode current linear within 2% at V_{ht} = 2000 V	up to	≈	250	mA	

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2500	V	13
Continuous anode current	max.	0,2	mA	14
Voltage between first dynode and photocathode	max. min.	800 300	V V	15
Voltage between consecutive dynodes	max.	400	V	
Voltage between anode and final dynode	max. min.	600 80	V V	16
Ambient temperature range				
operational (for short periods of time)	max. min.	+80 −30	°C °C	17
continuous operation and storage	max. min.	+50 −30	°C °C	

NOTES

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}6 \times 10^3$ for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Noise is measured at ambient temperature. After having been stored with its protective hood, the tube is placed in darkness with V_{ht} set to a value to give a gain of 3×10^7. After a 5 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0,2 photoelectron) are recorded. Lower values can be obtained after a longer stabilization period.
8. The single electron spectrum resolution to be optimized by adjusting the dynode 2 voltage.
9. Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.
10. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
    Non-inductive resistors of 51 Ω are connected in the base of type XP2252B to d11 and d12. See also *General Operational Recommendations Photomultiplier Tubes.*
11. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no.: 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count-rate used is $\approx 10^4$ c/s.

12. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of ≈ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of ≈ 1 μA and $\approx 0{,}1$ μA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
13. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
14. A value of < 10 μA is recommended for applications requiring good stability.
15. Minimum value to obtain good collection in the input optics.
16. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
17. For type XP2252B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

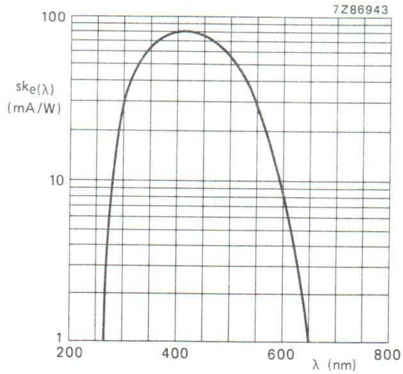


Fig. 4 Spectral sensitivity characteristic.

MECHANICAL DATA

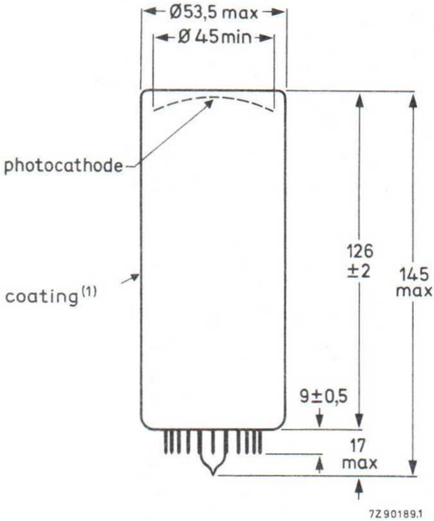


Fig. 5 XP2252.

Base 21-pin all glass

Net mass 160 g

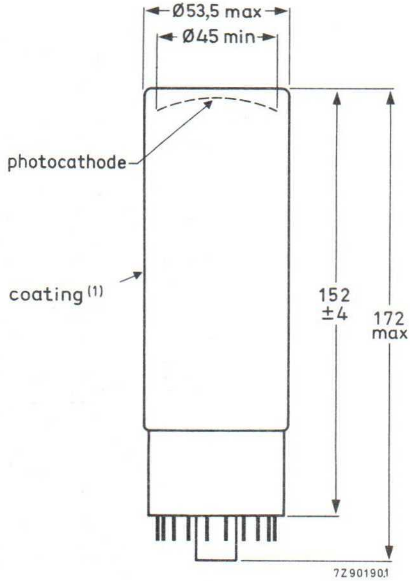
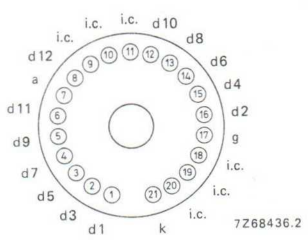


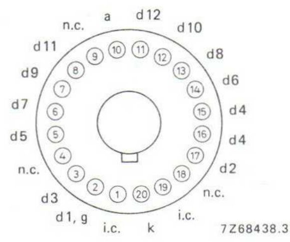
Fig. 6 XP2252B.

Base 20-pin (IEC 67-1-42a, JEDEC B20-102)

Net mass 190 g

PIN CONNECTIONS





ACCESSORIES

Socket for XP2252 type FE2021
Socket for XP 2252B type FE1020

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. On the top of this a black paint is applied which is neither guaranteed to be light tight nor isolating.
Care should be taken to avoid electric shock.

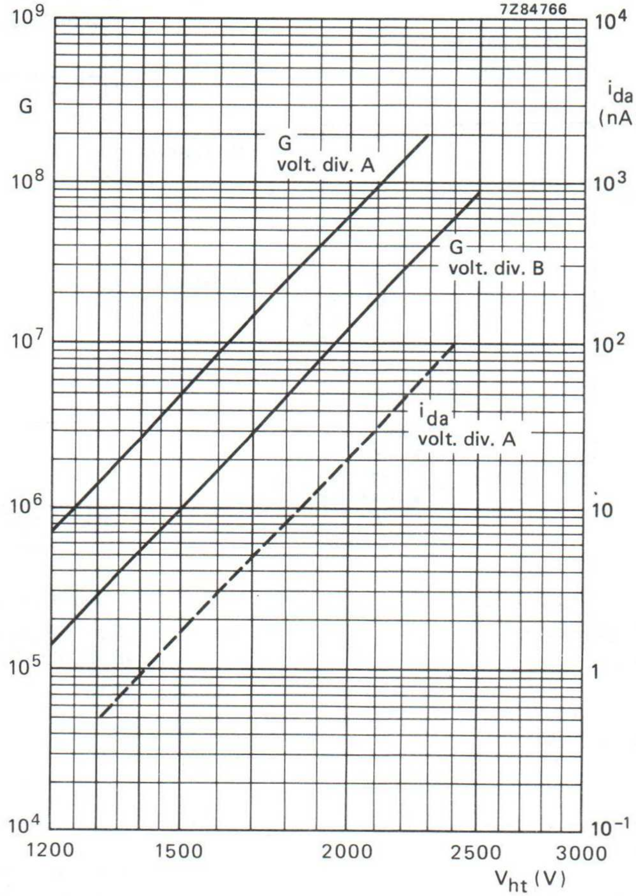


Fig. 7 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

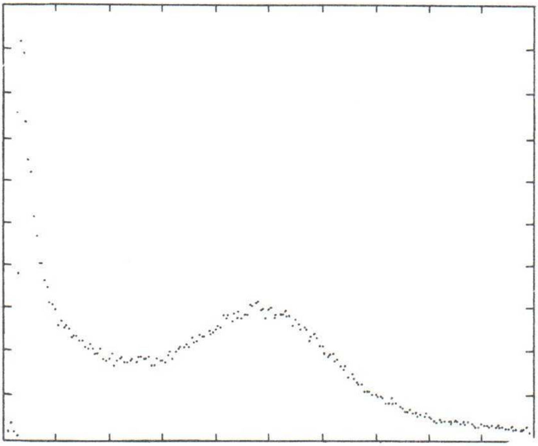


Fig. 8 Background noise spectrum, obtained with an XP2252 tube, series no. 9956. Gain: 3×10^7.

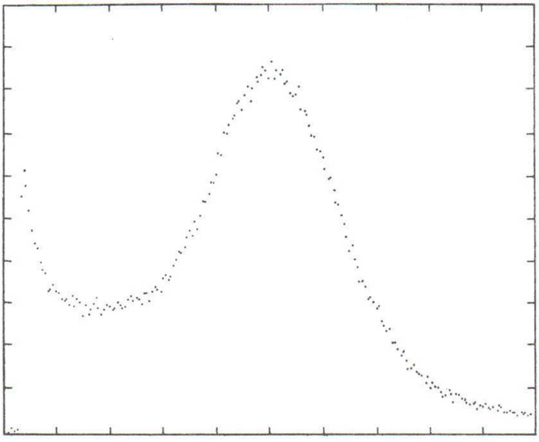


Fig. 9 Single electron spectrum obtained with an XP2252 tube, series no. 9956. Gain: 3×10^7.
Resolution 64,4%. Peak to valley ratio: 2,9 (see Note 9).

12-STAGE PHOTOMULTIPLIER TUBE

The XP2254B is a 44 mm useful diameter head-on photomultiplier tube with a plano-concave fused silica window and a semi-transparent trialkaline type TU photocathode.
The tube is intended for use in optical applications where a high sensitivity in the region from ultraviolet to the near infrared is required combined with good time characteristics. The XP2254B is unilaterally interchangeable with 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type TU		
Useful diameter of the photocathode		>	44	mm
Spectral sensitivity of the photocathode at 700 nm			15	mA/W
Supply voltage for a gain of 3×10^7			2300	V
Anode pulse rise time (with voltage divider B')		≈	1,5	ns
Linearity, with voltage divider B	up to	≈	280	mA

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

GENERAL CHARACTERISTICS

Window

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

Photocathode

Semi-transparent, head-on			
Material	Sb Na K Cs		
Useful diameter	>	44	mm
Spectral sensitivity characteristic (Fig. 6)	type TU		
Maximum spectral sensitivity at		420 ± 30	nm
Spectral sensitivity at 700 nm	typ.	15	mA/W
	>	7	mA/W
Luminous sensitivity	≈	150	µA/lm

Multiplier system

Number of stages	12
Dynode structure	linear focused
Dynode material	CuBe

Capacitances

Grid 1 to k + d1 + acc + g2 + d5	≈	20 pF
Anode to final dynode	≈	4 pF
Anode to all	≈	7 pF

Magnetic field

See Fig. 9.

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

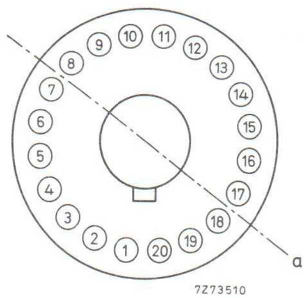


Fig. 1 Axis a with respect to base pins (bottom view).

DEVELOPMENT SAMPLE DATA

RECOMMENDED CIRCUITS

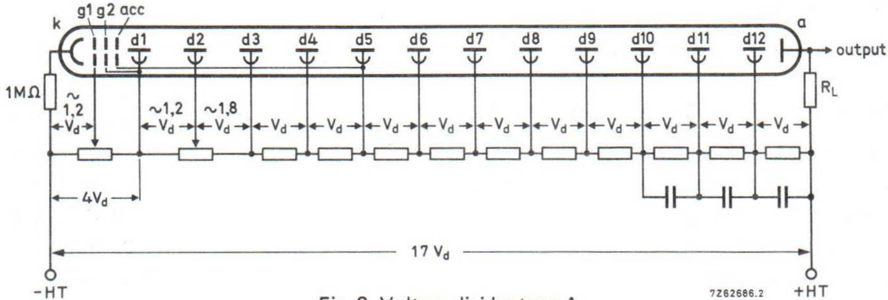


Fig. 2 Voltage divider type A.

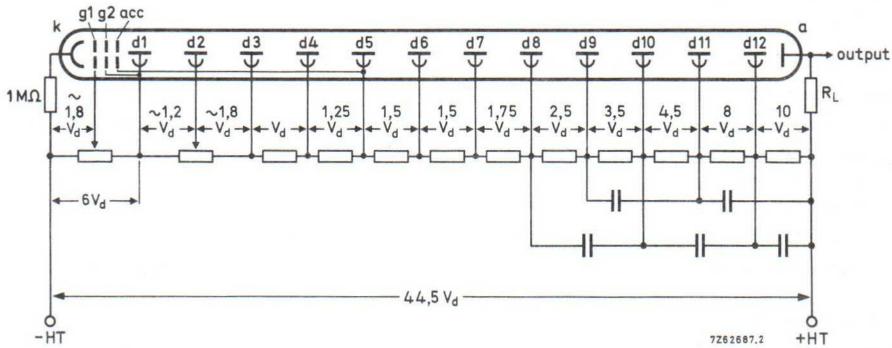


Fig. 3 Voltage divider type B.

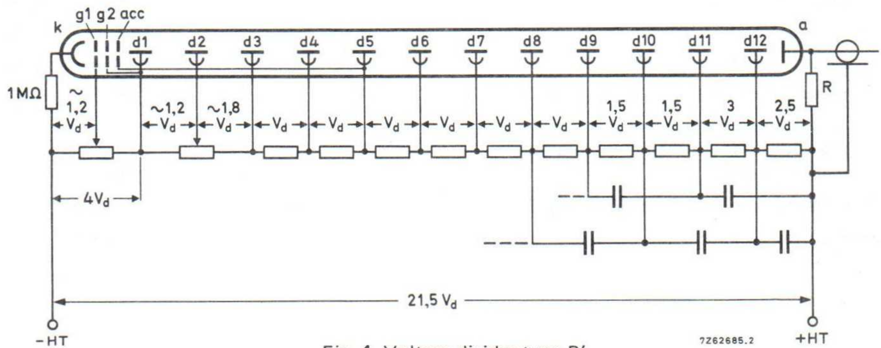


Fig. 4 Voltage divider type B'.

k = cathode
g1, g2 = focusing electrodes
acc = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

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

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

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				1
Supply voltage for a gain of 3×10^7 (Fig. 10)		typ. <	2300 V 2700 V	
Anode dark current at a gain of 3×10^7 (Fig. 10)		typ. <	60 nA 1500 nA	2, 3
Anode pulse rise time at V_{ht} = 2000 V		≈	1,6 ns	4, 5
Anode pulse duration at half height at V_{ht} = 2000 V		≈	3,7 ns	4, 5
Signal transit time at V_{ht} = 2000 V		≈	28 ns	4, 5
Anode current linear within 2% at V_{ht} = 2000 V	up to	≈	25 mA	
Obtainable peak anode current		≈	100 mA	
With voltage divider B (Fig. 3)				1
Gain at V_{ht} = 2800 V (Fig. 10)		≈	$1,5 \times 10^6$	
Anode pulse rise time at V_{ht} = 2800 V		≈	1,7 ns	4, 5
Anode pulse duration at half height at V_{ht} = 2800 V		≈	2,7 ns	4, 5
Signal transit time at V_{ht} = 2800 V		≈	31 ns	4, 5
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2800 V		≈	0,25 ns	
Anode current linear within 2% at V_{ht} = 2800 V	up to	≈	280 mA	
Obtainable peak anode current		≈	0,5 to 1 A	
With voltage divider B' (Fig. 4)				1
Gain at V_{ht} = 2500 V (Fig. 10)		≈	$1,5 \times 10^7$	
Anode pulse rise time at V_{ht} = 2500 V		≈	1,5 ns	4, 5
Anode pulse duration at half height at V_b = 2500 V		≈	2,4 ns	4, 5
Signal transit time at V_{ht} = 2500 V		≈	30 ns	4, 5
Signal transit time distribution at V_{ht} = 2500 V	σ	≈	0,25 ns	5, 6
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2500 V		≈	0,25 ns	
Anode current linear with 2% at V_{ht} = 2500 V	up to	≈	70 mA	
Obtainable peak anode current		≈	250 mA	

LIMITING VALUES (Absolute maximum rating system)

			notes
Supply voltage	max.	3000 V	7
Continuous anode current	max.	0,2 mA	8
Voltage between focusing electrode, g1 and photocathode	max.	300 V	
Voltage between first dynode and photocathode	max. min.	800 V 210 V	9
Voltage between consequtive dynodes (except d11 and d12)	max.	400 V	
Voltage between dynodes d11 and d12	max.	600 V	5
Voltage between anode and final dynode	max. min.	700 V 80 V	10
Ambient temperature range			11
operational (for short periods of time)	max. min.	+ 80 °C −30 °C	
continuous operation and storage	max. min.	+ 50 °C −30 °C	

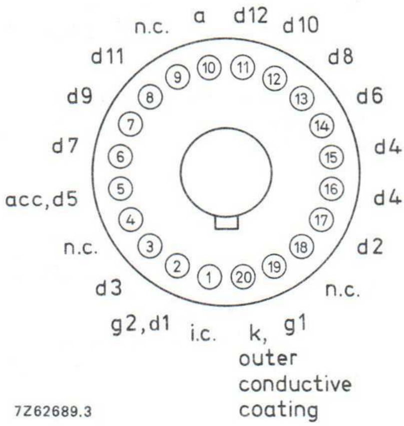
DEVELOPMENT SAMPLE DATA

Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Dividers B and B' are examples of "progressive" dividers, each giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used, this should be kept at cathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by insulators having an insulation resistance of $> 10^{15}\,\Omega$.
3. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈ ¼ h).
4. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
5. Non-inductive resistors of 51 Ω are incorporated in the base connected to d11 and d12. See also *General Operational Recommendations Photomultiplier Tubes*.
6. Transit time fluctuations of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation (σ).
7. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
8. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
9. Minimum value to obtain good collection in the inputs optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
11. This range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. Care should be taken to avoid electric shock.



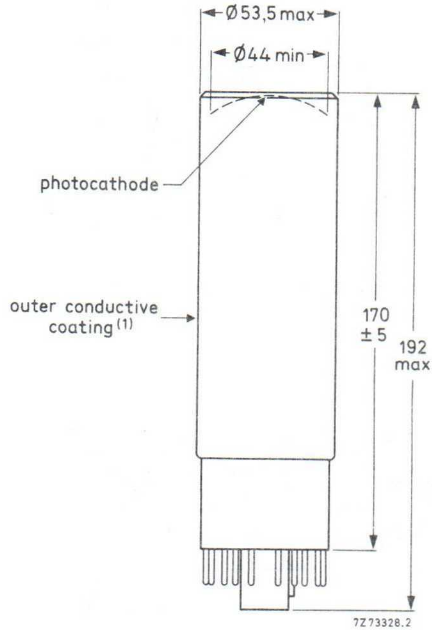


Fig. 5.

The base connections of the XP2254B are such that the tube is unilaterally interchangeable with the 56AVP-family tubes.

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

ACCESSORIES

Socket	type FE1020

DEVELOPMENT SAMPLE DATA

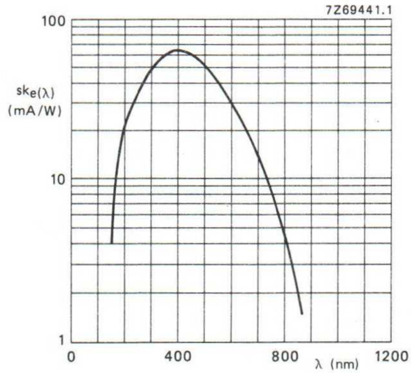


Fig. 6 Spectral sensitivity characteristic.

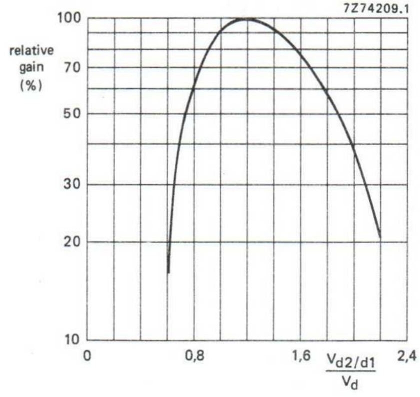


Fig. 7 Relative gain as a function of the voltage between d2 and d1, normalized to V_d $V_{d3/d1}$ constant.

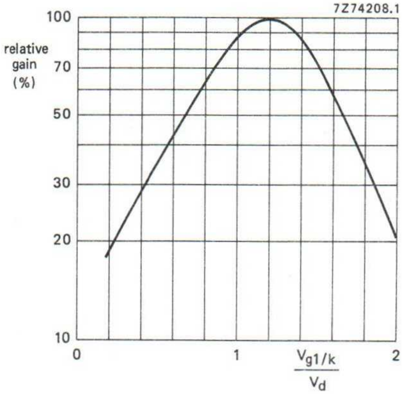


Fig. 8 Relative gain as a function of the voltage between grid 1 and cathode, normalized to V_d. $V_{d1/k}$ constant.

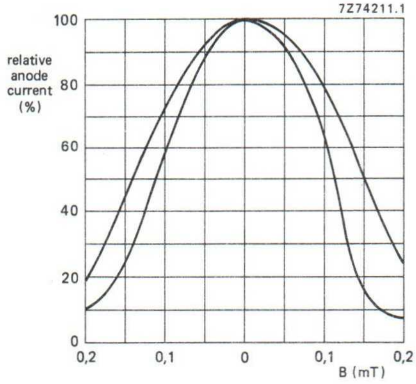


Fig. 9 Relative anode current as a function of the magnetic flux density B.

1. ⊥ axis a
2. // axis a

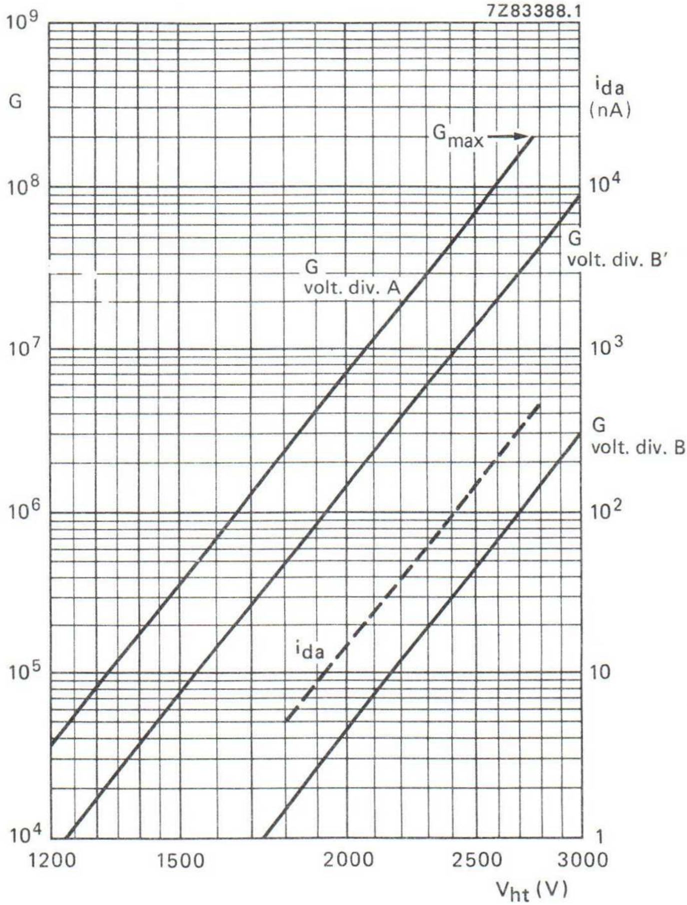


Fig. 10 Gain, G, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

The XP2262 replaces XP2232
The XP2262B replaces XP2232B, 56AVP and 56DVP

12-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-concave window
- semi-transparent bi-alkaline type D photocathode
- high cathode sensitivity
- very good linearity and time characteristics
- good single electron spectrum resolution
- for high-energy physics experiments
- XP2262 (with 19-pin base) is interchangeable with XP2232;
  XP2262B (with 20-pin base) is: interchangeable with XP2232B;
  pin-compatible with XP2020 and XP2230B;
  unilaterally pin-compatible with 56AVP-family tubes.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	$>$ 44 mm
Quantum efficiency at 400 nm	25%
Cathode blue sensitivity	10,5 μA/lmF
Single electron spectrum resolution	70%
Supply voltage for a gain of 3×10^7	1850 V
Pulse amplitude resolution for ^{137}Cs	$\approx$ 7,2%
Anode pulse rise time (with voltage divider B)	$\approx$ 2,0 ns
Linearity	
with voltage divider A (Fig. 2)	up to $\approx$ 100 mA
with voltage divider B (Fig. 3)	up to $\approx$ 250 mA

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

GENERAL CHARACTERISTICS

Window

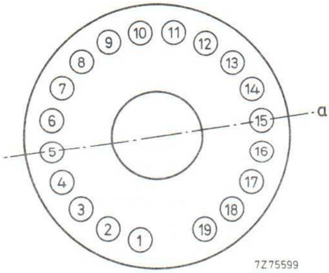
Material	lime-glass
Shape	plano-concave
Refractive index at 400 nm	1,54

		notes
Photocathode		
Semi-transparent, head-on		2
Material	Sb K Cs	
Useful diameter	> 44 mm	
Spectral sensitivity characteristic (Fig. 6)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lm	3
Blue sensitivity	typ. 10,5 μA/lmF > 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 80 mA/W	4
Quantum efficiency at 400 nm	25%	
Multiplier system		
Number of stages	12	
Dynode structure	linear focused	
Dynode material	Cu Be	
Capacitances		
anode to final dynode	≈ 3 pF	
anode to all	≈ 5 pF	

magnetic field

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

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



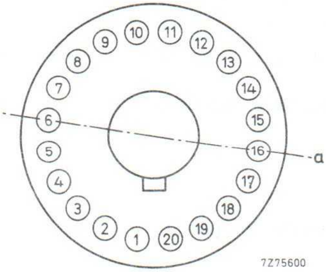


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

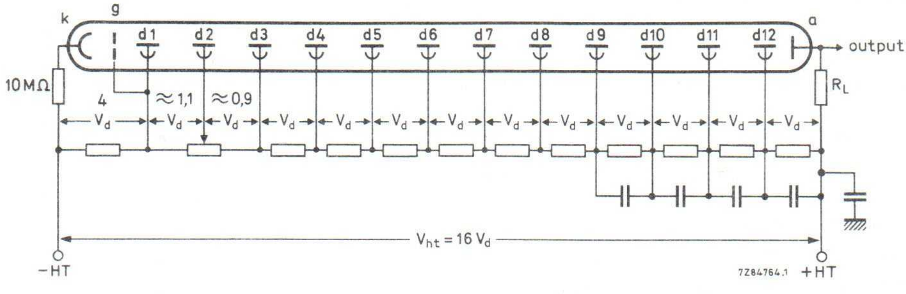


Fig. 2 Voltage divider A.

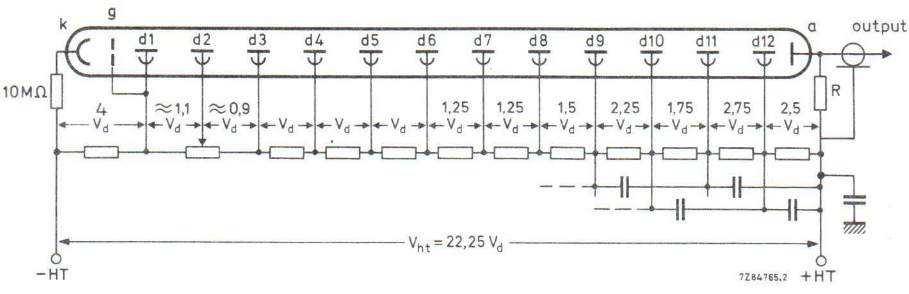


Fig. 3 Voltage divider B.

k = cathode;
g = accelerating electrode;
dn = dynode no.;
R_L = load resistor;
a = anode.

Typical values of capacitors 1 nF.

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.

The voltage, $V_{d2\text{-}d1}$, to be adjusted for maximum signal and optimum single electron spectrum resolution.

Resistor R (Fig. 3) connects the anode if the output cable is not terminated. Recommended value of R : 10 kΩ.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)

		notes
Supply voltage for a gain of 3×10^7 (Fig. 8)	< 2400 V typ. 1850 V	5
Anode dark current at a gain of 3×10^7 (Fig. 8)	≈ 10 nA	6
Background noise at a gain of 3×10^7	typ. 1×10^3 c/s < 6×10^3 c/s	7
Single electron spectrum at a gain of 3×10^7 (Fig. 7)		
resolution	≈ 70%	8
peak to valley ratio	≈ 3	9
Anode pulse rise time at V_{ht} = 1900 V	≈ 2,3 ns	10
Anode pulse duration at half height at V_{ht} = 1900 V	≈ 3,7 ns	10
Signal transit time at V_{ht} = 1900 V	≈ 31 ns	10
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 10 A/lmF	≈ 7,2%	1, 11
Anode current linear within 2% at V_{ht} = 1900 V	up to ≈ 100 mA	
Mean anode sensitivity deviation		12
long term (16 h)	≈ 1%	
after change of count rate	≈ 1%	
versus temp. between 0 °C and 40 °C at 450 nm	≈ 0,2%/K	

With voltage divider B (Fig. 3) — notes: 5

		notes
Gain at V_{ht} = 2400 V (Fig. 8)	≈ 6×10^7	
Anode pulse rise time at V_{ht} = 2200 V	≈ 2,0 ns	10
Anode pulse duration at half height at V_{ht} = 2200 V	≈ 3 ns	10
Signal transit time at V_{ht} = 2200 V	≈ 30 ns	10
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2200 V	≈ 0,7 ns	
Anode current linear within 2% at V_{ht} = 2000 V	up to ≈ 250 mA	

LIMITING VALUES (absolute maximum rating system)

		notes
Supply voltage	max. 2500 V	13
Continuous anode current	max. 0,2 mA	14
Voltage between first dynode and photocathode	max. 800 V min. 300 V	15
Voltage between consecutive dynodes	max. 400 V	
Voltage between anode and final dynode	max. 600 V min. 80 V	16
Ambient temperature range		
operational (for short periods of time)	max. +80 °C min. −30 °C	17
continuous operation and storage	max. +50 °C min. −30 °C	

NOTES

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}6 \times 10^3$ for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Noise is measured at ambient temperature. After having been stored with its protective hood, the tube is placed in darkness with V_{ht} set to a value to give a gain of 3×10^7. After a 5 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0,2 photoelectron) are recorded. Lower values can be obtained after a longer stabilization period.
8. The single electron spectrum resolution to be optimized by adjusting the dynode 2 voltage.
9. Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.
10. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
    Non-inductive resistors of 51 Ω are connected in the base of type XP2262B to d11 and d12. See also *General Operational Recommendations Photomultiplier Tubes.*
11. Pulse amplitude resolution for ^{137}Cs is measured with a NaI (Tl) cylindrical scintillator (Quartz et Silice ser. no.: 7256 or equivalent) with a diameter of 44 mm and a height of 50 mm. The count-rate used is $\approx 10^4$ c/s.

12. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 c/s corresponding to an average anode current of ≈ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of ≈ 1 μA and ≈ 0,1 μA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
13. Total HT supply voltage, or the voltage at which the tube has a gain of 2 x 10^8, whichever is lower.
14. A value of < 10 μA is recommended for applications requiring good stability.
15. Minimum value to obtain good collection in the input optics.
16. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
17. For type XP2262B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplied should be consulted.

MECHANICAL DATA

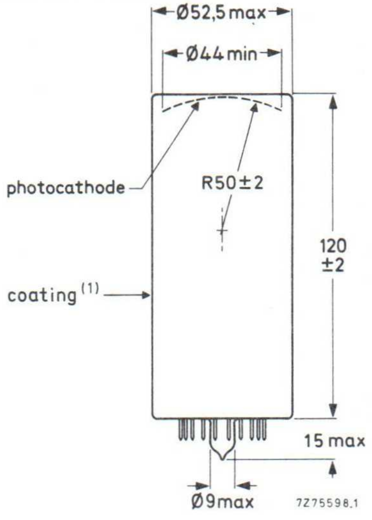


Fig. 4 XP2262.

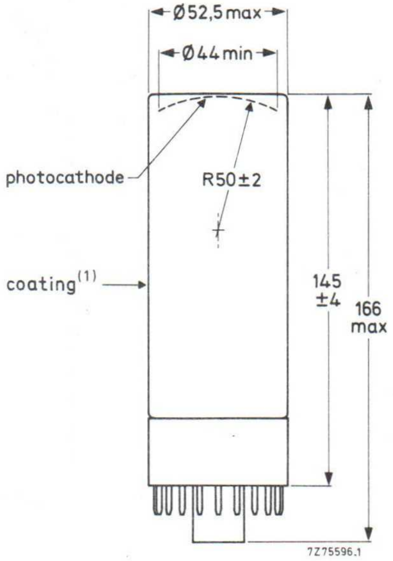
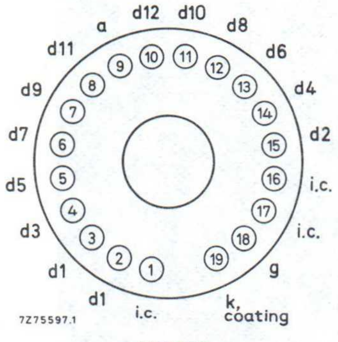


Fig. 5 XP2262B.

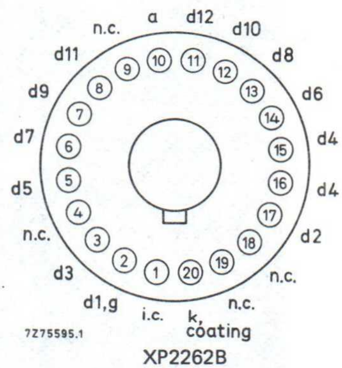
Base	19-pin all glass
Net mass	125 g

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

PIN CONNECTIONS



XP2262



XP2262B

ACCESSORIES

Socket
for XP2262 type FE2019
for XP2262B type FE1020

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. On top of this a black paint is applied which is neither guaranteed to be light tight nor isolating.
Care should be taken to avoid electric shock.

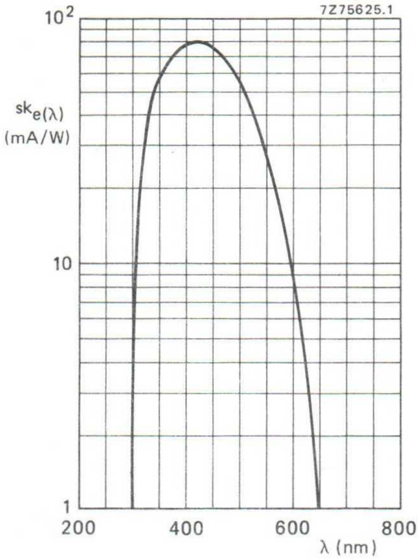


Fig. 6 Spectral sensitivity characteristic.

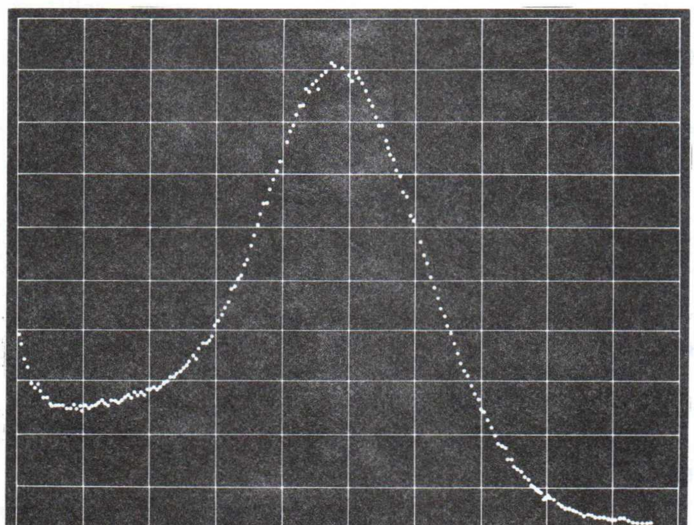


Fig. 7 Single electron spectrum obtained with an XP2262 tube.

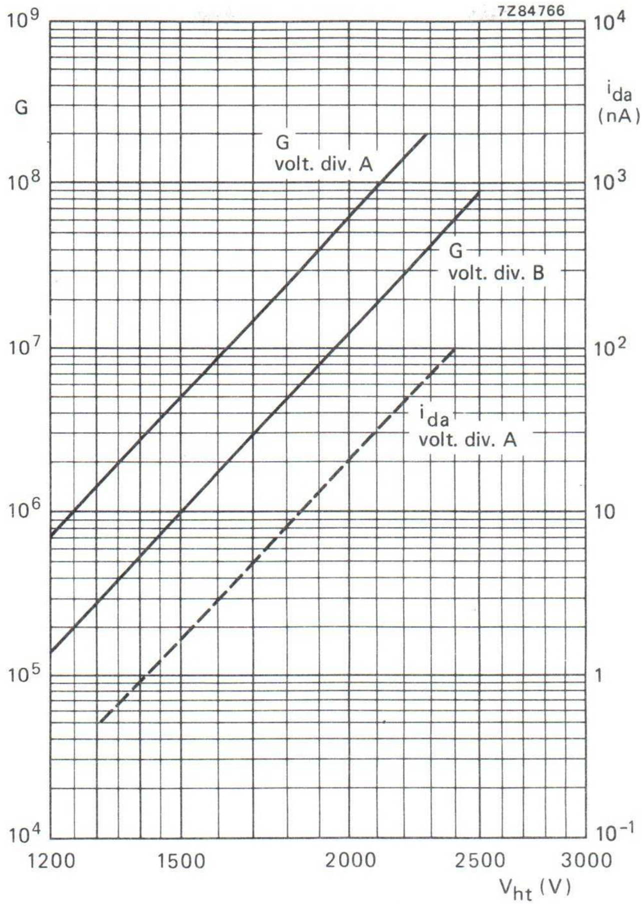


Fig. 8 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2312 and XP2312B are 68 mm useful diameter head-on photomultiplier tubes with a plano-concave window and a semi-transparant bialkaline type D photocathode. The tubes are intended for use in nuclear physics where the number of photons to be detected is very low and where good time characteristics and a good linearity are required (coincidence measurements, Cerenkov counters). The XP2312B is provided with a 20-pin plastic base. The XP2312 has a 19-pin all-glass base.

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D		
Useful diameter of the photocathode		>	68	mm
Quantum efficiency at 400 nm			26	%
Cathode spectral sensitivity at 400 nm			85	mA/W
Supply voltage for a gain of 3 x 10^7			2000	V
Pulse amplitude resolution for ^{137}Cs		≈	8,0	%
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Linearity				
with voltage divider A	up to	≈	100	mA
with voltage divider B	up to	≈	250	mA

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

GENERAL CHARACTERISTICS

Window

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

Photocathode (note 1)

Semi-transparent, head-on

Material	SbKCs		
Useful diameter	>	68	mm
Spectral sensitivity characteristic (Fig. 6)	type D		
Maximum spectral sensitivity at	400 ± 30		nm
Quantum efficiency at 400 nm		26	%
Spectral sensitivity at 400 nm	typ.	85	mA/W
	>	65	mA/W

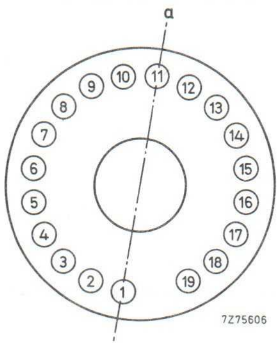
Multiplier system

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

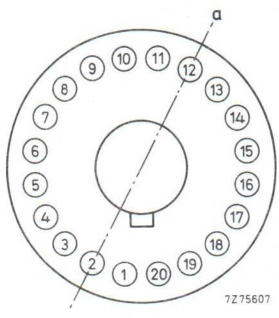
Magnetic field

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

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



XP2312



XP2312B

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

RECOMMENDED CIRCUITS

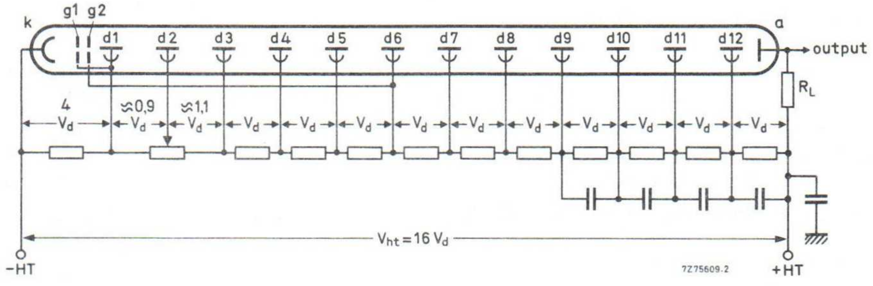


Fig. 2 Voltage divider A.

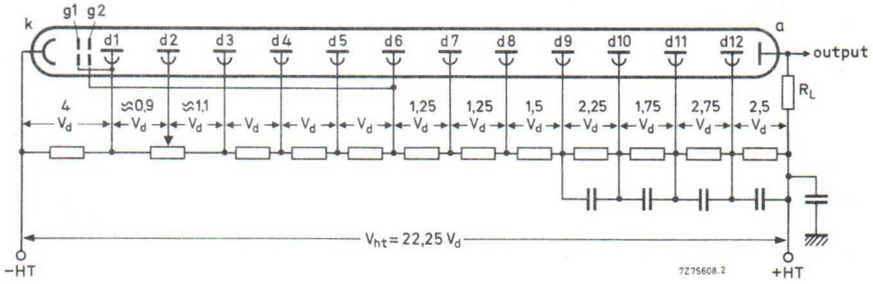


Fig. 3 Voltage divider B.

Typical value of capacitors: 1 nF; k = cathode; g1, g2 = accelerating electrodes; dn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

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

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	2500 V	8
Continuous anode current	max.	0,2 mA	12
Voltage between first dynode and photocathode	max. min.	700 V 300 V	9
Voltage between consecutive dynodes	max.	400 V	
Voltage between g2 and photocathode (g2 normally connected to d6)	max.	1500 V	
Voltage between anode and final dynode	max. min.	600 V 80 V	10
Ambient temperature range			11
operational (for short periods of time)	max. min.	+80 °C −30 °C	
continuous operation and storage	max. min.	+50 °C −30 °C	

Notes

1. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited to, for example, 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered to be an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departures of linearity.
2. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltages of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity.
   Other dividers can be conceived to achieve other compromises. It is generally recommended that the increase in voltage between one stage and the next be kept less than a factor of 2.
3. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The glass envelope of the tube should be supported only by insulators having an insulation resistance of $> 10^{15}\,\Omega$.
4. Dark current is measured at ambient temperature, after a stabilization period of the tube in darkness (≈¼ h).
5. After having been stored with its protective hood, the tube is placed in darkness with V_{ht} set to a value to give a gain of 3×10^7. After a 30 min stabilization period noise pulses with a threshold of $1{,}4 \times 10^{-12}$ C (corresponding to 0,3 photoelectron) are recorded (Fig. 7).
6. Pulse amplitude resolution for ^{137}Cs is measured with a NaI(Tl) cylindrical scintillator (Quartz et Silice ser. no. 4170 equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is $\approx 10^4$ c/s.
7. Measured with a pulsed-light source, with a pulse duration (FWHM) of < 1 ns, the cathode being completely illuminated.
   The rise time is determined between 10% and 90% of the amplitude of the anode pulse.
   The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.

   Non-inductive resistors of 51 Ω are connected in the base of type XP2312B to d11 and d12.
   See also *General Operational Recommendations Photomultiplier Tubes.*
8. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage, the voltage drop across the load resistor should be taken into account.
11. For type XP2312B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

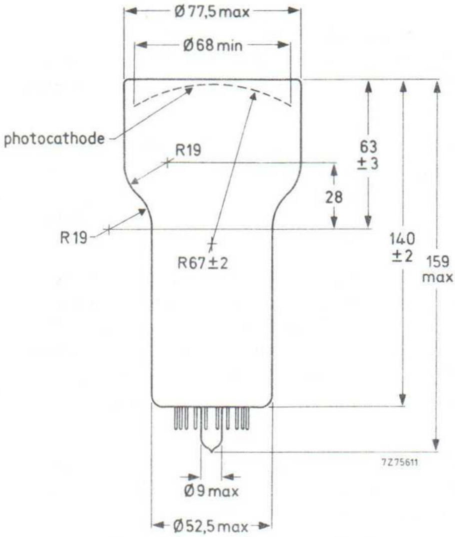


Fig. 4 XP2312.

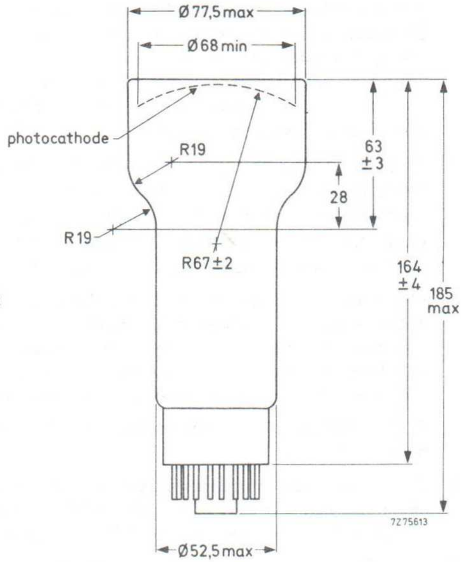
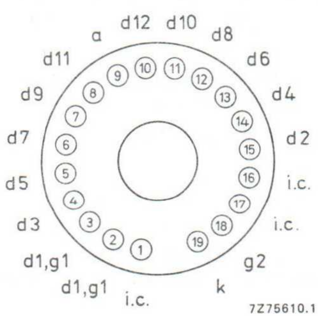


Fig. 5 XP2312B.

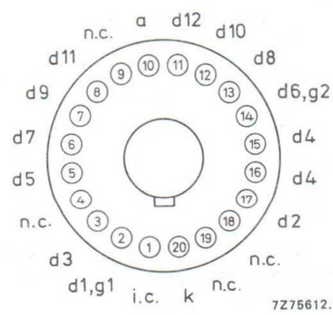
Base	19-pin all-glass
Net mass	215 g

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

PIN CONNECTIONS



XP2312



XP2312B

ACCESSORIES

Socket

for XP2312	type FE2019
for XP2312B	type FE1020

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

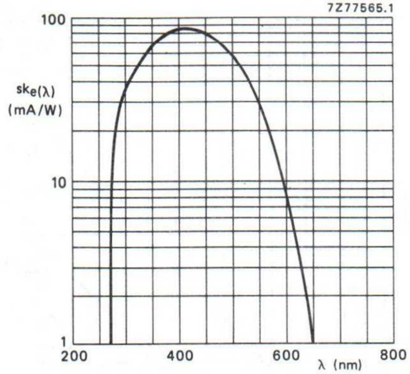


Fig. 6 Spectral sensitivity characteristic.

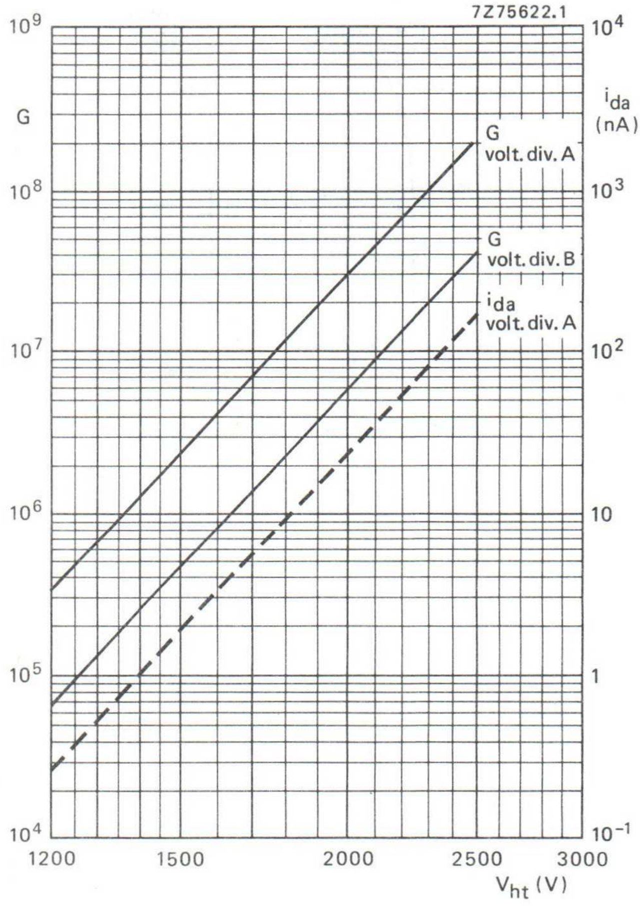


Fig. 7 Gain G, and anode dark current i_{da} as a function of the supply voltage V_{ht}.

XP2412 replaces XP2030UB
XP2412B replaces XP2030

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBES

- 70 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Very good pulse amplitude resolution
- Very low dark current
- Very good stability
- For scintillation detection applications, e.g. gamma cameras, high energy physics experiments

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	$>$ 70 mm
Cathode blue sensitivity	13 μA/lmF
Supply voltage	
for anode blue sensitivity = 1,5 A/lmF	1250 V
Anode dark current	
at anode blue sensitivity = 1,5 A/lmF	0,5 nA
Pulse amplitude resolution (^{57}Co)	$\approx$ 10%
Mean anode sensitivity deviation (30 days)	$\approx$ 1%

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	$>$ 70 mm	
Spectral sensitivity characteristic (Fig. 2)	type D	
Maximum spectral sensitivity	400 $\pm$ 30 nm	
Luminous sensitivity	$\approx$ 78 μA/lm	3
Blue sensitivity	typ. 13 μA/lmF $>$ 10 μA/lmF	1
Spectral sensitivity at 400 nm	$\approx$ 105 mA/W	4

Multiplier system

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

Magnetic field

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

A mu-metal shield extending more than 15 mm beyond the cathode is recommended for magnetic screening.

RECOMMENDED CIRCUIT

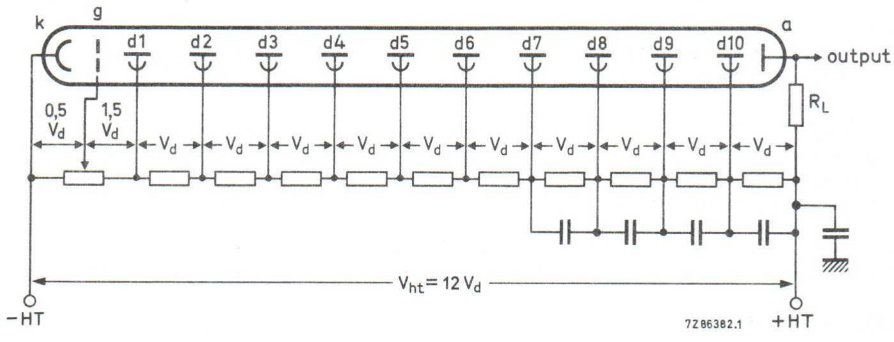


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

Note

For optimum pulse-amplitude resolution, the accelerating-electrode potential should be between the cathode and first dynode potentials. If the tube is used in a socket wired for an XP2030UB or XP2030 with the accelerating electrode connected to the first dynode, the pulse amplitude resolution for ^{57}Co is about 10,2%.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 1)

		notes
		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig. 5)	< 1450 V typ. 1250 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1250 V	≈ 12 kA/W	
Gain at V_{ht} = 1250 V	≈ $1,2 \times 10^5$	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 5)	< 5 nA typ. 0,5 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF	≈ 10%	1, 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 38%	1, 8
Peak to valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 40	1, 8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 0,5%	
long term (30 days)	≈ 1%	
after change of count rate	≈ 0,8%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,1% per K	
Anode pulse rise time at V_{ht} = 1500 V	≈ 11 ns	10
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 22 ns	10
Signal transit time at V_{ht} = 1500 V	≈ 54 ns	10
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 10 mA	11

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max. 2000 V	12
Continuous anode current	max. 0,2 mA	13
Voltage between first dynode and photocathode	max. 500 V min. 150 V	14
Voltage between accelerating electrode and photocathode	max. 500 V	
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V	15
Ambient temperature range operational (for short periods)	max. + 80 °C min. −30 °C	16
continuous operation and storage	max. + 50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS No. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4186 or equivalent) with a diameter of 76 mm and a height of 76 mm (3″ x 3″). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 1 μA and $\approx$ 0,1 μA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, whichever is lower.
13. A value of < 10 μA is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the input optics.
15. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
16. For type XP2412B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

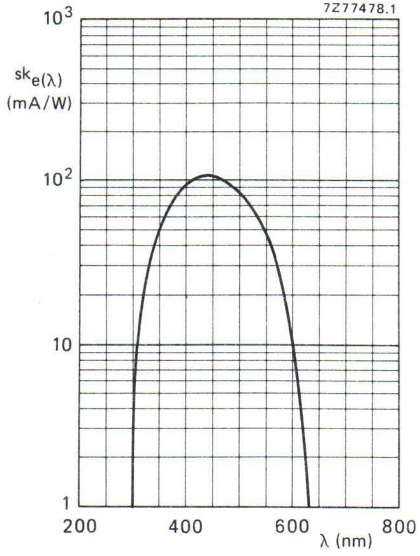


Fig. 2 Spectral sensitivity characteristic.

MECHANICAL DATA

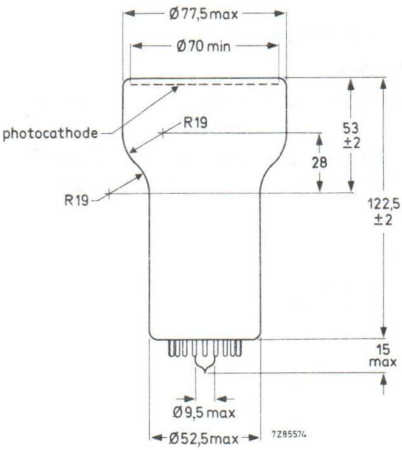


Fig. 3 XP2412.

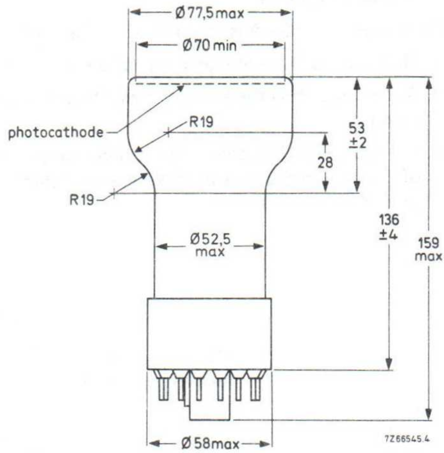
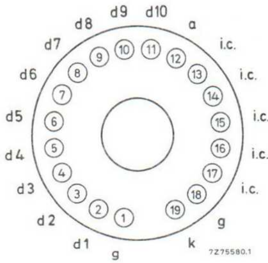


Fig. 4 XP2412B.

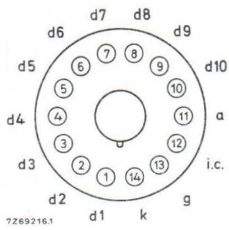
Base	19-pin all-glass
Net mass	163 g

Base	14-pin IEC 67-1-16a (JEDEC B14-38)
Net mass	206 g

PIN CONNECTIONS



XP2412



XP2412B

ACCESSORIES

Socket

for XP2412	type FE2019
for XP2412B	type FE1014

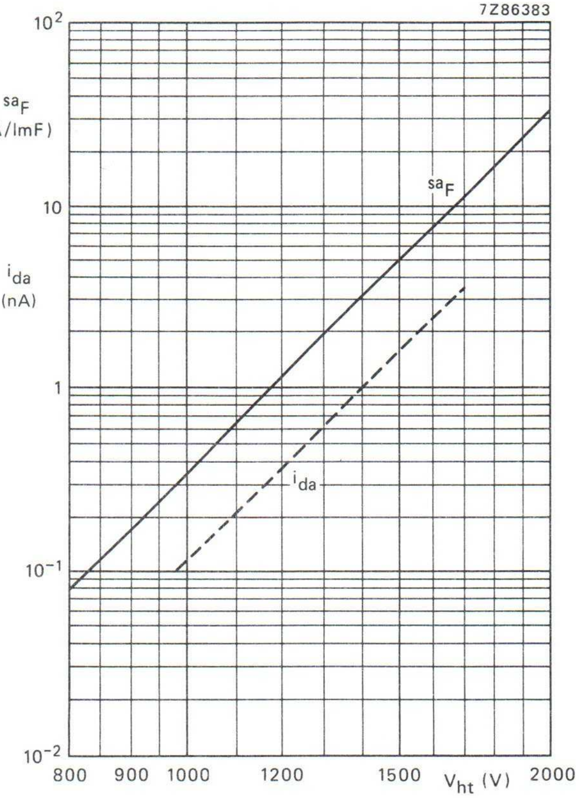


Fig. 5 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBES

- 56 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Very good pulse amplitude resolution
- Very low dark current
- Very good stability
- For nuclear medicine applications, e.g. gamma cameras

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 56 mm
Cathode blue sensitivity	12 μA/lmF
Supply voltage	
for anode blue sensitivity = 1,5 A/lmF	1250 V
Anode dark current	
at anode blue sensitivity = 1,5 A/lmF	0,5 nA
Pulse amplitude resolution (^{57}Co)	≈ 9,2%
Mean anode sensitivity deviation (30 days)	≈ 1%

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 56 mm	
Spectral sensitivity characteristic (Fig. 2)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 72 μA/lm	3
Blue sensitivity	typ. 12 μA/lmF > 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 90 mA/W	4

Multiplier system

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

Magnetic field

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

A mu-metal shield extending more than 15 mm beyond the cathode is recommended for magnetic screening.

RECOMMENDED CIRCUIT

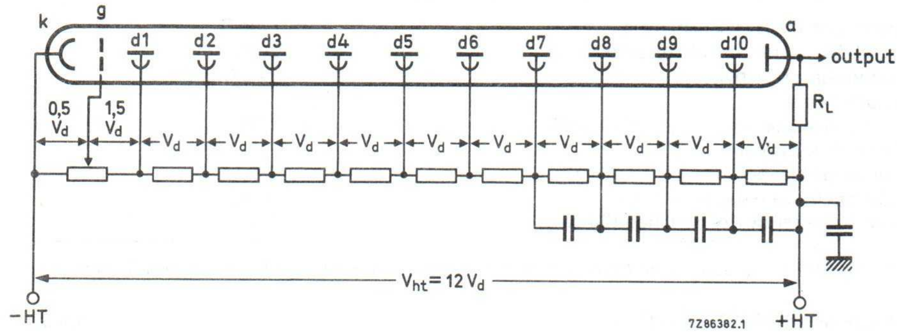


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

Note

For optimum pulse amplitude resolution, the accelerating-electrode potential should be between the cathode and first dynode potentials. If the accelerating electrode is connected to the first dynode, the pulse amplitude resolution for ^{57}Co is about 9,4%.

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 1)		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig.5)	< 1450 V typ. 1250 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1250 V	≈ 12 kA/W	
Gain at V_{ht} = 1250 V	≈ $1{,}3 \times 10^5$	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 5)	< 5 nA typ. 0,5 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF	≈ 9,2%	1, 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 38%	1, 8
Peak to valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 40	1,8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 0,5%	
long term (30 days)	≈ 1%	
after change of count rate	≈ 0,8%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,1% per K	
Anode pulse rise time at V_{ht} = 1500 V	≈ 10 ns	10
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 20 ns	10
Signal transit time at V_{ht} = 1500 V	≈ 46 ns	10
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 10 mA	11

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max. 2000 V	12
Continuous anode current	max. 0,2 mA	13
Voltage between first dynode and photocathode	max. 500 V min. 150 V	14
Voltage between accelerating electrode and photocathode	max. 500 V	
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V	15
Ambient temperature range		
operational (for short periods)	max. +80 °C min. −30 °C	16
continuous operation and storage	max. +50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4856 or equivalent) with a diameter of 50 mm and a height of 50 mm (2″ x 2″). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of ≈ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of ≈ 1 μA and ≈ 0,1 μA respectively. Both tests are carried out according to ANSI−N42−9−1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, whichever is lower.
13. A value of < 10 μA is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the input optics.
15. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
16. For type XP2432B this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

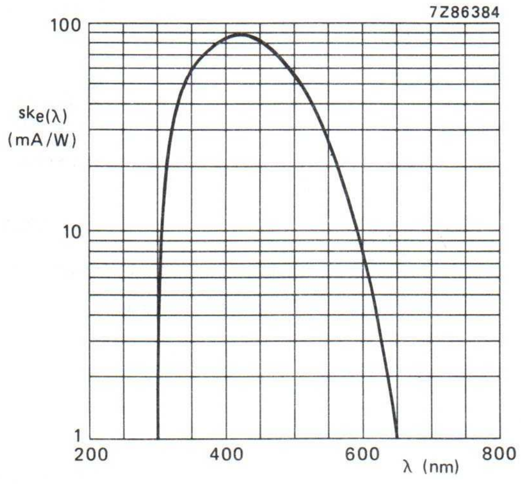


Fig. 2 Spectral sensitivity characteristic.

MECHANICAL DATA

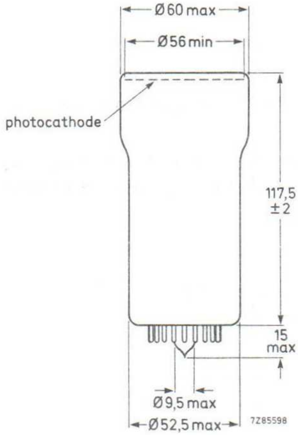


Fig. 3 XP2432.

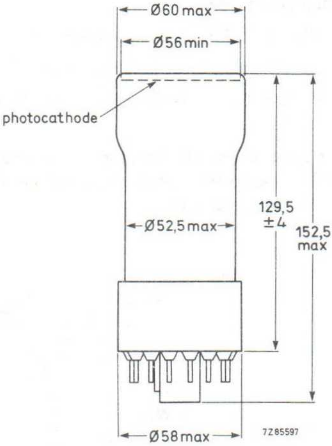
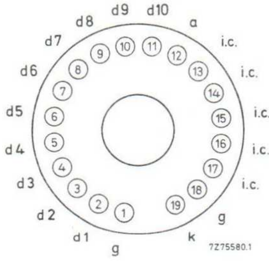


Fig. 4 XP2432B.

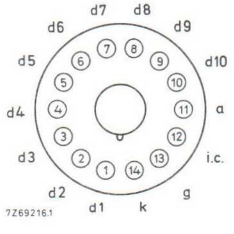
Base	19-pin all-glass
Net mass	146 g

Base	14-pin IEC 67-1-16a (JEDEC B14-38)
Net mass	189 g

PIN CONNECTIONS



XP2432



XP2432B

ACCESSORIES

Socket

for XP2432	type FE2019
for XP2432B	type FE1014

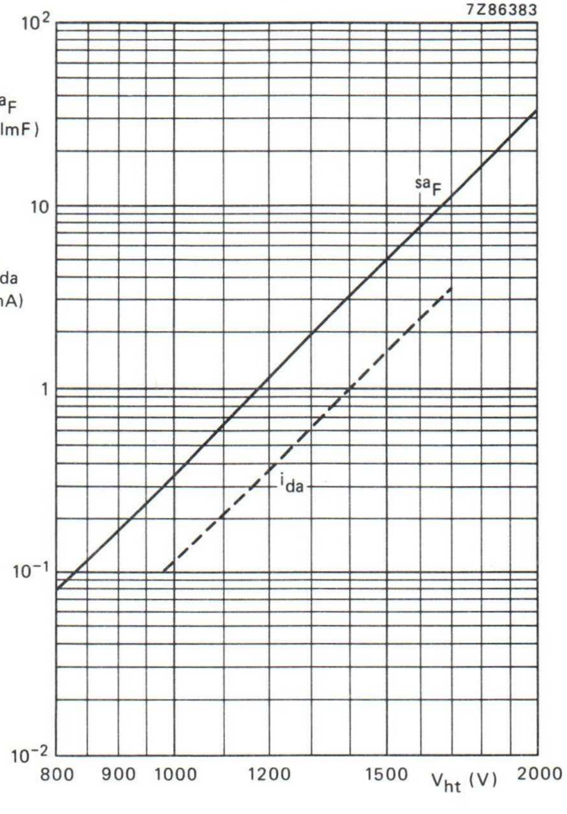


Fig. 5 Anode spectral sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

8-STAGE PHOTOMULTIPLIER TUBE

- 23 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- Very good time characteristics
- For e.g. high-energy physics, scintillation counting.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 23 mm
Cathode blue sensitivity	10,8 μA/lmF
Supply voltage for anode blue sensitivity = 1 A/lmF	1100 V
Anode pulse rise time (with voltage divider B)	≈ 1,8 ns
Linearity	
with voltage divider A (Fig. 2)	≈ 20 mA
with voltage divider B (Fig. 3)	≈ 80 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-concave	
Refractive index at 400 mm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 23 mm	
Spectral sensitivity characteristic (Fig. 5)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 65 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 75 mA/W	4

Multiplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	Cu Be
Capacitances	
anode to final dynode	≈ 2 pF
anode to all	≈ 4 pF

Magnetic field

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

0,4 mT perpendicular to axis a (Fig. 1);
0,2 mT parallel to axis a.

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

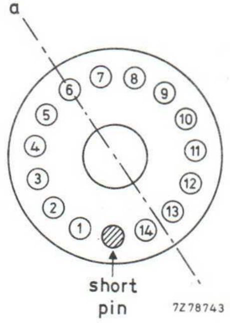


Fig. 1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

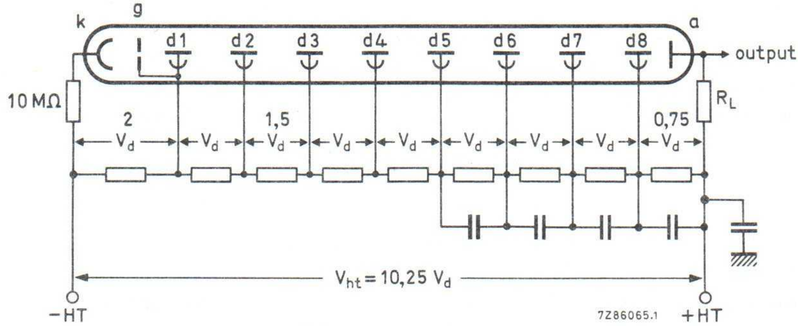


Fig. 2 Voltage divider A.

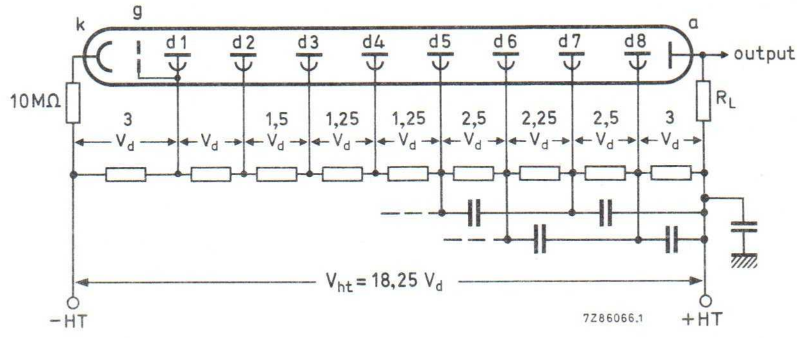


Fig. 3 Voltage divider B.

DEVELOPMENT SAMPLE DATA

k = cathode
g = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 1 nF

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between an outer coating and earth when the anode is earthed.

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		5
Supply voltage for an anode blue sensitivity of 1 A/lmF	< 1500 V typ. 1100 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1100 V	≈ 7 kA/W	
Gain at V_{ht} = 1100 V (Fig. 6)	≈ $9{,}3 \times 10^4$	
Anode dark current at an anode blue sensitivity of 1 A/lmF (Fig. 6)	< 5 nA typ. 1 nA	6,7
Anode pulse rise time at V_{ht} = 1300 V	≈ 2 ns	8
Anode pulse duration at half height at V_{ht} = 1300 V	≈ 3 ns	8
Signal transit time at V_{ht} = 1300 V	≈ 20 ns	8
Anode current linear within 2% at V_{ht} = 1300 V	up to ≈ 20 mA	
With voltage divider B (Fig. 3)		5
Gain at V_{ht} = 1500 V (Fig. 6)	≈ 2×10^5	
Anode pulse rise time at V_{ht} = 1500 V	≈ 1,8 ns	8
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 2,8 ns	8
Signal transit time at V_{ht} = 1500 V	≈ 20 ns	8
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 80 mA	

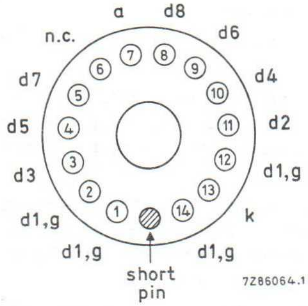
LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max. 1800 V	
Continuous anode current	max. 0,2 mA	
Voltage between first dynode and photocathode	max. 350 V min. 150 V	9
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	10
Ambient temperature range		
operational (for short periods of time)	max. +80 °C min. −30 °C	
continuous operation and storage	max. +50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at -30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at $-$HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
8. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA



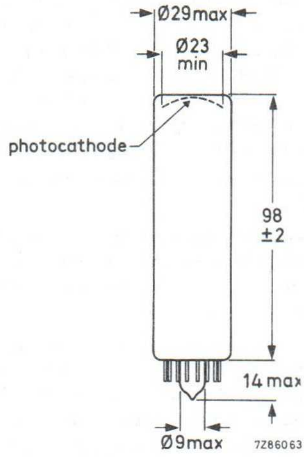


Fig. 4.

Base	14-pin all-glass
Net mass	34 g

ACCESSORIES

Socket	type FE1114

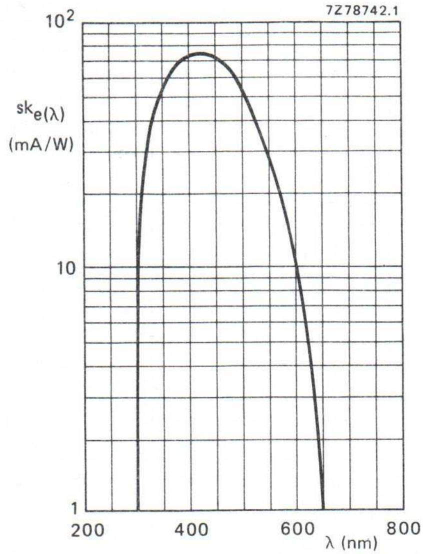


Fig. 5 Spectral sensitivity characteristic.

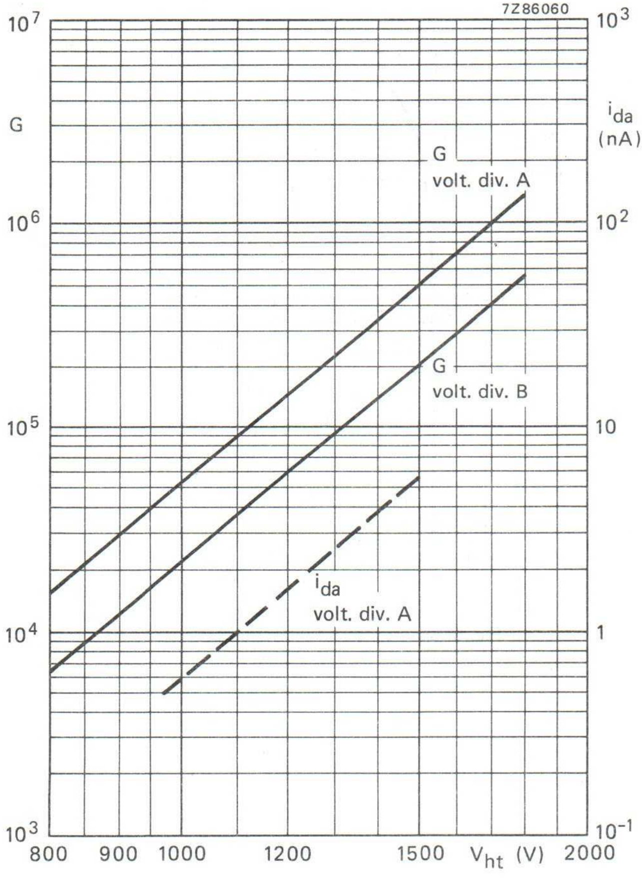


Fig. 6 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

8-STAGE PHOTOMULTIPLIER TUBE

- 23 mm useful diameter head-on type
- Flat window
- Semi-transparent tri-alkaline S20 (type T) photocathode
- Very good time characteristics
- For industrial applications, e.g. laser reading

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S20 (type T)
Useful diameter of the photocathode	> 23 mm
Spectral sensitivity of the cathode at 700 nm	20 mA/W
Supply voltage for anode luminous sensitivity = 6 A/lm	1120 V
Anode pulse rise time (with voltage divider B)	≈ 1,8 ns
Linearity, with voltage divider B (Fig. 3)	≈ 80 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	borosilicate	
Shape	plano-concave	
Refractive index at 550 nm	1,48	
Photocathode		
Semi-transparent, head-on		
Material	SbNaKCs	
Useful diameter	> 23 mm	
Spectral sensitivity characteristic (Fig. 4)	S20 (type T)	
Maximum spectral sensitivity	420 ± 30 nm	
Luminous sensitivity	≈ 200 μA/lm	1
Spectral sensitivity at 700 nm	typ. 20 mA/W > 10 mA/W	2
Spectral sensitivity at 630 nm	≈ 40 mA/W	2

Multiplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 2 pF
anode to all	≈ 4 pF

Magnetic field

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

0,4 mT perpendicular to axis a (Fig. 1);
0,2 mT parallel with axis a.

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

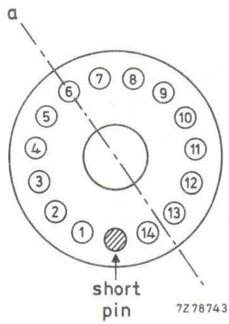


Fig. 1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

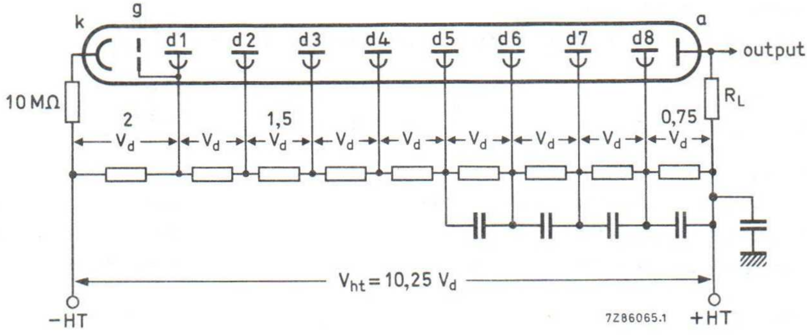


Fig. 2 Voltage divider A.

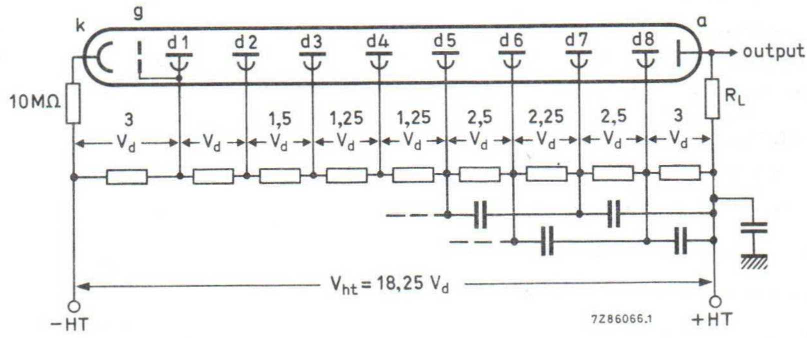


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 1 nF

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		3
Supply voltage for an anode luminous sensitivity of 6 A/lm (Fig. 6)	< 1300 V typ. 1120 V	1
Gain at V_{ht} = 1120 V	≈ 3 x 10^4	
Anode dark current at an anode luminous sensitivity of 6 A/lm (Fig. 6)	< 5 nA typ. 1 nA	4,5
Anode pulse rise time at V_{ht} = 1300 V	≈ 2 ns	6
Anode pulse duration at half height at V_{ht} = 1300 V	≈ 3 ns	6
Signal transit time at V_{ht} = 1300 V	≈ 20 ns	6
Anode current linear within 2% at V_{ht} = 1300 V	up to ≈ 20 mA	
With voltage divider B (Fig. 3)		3
Anode luminous sensitivity at V_{ht} = 1500 V (Fig. 6)	≈ 7 A/lm	
Anode pulse rise time at V_{ht} = 1500 V	≈ 1,8 ns	6
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 2,8 ns	6
Signal transit time at V_{ht} = 1500 V	≈ 20 ns	6
Anode current linear within 2% at V_{ht} = 1500 V	up to ≈ 80 mA	

LIMITING VALUES (Absolute maximum rating system)

		notes
Supply voltage	max. 1800 V	7
Continuous anode current	max. 0,2 mA	8
Voltage between first dynode and photocathode	max. 350 V min. 150 V	9
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	10
Ambient temperature range		
operational (for short periods of time)	max. + 80 °C min. −30 °C	
continuous operation and storage	max. + 50 °C min. −30 °C	

NOTES

1. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
2. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter.
3. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
4. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\,\Omega$.
5. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
6. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
7. Total HT supply voltage or the voltage at which the tube has an anode luminous sensitivity of ≈ 120 A/lm (test certificate voltage multiplied by 1,65), whichever is lower.
8. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
9. Minimum value to obtain good collection in the input optics.
10. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

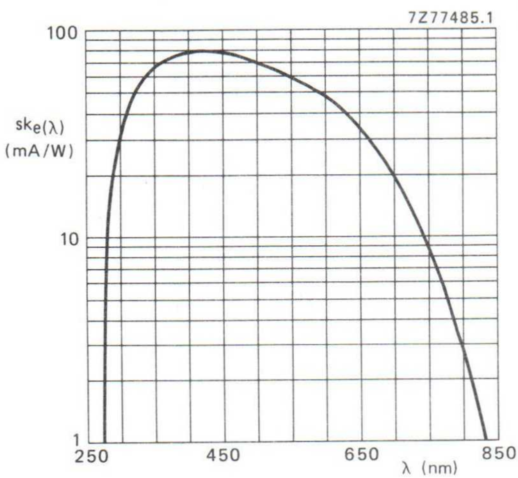


Fig. 4 Spectral sensitivity characteristic

MECHANICAL DATA

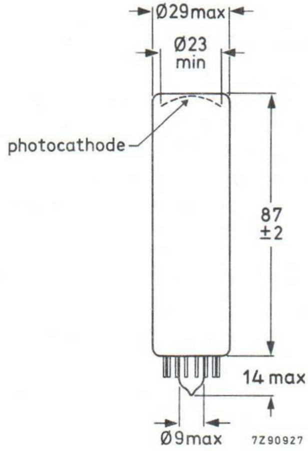
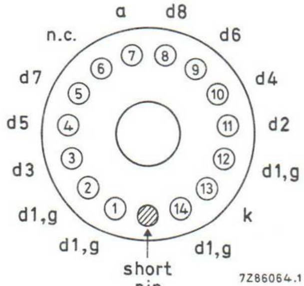


Fig. 5

Base	14-pin all-glass
Net mass	32 g

PIN CONNECTIONS



ACCESSORIES

Socket type FE1114

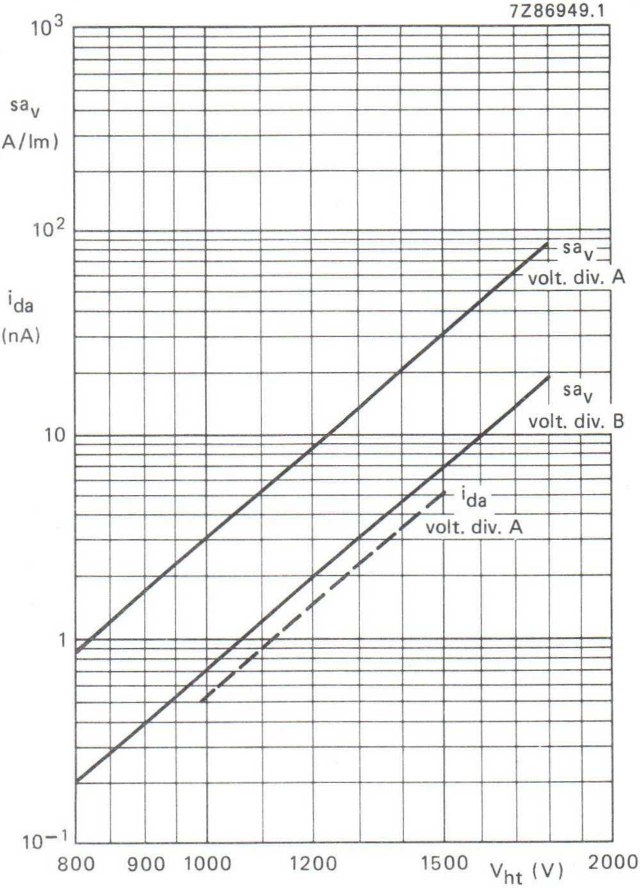


Fig. 6 Anode luminous sensitivity sa_v and anode dark current i_{da} as a function of the supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

10-STAGE PHOTOMULTIPLIER TUBE

- 23 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- For high-energy physics and scintillation counting where good time characteristics are required, e.g. coincidence measurements and Cerenkov light detection
- Pin-compatible with XP1980

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 23 mm
Cathode blue sensitivity	10,8 μA/lmF
Supply voltage for anode blue sensitivity = 10 A/lmF	1300 V
Pulse amplitude resolution for ^{137}Cs	≈ 7,7%
Anode pulse rise time (with voltage divider B)	≈ 1,9 ns
Linearity with voltage divider A (Fig. 2) with voltage divider B (Fig. 3)	 ≈ 30 mA ≈ 80 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-concave	
Refractive index at 400 nm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 23 mm	
Spectral sensitivity characteristic (Fig. 5)	type D	
Wavelength for maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 65 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 75 mA/W	4

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

Magnetic field

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

0,4 mT perpendicular to axis a (see Fig. 1);
0,2 mT parallel to axis a.

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

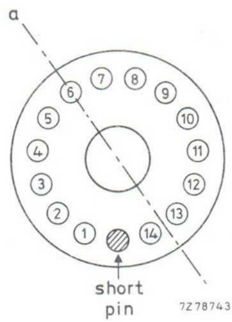


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

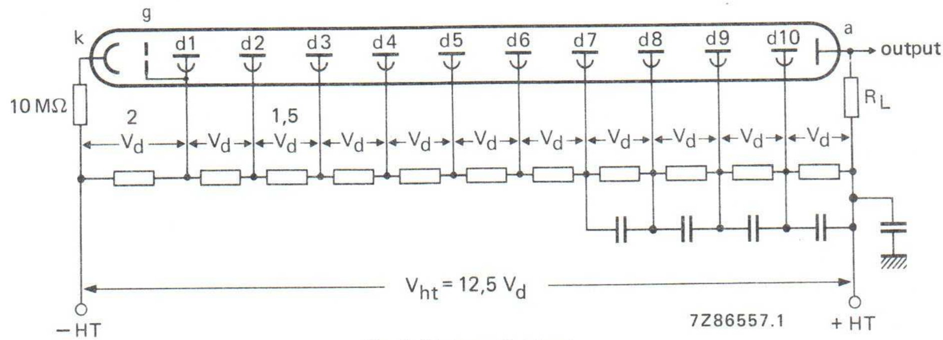


Fig. 2 Voltage divider A.

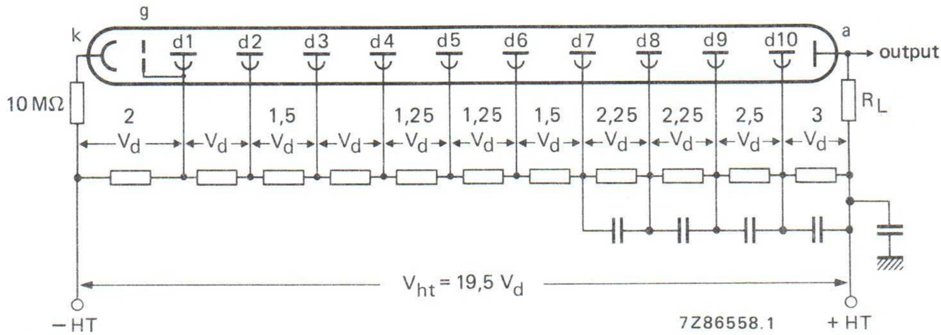


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 1 nF

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between an outer coating and earth when the anode is earthed.

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		5
Supply voltage for an anode blue sensitivity of 10 A/lmF	< 1600 V typ. 1300 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1300 V	≈ 70 kA/W	
Gain at V_{ht} = 1300 V (Fig. 7)	≈ 0,9 x 10^6	
Anode dark current at an anode blue sensitivity of 10 A/lmF	< 20 nA typ. 1 nA	6,7
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 10 A/lmF	≈ 7,7%	8
Anode pulse rise time at V_{ht} = 1500 V	≈ 2,1 ns	9
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 3,5 ns	9
Signal transit time at V_{ht} = 1500 V	≈ 23 ns	9
Anode current-linear within 2% at V_{ht} = 1500 V	up to ≈ 30 mA	
With voltage divider B (Fig. 3)		5
Gain at V_{ht} = 1800 V (Fig. 7)	≈ 3 x 10^6	
Anode pulse rise time at V_{ht} = 1800 V	≈ 1,9 ns	9
Anode pulse duration at half height at V_{ht} = 1800 V	≈ 3,0 ns	9
Signal transit time at V_{ht} = 1800 V	≈ 23 ns	9
Signal transit time difference between the centre of the photocathode and 11 mm from the centre at V_{ht} = 1800 V	≈ 0,8 ns	9
Anode current linear within 2% at V_{ht} = 1800 V	up to ≈ 80 mA	

LIMITING VALUES (Absolute maximum rating system)

		notes
Supply voltage	max. 1900 V	10
Continuous anode current	max. 0,2 mA	
Voltage between first dynode and photocathode	max. 350 V min. 150 V	11
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	12
Ambient temperature range		
operational (for short periods of time)	max. + 80 °C min. −30 °C	
continuous operation and storage	max. + 50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage.
   The envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
8. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 1162 or equivalent) with a diameter of 22 mm and a height of 6 mm. The count rate used is $\approx 10^4$ c/s.
9. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
10. Total HT supply voltage, or the voltage at which the tube has a gain of 2×10^7, whichever is lower.
11. Minimum value to obtain good collection in the input optics.
12. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

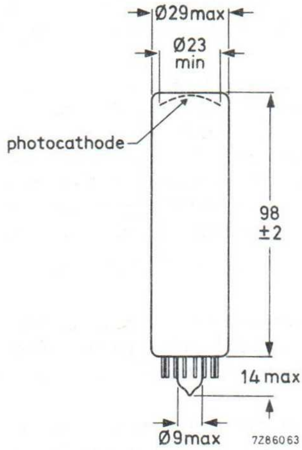
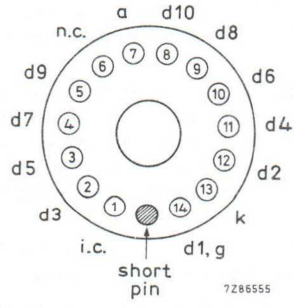


Fig. 4.

Base	14-pin all-glass
Net mass	34 g

PIN CONNECTIONS



ACCESSORIES

Socket	type FE1114

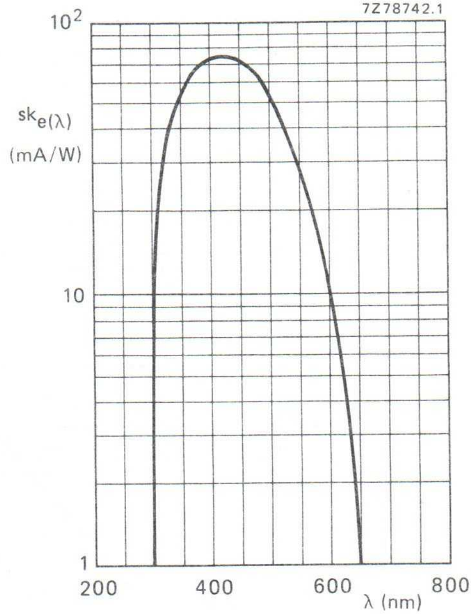


Fig. 5 Spectral sensitivity characteristic.

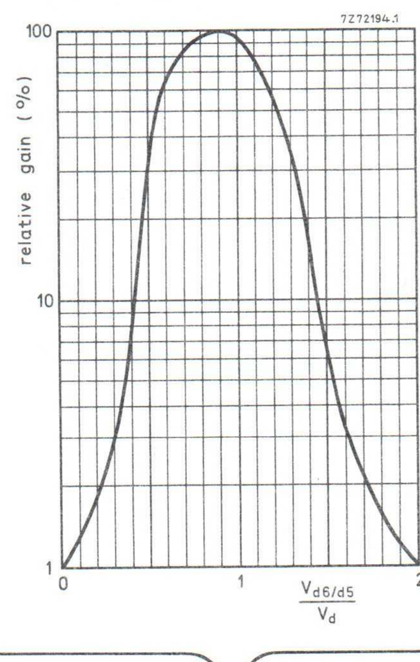


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

Note: Gain regulation by changing the voltage between d6 and d5 may cause a degradation of other parameters such as stability and linearity.

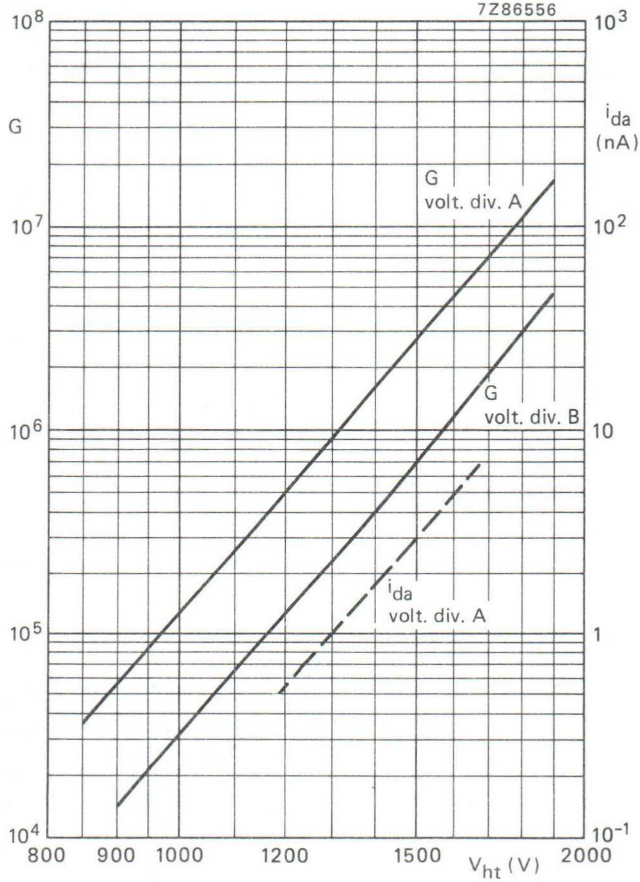


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

11-STAGE PHOTOMULTIPLIER TUBE

- 23 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- For high-energy physics and scintillation counting where good time characteristics are required, e.g. coincidence measurements and Cerenkov light detection.
- Pin-compatible with XP1982

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 23 mm
Cathode blue sensitivity	10,8 μA/lmF
Supply voltage for anode blue sensitivity = 30 A/lmF	1350 V
Pulse amplitude resolution for ^{137}Cs	≈ 7,7%
Anode pulse rise time (with voltage divider B)	≈ 1,9 ns
Linearity with voltage divider A (Fig. 2) with voltage divider B (Fig. 3)	 ≈ 30 mA ≈ 80 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-concave	
Refractive index at 400 nm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 23 mm	
Spectral sensitivity characteristic (Fig. 5)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 65 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 75 mA/W	4

Multiplier system

Number of stages	11
Dynode structure	linear focused
Dynode material	Cu Be
Capacitances	
anode to final dynode	≈ 2 pF
anode to all	≈ 4 pF

Magnetic field

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

0,4 mT perpendicular to axis a (see Fig. 1);
0,2 mT parallel to axis a.

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

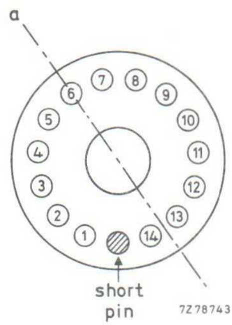


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

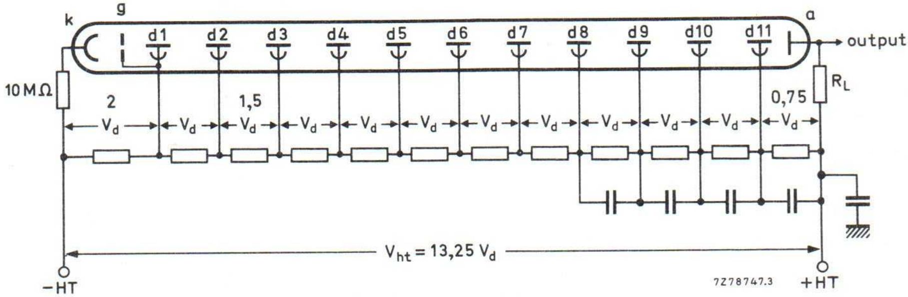


Fig. 2 Voltage divider A.

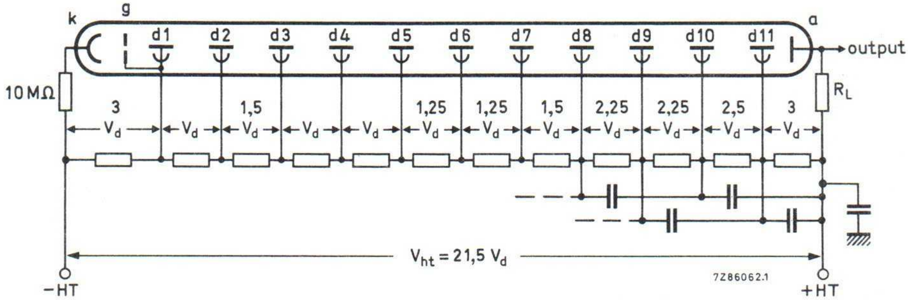


Fig. 3 Voltage divider B.

k = cathode
g = accelerating electrode
dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 1 nF

The cathode resistor of 10 MΩ limits the current should there be unintentional contact between the coating and earth when the anode is earthed.

TYPICAL CHARACTERISTICS

			notes
With voltage divider A (Fig. 2)			5
Supply voltage for an anode blue sensitivity of 30 A/lmF		< 1650 V typ. 1350 V	1
Anode radiant sensitivity at 400 nm and V_{ht} = 1350 V		≈ 210 kA/W	
Gain at V_{ht} = 1350 V (Fig. 7)		≈ $2,7 \times 10^6$	
Anode dark current at an anode blue sensitivity of 30 A/lmF		< 25 nA typ. 2,5 nA	6,7
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 10 A/lmF		≈ 7,7%	8
Anode pulse rise time at V_{ht} = 1500 V		≈ 2,2 ns	9
Anode pulse duration at half height at V_{ht} = 1500 V		≈ 3,7 ns	9
Signal transit time at V_{ht} = 1500 V		≈ 25 ns	9
Anode current linear within 2% at V_{ht} = 1500 V		up to ≈ 30 mA	
With voltage divider B (Fig. 3)			5
Gain at V_{ht} = 1800 V (Fig. 7)		≈ $6,5 \times 10^6$	
Anode pulse rise time at V_{ht} = 1800 V		≈ 1,9 ns	9
Anode pulse duration at half height at V_{ht} = 1800 V		≈ 3,3 ns	9
Signal transit time at V_{ht} = 1800 V		≈ 25 ns	9
Signal transit time difference between the centre of the photocathode and 11 mm from the centre at V_{ht} = 1800 V		≈ 0,8 ns	9
Signal transit time distribution at V_{ht} = 1800 V	σ	≈ 0,3 ns	9,10
Anode current linear within 2% at V_{ht} = 1800 V		up to ≈ 80 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max. 2000 V	11
Continuous anode current	max. 0,2 mA	
Voltage between first dynode and photocathode	max. 350 V min. 150 V	12
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	13
Ambient temperature range		
operational (for short periods of time)	max. + 80 °C min. −30 °C	
continuous operation and storage	max. + 50 °C min. −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity. In applications with short pulse times the photocathode is able to deliver pulses containing 10^6 to 10^7 photoelectrons without disturbance.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Divider circuit B is an example of a "progressive" divider, giving a compromise between gain, speed, and linearity. Other dividers can be conceived to achieve other compromises after consulting the supplier.
6. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used this be kept at photocathode potential. This implies safety precautions to protect the user. The envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\ \Omega$.
7. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
8. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator (Quartz et Silice serial no. 1162 or equivalent) with a diameter of 22 mm and a height of 6 mm. The count rate used is $\approx 10^4$ c/s.
9. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
10. Transit time fluctuations of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation σ.
11. Total HT supply voltage, or the voltage at which the tube has a gain of 3×10^7, whichever is lower.
12. Minimum value to obtain good collection in the input optics.
13. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.

MECHANICAL DATA

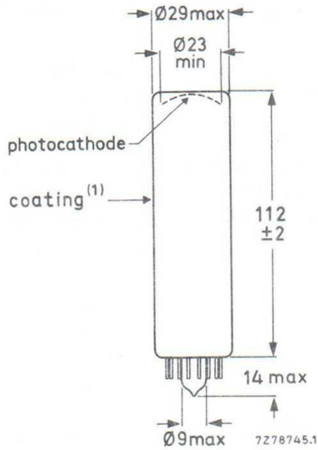
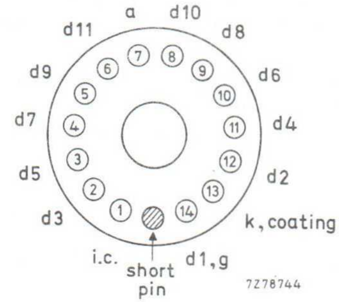


Fig. 4

Base	14-pin all-glass
Net mass	37 g

PIN CONNECTIONS



ACCESSORIES

Socket type FE1114

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. On top of this a black paint is applied which is neither guaranteed to be light tight nor isolating. Care should be taken to avoid electrical shock.

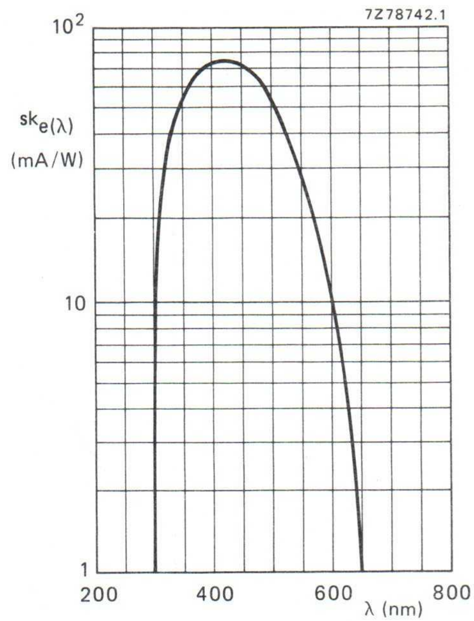


Fig. 5 Spectral sensitivity characteristic.

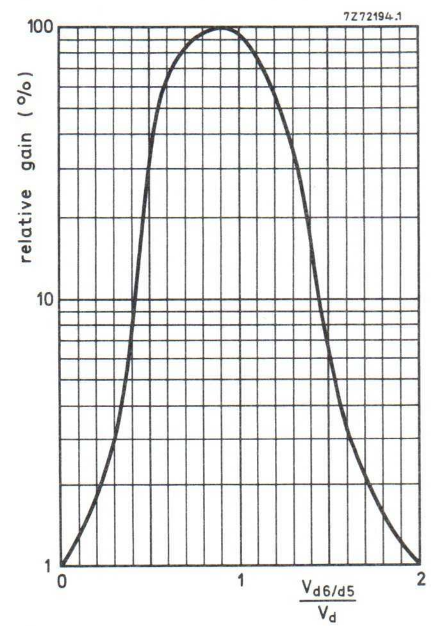


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

Note: Gain regulation by changing the voltage between d6 and d5 may cause a degradation of other parameters such as stability and linearity

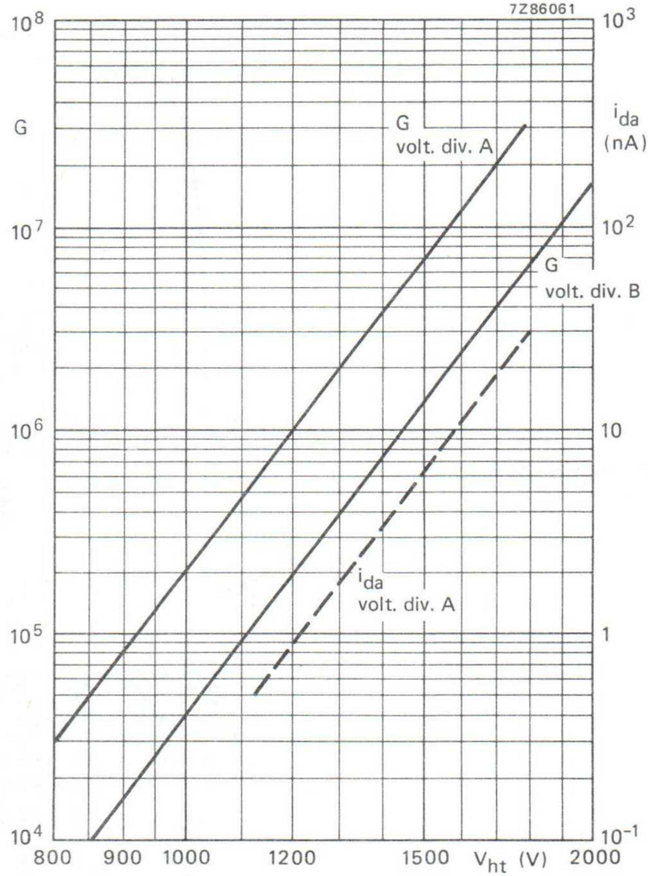


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

XP3102 replaces XP2102
XP3102B replaces XP2102B

8-STAGE PHOTOMULTIPLIER TUBES

- 46 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Very good pulse amplitude resolution
- Very low dark current
- Very good stability
- For nuclear medicine applications, e.g. gamma cameras

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful diameter of the photocathode	> 46 mm
Cathode blue sensitivity	11,8 μA/lmF
Supply voltage for anode blue sensitivity = 1,5 A/lmF	950 V
Anode dark current at anode blue sensitivity = 1,5 A/lmF	0,5 nA
Pulse amplitude resolution (^{57}Co)	≈ 9,3%
Mean anode sensitivity deviation (30 days)	≈ 1%

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

GENERAL CHARACTERISTICS

Window

		notes
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1,54	

Photocathode

		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 46 mm	
Spectral sensitivity characteristic (Fig. 4)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lmF	3
Blue sensitivity	typ. 11,8 μA/lmF > 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 90 mA/W	4

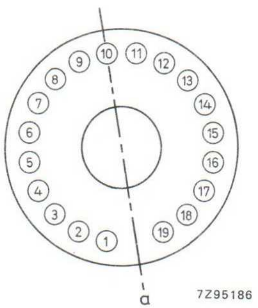
Multiplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

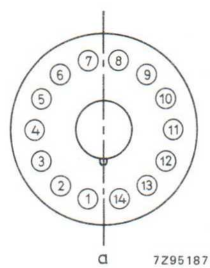
Magnetic field, Fig. 1

When the photocathode is uniformly illuminated the anode current is halved (at V_{ht} = 1200 V)
– at a magnetic flux density of 0,15 mT perpendicular to the tube axis and to axis a;
– at a magnetic flux density of 0,3 mT perpendicular to the tube axis and parallel to axis a.

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



XP3102.



XP3102B.

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

RECOMMENDED CIRCUITS

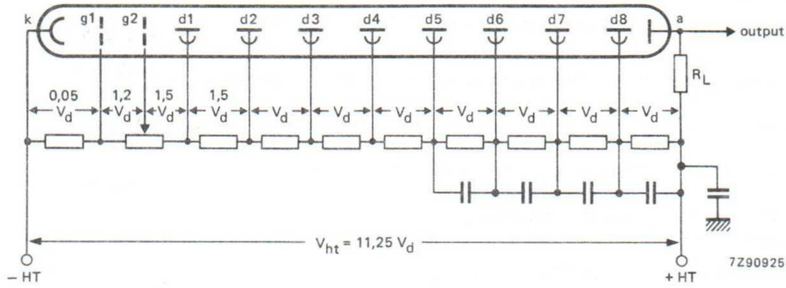


Fig. 2 Voltage divider A.

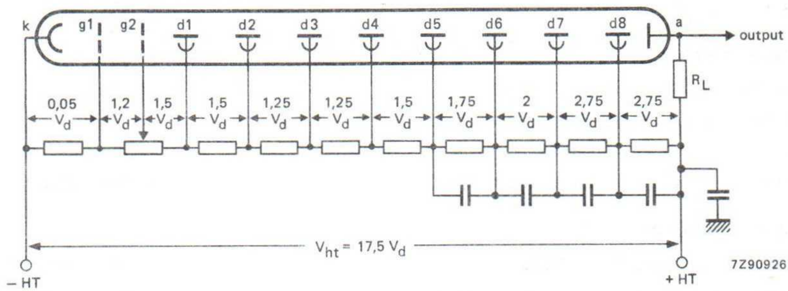


Fig. 3 Voltage divider B.

k = cathode
g1 = focusing electrode 1
g2 = accelerating electrode 2

dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig. 7)	< 1250 V typ. 950 V	1
Supply voltage for an anode blue sensitivity of 7,5 A/lmF (≈ 60 kA/W)	≈ 1250 V < 1600 V	
Gain at V_{ht} = 950 V	≈ 1,3 x 10^5	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 7)	< 5 nA typ. 0,5 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF	≈ 9,3%	1, 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 37%	1, 8
Peak-to-valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 40	1, 8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 0,5%	
long term (30 days)	≈ 1%	
after change of count rate	≈ 0,8%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,1% per K	
Anode pulse rise time at V_{ht} = 1200 V	≈ 3 ns	10
Anode pulse duration at half height at V_{ht} = 1200 V	≈ 4,5 ns	10
Signal transit time at V_{ht} = 1200 V	≈ 34 ns	10
Anode current linear within 2% at V_{ht} = 1200 V	up to ≈ 50 mA	
With voltage divider B (Fig. 3)		11
Anode blue sensitivity at V_{ht} = 1600 V	≈ 9,5 A/lmF	
Anode current linear within 2% at V_{ht} = 1600 V	up to ≈ 200 mA	

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max. 1700 V	12
Continuous anode current	max. 0,2 mA	13
Voltage between first dynode and photocathode	max. 500 V min. 150 V	14
Voltage between focusing electrode g_1 and photocathode	max. 20 V	
Voltage between accelerating electrode g_2 and photocathode	max. 500 V	
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V	15
Ambient temperature range		
operational (for short periods)	max. + 80 °C min. −30 °C	16
continuous operation and storage	max. + 50 °C min. −30 °C	

DEVELOPMENT SAMPLE DATA

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that is should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}\,\Omega$.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4856 or equivalent) with a diameter of 50 mm and a height of 50 mm (2" x 2"). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx$ 1 μA and $\approx$ 0,1 μA respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, (voltage for 1,5 A/lmF given on the test certificate, multiplied by 1,7), whichever is lower. For applications where dark current is critical, a maximum sensitivity of 15 A/lmF is recommended (voltage for 1,5 A/lmF, multiplied by 1,45).
13. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the input optics.
15. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
16. For type XP3102B this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

Interchangeability

The pinnings of these 8-stage linear focused photomultiplier tubes have been designed to facilitate exchangeability of old 10-stage venetian blind types.
The best performance will be obtained by using their own voltage divider but they can be directly mounted in sockets wired for the old types, involving only minor degraded characteristics.

When mounting XP3102 in sockets wired for XP2102 the cathode connection is secured by the electrode g1, connected to the cathode via the internal bialkali layer.
XP3102B can also be mounted in sockets wired for XP2202B but pin 13 (g2) has to be connected properly.

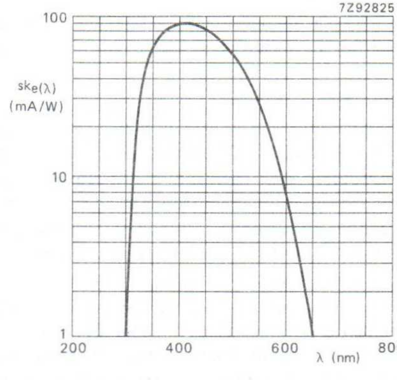


Fig. 4 Spectral sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm

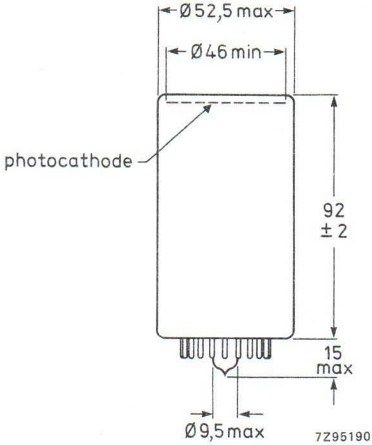


Fig. 5 XP3102.

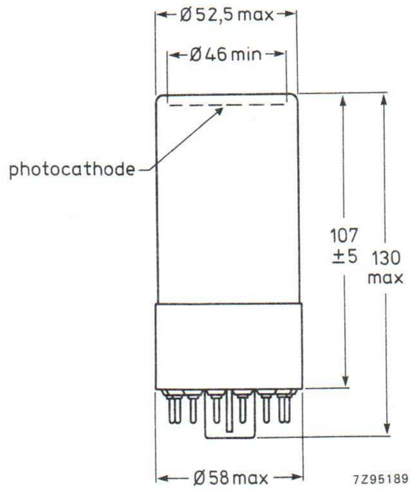
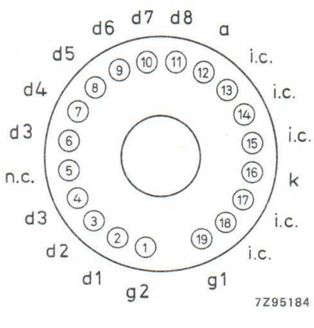


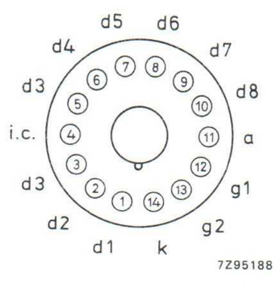
Fig. 6 XP3102B.

Base	19-pin all-glass
Net mass	100 g

Base	14-pin IEC 67-1-16a (JEDEC B14-38)
Net mass	145 g

PIN CONNECTIONS





ACCESSORIES

Socket

for XP3102	type FE2019
for XP3102B	type FE1014

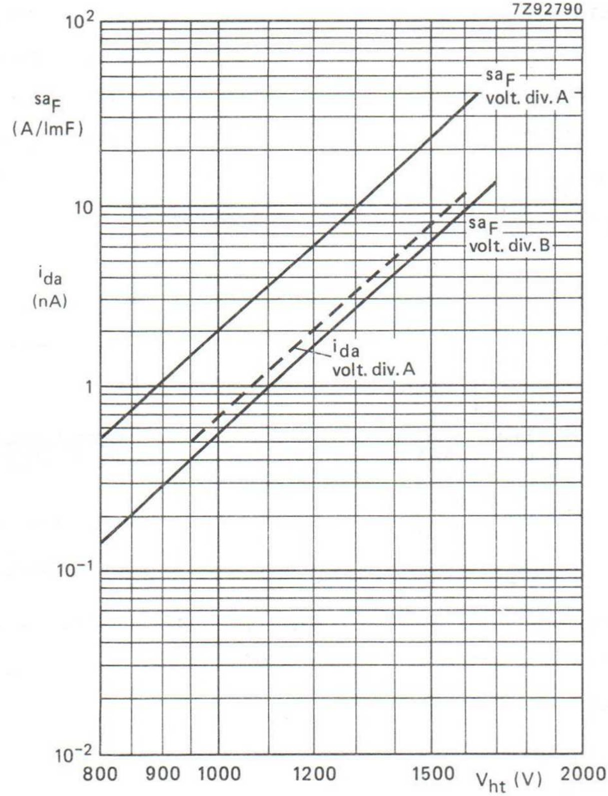


Fig. 7 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

XP3202 replaces XP2202
XP3202B replaces XP2202B

8-STAGE PHOTOMULTIPLIER TUBES

- 46 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Good pulse amplitude resolution
- Low dark current
- Good stability
- For scintillation detection applications, laboratory and industrial photometry

QUICK REFERENCE DATA

Spectral sensitivity characteristic		type D
Useful diameter of the photocathode		> 46 mm
Cathode blue sensitivity		11,5 μA/mF
Supply voltage for anode blue sensitivity = 1,5 A/lmF		950 V
Anode dark current at anode blue sensitivity = 1,5 A/lmF		1 nA
Pulse amplitude resolution (^{137}Cs)		≈ 7,2%
Linearity with voltage divider B	up to	≈ 200 mA

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

GENERAL CHARACTERISTICS

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 mm	1,54	
Photocathode		2
Semi-transparent, head-on		
Material	Sb K Cs	
Useful diameter	> 46 mm	
Spectral sensitivity characteristic (Fig. 4)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lmF	3
Blue sensitivity	typ. 11,5 μA/lmF > 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 85 mA/W	4

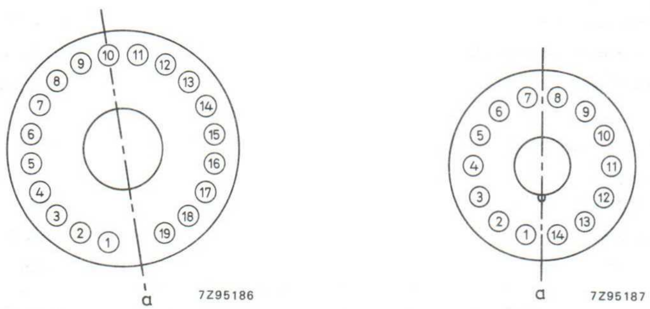
Multiplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

Magnetic field, Fig. 1

When the photocathode is uniformly illuminated the anode current is halved (at V_{ht} = 1200 V)
– at a magnetic flux density of 0,15 mT perpendicular to the tube axis and to axis a;
– at a magnetic flux density of 0,3 mT perpendicular to the tube axis and parallel to axis a.

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



XP3202 XP3202B

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

RECOMMENDED CIRCUITS

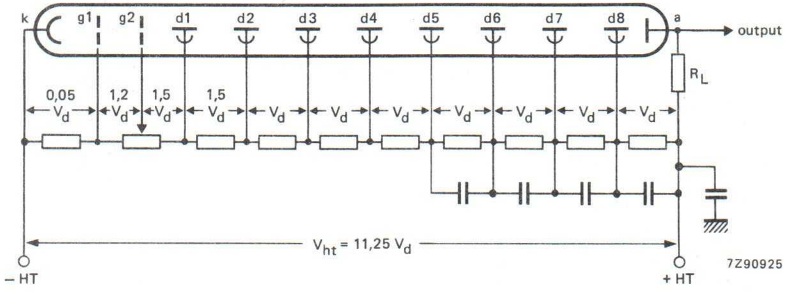


Fig. 2 Voltage divider A.

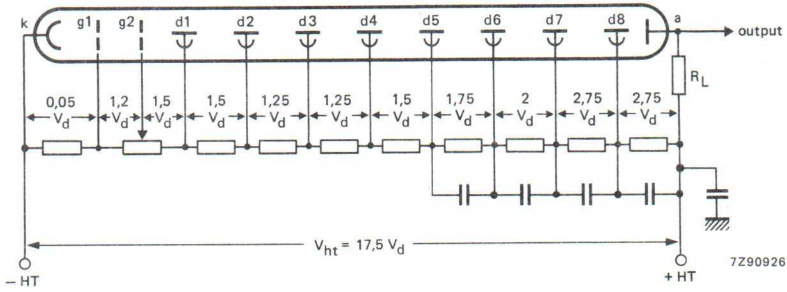


Fig. 3 Voltage divider B.

k = cathode
g1 = focusing electrode
g2 = accelerating electrode

Typical value of capacitors: 10 nF

dn = dynode no.
a = anode
R_L = load resistor

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig. 7)	< 1250 V typ. 950 V	1
Supply voltage for an anode sensitivity of 7,5 A/lmF (≈ 60 kA/W)	≈ 1250 < 1600 V	
Gain at V_{ht} = 950 V	≈ 1,3 x 10^5	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 7)	< 5 nA typ. 1 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7,2%	1, 7
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 42%	1, 8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 1%	
after change of count rate	≈ 1%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,2% per K	
Anode pulse rise time at V_{ht} = 1200 V	≈ 3 ns	10
Anode pulse duration at half height at V_{ht} = 1200 V	≈ 4,5 ns	10
Signal transit time at V_{ht} = 1200 V	≈ 34 ns	10
Anode current linear within 2% at V_{ht} = 1200 V	up to ≈ 50 mA	
With voltage divider B (Fig. 3)		11
Anode blue sensitivity at V_{ht} = 1600 V	≈ 9,5 A/lmF	
Anode current linear within 2% at V_{ht} = 1600 V	up to ≈ 200 mA	

LIMITING VALUES (absolute maximum rating system)

			notes
Supply voltage	max.	1700 V	12
Continuous anode current	max.	0,2 mA	13
Voltage between first dynode and photocathode	max. min.	500 V 150 V	14
Voltage between focusing electrode g_1 and photocathode	max.	20 V	
Voltage between accelerating electrode g_2 and photocathode	max.	500 V	
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max.	300 V	15
Ambient temperature range operational (for short periods)	max. min.	+80 °C −30 °C	16
continuous operation and storage	max. min.	+50 °C −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that is should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only be insulation resistance of $> 10^{15}\ \Omega$.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4856 or equivalent) with a diameter of 50 mm and a height of 50 mm (2" x 2"). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The means anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu$A and $\approx 0{,}1\ \mu$A respectively. Both tests are carried out according to ANSI–N42–9–1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, (voltage for 1,5 A/lmF given on the test certificate, multiplied by 1,7), whichever is lower. For applications where dark current is critical, a maximum sensitivity of 15 A/lmF is recommended (voltage for 1,5 A/lmF, multiplied by 1,45).
13. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the output optics.
15. When calculating the anode voltage the voltage drop across the load resistor ahould be taken into account.
16. For type XP3202B this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

Interchangeability

The pinnings of these 8-stage linear focused photomultiplier tubes have been designed to facilitate exchangeability of XP2202 and XP2202B.
The best performance will be obtained by using their own voltage divider. They can be directly mounted in sockets wired for the old types, involving only minor degraded characteristics. It is, however, advisable to connect at least g2 properly.
When mounting XP3202 in Sockets wired for XP2202 the cathode connection is secured by the electrode g1, connected to the cathode via the internal bialkali layer.

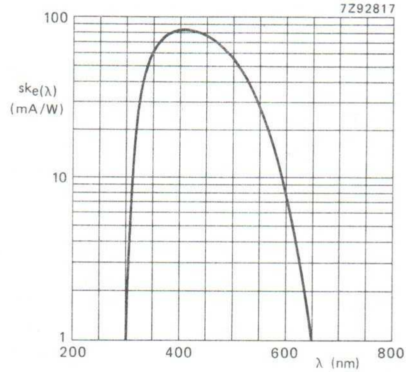


Fig. 4 Spectral sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm

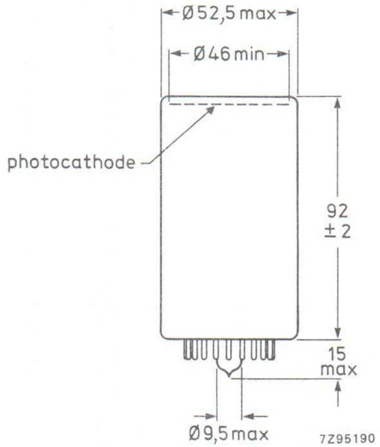


Fig. 5 XP3202.

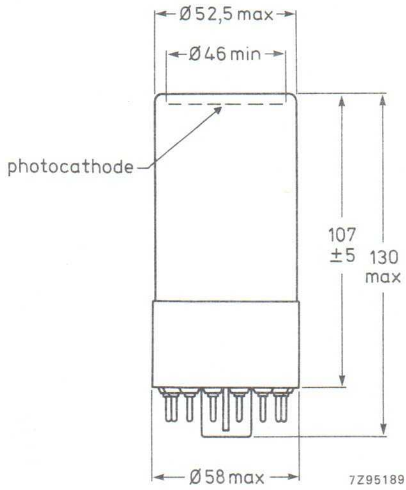
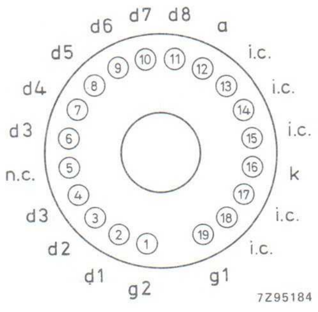


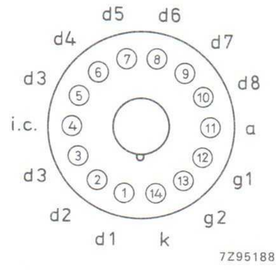
Fig. 6 XP3202B.

Base	19-pin all-glass
Net mass	100 g

Base	14-pin IEC 67-1-16a (JEDEC B14-38)
Net mass	145 g

PIN CONNECTIONS





ACCESSORIES

Socket

for XP3202	type FE2019
for XP3202B	type FE1014

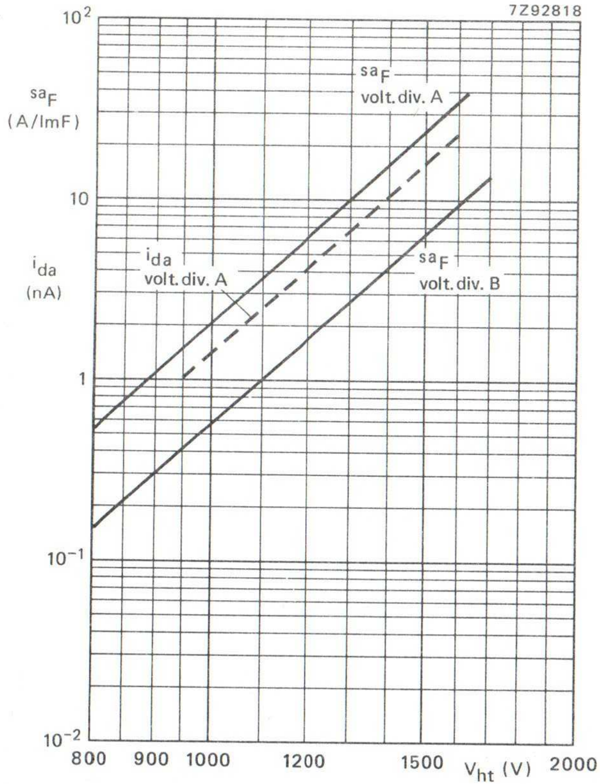


Fig. 7 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

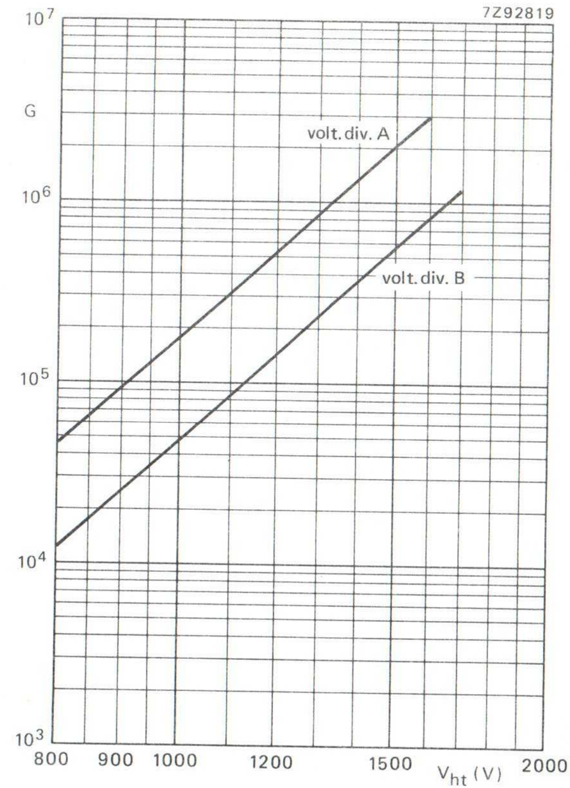


Fig. 8 Gain as function of supply voltage V_{hc}.

XP3422 replaces XP2422
XP3422B replaces XP2422B

8-STAGE PHOTOMULTIPLIER TUBES

- Hexagonal head-on type; useful size 56 mm across flats
- Flat window
- Semi-transparent bi-alkaline type D photocathode
- High cathode sensitivity; excellent collection from the entire cathode
- Very good pulse amplitude resolution
- Very low dark current
- Very good stability
- For nuclear medicine applications, e.g. gamma cameras

QUICK REFERENCE DATA

Spectral sensitivity characteristic	type D
Useful size of the photocathode	> 56 mm across flats
Cathode blue sensitivity	12 μA/lmF
Supply voltage for anode blue sensitivity = 1,5 A/lmF	950 V
Anode dark current at anode blue sensitivity = 1,5 A/lmF	0,5 nA
Pulse amplitude resolution (^{57}Co)	≈ 9,0%
Mean anode sensitivity deviation (30 days)	≈ 1%

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

GENERAL CHARACTERISTICS

Window

		notes
Material	lime glass	
Shape	hexagonal, plano-plano	
Refractive index at 400 nm	1,54	

Photocathode

		notes
Semi-transparent, head-on		2
Material	Sb K Cs	
Useful size	> 56 mm across flats	
Spectral sensitivity characteristic (Fig. 3)	type D	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lm	3
Blue sensitivity	typ. 12 μA/lmF > 9,0 μA/lmF	1
Spectral sensitivity at 400 nm	≈ 90 mA/W	4

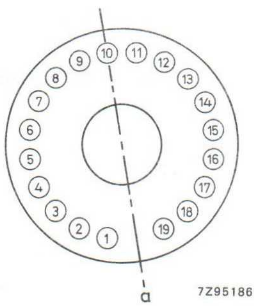
Multiplier system

Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

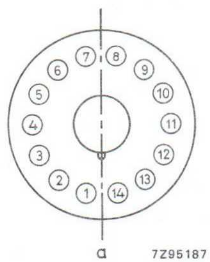
Magnetic field, Fig. 1

When the photocathode is uniformly illuminated the anode current is halved (at V_{ht} = 1200 V)
– at a magnetic flux density of 0,10 mT perpendicular to the tube axis and to axis a;
– at a magnetic flux density of 0,25 mT perpendicular to the tube axis and parallel to axis a.

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



XP3422.



XP3422B.

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

RECOMMENDED CIRCUIT

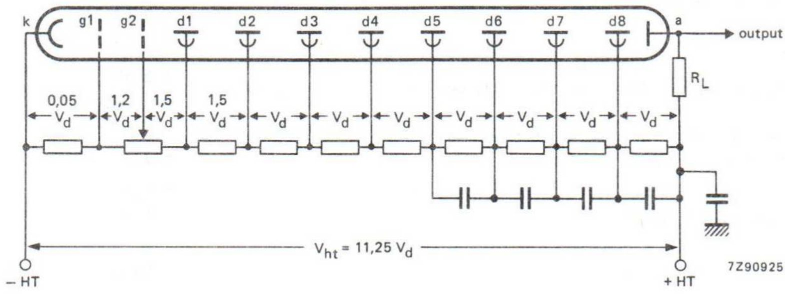


Fig. 2 Voltage divider A.

k = cathode
g1 = focusing electrode 1
g2 = accelerating electrode 2

dn = dynode no.
a = anode
R_L = load resistor

Typical value of capacitors: 10 nF

TYPICAL CHARACTERISTICS

		notes
With voltage divider A (Fig. 2)		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig. 6)	< 1250 V typ. 950 V	1
Gain at V_{ht} = 950 V	≈ 1,3 x 10^5	
Anode dark current at an anode blue sensitivity of 1,5 A/lmF (Fig. 6)	< 5 nA typ. 0,5 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF	≈ 9,0% ≈ 11%	1, 7 1, 17
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 37%	1, 8
Peak to valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF	≈ 40	1, 8
Mean anode sensitivity deviation		9
long term (16 h)	≈ 0,5%	
long term (30 days)	≈ 1%	
after change of count rate	≈ 0,8%	
versus temperature between 20 and 60 °C at 450 nm	≈ 0,1% per K	
Anode pulse rise time at V_{ht} = 1200 V	≈ 3 ns	10
Anode pulse duration at half height at V_{ht} = 1200 V	≈ 5 ns	10
Signal transit time at V_{ht} = 1200 V	≈ 37 ns	10
Anode current linear within 2% at V_{ht} = 1200 V	up to ≈ 100 mA	11

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	1700 V	12
Continuous anode current	max.	0,2 mA	13
Voltage between first dynode and photocathode	max. min.	500 V 150 V	14
Voltage between focusing electrode g1 and photocathode	max.	20 V	
Voltage between accelerating electrode g2 and photocathode	max.	500 V	
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max.	300 V	15
Ambient temperature range			
operational (for short periods)	max. min.	+ 80 °C −30 °C	16
continuous operation and storage	max. min.	+ 50 °C −30 °C	

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. The bialkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is therefore recommended that it should not be exposed to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. If too high a photocurrent is passed, the cathode can no longer be considered an equipotential surface, and the focusing of electrons onto the first dynode will be affected, resulting in departure from linearity.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by $7{,}7 \times 10^3$ for this type of tube.
5. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at +HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulation resistance of $> 10^{15}$ ohm.
6. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower values can be obtained after a longer stabilization period in darkness (approx. 30 min).
7. Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4856 or equivalent) with a diameter of 50 mm and a height of 50 mm (2″ x 2″). The count rate used is $\approx 10^4$ c/s.
8. Pulse amplitude resolution for ^{55}Fe is measured with an NaI(Tl) cylindrical scintillator with a diameter of 25 mm and a height of 1 mm provided with a beryllium window. The count rate used is $\approx 2 \times 10^3$ c/s.
9. The mean anode sensitivity deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is $\approx 10^4$ c/s corresponding to an average anode current of $\approx$ 300 nA. Anode sensitivity deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an average anode current of $\approx 1\ \mu$A and $\approx 0{,}1\ \mu$A respectively. Both tests are carried out according to ANSI−N42−9−1972 of IEEE recommendations.
10. Measured with a pulsed light source, with a pulse duration (FWHM) of < 1 ns; the cathode being completely illuminated. The rise time is determined between 10% and 90% of the amplitude of the anode pulse. The signal transit time is measured between the instant at which the illuminating pulse at the cathode becomes maximum, and the instant at which the anode pulse attains its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.
11. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage of the stages progressively. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage difference between one stage and the next is less than a factor of 2.

Notes (continued)

12. Total HT supply voltage, or the voltage at which the tube has an anode blue sensitivity of 40 A/lmF, (voltage for 1,5 A/lmF given on the test certificate, multiplied by 1,7), whichever is lower. For applications where dark current is critical, a maximum sensitivity of 15 A/lmF is recommended (voltage for 1,5 A/lmF, multiplied by 1,45).
13. A value of $< 10\ \mu A$ is recommended for applications requiring good stability.
14. Minimum value to obtain good collection in the input optics.
15. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
16. For type XP3422B this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.
17. Pulse amplitude resolution is measured with an NaI(Tl) cylindrical scintillator (Quartz et Silice serial no. 4186 or equivalent) with a diameter of 76 mm and height of 76 mm (3" x 3"). The count rate used is $\approx 10^4$ c/s.

Interchangeability

The pinnings of these 8-stage linear focused photomultiplier tubes have been designed to facilitate exchangeability of old 10-stage venetian blind types.
The best performance will be obtained by using their own voltage divider but they can be directly mounted in sockets wired for the old types, involving only minor degraded characteristics.

When mounting XP3422 in sockets wired for XP2422 the cathode connection is secured by the electrode g1, connected to the cathode via the internal bialkali layer.

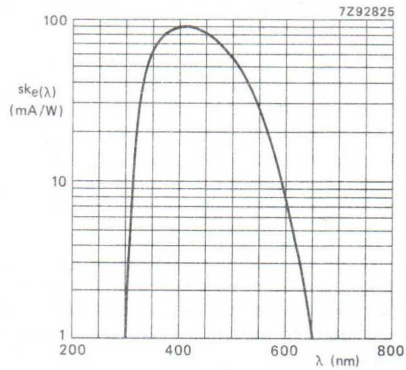


Fig. 3 Spectral sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm

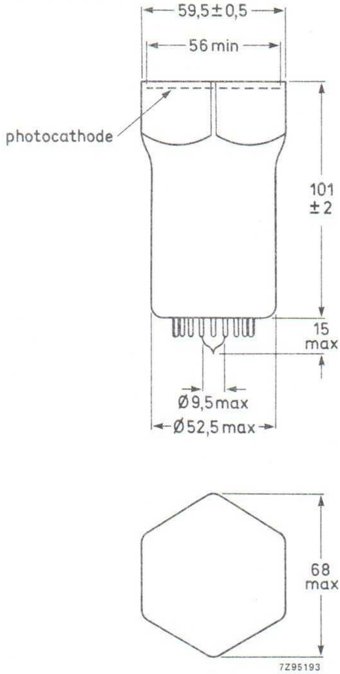


Fig. 4 XP3422.

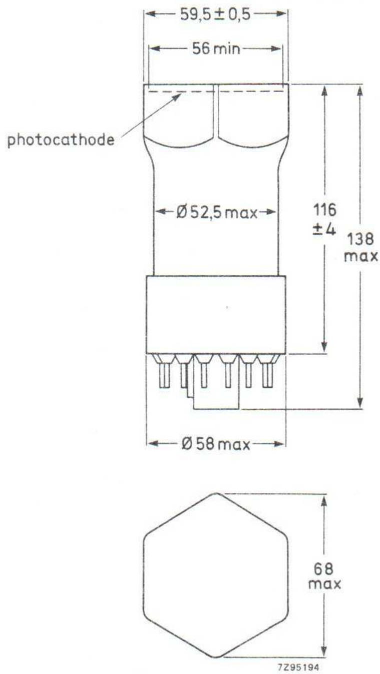
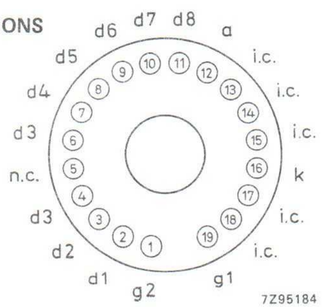


Fig. 5 XP3422B.

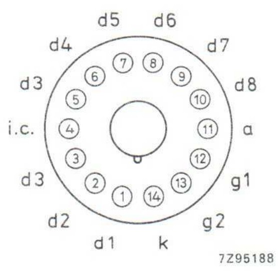
Base	19-pin all-glass
Net mass	120 g

Base	14-pin IEC 67-1-16a (JEDEC B 14-38)
Net mass	165 g

PIN CONNECTIONS



XP3422.



XP3422B.

ACCESSORIES

Socket
for XP3422: type FE2019
for XP3422B: type FE1014

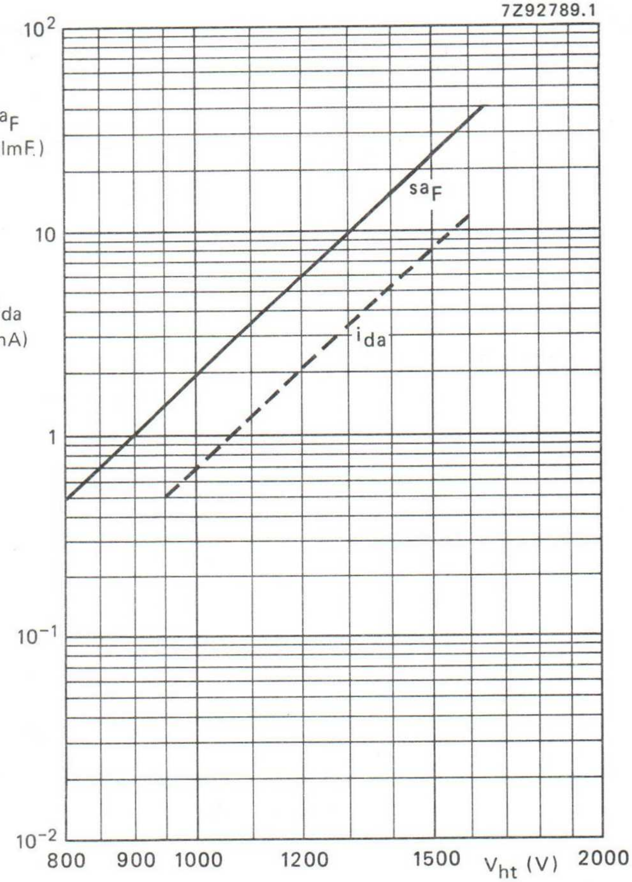


Fig. 6 Anode spectral sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.

i_{da} is given as a dotted line to indicate its principle behaviour only.

PHOTOTUBES

SURVEY OF TYPES

photocathode dimensions mm	tube type	spectral response		page
		S11 (A)	bi-alkaline Sb Rb Cs	
ϕ 20	AV29		X	295
ϕ 30	150AV	X		299

LIST OF SYMBOLS

Supply voltage	V_b (V_{ht})
Cathode current	I_k
Anode series resistance	R_a
Sensitivity	N
Capacitance, anode to cathode	C_{ak}
Ambient temperature	T_{amb}
Envelope temperature	T_{env}

See also the General Section on Photomultiplier tubes.

PHOTOTUBE

- Head-on type vacuum diode with 20 mm useful diameter photocathode
- Flat window
- Semi-transparent bi-alkaline photocathode
- Fast, large-area detector for medium and high light levels
- For precision photometry and for detection in high-magnetic fields (high energy physics)

QUICK REFERENCE DATA

Spectral sensitivity characteristic	Fig. 2
Useful diameter of the photocathode	> 20 mm
Blue sensitivity of the photocathode	10,5 μA/lmF
Spectral sensitivity of the photocathode at 400 nm	80 mA/W
Anode voltage	⩽ 1500 V
Pulse rise time	≈ 3 ns
Capacitance, anode to cathode	≈ 6 pF

To be read in conjunction with *General Operational Recommendations Phototubes*

GENERAL CHARACTERISTICS

Window

Material	lime glass
Shape	plano-plano
Refractive index at 400 nm	1,54

Photocathode

Type	semi-transparent, head-on	
Material	Sb Rb Cs	
Useful diameter	> 20 mm	
Spectral sensitivity characteristic	see Fig. 2	
Wavelength for maximum spectral sensitivity	420 ± 30 nm	
Spectral sensitivity at 400 nm	≈ 80 mA/W	note 2
Luminous sensitivity	≈ 100 μA/lm	note 3
Blue sensitivity	typ. 10,5 μA/lmF > 7,0 μA/lmF	note 1

Operating characteristics

Operating voltage, d.c.	1 to 1000 V	
Saturation voltage for anode current = 100 nA	≈ 10 V	
Dark current at V_{ht} = 350 V and R.H. 50 to 60%	typ. 10 pA < 100 pA	note 4
Anode pulse rise time at V_{ht} = 350 V	≈ 3 ns	
Capacitance, anode to cathode	≈ 6 pF	
Recommended angle between magnetic flux density and tube axis	< 70°	
Anode sensitivity drop at a magnetic flux density of 0,3 T, at an angle of 70° with respect to the tube axis, and V_{ht} = 300 V (see also Fig. 4)	≈ 10%	

LIMITING VALUES (Absolute maximum rating system)

Anode voltage, d.c.	max. 1500 V	
Cathode current		
peak	max. 50 nA/mm²	
mean, averaging time 1 s	max. 70 pA/mm²	
Total cathode current		
peak, at V_{ht} = 1000 V	max. 15 μA	notes 5, 6
mean, averaging time 1 s	max. 20 nA	notes 5, 6
Ambient temperature range		
operational (for short periods of time)	max. + 80 °C min. −30 °C	
continuous operation and storage	max. + 50 °C min. −30 °C	

STABILITY

For most tubes, the decrease of anode sensitivity after 72 h, at a cathode current of 20 nA, V_{ht} = 350 V, is anticipated to be less than 2%.

For maximum stability it is recommended that the cathode current be minimized.

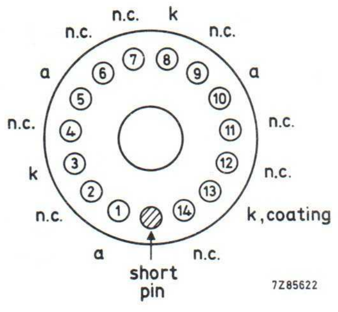
Warnings

1. After an idle period of more than 8 days a high voltage level should be applied in steps.
2. The cathode should not be exposed to direct sunlight.
3. The cathode is connected to the external conductive coating of the tube. Take care to avoid electric shock.

Notes

1. Blue sensitivity, expressed in μA/lmF, is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through a blue filter (Corning CS no. 5-58, polished to half stock thickness).
2. Spectral sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Spectral sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7,7 x 10^3 for this type of tube.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. As the dark current is a leakage current, it is approximately proportional to the applied voltage. It can be minimized by operating the tube in a dry atmosphere (R.H. < 10%).
5. Cathode uniformly illuminated.
6. The relationship between the incident luminous flux and the cathode current is linear (within measuring errors) when the anode voltage is higher than the saturation voltage.

MECHANICAL DATA



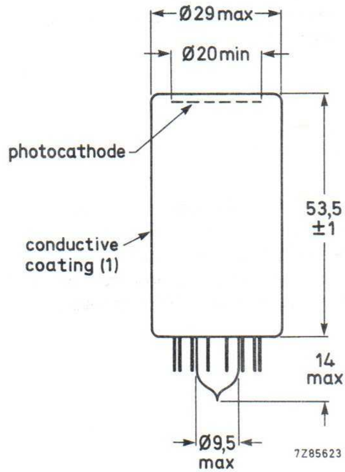


Fig. 1.

Base 14-pin all-glass
Net mass 25 g

(1) The envelope of the tube is covered with a conductive coating, connected to the cathode. Take care to avoid electric shock.

ACCESSORIES

Socket: type FE1114

Note: If minimum leakage current is required it is advised to use separate anode and cathode connections instead of a socket.

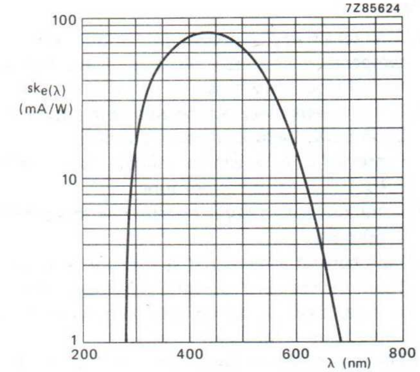


Fig. 2 Spectral sensitivity characteristic.

Curves of Figs 3 and 4 are typical results from measurements performed at CERN Experiment R808.

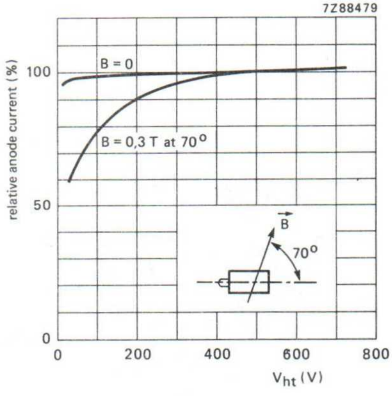


Fig. 3 Relative anode current as a function of supply voltage; typical curves. Tube is in a magnetic field with flux densities B = 0 or 0,3 T; angle between flux density and tube axis is 70°. (Curves by courtesy of CERN, Geneva.)

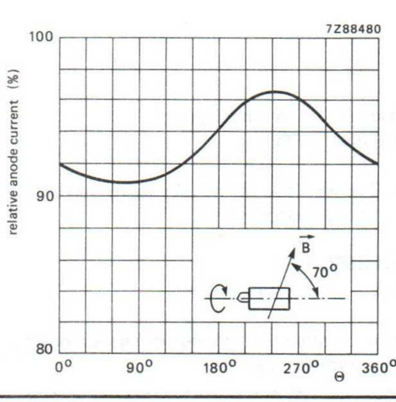


Fig. 4 Relative anode current as a function of tube rotation angle; typical curve. Tube is in a magnetic field with flux density B = 0,3 T; angle between flux density and tube axis is 70 °; V_{ht} = 300 V. (Curve by courtesy of CERN, Geneva.)

PHOTOTUBE

The 150A V is a 30 mm useful diameter head-on phototube with a flat window and a semi-transparent S11 (type A) photocathode. The tube is intended for use in high precision photometry and for measurement of quickly changing light phenomena and features a high stability and linearity.

QUICK REFERENCE DATA

Spectral sensitivity characteristic	S11 (type A)
Useful diameter of the photocathode	30 mm
Spectral sensitivity of the photocathode at 437 nm	60 mA/W
Anode voltage	1 to 90 V

To be read in conjunction with *"General Operational Recommendations Phototubes"*.

CHARACTERISTICS

Photocathode

Semi-transparent head-on			
Material			Cs-Sb
Useful diameter		>	30 mm
Spectral sensitivity characteristic Fig. 1			S11 (type A)
Maximum spectral sensitivity at			420 ± 30 nm
Luminous sensitivity	(note 1)	typ.	70 μA/lm
		>	35 μA/lm
Spectral sensitivity at 437 ± 5 nm	(note 2)	≈	60 mA/W

Operating characteristics

Operating voltage, d.c.			1 to 90	V
Saturation voltage				
for a luminous flux of 0,05 lm		≈	4,5	V
for a luminous flux of 0,01 lm		≈	1	V
Dark current at V_{ht} = 1 V	(note 3)	typ.	1	pA
		<	2	pA
Rise time at V_{ht} = 50 V			14	ns
Capacitance, anode to cathode		C_{ak}	13	pF

LIMITING VALUES

(Absolute maximum rating system)

Anode voltage, d.c.		max.	100	V
Cathode current per mm²,				
peak		max.	50	nA/mm²
mean, averaging time 1 s		max.	70	pA/mm²
Total cathode current,	(notes 4, 5)			
peak		max.	35	μA
mean, avering time 1 s		max.	500	nA
Ambient temperature	(note 6)	max.	60	°C
		min.	−40	°C

LIFE EXPECTANCY

With a cathode current of 2 μA the decrease in sensitivity may be:

at 400 nm 0,4%/h

at 560 nm 0,8%/h.

With an average cathode current of 50 nA the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

To attain high stability it is recommended that the cathode current be kept as low as possible.

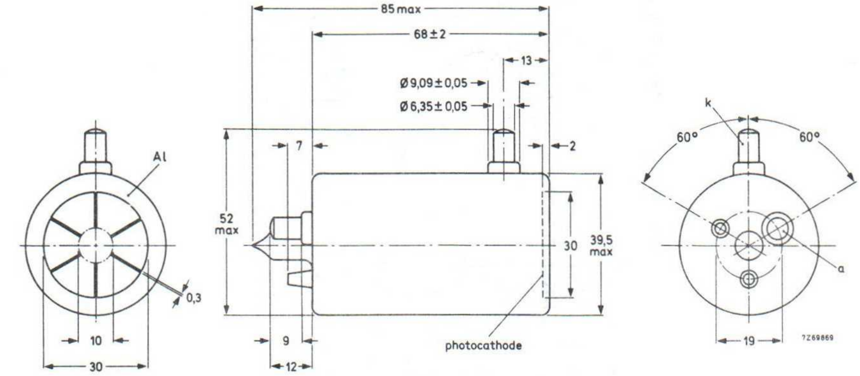
REMARKS

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

The cathode should not be exposed to direct sunlight.

MECHANICAL DATA

Net mass: 60 g



An external guard ring significantly decreases the dark current ($\approx 10^{-14}$ A). This can be obtained by applying a ring of silver paste.

Notes

1. Cathode luminous sensitivity is measured by means of a tungsten filament lamp of colour temperature 2856 °K.
2. Measuring equipment is calibrated by comparison with a Schwartz thermocouple.
3. Dark current is measured at 25 °C after a stabilization period in darkness, with anode voltage applied, of 0,5 h. The dark current is approximately proportional to the applied voltage. An external guard ring, made of silver paste, may be put on the tube envelope when the tube is used with very low cathode current.
4. Cathode uniformly illuminated.
5. The relation between the incident luminous flux and the cathode current is linear within measuring errors provided the anode voltage is higher than the saturation voltage.
6. During not more than some hours.

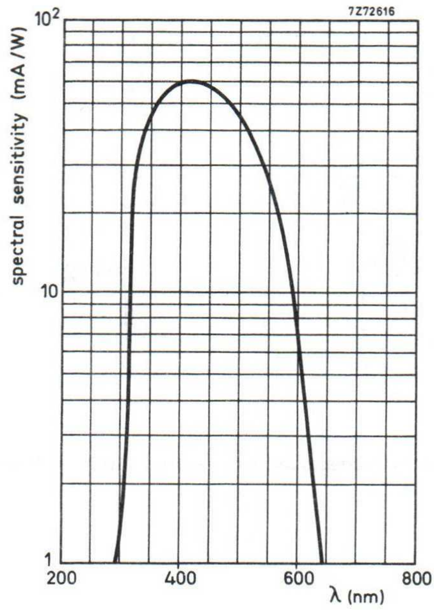


Fig. 1 Spectral sensitivity characteristic.

SINGLE CHANNEL ELECTRON MULTIPLIERS

SURVEY OF TYPES

type no.	input configuration	dimensions (nom.) mm	resistance Ω (typ.)	page
B310AL/01	circular	ϕ 1.25	3.0×10^9	313
B310BL/01	circular	ϕ 1.25	3.0×10^9	313
B312AL/01	rectangular	2 x 8	3.0×10^9	315
B312BL/01	rectangular	2 x 8	3.0×10^9	315
B314AL/01	rectangular	2 x 8	3.0×10^9	317
8314BL/01	rectangular	2 x 8	3.0×10^9	317
B318AL/01	conical	ϕ 5	3.0×10^9	319
B318BL/01	conical	ϕ 5	3.0×10^9	319
B410AL/01	circular	ϕ 2.2	3.0×10^9	321
B410BL/01	circular	ϕ 2.2	3.0×10^9	321
B413AL/	rectangular	3.5 x 15.5	3.0×10^9	323
B413BL/01	rectangular	3.5 x 15.5	3.0×10^9	323
B419AL/01	conical	ϕ 10	3.0×10^9	325
B419BL/01	conical	ϕ 10	3.0×10^9	325
X810AL	circular	ϕ 1.25	6.0×10^8	327
X812AL	rectangular	2 x 8	6.0×10^8	329
X814AL	rectangular	2 x 8	6.0×10^8	331
X818AL	conical	ϕ 5	6.0×10^8	333
X910AL	circular	ϕ 2.2	6.0×10^8	335
X910BL	circular	ϕ 2.2	6.0×10^8	335
X913AL	rectangular	3.5 x 15.5	6.0×10^8	339
X913BL	rectangular	3.5 x 15.5	6.0×10^8	339
X914AL	rectangular	3.5 x 15.5	6.0×10^8	343
X914BL	rectangular	3.5 x 15.5	6.0×10^8	343
X919AL	conical	ϕ 10	6.0×10^8	347
X919BL	conical	ϕ 10	6.0×10^8	347
X959AL	conical	ϕ 15	6.0×10^8	351
X959BL	conical	ϕ 15	6.0×10^8	351

NOTE

Alternative configuration and customized designs to other dimensions may be made available; please contact the supplier.

SINGLE CHANNEL ELECTRON MULTIPLIERS
GENERAL EXPLANATORY NOTES

PRINCIPLES OF OPERATION

A single channel electron multiplier is a small, curved, glass tube, the inside wall of which has a high surface resistance. If a potential is applied between the ends of the tube, the resistive surface becomes a continuous dynode, electrically analogous to the separate dynodes of a conventional photomultiplier together with the resistive chain used to establish the separate dynode potentials.

The channel electron multiplier operates in a vacuum. For space research, the environmental vacuum is sufficient. In the laboratory, the multiplier must be used in a vacuum chamber.

An electron entering the low-potential end of the channel multiplier generates secondary electrons on collision with the wall of the tube. These are accelerated along the tube until they strike the wall again, where they generate further secondary electrons. This avalanching process produces a large number of electrons at the positive end of the tube. This is illustrated in Fig.1.

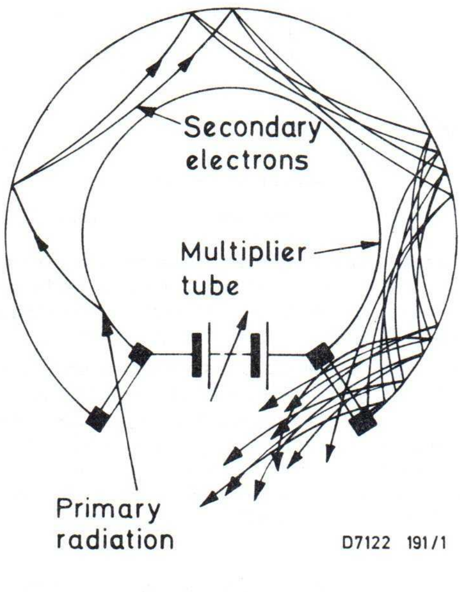


Fig.1 Electron multiplication

A channel multiplier thus responds to an input of one electron by producing an output pulse of charge. This pulse may contain up to about 10^8 electrons and its duration (full width at half height) is about 10 nanoseconds. The amplitude of the resulting voltage pulse depends, of course, upon the values of resistance and capacitance in the anode circuit of the multiplier. The gain (Fig.2) is an exponential and very steep function of voltage for values below 10^7. Above 10^7, saturation effects are observed which are discussed later.

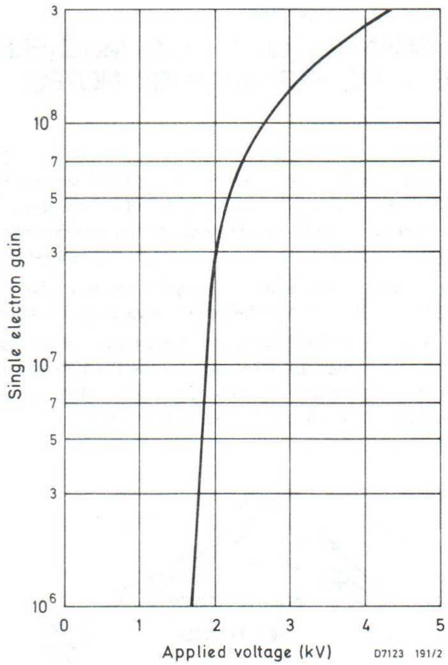


Fig.2 Typical variation of gain as a function of applied voltage

The multiplier will also respond to ions, β particles, X-rays, ultraviolet, or any other sufficiently energetic radiation. The detection efficiency of a channel multiplier is different for different forms and energies of excitation, but any particle or quantum capable of exciting an electron from the dynode surface has a finite probability of detection, (see Figs. 7 and 8).

Since the resistive coating is continuous, many electron paths are possible, and the number of stages of multiplication is thus indeterminate. The electron trajectories are scaled in proportion to the dimensions of the channel for a given applied voltage. Thus, if the length-to-diameter ratio is preserved, the same multiplication processes go on, and the same gain is achieved, irrespective of the absolute length of the channel. In practice, it is necessary for the length-to-diameter ratio to exceed about 30:1. Channels are almost invariably curved, and the gain is then less critically dependent on the length-to-diameter ratio. The ratios generally used are between 50:1 and 100:1.

IONIC FEEDBACK

The tube forming the channel multiplier is curved because the gain of a straight tube would be sensitive to changes in ambient pressure. When the first cloud of electrons nears the output end of the multiplier, it is sufficiently dense to ionise a considerable number of the residual gas atoms in the tube. These positive ions drift under the influence of the applied field towards the more negative potential at the input end of the channel.

If the channel is straight, the ions may acquire considerable energy before they collide with the wall of the tube. Consequently they may release from the wall electrons which initiate a further process of multiplication through the tube, resulting in a spurious output pulse. This process is repeated, and thus a sequence of 'after pulses' may be observed. This pulse train lasts typically for about a microsecond until the capacity of the channel is exhausted and the pulse train dies out.

In a curved tube, the ions strike the wall of the tube before they have acquired sufficient energy to release secondary electrons. Electron multiplication is unaffected however since electrons need acquire an energy of only about 50 eV to release secondary electrons from the wall. The output of the curved multiplier is therefore independent of the ambient pressure, provided it does not exceed 50 $mN.m^{-2}$ *. Above this pressure, spurious pulses occur, and effects similar to those seen with straight channels are observed.

SATURATION DUE TO SPACE CHARGE

One of the more significant aspects of the behaviour of a channel multiplier is the saturation effect caused by space-charge limitation. When the total amount of charge in the electron cloud in a channel multiplier reaches nearly 10^9 electrons, the gain cannot increase further.The space-charge repels the emitted-secondary electrons so that they strike the wall before acquiring sufficient energy from the field to make useful multiplying collisions. The space-charge limit is unaffected by the channel diameter. Increasing the applied voltage increases the amplitude of those pulses which would not otherwise have reached $\approx 10^9$ electrons, but as the maximum charge output cannot exceed this level, the amplitude of all pulses tends to the same value. The multiplier thus has a narrow pulse-height distribution. When it is operated in the saturated mode, it is analogous to a Geiger counter, producing a pulse of a given amplitude irrespective of the manner of its excitation. It is unable in this condition to give information about the number of particles simultaneously striking the input or about their energy.

When the multiplier is not operated in its saturated mode, that is when the gain is less than 10^7, there is some proportionality between input and output. However, there is a spread of pulse amplitudes because of the many possible electron paths through the multiplier. The pulse-amplitude distribution is exponential: smaller pulses are more probable then larger ones by an amount exponentially dependent on the amplitude.

SATURATION DUE TO FIELD DISTORTION

In a straight channel, ionic feedback gives rise to a pulse train about 1 microsecond in duration which may contain a total charge of more than 10^9 electrons. The pulse train dies out only when the field inside the channel is distorted by wall-charging to such an extent that the multiplication process can no longer sustain feedback.

The field is restored during a 'dead time', after which an output pulse can again be observed. The dead time depends on the resistance of the channel and may be some tens of microseconds.

The dead-time effect may be caused by a single event in a straight channel. This is not possible, however, in curved channels because the probability of ionic feedback is very low, and the pulse train is replaced by a single pulse of about 10 nanoseconds duration which is space-charge limited to about 10^9 electrons. Consequently, the curved channel may produce two pulses of the same amplitude separated in time only by the pulse duration. However, if the mean pulse repetition rate is high, the field inside the channel is distorted. A state of dynamic equilibrium is achieved: the mean gain is reduced so that the average rate of flow of charge in the output pulses is less than the current flowing in the channel wall.

The same considerations apply when a channel multiplier is used as a current amplifier. The amplification is generally linear up to a maximum of 10% of the standing (wall) current. For example, a channel of resistance $5.10^8\,\Omega$ operated at 2.5 kV should maintain a linear current-transfer characteristic up to a maximum output of 0.5 μA.

RESISTANCE

The resistance of a channel electron multiplier is measured between input and output terminals at atmospheric pressure i.e. at room temperature with no space current flow.

*50 mPa or 5.10^{-4} mbar

BACKGROUND OR SPONTANEOUS PULSE COUNTING RATE

The background or spontaneous pulse counting rate is the number of pulses detected per second above a specified equivalent threshold when the input end of the multiplier is closed. The equivalent threshold is the amount of charge produced by the multiplier which, when amplified, just appears above the threshold of the discriminator used for pulse counting. The count is made with a multiplier voltage and equivalent threshold as specified in the data.

STARTING VOLTAGE

As the voltage applied to the channel is increased, the gain rises and the output pulses become larger. The pulses are not all the same size, but as the gain increases, more of them exceed the equivalent threshold. The process continues until all the pulses are above the threshold. The observed counting rate is shown as a function of voltage in Fig.3 and this graph shows a steeply rising portion followed by a plateau.

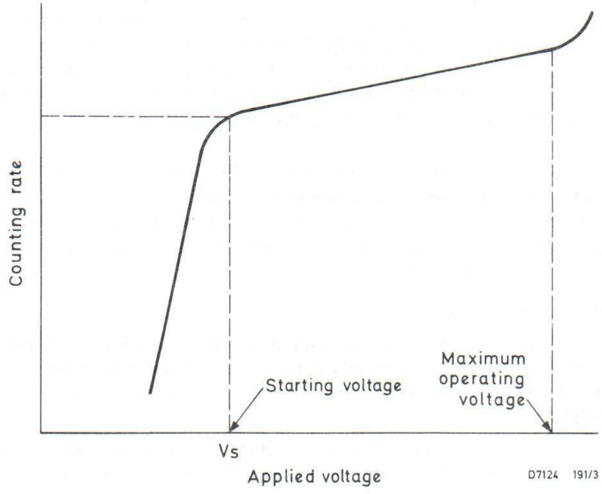


Fig.3 Definition of starting voltage

The starting voltage is the voltage at which the pulse counting rate is 90% of the plateau counting rate, where the plateau is defined as the region over which the counting rate changes by less than 3% for each 100 V increment.

The starting voltage is measured using an input source adjusted to give a fixed counting rate at a high applied voltage. The counting rate and voltage, together with the equivalent threshold, are given in the data.

PULSE GAIN

The output pulses resulting from input particles or quanta (events) will show a statistical spread. Due to saturation effects in the multiplier this spread is approximately Gaussian and the gain is defined as its median value.

The resistance of the multiplier glass limits the counting rate below which the gain is constant, (see Fig.10).

OUTPUT

The output pulse corresponding to one input electron will consist of G electrons. The corresponding charge in the output pulse will thus be G x 1.6×10^{-19} coulombs, where 1.6×10^{-19} coulombs is the electron charge. The charge in the output pulse raises the potential across the input capacitance of a pulse amplifier and this voltage change is referred to as the pulse height (usually in millivolts).

This expression of output as a voltage is common practice, but the capacitance to be charged must also be known.

When a channel multiplier is used for direct current amplification, the output current must be collected at a separate electrode. If it is used for pulse counting, the output can be detected at the positive terminal of the multiplier; in this case, the multiplier is a two-terminal device, (Figs.5 and 6).

PULSE HEIGHT DISTRIBUTION

The nominal gain of a channel multiplier will not be achieved every time an event produces an output pulse; there is a variation in gain because of the statistical nature of the multiplication process. However, the spread is not usually very great at high values of gain and it is expressed in terms of the resolution of the pulse height distribution.

A typical pulse distribution is given in Fig.4. This is seen to be Gaussian. The resolution is defined as the ratio of the full width of the distribution at half maximum frequency (F.W.H.M.) to the modal pulse height. The resolution depends on applied voltage and gain. Values for various multipliers are quoted in the data.

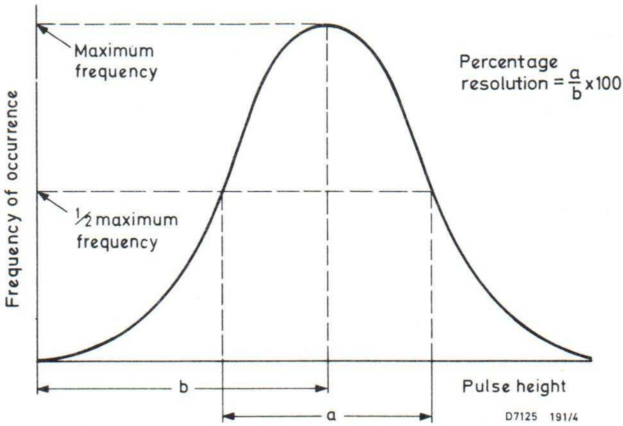


Fig.4 Definition of resolution of pulse height distribution

INPUT APERTURE

Larger input apertures may be achieved without increasing the overall dimensions of the multiplier by fitting a cone-shaped or flared end. Because the response of a channel multiplier depends on the angle of incidence of the input flux, it is not practicable to quote dimensions of effective apertures which are valid in all situations. The effective aperture of standard multipliers is not necessarily the same as the geometric aperture, but may be smaller.

MODE OF OPERATION

The multiplier is most commonly used with pulse counting ciruicts to detect individual particles or quanta. For this application closed end multipliers are recommended. A typical circuit is shown in Fig.5. The output pulse is capacitively coupled into a suitable charge sensitive pulse amplifier and discriminator. Under certain circumstances the multiplier may be used as a current amplifier. In this case an open-ended multiplier is necessary, the output being collected at a separate electrode as shown in Fig.6. The collector electrode should be biased positively to ensure collection of all output electrons.

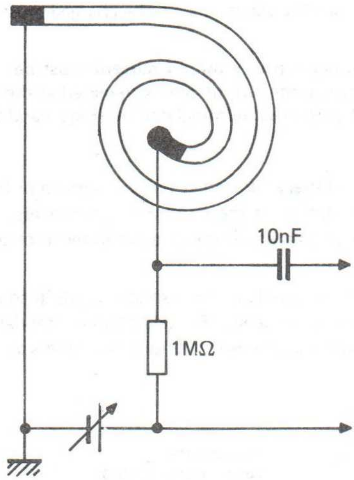


Fig.5

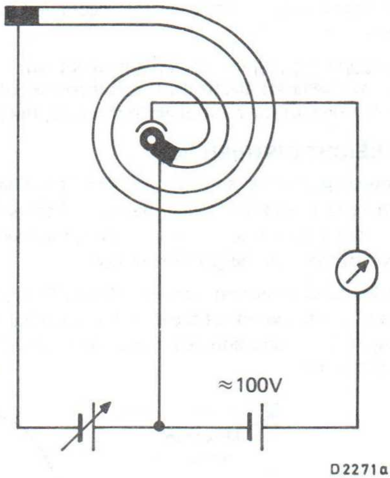


Fig.6

OPERATIONAL NOTES

Mounting

It is recommended that the leads are not used for mounting the device as sustained vibration may result in fracture of electrical connections.

The outer surface of the device is also a conductor and supports to the glass must be insulated.

Vacuum environment

Normal vacuum precautions must be observed. In particular, gross contamination with hydrocarbon vapours will cause rapid loss of gain and should be avoided.

The device is stable in dry air and may be vacuum cycled repeatedly without damage. If it has to be stored at atmospheric pressure it is advisable to use a desiccator as high humidity can cause loss of gain.

Baking conditions

The specified baking conditions apply only when the device is under vacuum. The temperature must not exceed that specified in the data. A voltage must not be applied to the device during bake-out.

Thermal stability

Due to the negative temperature coefficient of resistance of multipliers, thermal runaway is possible. Operation below the maximum voltage and temperature limits specified will ensure that this does not occur.

Choice of operating voltage

Use of an operating voltage approximately 500 volts greater than the starting voltage should ensure that all output pulses exceed the threshold. If, as a result of prolonged use, the median gain of the multiplier falls, the operating voltage may be increased in order to restore the gain to its original value.

To avoid contamination, these devices must be handled only with gloved hands or tweezers.

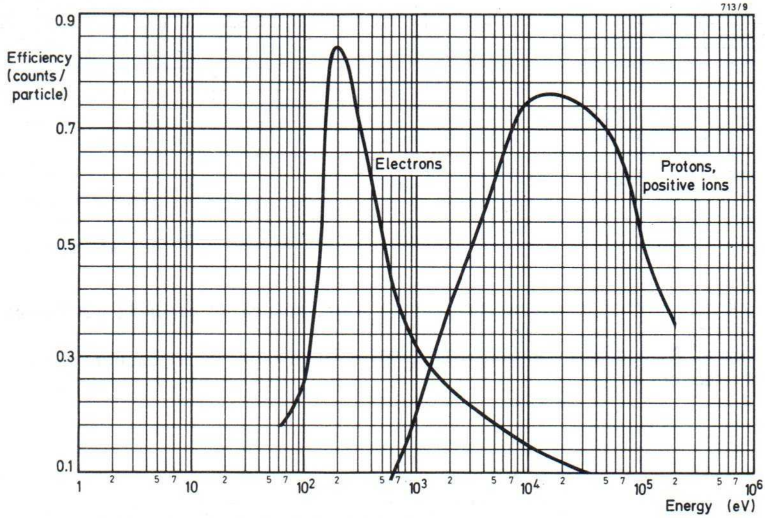


Fig.7 Typical detection efficiencies for electrons, protons and positive ions

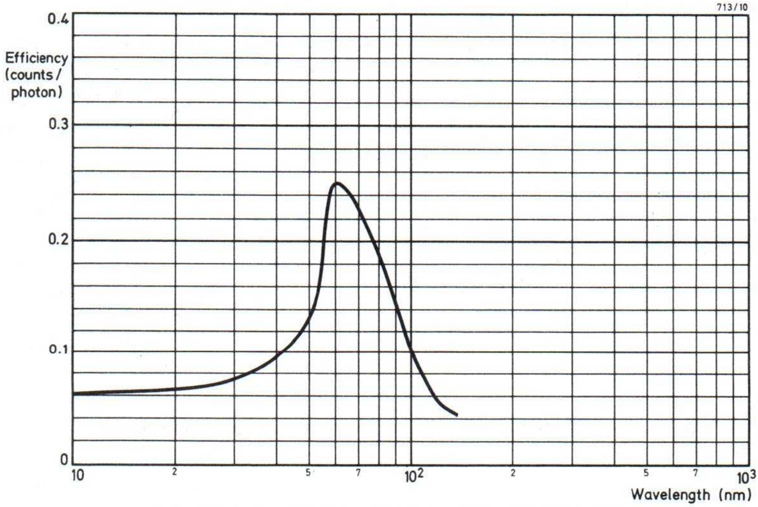


Fig.8 Typical detection efficiency for ultraviolet radiation

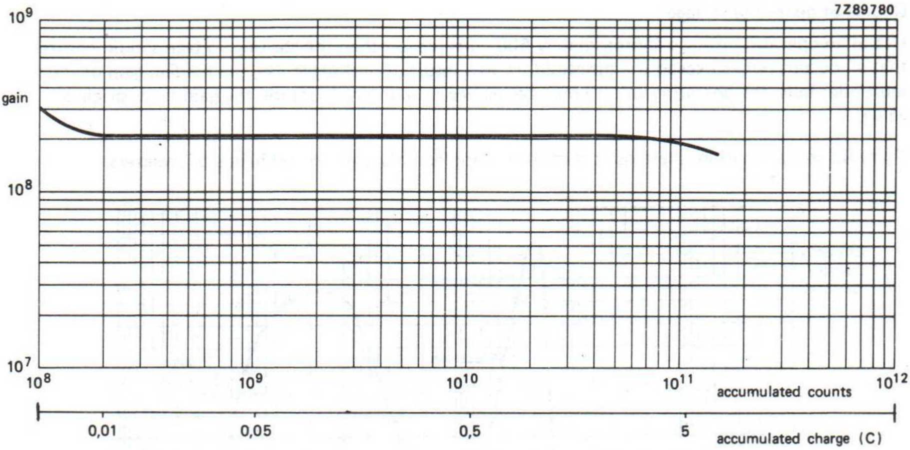


Fig.9 Typical gain as a function of accumulated counts and accumulated charge for the X900 series of single channel electron multipliers.
Operating voltage = 2.8 kV, ambient pressure = 0.013 $mN.m^{-2}$ (1.3×10^{-7} mbar), counting rate = 10^4 count/s, source: electrons.

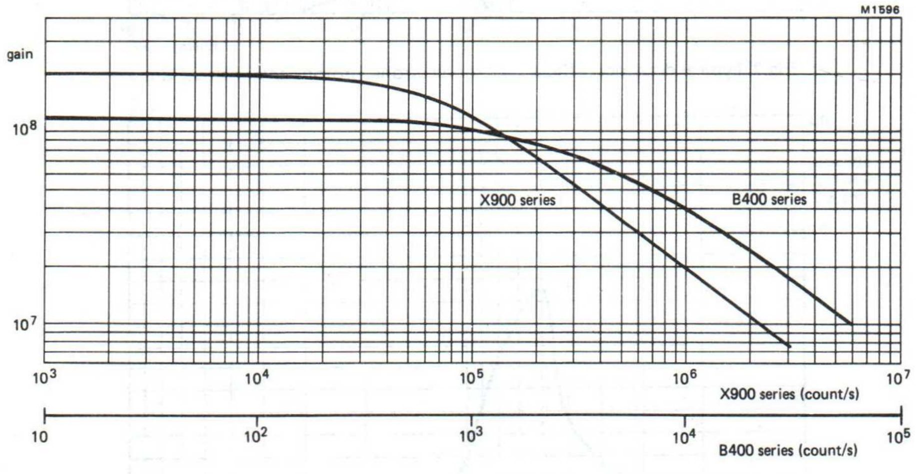


Fig.10 Typical gain as a function of counting rate for single channel electron multipliers.
Operating voltage = 2.5 kV.

SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube.
The B310AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B310BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 3.0 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	1.1	1.25	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS 1.0 g

MOUNTING POSITION

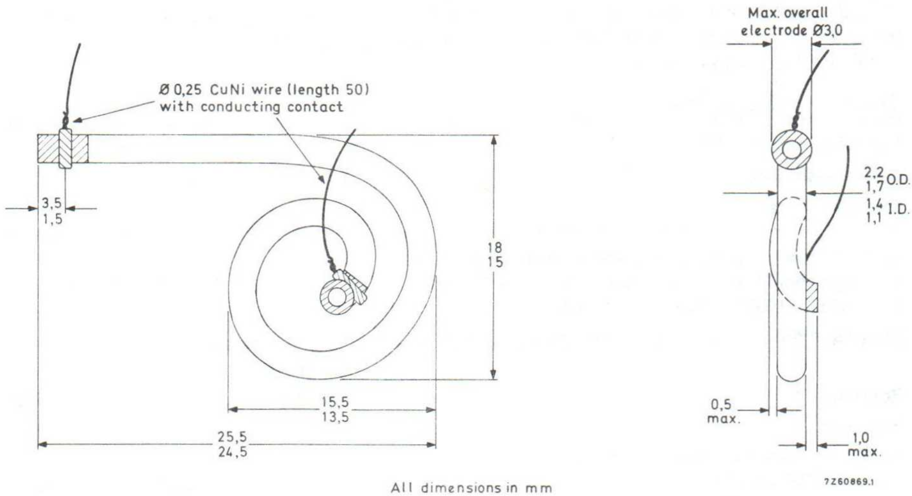
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



All dimensions in mm

SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a rectangular section input cone 2.0 x 8.0 mm.
The B312AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B312BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 3.0 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES - SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input aperture	1.7 x 7.5	2.0 x 8.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

1.0 g

MOUNTING POSITION

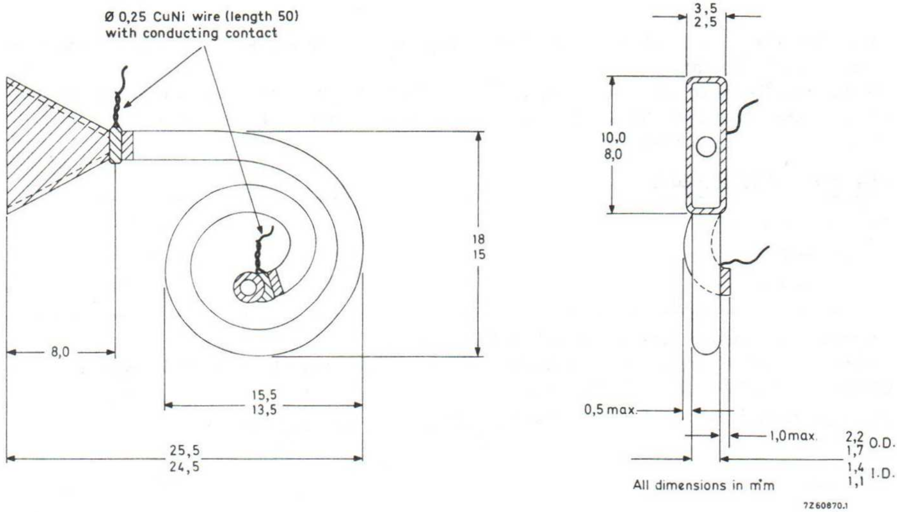
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a rectangular section input cone 2.0 x 8.0 mm.
The B314AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B314BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 3.0 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input aperture	1.7 x 7.5	2.0 x 8.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

1.0 g

MOUNTING POSITION

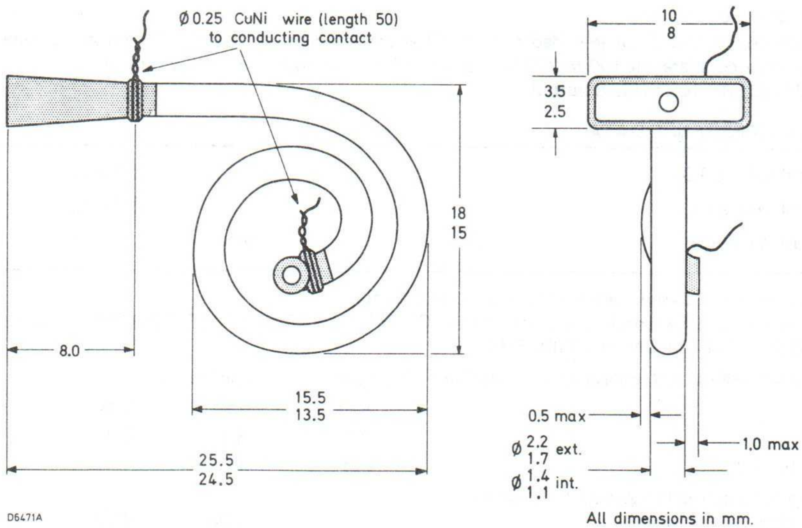
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a 5.0 mm diameter input cone.
The B318AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B318BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 3.0 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 3.0 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	4.0	5.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature, operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS 1.0 g

MOUNTING POSITION

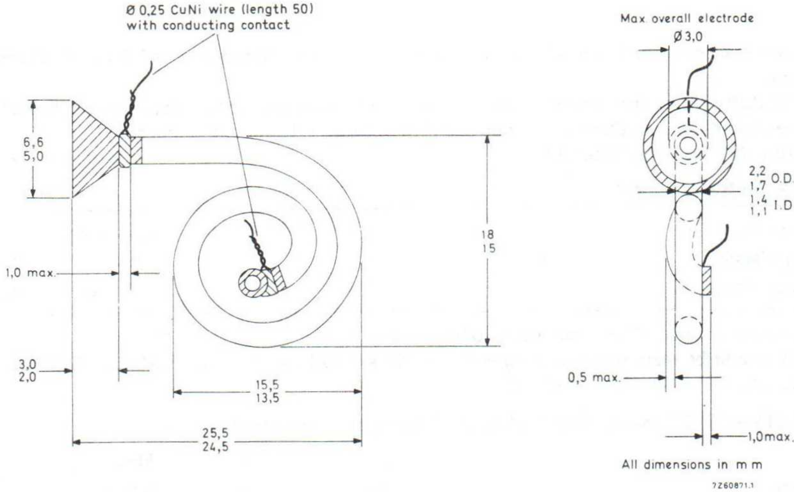
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube.
The B410AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B410BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	3.5	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 2.5 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	2.0	2.2	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

3.0 g

MOUNTING POSITION

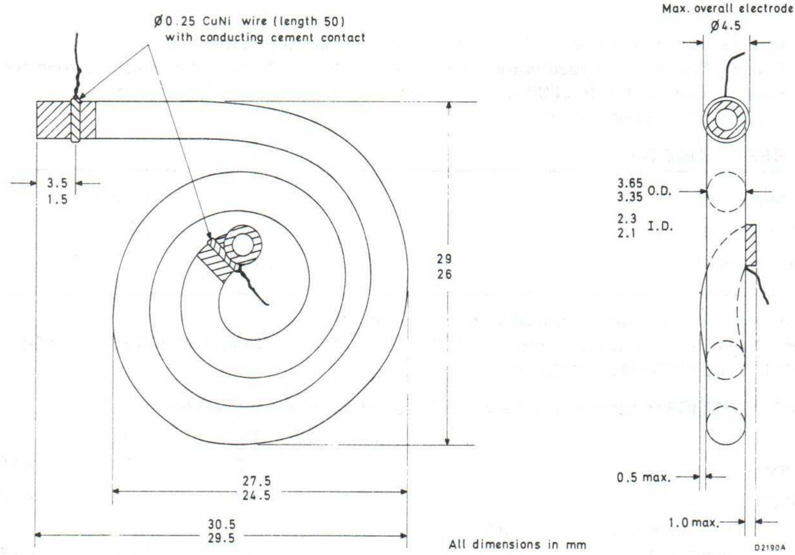
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a rectangular section input cone 3.5 x 15.5 mm.
The B413AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B413BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	3.5	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 2.5 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input aperture	3.0 x 14.5	3.5 x 15.5	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$
MASS		4.0	g

MOUNTING POSITION

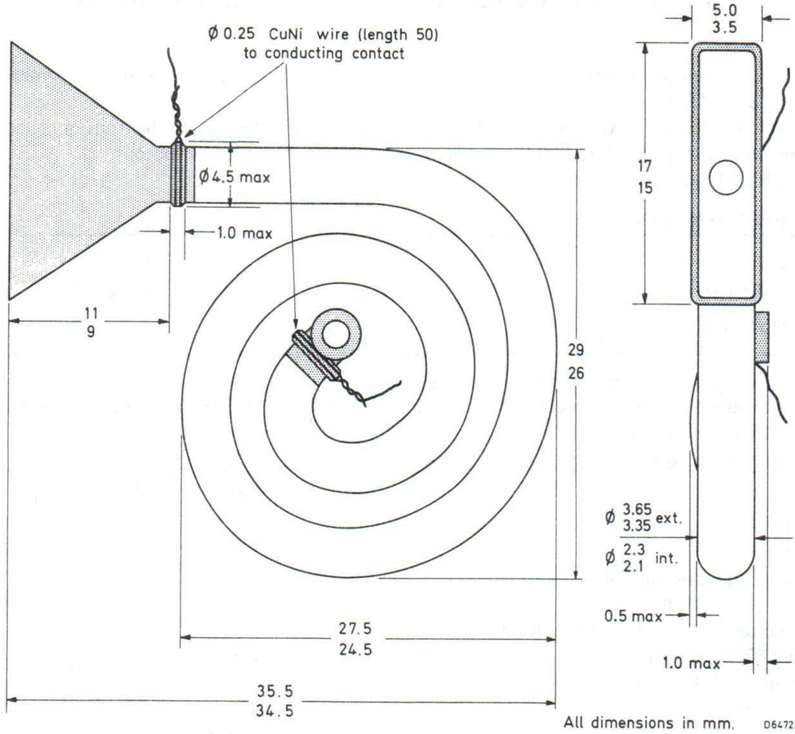
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a 10 mm diameter input cone.
The B419AL/01 has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The B419BL/01 has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.2×10^8	
Typical resistance		3.0×10^9	Ω
Operating voltage	max.	3.5	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS.

CHARACTERISTICS (measured at 2.5 kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^8$ Ω
Gain (note 1)	0.8	1.2	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.03	0.20	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	9.0	10	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS 4.0 g

MOUNTING POSITION

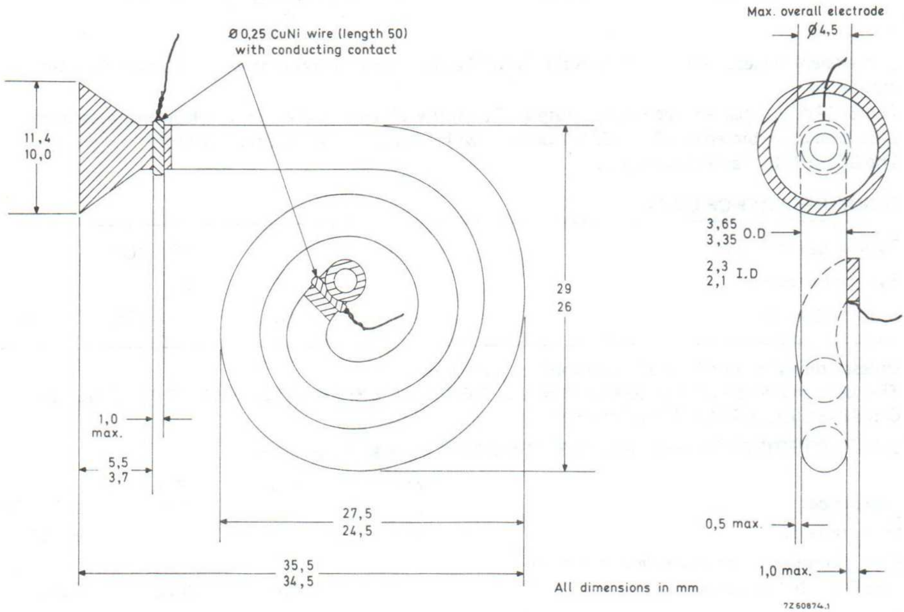
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIER

Single channel electron multiplier in the form of a glass planar spiral tube. It has an open-ended output.
To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
A closed output version, X810BL, may be made available on request.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		5.0×10^7	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	3.5	kV

This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	2.0	5.0	–	$\times 10^7$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s ←
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.8	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 5.0×10^7	–	50	70	%
Effective input diameter	1.1	1.25	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature, operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

1.0 g

MOUNTING POSITION

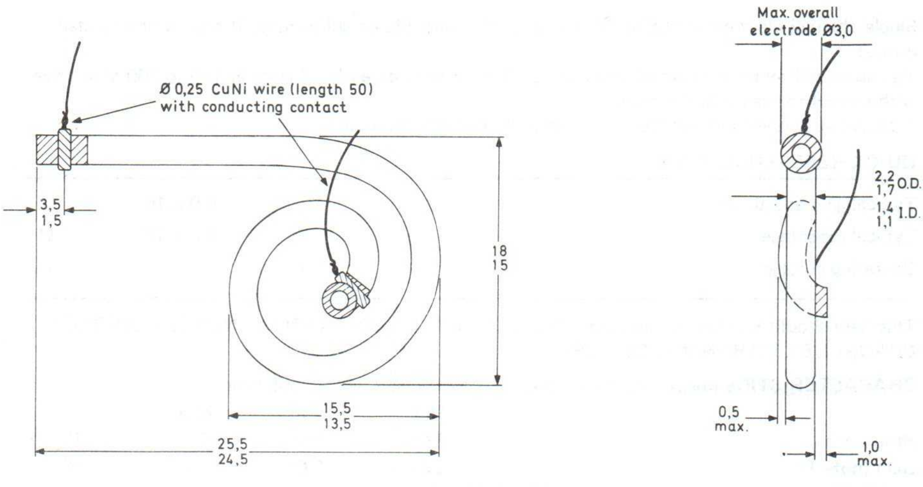
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



All dimensions in mm

SINGLE CHANNEL ELECTRON MULTIPLIER

Single channel electron multiplier in the form of a glass planar spiral tube with a rectangular section input cone 2.0 x 8.0 mm. It has an open-ended output.
To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
A closed output version, X812BL, may be made available on request.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		5.0×10^7	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	3.5	kV

This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	2.0	5.0	–	$\times 10^7$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s ←
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.8	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 5.0×10^7	–	50	70	%
Effective input aperture	1.7 x 7.5	2.0 x 8.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$
MASS		1.0	g

MOUNTING POSITION

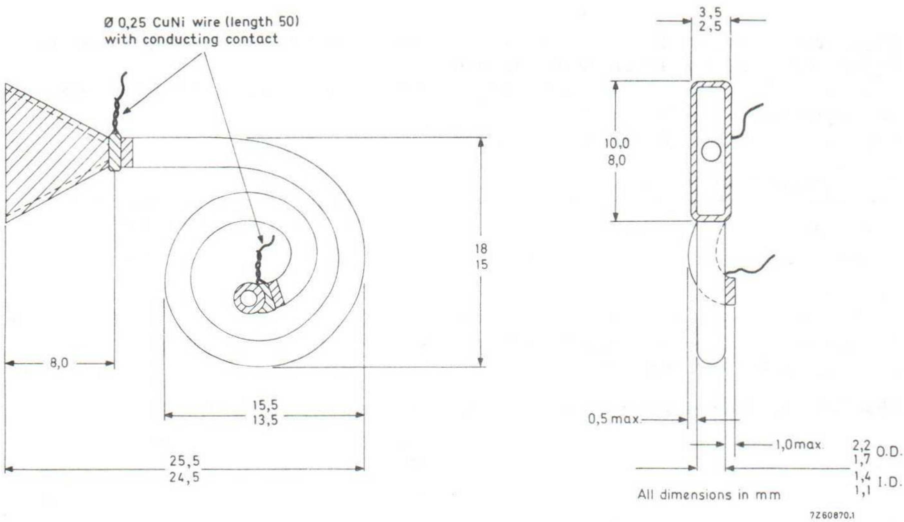
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIER

Single channel electron multiplier in the form of a glass planar spiral tube with a rectangular section input cone 2.0 x 8.0 mm. It has an open-ended output.
To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
A closed output version, X814BL, may be made available on request.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		5.0×10^7	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	3.5	kV

This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	2.0	5.0	–	$\times 10^7$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.8	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 5.0×10^7	–	50	70	%
Effective input aperture	1.7 x 7.5	2.0 x 8.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

1.0 g

MOUNTING POSITION

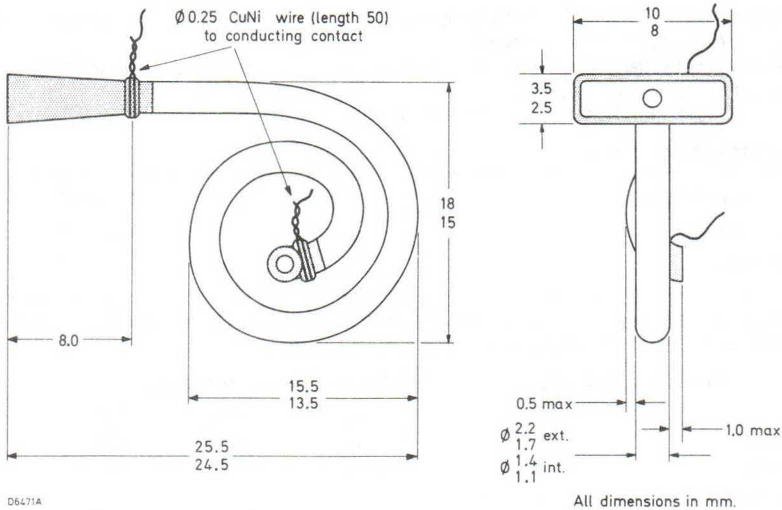
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIER

Single channel electron multiplier in the form of a glass planar spiral tube with a 5.0 mm diameter input cone. It has an open-ended output.
To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
A closed output version, X818BL, may be made available on request.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		5.0×10^7	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	3.5	kV

This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	2.0	5.0	–	$\times 10^7$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.8	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 5.0×10^7	–	50	70	%
Effective input diameter	4.0	5.0	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	3.5	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS 1.0 g

MOUNTING POSITION

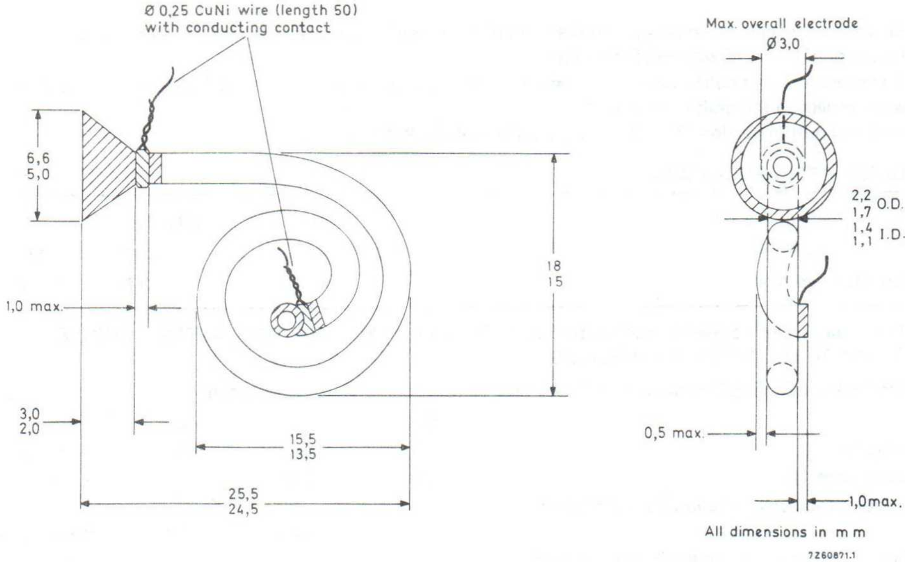
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube.
The X910AL has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The X910BL has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.8×10^8	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	1.0	1.8	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.6	1.8	kV
Resolution (F.W.H.M.) at a modal gain of 1.8×10^8	–	50	70	%
Effective input diameter	2.0	2.2	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

4.0 g

MOUNTING POSITION

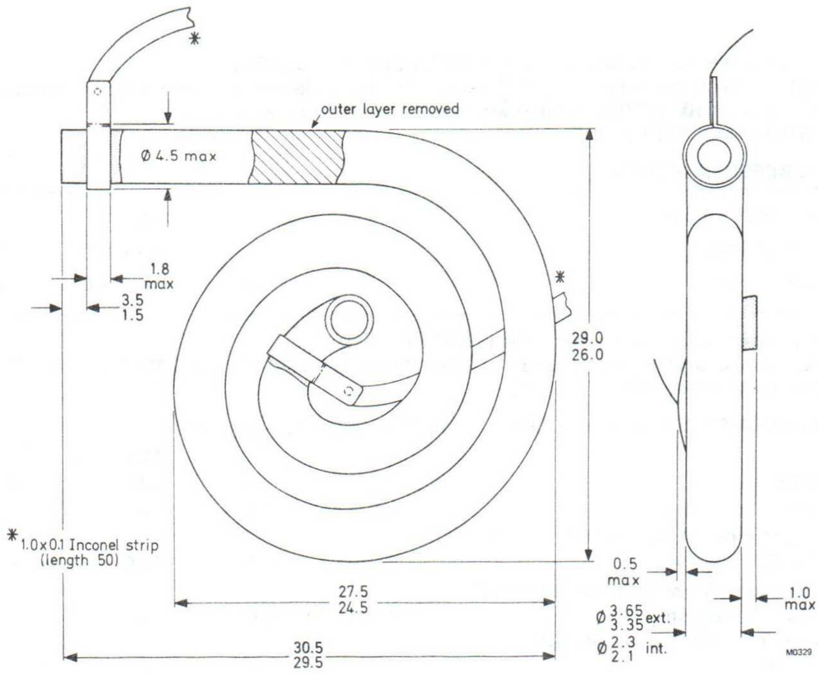
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

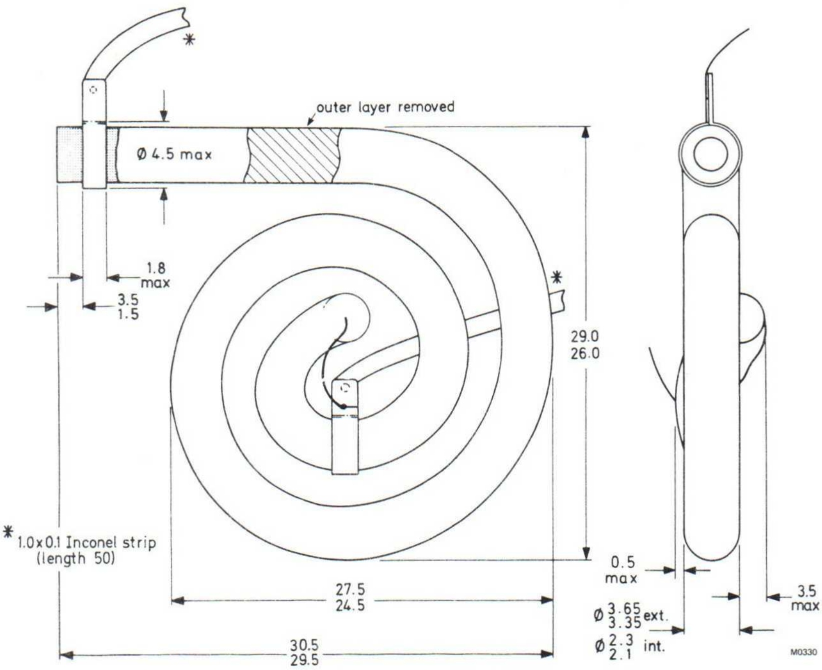
1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA X910AL

Dimensions in mm



MECHANICAL DATA X910BL



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a rectangular section input cone 3.5 x 15.5 mm.
The X913AL has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The X913BL has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.8×10^8	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	1.0	1.8	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.6	1.8	kV
Resolution (F.W.H.M.) at a modal gain of 1.8×10^8	–	50	70	%
Effective input aperature	3.0 x 14.5	3.5 x 15.5	5.0 x 17	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

4.0 g

MOUNTING POSITION

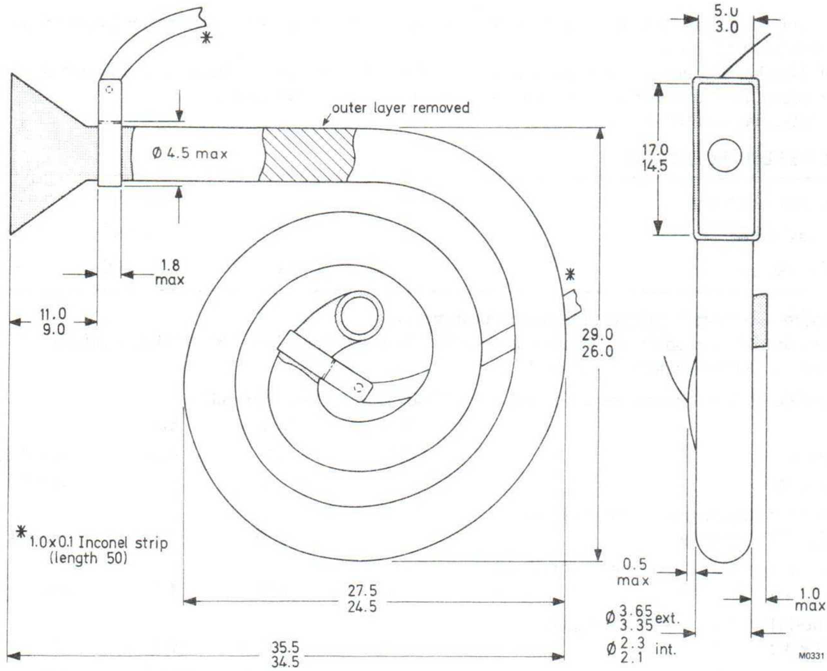
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

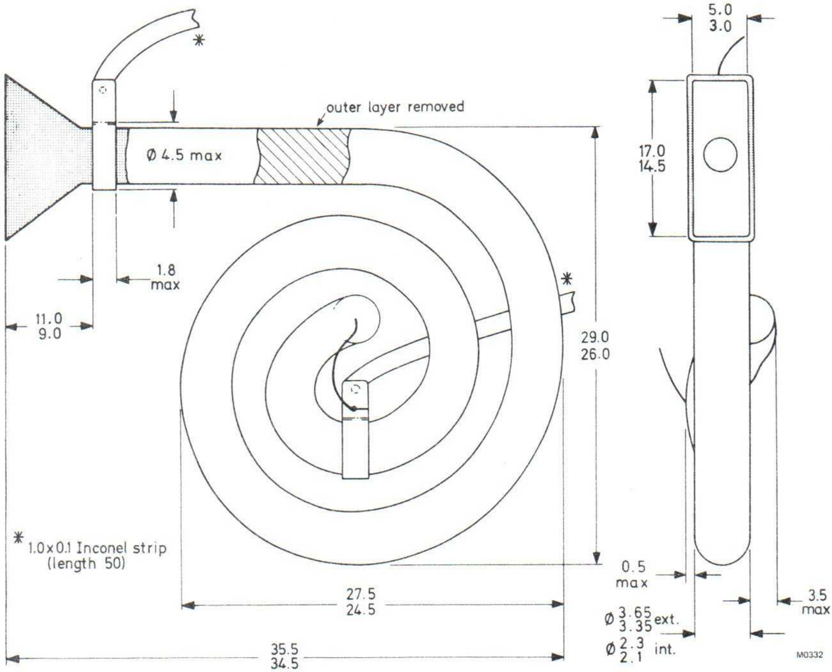
MECHANICAL DATA X913AL

Dimensions in mm



MECHANICAL DATA X913BL

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a rectangular section input cone 3.5 x 15.5 mm.
The X914AL has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The X914BL has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.8×10^8	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	1.0	1.8	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.6	1.8	kV
Resolution (F.W.H.M.) at a modal gain of 1.8×10^8	–	50	70	%
Effective input aperture	3.0 x 14.5	3.5 x 15.5	5.0 x 17	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

4.0 g

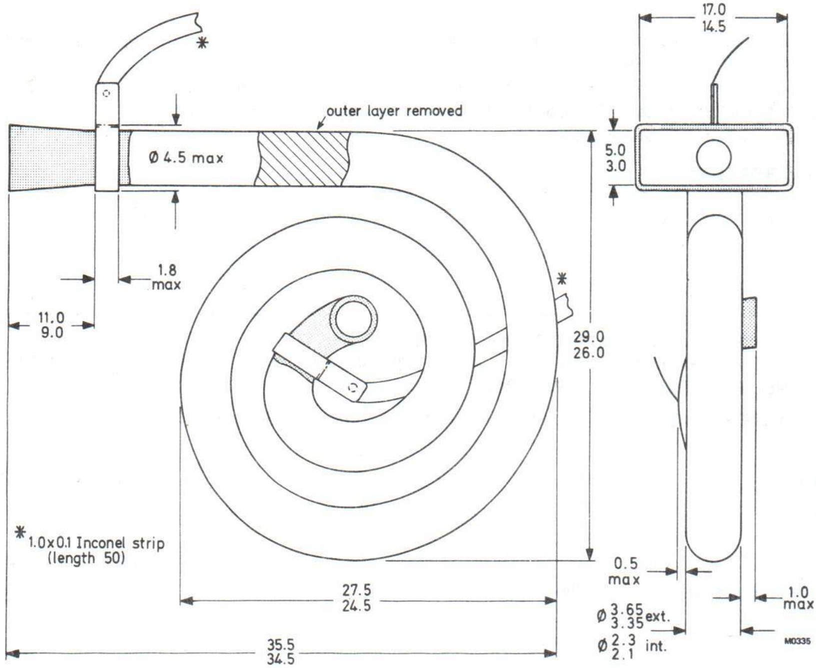
MOUNTING POSITION

Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

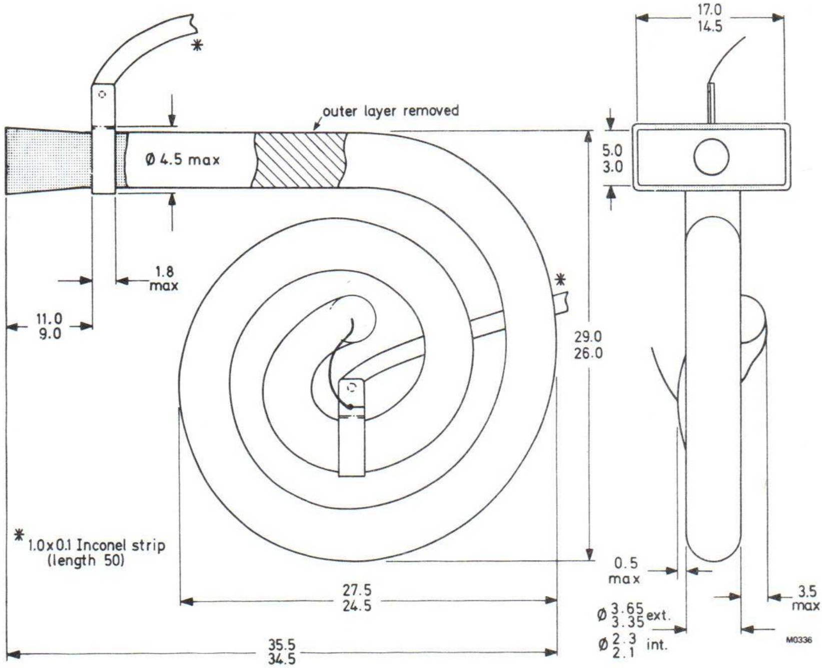
1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

MECHANICAL DATA X914AL Dimensions in mm



MECHANICAL DATA X914BL

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a 10 mm diameter input cone.
The X919AL has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The X919BL has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.8×10^8	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8$ Ω
Gain (note 1)	1.0	1.8	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.6	1.8	kV
Resolution (F.W.H.M.) at a modal gain of 1.8×10^8	–	50	70	%
Effective input diameter	9.0	10	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	°C
Bake temperature in vacuo (note 2)	max.	400	°C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS

4.0 g

MOUNTING POSITION

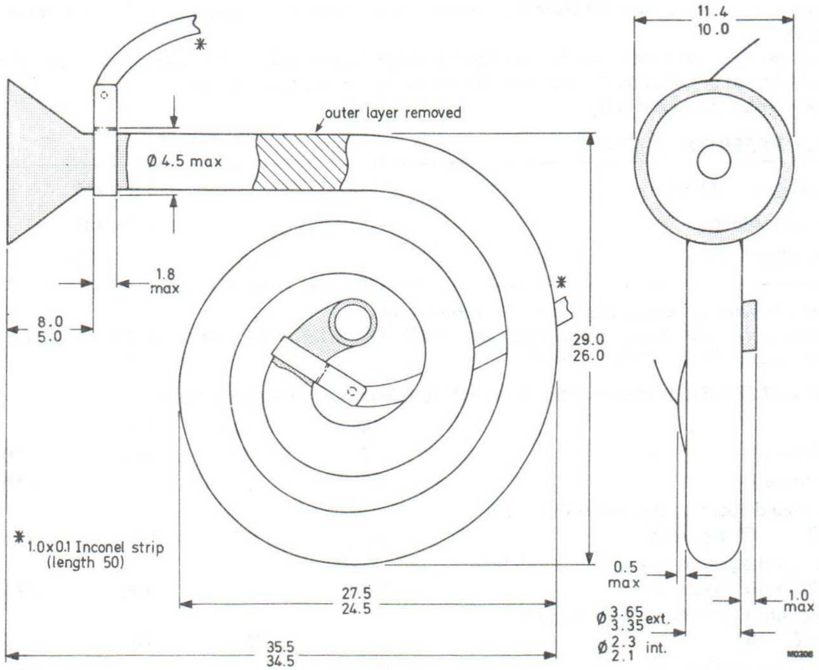
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 °C could reduce the gain by approximately a factor of 2.

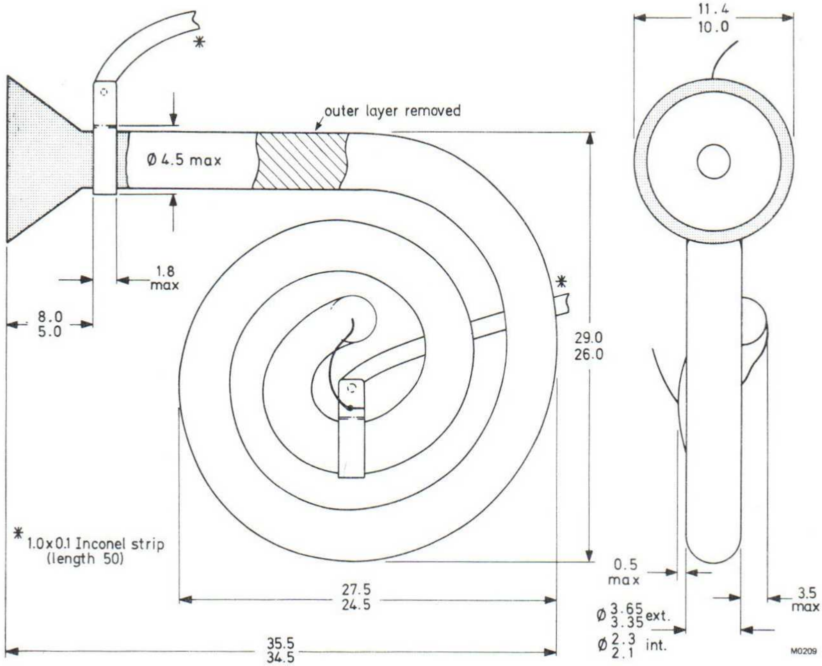
MECHANICAL DATA X919AL

Dimensions in mm



MECHANICAL DATA X919BL

Dimensions in mm



SINGLE CHANNEL ELECTRON MULTIPLIERS

Single channel electron multipliers in the form of a glass planar spiral tube with a 15 mm diameter input cone.
The X959AL has an open-ended output. To ensure efficient collection of electrons, a collector should be used, biased at 100 to 200 V positive with respect to the multiplier output.
The X959BL has a closed output.

QUICK REFERENCE DATA

Typical gain at 2.5 kV		1.8×10^8	
Typical resistance		6.0×10^8	Ω
Operating voltage	max.	4.0	kV

Unless otherwise stated, data is applicable to both types.
This data should be read in conjunction with GENERAL EXPLANATORY NOTES – SINGLE CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5 kV and 10 000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	4.0	6.0	8.0	$\times 10^8\ \Omega$
Gain (note 1)	1.0	1.8	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^6 electrons	–	0.15	0.50	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^6 electrons	1.4	1.6	1.8	kV
Resolution (F.W.H.M.) at a modal gain of 1.8×10^8	–	50	70	%
Effective input diameter	14	15	–	mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Operating voltage	max.	4.0	kV
Temperature operating and storage	max.	70	^{o}C
Bake temperature in vacuo (note 2)	max.	400	^{o}C
Ambient pressure with high voltage applied	max.	50	$mN.m^{-2}$

MASS 4.0 g

MOUNTING POSITION

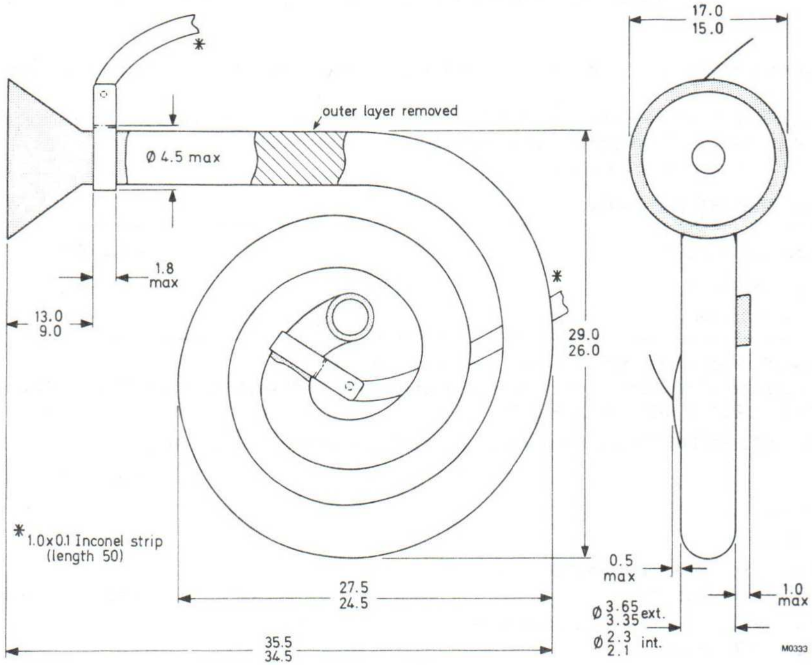
Any. In environments where vibration may be encountered, the device must not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of approx. 2 for an increase of operating voltage of 500 V.
2. Baking will cause a permanent slight loss of gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400 ^{o}C could reduce the gain by approximately a factor of 2.

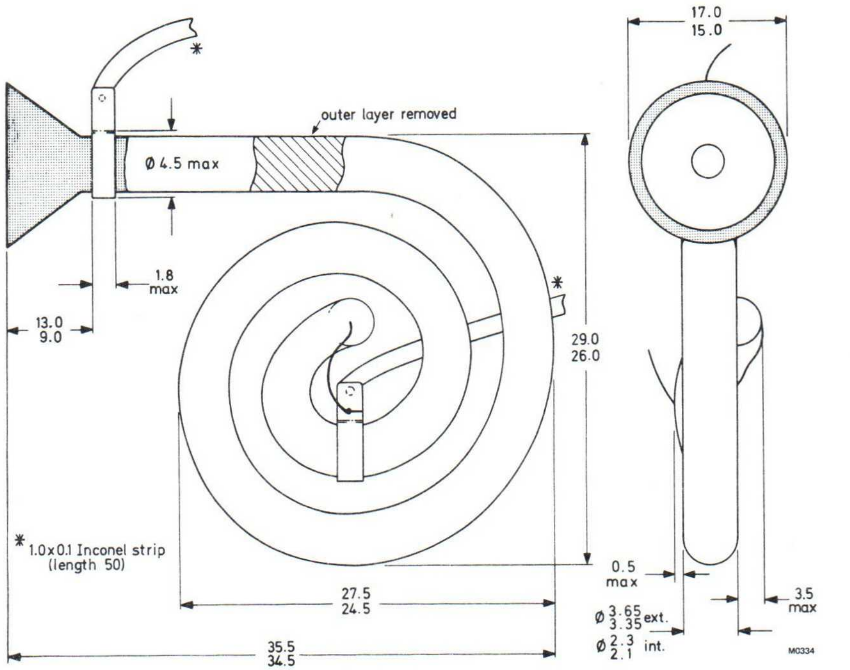
MECHANICAL DATA X959AL

Dimensions in mm



MECHANICAL DATA X959BL

Dimensions in mm



CHANNEL ELECTRON MULTIPLIER PLATES

SURVEY OF TYPES

type no.	plate dimensions mm	channel diameter μm	channel angle degrees	page
G12-20x50	20 x 50	12.5	13	361
G12-25SE	ϕ 25	12.5	13	365
G12-25SE/A	ϕ 25	12.5	13	
G12-36	ϕ 36	12.5	13	369
G12-36/A	ϕ 36	12.5	13	
G12-36DT/0	ϕ 36	12.5	0	373
G12-36DT/13	ϕ 36	12.5	13	
G12-46	ϕ 46	12.5	13	377
G12-46/A	ϕ 46	12.5	13	
G12-46DT/0	ϕ 46	12.5	0	381
G12-46DT/13	ϕ 46	12.5	13	
G12-70	ϕ 70	12.5	13	385
G25-20x50	20 x 50	25	13	389
G25-25	ϕ 27	25	13	393
G25-25/A	ϕ 27	25	13	
G25-50	ϕ 53	25	13	397
G25-70	ϕ 70	25	13	401

*SE = solid edge, DT = double thickness, A = matched pair of plates.

NOTE

Alternative configurations may be made available for scientific applications. Please contact the supplier for information.

CHANNEL ELECTRON MULTIPLIER PLATES GENERAL EXPLANATORY NOTES

PRINCIPLES OF OPERATION

Multi-channel plates depend on the same physical phenomenon as single channel electron multipliers. They comprise a plate of special glass through which pass a large number of channels. The walls of the holes are specially processed to coat them with a high resistance material which also has a coefficient of secondary emission greater than 1. If a potential is applied between opposite faces of the plate each channel becomes a continuous dynode analogous to the separate dynodes of a photomultiplier together with its resistive chain.

As with single channel electron multipliers, the channel plate operates in a vacuum. It is important that the vacuum should be better than 13.3 $mN.m^{-2}$. An electron entering the low voltage end of one of the channels will generate secondary electrons upon striking the wall. These in turn will be accelerated by the axial field and will again strike the wall, producing a further increase in the number of secondaries and so on. The avalanching process produces a large burst of electrons at the output end of the channel, corresponding to each input electron. As illustrated in Fig.1 there is a statistical variation in pulse size depending on several factors. The channels are set at an angle to the face of the plate to ensure that electrons approaching the plate normally will not fail to strike the wall. The output contains about 10^3 electrons for each input electron. The gain is a steep function of the applied voltage and the supply should be well regulated for stability of operation.

The multiplier is usually used to amplify the electrons emitted from a photocathode placed close to the input face and excites a phosphor screen placed close to the output, preserving the spatial resolution and making an amplified image of the information on the photocathode. The input of the channel is also sensitive to ions, beta particles, X-rays, or any radiation of a suitable energy and this extends its use to many other applications. Since the resistive path is continuous, many electron paths are possible and the number of stages of amplification is indeterminate. The electron trajectories are scaled in proportion to the dimensions of the channel for a given applied voltage. Thus if the length to diameter ratio is kept constant the gain per channel remains constant, irrespective of the absolute length of the channel. For most applications the spatial resolution is important and in order to achieve the highest resolutions the channel diameters and the walls between channels are kept as small as possible.

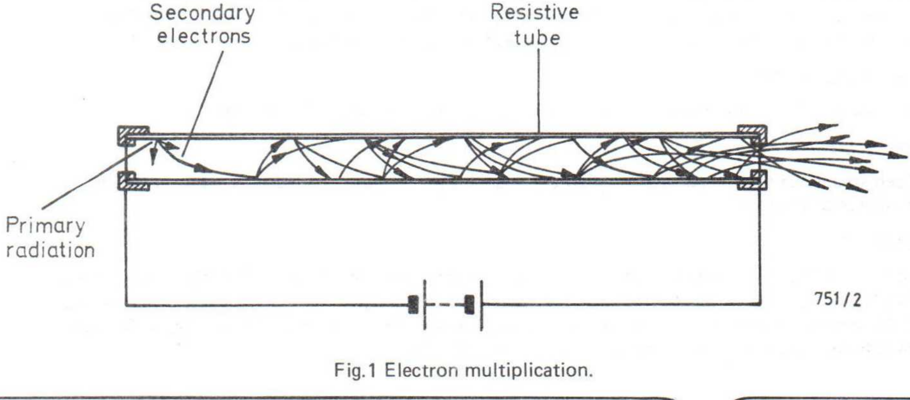


Fig.1 Electron multiplication.

IONIC FEEDBACK

The electron cloud at the output of the plate is sufficiently intense to generate an appreciable number of ions and these drift towards the input of the channel and, upon striking the wall, can produce a further burst of secondary electrons. This pulse, starting near the output, will be smaller than the first pulse, but may also generate ions which will drift backwards, so that a train of pulses is generated. This train of pulses alters the charge on the wall, which reduces the gain. This effect limits the voltage that can be applied to the plate and thus the gain that can be achieved. By placing two plates in cascade with the channels angled in opposite directions, ions fed back from the output plate cannot enter the input plate and high gain can be achieved without excessive ion feedback and consequent loss of linearity.

SATURATION DUE TO SPACE CHARGE

If the charge in the output pulse reaches about 10^8 electrons, the gain cannot increase further. The space charge in the output end of the channel repels secondary electrons, causing them to return to the wall without generating further electrons. When this occurs with an imaging application it will cause poor highlights and loss of detail. Imaging plates usually operate at gains of around 10^3.

SATURATION DUE TO FIELD DISTORTION

When the current in the output averages more than 10% of the total current, the voltage gradient in the wall is no longer linear and the gain falls so that there is a loss of linearity between input and output currents and a loss of highlights in the image.

SATURATION DUE TO FIELD EMISSION

It is important to keep channel plates scrupulously clean. Particles lodging in a channel can give rise to field emission which is multiplied in the channel and produces a permanently saturated condition. This is known as a switched-on channel and is a condition extremely difficult to correct.

→ PULSED OPERATION

If channel plates are required to be used in a pulsed mode, saturation will be more easily achieved by the use of double thickness plates (DT types), i.e. having a length to diameter ratio of 80:1. (See Fig.2).

RESISTANCE

The resistance of a channel plate is the value measured in vacuo between electrodes applied to the input and output faces.

→ OVERLOAD PROTECTION

Due to the characteristics of the glass, it is essential the power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows: R = operating voltage (max.) x 10^3 Ω.

DARK CURRENT

Dark current is generally very low, much less than 1 count/sec/cm^2 of plate area.

OPEN AREA

Open area is the total cross section of all the channels in the plate expressed as a percentage of the total area of the plate.

GAIN

Gain in the linear region of operation is defined as the output current divided by the input current. This is always better than 1000 for 1000 volts applied to the plate and increases one order for each 200 V increase in applied voltage. The recommended operating voltage is 800 to 1200 V. Outside these limits spatial non-uniformity can become a problem.

MOUNTING

The opposite faces of channel plates are ground flat and parallel during manufacture. As the devices are fragile, care must be taken to ensure that they are not stressed unduly when mounting them in systems. It is recommended that they are placed between perfectly flat polished stainless steel rings spring loaded only sufficiently to ensure reliable connections to the metallized faces of the plate. A loading of 300 gms per cm of periphery has been found adequate. Care must be taken to minimize the possibility of leakage or other currents between the contact rings when the working voltage is applied.

OPERATING TEMPERATURE AND OUTGASSING

The devices can be operated up to maximum of 70 ^{o}C and degassed up to a maximum of 300 ^{o}C. Further evolution of gas may take place during operation. The pressure should never be allowed to rise above 13.3 $mN.m^{-2}$ while the operating voltage is applied, but exposure to the atmosphere for a few hours at a time does not cause any loss of performance. It is prudent to store devices in a well desiccated container if they have to be removed from the vacuum environment for longer periods. The devices may be damaged permanently if exposed to gross contamination by hydrocarbon vapours.

If the output is to be detected by means of a phosphor screen, it is desirable to place it as close to the channel plate as can be arranged, commensurate with voltage and mechanical considerations. The electrons leave the outputs over a very wide angle, and detail can be lost if the spacing is excessive. For similar reason a photocathode input source should be placed close to the input face.

A suitable distance for the channel plate-screen gap is 1 mm, with a potential between screen and channel plate output of about 5 kV. Either the screen distance or the screen potential may be adjusted in order to optimize the resolution of the system.

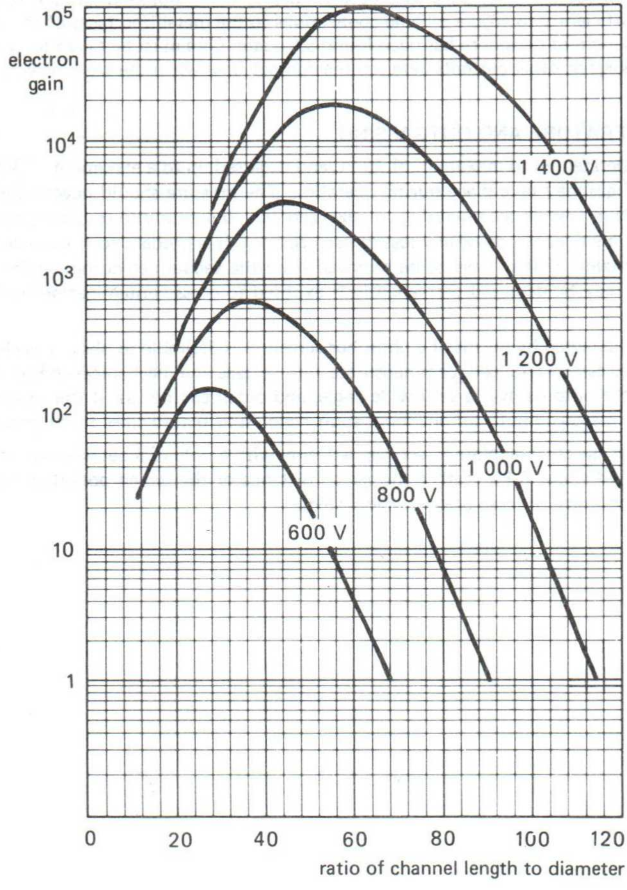

D8535
10^5
electron gain
10^4
10^3
10^2
10
1
0
20
40
60
80
100
120
ratio of channel length to diameter
1 400 V
1 200 V
1 000 V
800 V
600 V

Fig.2

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a rectangle. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the plate.

SPECIFICATION

Area of plate		$20^{+0}_{-0.2} \times 50^{+0}_{-0.2}$	mm
Useful area	min.	18.8 x 48.8	mm
Plate thickness		0.5 ± 0.1	mm
Channel diameter		12.5	μm
Channel pitch		15.0	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		80 to 300	MΩ ←
Current gain at 1.0 kV	min.	10^3	
Angle of channel to perpendicular axis of plate		13	degrees

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the plate, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature* (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3	$mN.m^{-2}$
		1.0×10^{-4}	torr

*The plate should be stored in a dry or vacuum environment.

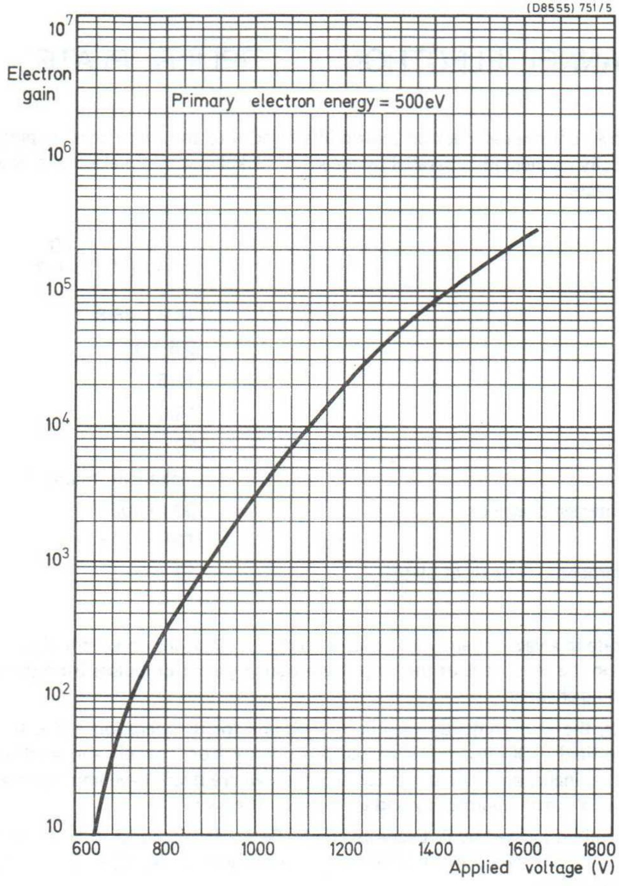


Fig.1 Typical current gain as a function of applied voltage

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

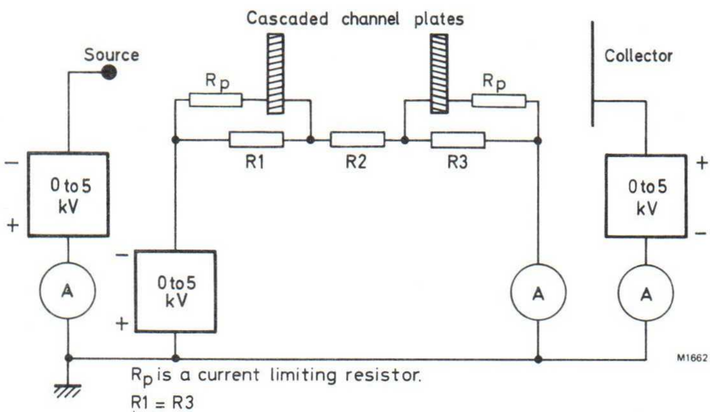


Fig.2 Circuit for cascaded channel plates

SOLID EDGE CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc with a solid edge. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Disc diameter		$25^{+0}_{-0.1}$	mm
Useful diameter	min.	19	mm
Disc thickness		0.5 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15.0	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		200 to 750	MΩ ←
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of disc		13	degrees

For a linear relationship between input and output, the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling in the input face of the disc by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature** (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3 (1.0×10^{-4} torr)	$mN.m^{-2}$

* The suffix /A denotes a pair of plates which are resistance matched for applications requring two plates in cascade, (see Fig.2).

** The plate should be stored in a dry or vacuum environment.

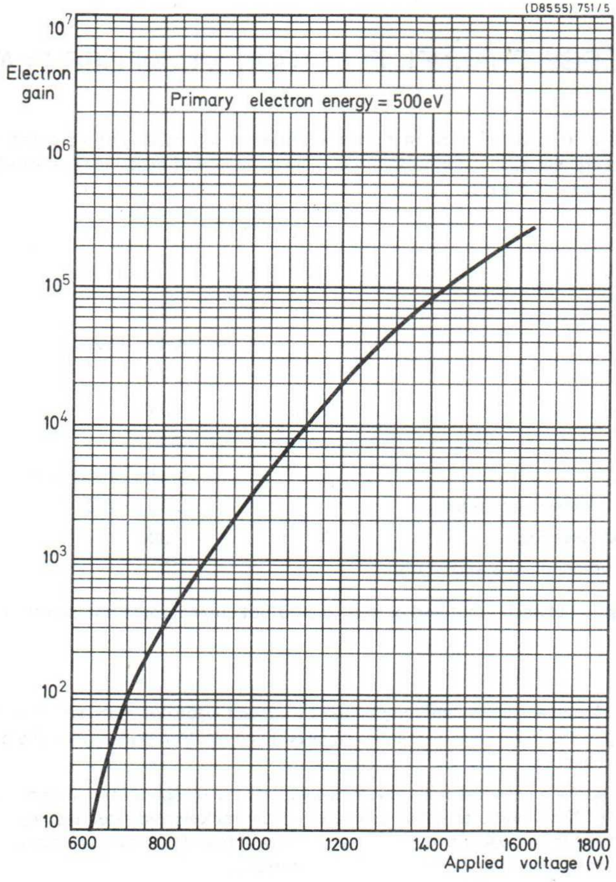


Fig. 1 Typical current gain as a function of applied voltage.

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

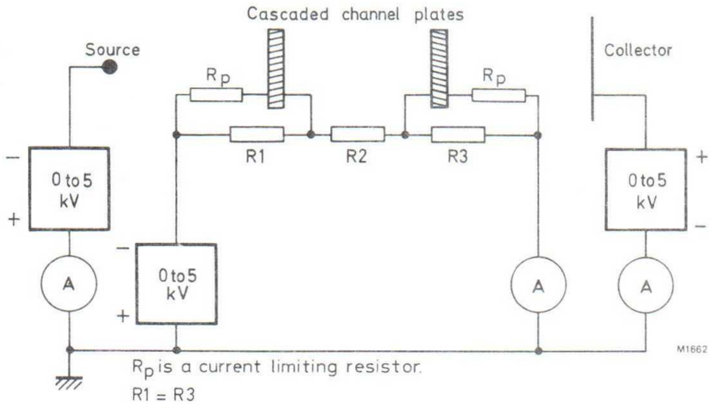


Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Disc diameter		$36^{+0}_{-0.1}$	mm
Useful diameter	min.	32.5	mm
Disc thickness		0.5 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		80 to 300	MΩ ←
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of disc		13	degrees

For a linear relationship between input and output, the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2. April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature ** (operating and storage)	max.	70	°C
Bake temperature	max.	300	°C
Ambient pressure with high voltage applied	max.	13.3 (1.0×10^{-4} torr)	$mN.m^{-2}$
Plate clamping rings internal diameter	max.	33	mm

* The suffix /A denotes a pair of plates which are resistance matched for applications requiring two plates in cascade, (see Fig.2).

** The plate should be stored in a dry or vacuum environment.

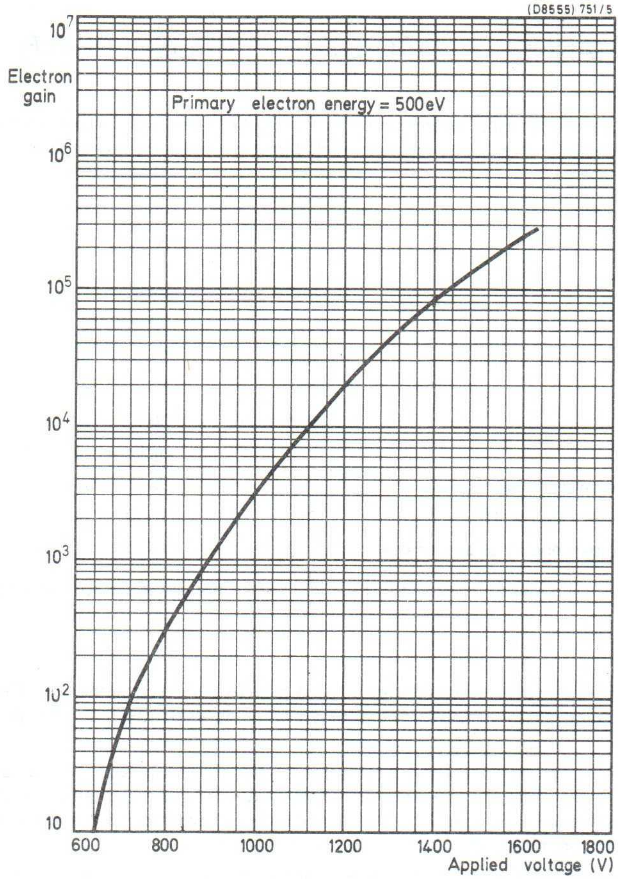


Fig. 1 Typical current gain as a function of applied voltage.

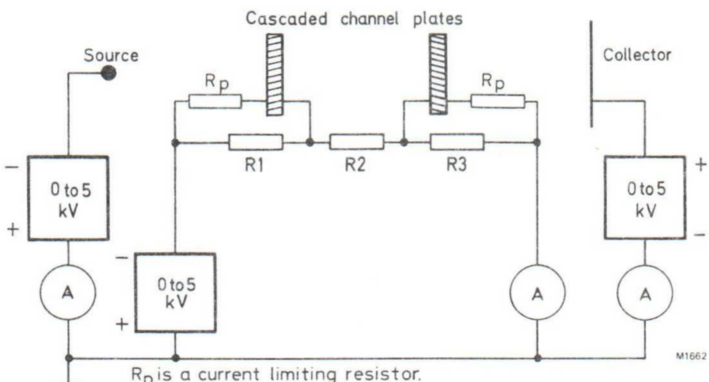
MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 $N.m^{-2}$ (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$



R_p is a current limiting resistor.
R1 = R3

Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATES

Each plate consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc. These plates have been specially developed for use in pairs in the pulse detection mode for X-rays and other types of radiation. The suffix DT indicates double thickness. The G12-36DT/0 is cut so that the channels form an angle of 0 degrees to the perpendicular axis; in the G12-36DT/13 the channels form an angle of 13° to the perpendicular axis.

SPECIFICATION

Disc diameter		$36^{+0}_{-0.1}$	mm
Useful diameter	min.	32.5	mm
Disc thickness		1.0 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15.0	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		200 to 600	MΩ ←
Length to diameter ratio		80:1	
Current gain (pair of plates at 1.2 kV/plate)	nom.	$>10^6$	

APPLICATIONS

These devices must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for their operation and they have considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use they must be incorporated in a vacuum chamber, where they will have important applications in field ion microscopy, electron microscopy and allied areas of research.

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RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage (pair of plates)	max.	6.0	kV
Operating voltage (single plate)	max.	3.0	kV
Temperature* (operating and storage)	max.	70	$^{\circ}$C
Bake temperature	max.	300	$^{\circ}$C
Ambient pressure with high voltage applied	max.	13.3 (1.0×10^{-4} torr)	mN.m^{-2}
Plate clamping rings internal diameter	max.	33	mm

*The plate should be stored in a dry or vacuum environment.

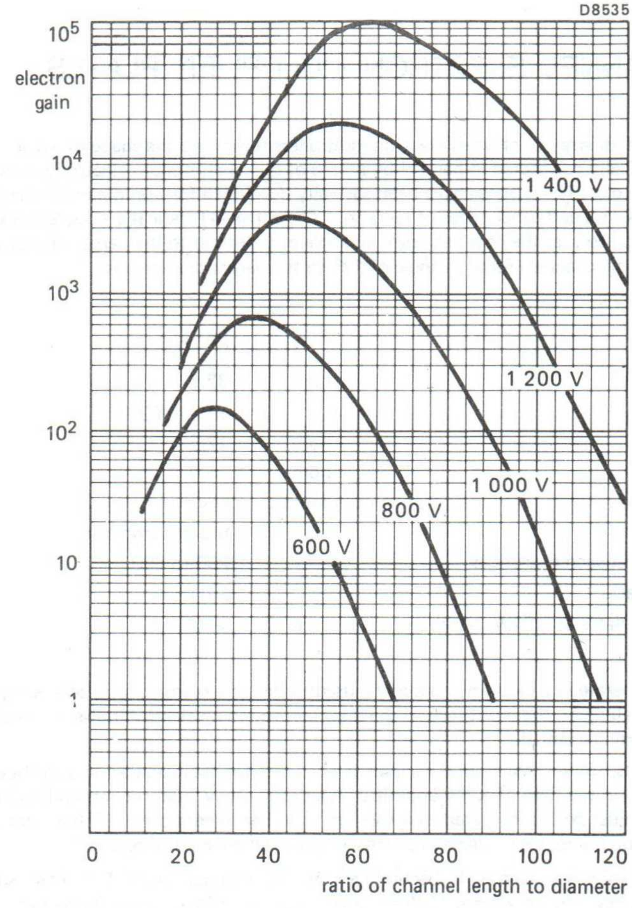


Fig. 1 Typical universal gain curves

MOUNTING

Channel plates are fragile and great care must be taken to ensure that they are not unduly stressed when mounted in the vacuum system. It is recommended that the plates are mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The devices will withstand a contact pressure of at least 10^4 $N.m^{-2}$ (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

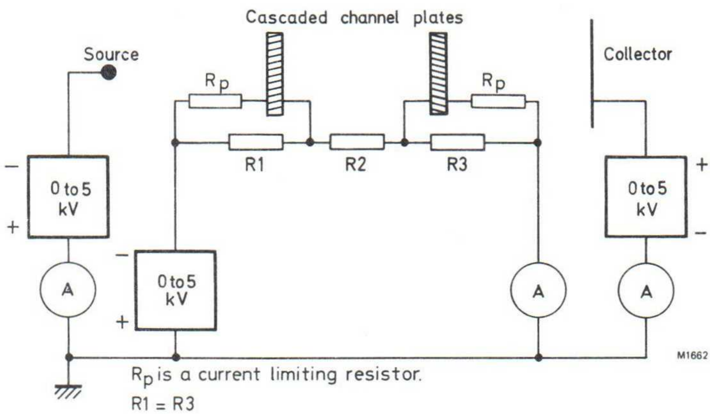


Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Disc diameter		$46^{+0}_{-0.1}$	mm
Useful diameter	min.	42	mm
Disc thickness		0.5 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15.0	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		30 to 100	MΩ
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of disc		13	degrees

For a linear relationship between input and output, the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	1.5	kV
Temperature** (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied		13.3 (1.0×10^{-4}) torr	mN.m^{-2}
Plate clamping rings internal diameter	max.	42.5	mm

* The suffix/A denotes a pair of plates which are resistance matched for applications requiring two plates in cascade, (see Fig.2).

** The plate should be stored in a dry vacuum environment.

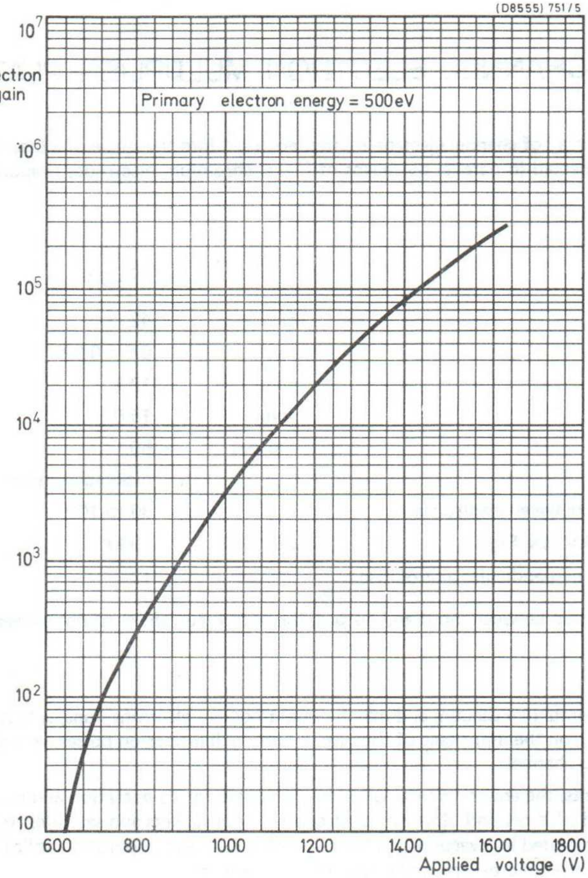


Fig.1 Typical current gain as a function of applied voltage

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

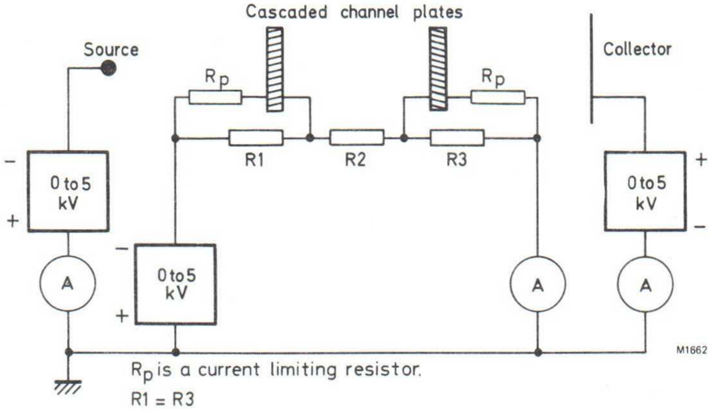


Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATES

Each plate consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc. These plates have been specially developed for use in pairs in the pulse detection mode for X-rays and other types of radiation. The suffix DT indicates double thickness. The G12-46DT/0 is cut so that the channels form an angle of 0 degrees to the perpendicular axis; in the G12-46DT/13 the channels form an angle of 13^{o} to the perpendicular axis.

SPECIFICATION

Disc diameter		$46^{+0}_{-0.1}$	mm
Useful diameter	min.	42	mm
Disc thickness		1.0 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15.0	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		60 to 250	MΩ ←
Length to diameter ratio		80:1	
Current gain (pair of plates at 1.2 kV/plate)	nom.	$> 10^6$	

APPLICATIONS

These devices must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultraviolet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for their operation and they have considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use they must be incorporated in a vacuum chamber, where they will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage (pair of plates)	max.	6.0	kV
Operating voltage (single plate)	max.	3.0	kV
Temperature* (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3 (1.0 x 10^{-4} torr)	$mN.m^{-2}$
Plate clamping rings internal diameter	max.	42.5	mm

*This plate should be stored in a dry or vacuum environment.

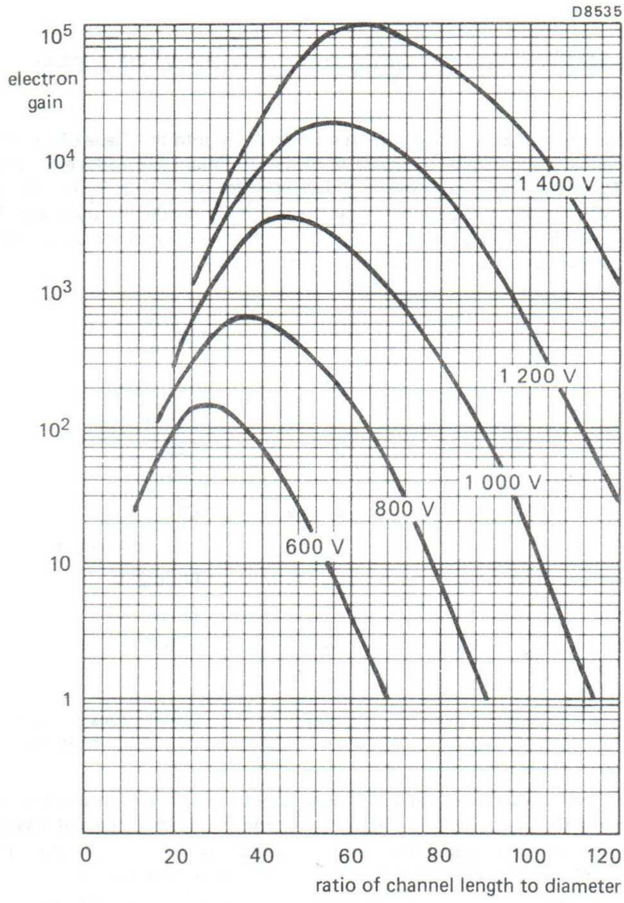


Fig.1 Typical universal gain curves

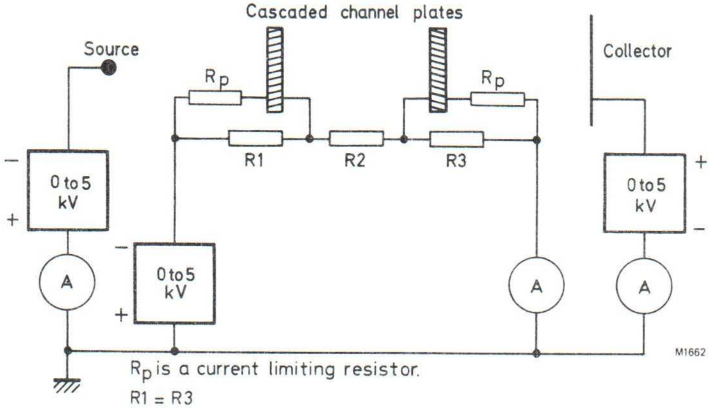
MOUNTING

Channel plates are fragile and great care must be taken to ensure that they are not unduly stressed when mounted in the vacuum system. It is recommended that the plates are mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The devices will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$



R_p is a current limiting resistor.
R1 = R3

Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Disc diameter		$70.0^{+0}_{-0.1}$	mm
Useful diameter	min.	67	mm
Disc thickness		0.5 ± 0.02	mm
Channel diameter	nom.	12.5	μm
Channel pitch	nom.	15	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes	approx.	20	MΩ
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of plate		13	degrees

For a linear relationship between input and output, the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling in the input face of the plate, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	1.5	kV
Temperature* (operating and storage)	max.	70	°C
Bake temperature	max.	300	°C
Ambient pressure with high voltage applied	max.	13.3 (1.0×10^{-4} torr)	$mN.m^{-2}$
Plate clamping rings internal diameter	max.	67.5	mm

*The plate should be stored in a dry or vacuum environment.

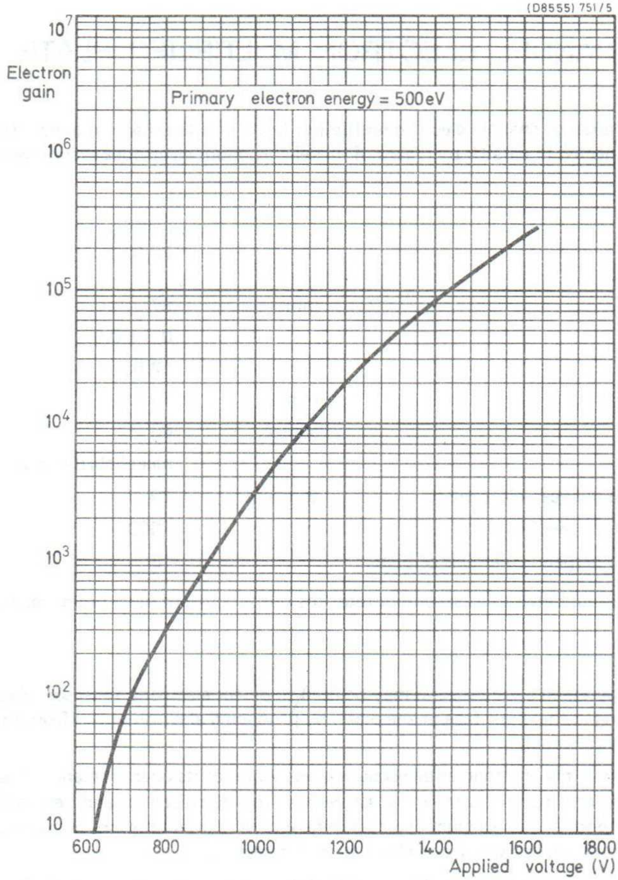


Fig. 1 Typical current gain as a function of applied voltage

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

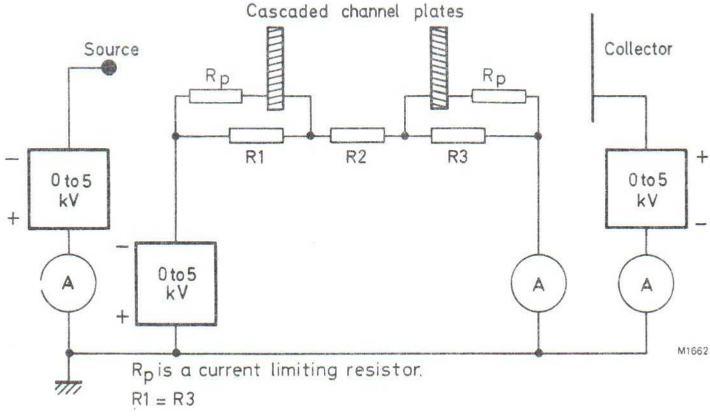


Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a rectangle. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the plate.

SPECIFICATION

Area of plate		$20^{+0}_{-0.2} \times 50^{+0}_{-0.2}$	mm
Useful area	min.	18.8 x 48.8	mm
Plate thickness		1 ± 0.1	mm
Channel diameter		25	μm
Channel pitch		31	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes	nom.	35	MΩ
Current gain at 1.0 kV	min.	10^3	
Angle of channel to perpendicular axis of plate		13	degrees

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the plate, by producing electron pulses from the output face of the corresponding channel.

For space experiments, the environmental vacuum is adequate for its operation and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites. In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of research.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature* (operating and storage)	max.	70	°C
Bake temperature	max.	300	°C
Ambient pressure with high voltage applied	max.	13.3	$mN.m^{-2}$
		1.0×10^{-4}	torr

*The plate should be stored in a dry or vacuum environment.

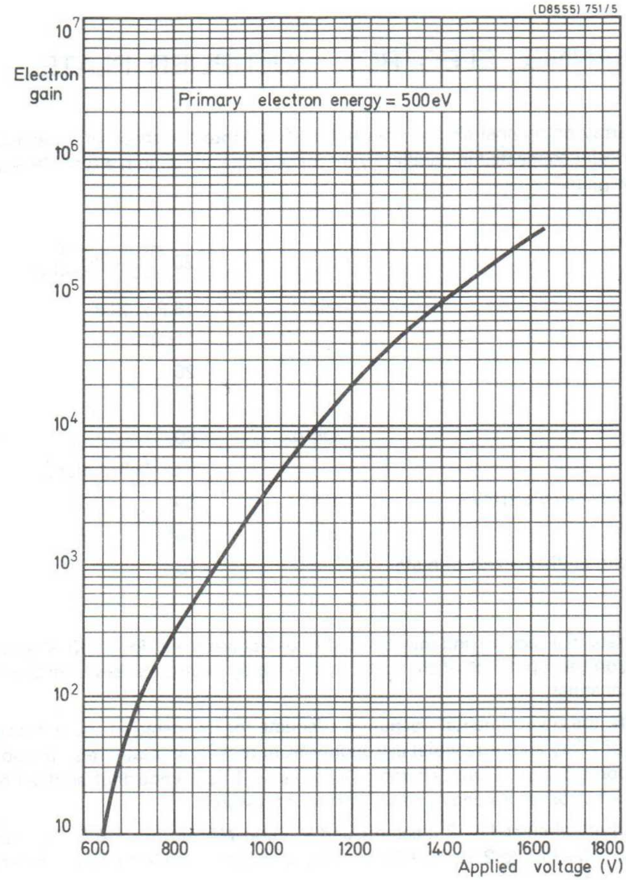


Fig. 1 Typical current gain as a function of applied voltage.

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

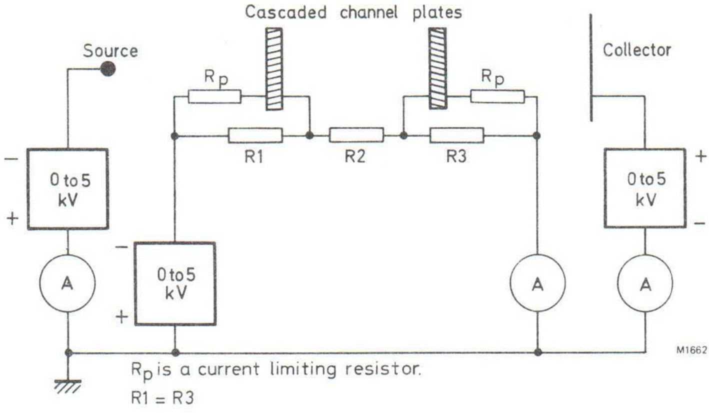


Fig.2 Circuit for cascaded channel plates

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc		27.1 ± 0.1	mm
Useful diameter	min.	26.5	mm
Disc thickness		1.0 ± 0.1	mm
Channel diameter		25	μm
Channel pitch		31	μm
Open area	approx.	60	%
Electrode material		nickel chromium	
Electrical resistance between electrodes		30 to 150	MΩ
Current gain at 1.0 kV (see Fig.1)	>	1000	
Maximum current output at 1.0 kV for linear operation		1.0	μA
Angle of channel to perpendicular axis of plate		13	degrees

APPLICATIONS

This device must operate in a vacuum, and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments the environmental vacuum is adequate for its operation, and it has considerable potential in the field of X-ray and ultra-violet astronomy from rockets and satellites.

In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of work.

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RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature** (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3 (1.0 x 10^{-4} torr)	mN.m^{-2}
Plate clamping rings diameter	max.	26.6	mm

* The suffix /A denotes a pair of plates which are resistance matched for applications requiring two plates in cascade, (see Fig.2).

** The plate should be stored in a dry or vacuum environment.

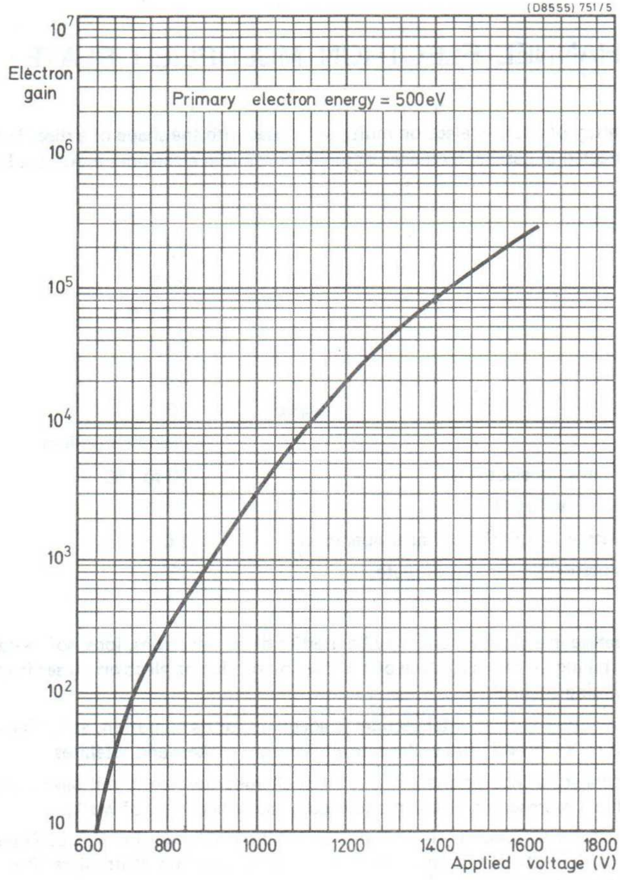


Fig.1 Typical current gain as a function of applied voltage.

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

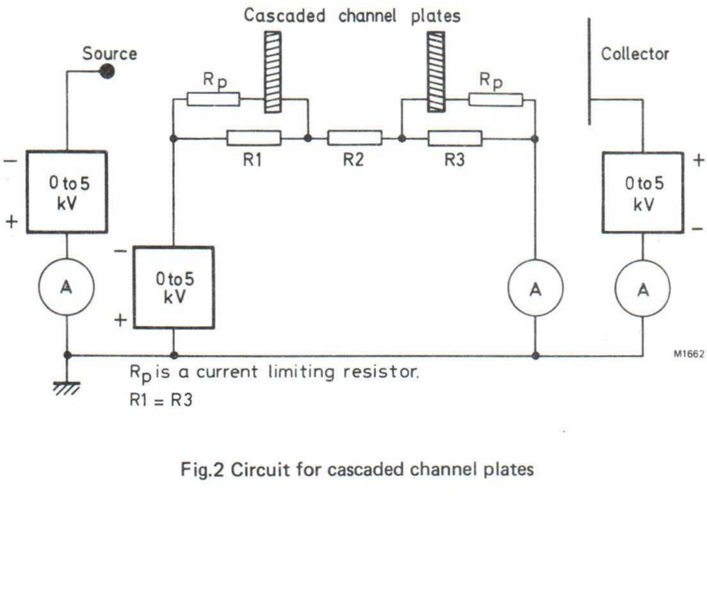


Fig.2 Circuit for cascaded channel plates

See also G12-46

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc		$53.0^{+0}_{-0.2}$	mm
Useful diameter	min.	51.8	mm
Thickness		1.0 ± 0.1	mm
Channel diameter		25	μm
Channel pitch		31	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes		7 to 40	MΩ ←
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of plate		13	degrees

For linear relationship between input and output the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum, and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments the environmental vacuum is adequate for its operation.

In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of work.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature* (operating and storage)	max.	70	^{o}C
Bake temperature	max.	300	^{o}C
Ambient pressure with high voltage applied	max.	13.3 (1.0×10^{-4} torr)	$mN.m^{-2}$
Plate clamping rings diameter	max.	52.4	mm

*The plate should be stored in a dry or vacuum environment.

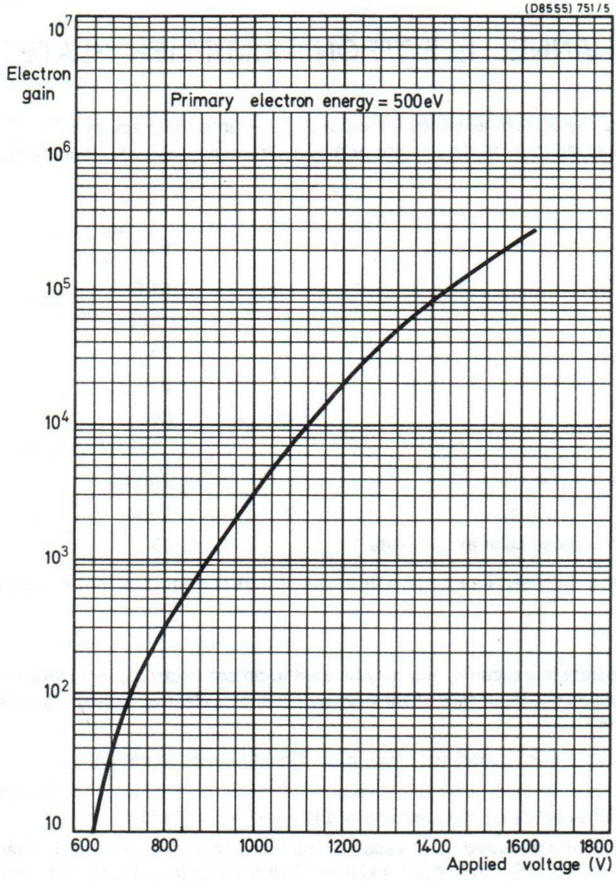


Fig.1 Typical current gain as a function of applied voltage

MOUNTING

A channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 N.m^{-2} (corresponding to a load of ~1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 mm wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

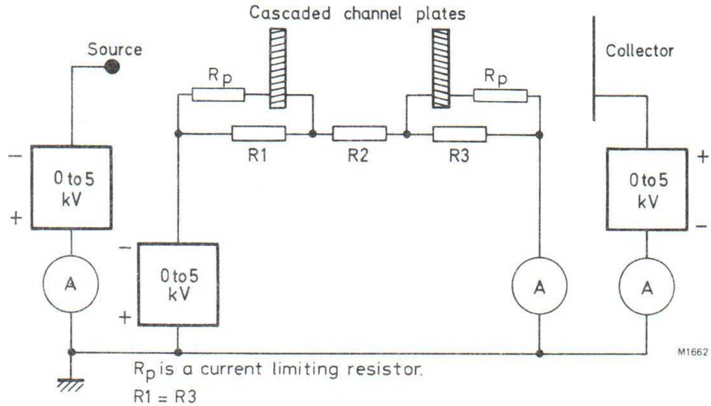


Fig.2 Circuit for cascaded channel plates

Replaced by G12-70

CHANNEL ELECTRON MULTIPLIER PLATE

This consists of an array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc		$70.0^{+0}_{-0.2}$	mm
Useful diameter	min.	68.0	mm
Disc thickness		1.0 ± 0.1	mm
Channel diameter		25	μm
Channel pitch		31	μm
Open area	approx.	60	%
Electrode material		nickel-chromium	
Electrical resistance between electrodes	nom.	5	MΩ
Current gain at 1.0 kV (see Fig.1)	>	1000	
Angle of channel to perpendicular axis of plate		13	degrees

For linear relationship between input and output the output current must not exceed 0.1 of the standing current.

APPLICATIONS

This device must operate in a vacuum and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments the environmental vacuum is adequate for its operation.

In laboratory use it must be incorporated in a vacuum chamber, where it will have important applications in field ion microscopy, electron microscopy and allied areas of work.

Such applications are fully discussed by P. Lecomte and V. Perez-Mendez in I.E.E.E. Transactions on Nuclear Science, Vol. NS–25, No.2 April 1978 – 'Channel Electron Multipliers: Properties, Development and Applications'.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Operating voltage	max.	2.0	kV
Temperature* (operating and storage)	max.	70	°C
Bake temperature	max.	300	°C
Ambient pressure wuth high voltage applied	max.	13.3 (1.0×10^{-4} torr)	$mN.m^{-2}$
Plate clamping rings diameter	max.	68.5	mm

*The plate should be stored in a dry or vacuum environment.

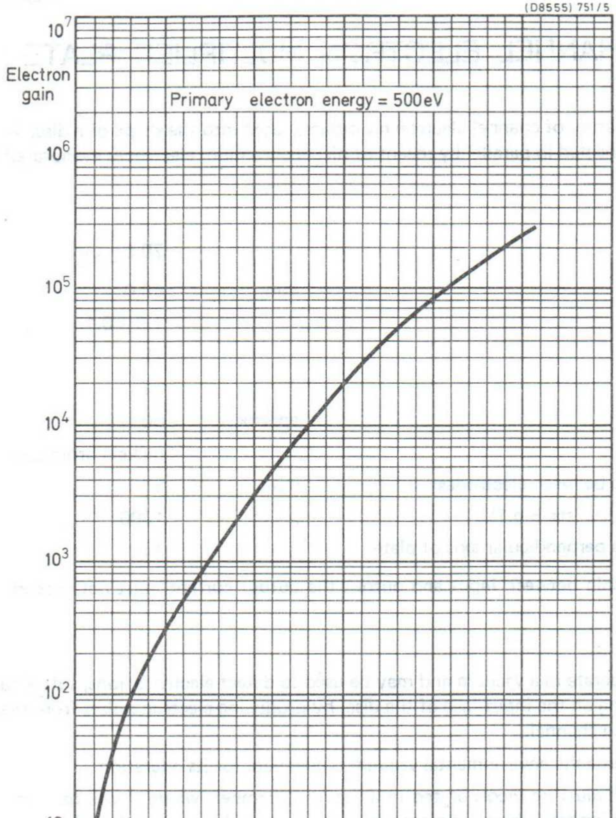


Fig.1 Typical current gain as a function of applied voltage

MOUNTING

As channel plate is fragile and great care must be taken to ensure that it is not unduly stressed when mounted in the vacuum system. It is recommended that the plate is mounted between clean polished brass or stainless steel rings, giving noise-free electrical contacts. The device will withstand a contact pressure of at least 10^4 $N.m^{-2}$ (corresponding to a load of ~ 1 g per mm^2) applied via screws pushing against small helical springs. Polished brass annular shims, about 1.5 m wide and 50 μm thick, are recommended for insertion between plates operating in cascade.

OVERLOAD PROTECTION

Due to the glass characteristics, it is essential that power supplies should not be capable of delivering a current in excess of 1 mA. This can be achieved by the use of a series current limiting resistor, the value of which may be calculated as follows:

$$R_p = \text{operating voltage (max.)} \times 10^3\ \Omega.$$

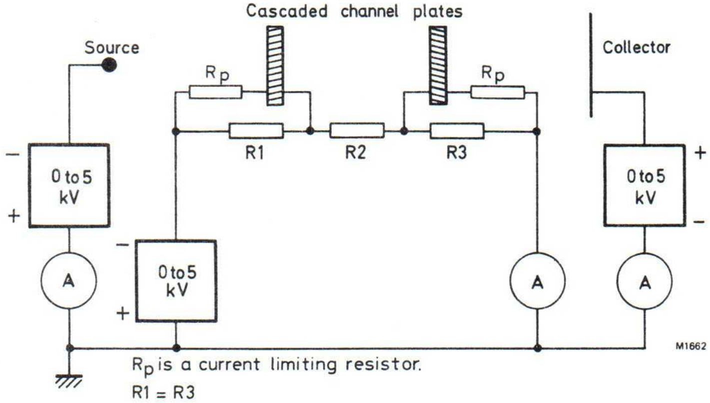


Fig.2 Circuit for cascaded channel plates

ASSOCIATED ACCESSORIES

SURVEY OF TYPES

SOCKET

DESCRIPTION

This socket consists of a plastic moulding with 12 gold-plated contacts. The connections to the socket can be made by means of wire soldering. Mounting is done with two M3 screws.

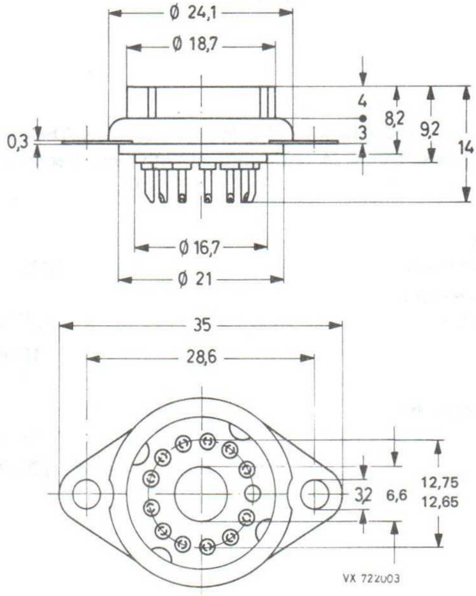
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13} Ω
Contact resistance	<	10 mΩ
Capacitance		
between two adjacent contacts		0,8 pF
one contact to all		1,3 pF
Temperature range		−55 to + 100 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass	7 g
Mounting hole diameter	22,5 mm

The use of flexible connecting wires is strongly recommended.

DUODECAL SOCKET

DESCRIPTION

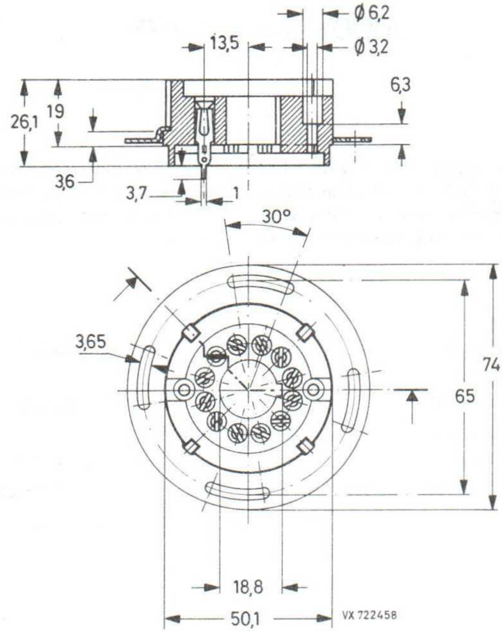
This socket consists of an epoxy moulding with 12 tin-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of two M3 screws.

ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Maximum working voltage between any contact and saddle		3000 V
Insulation resistance between two adjacent contacts (at 500 V)	$>$	10^{13} Ω
Contact resistance	$<$	50 mΩ
Temperature	max.	80 °C

MECHANICAL DATA Dimensions in mm

Outlines



Mass

socket	50 g
mounting ring	15 g

DIHEPTAL SOCKET

DESCRIPTION

This socket consists of an epoxy moulding with 14 tin-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of two M3 screws.

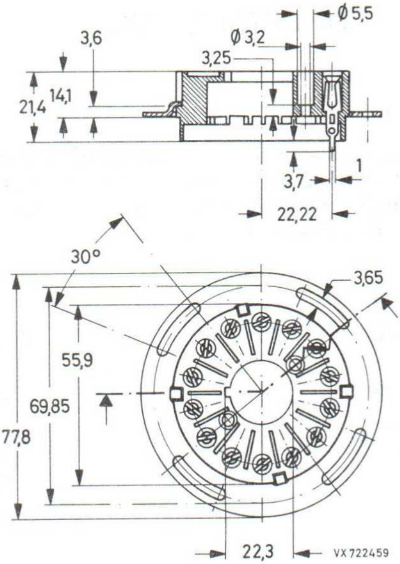
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000	V
Maximum working voltage between any contact and saddle		3000	V
Insulation resistance between two adjacent contacts (at 500 V)		$> 10^{13}$	Ω
Contact resistance		< 50	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	45 g
mounting ring	15 g

BIDECAL SOCKET

DESCRIPTION

This socket consists of an epoxy moulding with 20 tin-plated phosphor-bronze contacts, spigot keyway in the centre hole and separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with or without the separate mounting ring by means of three M4 or three M3 screws respectively.

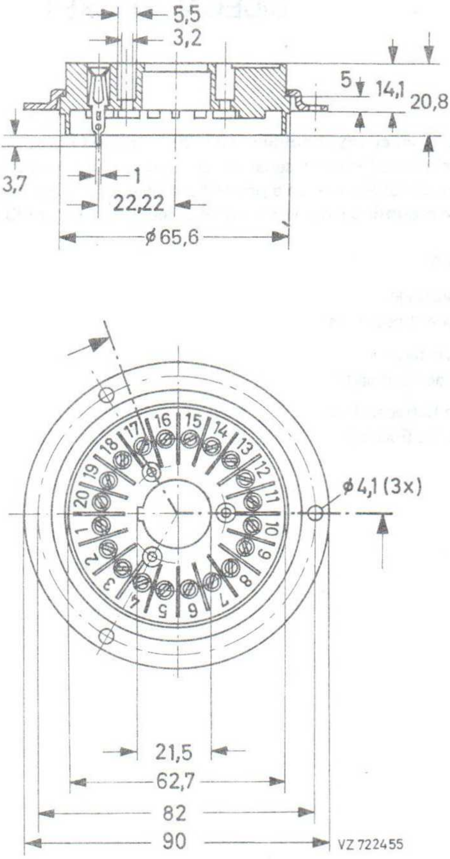
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts	2000 V
Maximum working voltage between any contact and saddle	4000 V
Insulation resistance between two adjacent contacts (at 500 V)	$> 10^{13}$ Ω
Contact resistance	$<$ 50 mΩ
Temperature	max. 80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	64 g
mounting ring	44 g

SOCKET

DESCRIPTION

This socket has a plastic moulding with 12 tin-plated printed-wiring contacts.

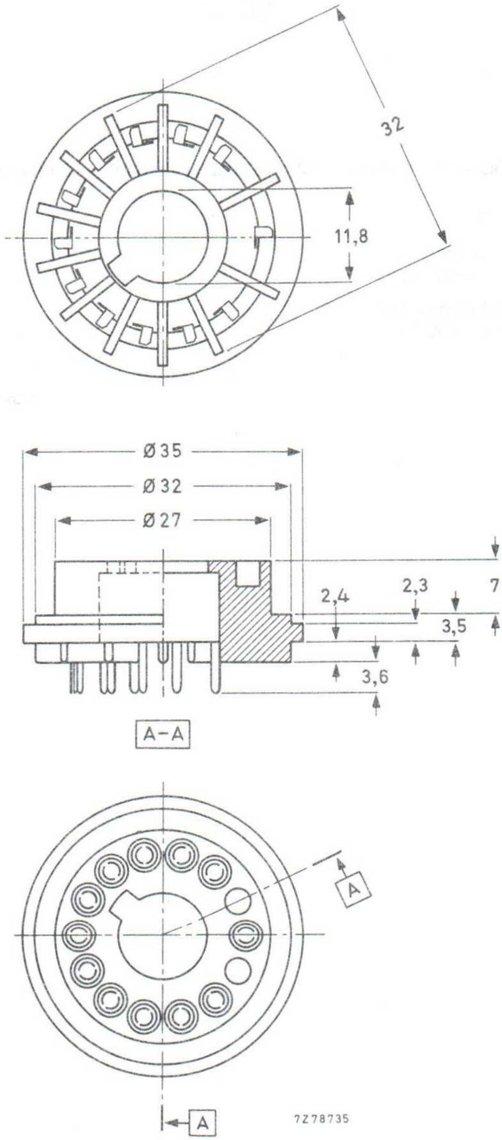
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000	V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13}	Ω
Contact resistance	<	10	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass 7 g

SOCKET

DESCRIPTION

This socket consists of a plastic moulding with 14 gold-plated contacts. The connections to the socket can be made by means of wire soldering. Mounting is done with two M3 screws.

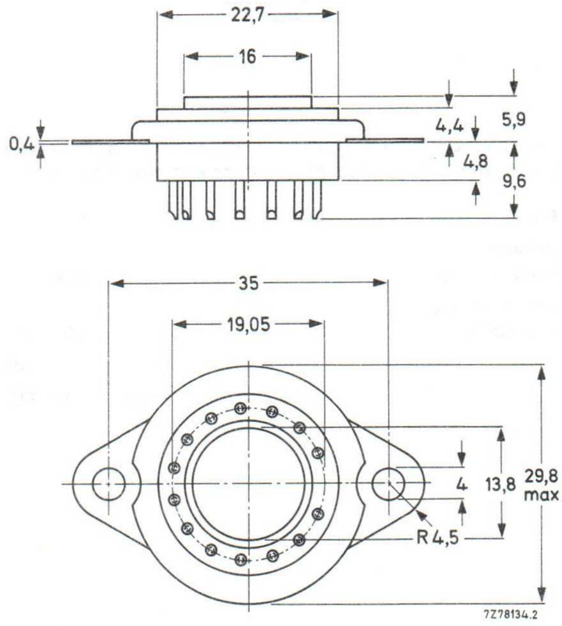
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13} Ω
Contact resistance	<	10 mΩ
Temperature	max.	80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



SOCKET

DESCRIPTION

This socket consists of a polytetrafluoraethylene moulding with 19 tin-plated phosphor-bronze contacts and a separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with the separate mounting ring by means of two M3 screws.

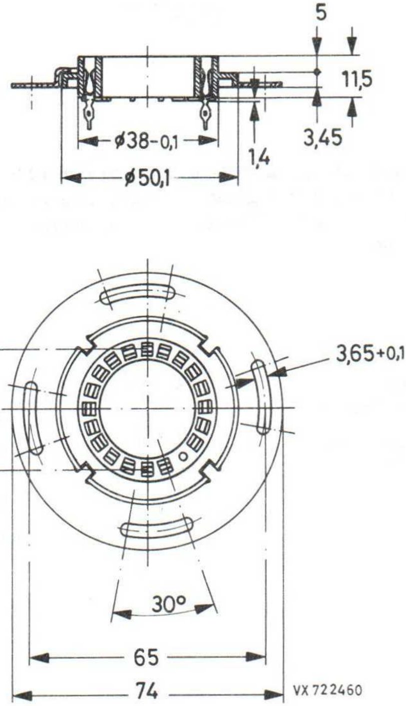
ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000 V
Maximum working voltage between any contact and saddle		3000 V
Insulation resistance between two adjacent contacts (at 500 V)	$>$	10^{13} Ω
Contact resistance	$<$	50 mΩ
Temperature	max.	80 °C

MECHANICAL DATA

Dimensions in mm

Outlines



Mass

socket	18 g
mounting ring	15 g

SOCKET

DESCRIPTION

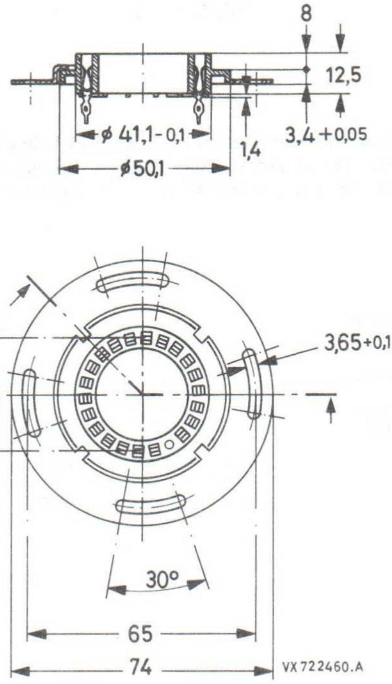
This socket consists of a polytetrafluoraethylene moulding with 21 tin-plated phosphor-bronze contacts and a separate cadmium-plated saddle. The socket pins are suitable for either wire soldering, or soldering into a printed-wiring board. The socket can be mounted with the separate mounting ring by means of two M3 screws.

ELECTRICAL DATA

Maximum working voltage between two adjacent contacts		2000	V
Maximum working voltage between any contact and saddle		3000	V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13}	Ω
Contact resistance	<	50	mΩ
Temperature	max.	80	°C

MECHANICAL DATA Dimensions in mm

Outlines



Mass

socket	35 g
mounting ring	15 g

PHOTOMULTIPLIER BASE ASSEMBLY

This base assembly is for tubes used to detect very brief low-intensity light pulses in physics experiments using coincidence measurements, Cerenkov light, high-speed scintillators, or the counting of single photoelectrons.

QUICK REFERENCE DATA

H.T. supply	see data sheet of relevant photomultiplier tube
Maximum current consumption	0,6 mA/kV
Outputs	anode output, 50 Ω, BNC dynode output, 50 Ω, BNC

The base assembly S5632 consists of two parts that screw together:

S5632/AV shielding part for fast photomultiplier tubes with a useful diameter of 44 mm;

S563 voltage divider part for fast photomultiplier tubes with a useful diameter of 44 mm or 110 mm, and a 20-pin plastic base.

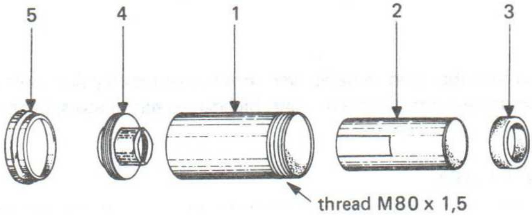
The parts can also be used separately; see table below.

photomultiplier tube		shielding + voltage divider	shielding	voltage divider
useful diameter of photocathode	type			
44 mm	XP2020(Q) XP2230B XP2252B XP2262B XP2233B XP2254B 56AVP family	S5632	S5632/AV	S563
110 mm	XP2040(Q) XP2041(Q)	information on request		S563

MECHANICAL DATA

Outlines

S5632/AV



1 = Soft iron shield
2 = Mumetal shield
3 = Foam plastic ring
4 = Fastening ring for light guide
5 = Lock ring

S563

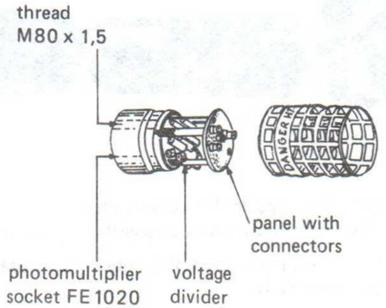


Fig. 1 S5632 = S5632/AV + S563.

assembly	overall length mm	overall diameter mm	mass g
S5632	334	90	4490
S5632/AV	240	80	4000
S563	108	90	490

ELECTRICAL DATA

Maximum supply voltage	−3 kV
Maximum current consumption	0,6 mA/kV

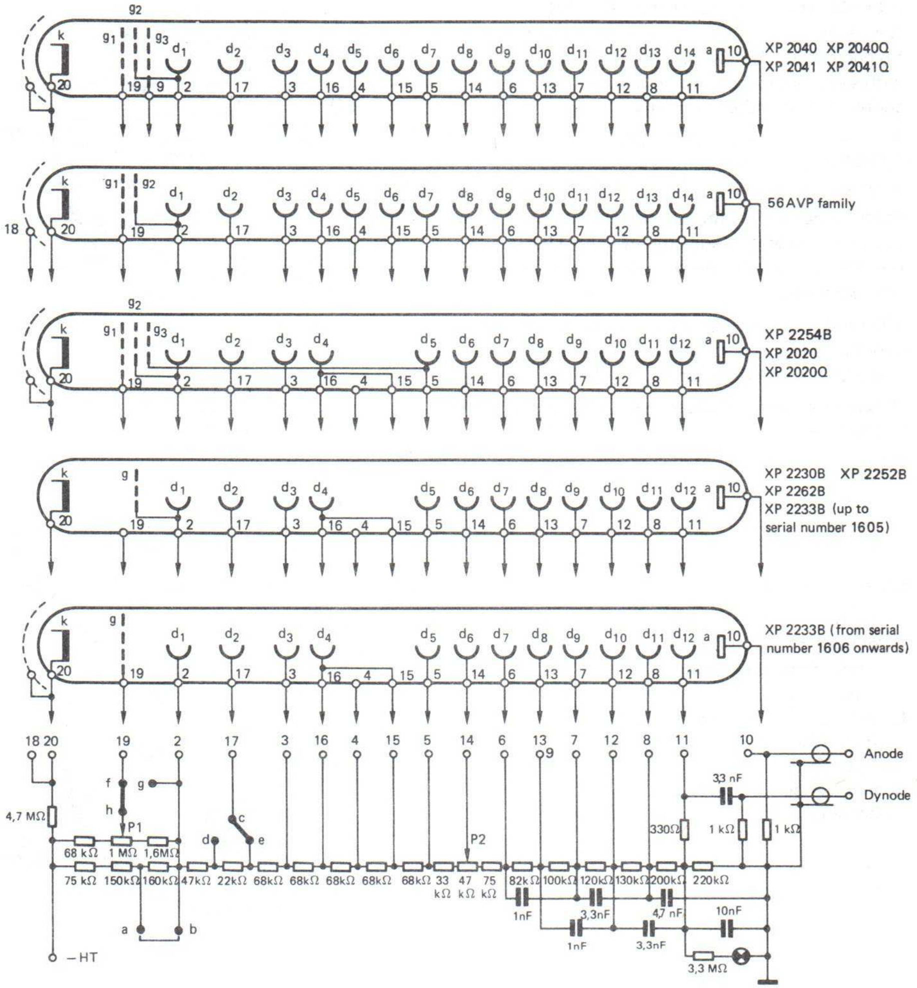


Fig. 2.

The voltage divider is wired for 12-stage and 14-stage tubes (see Fig. 2); in 12-stage tubes two of the resistors are short-circuited by the internal connection of dynode d_4 to pins 15 and 16.

The divider can be used as-is with any of the listed 44 mm tubes except the XP2233B. For use with the XP2233B, remove jumper f-h and connect a new jumper f-g. (Tubes with serial numbers up to 1605 have this connection provided internally.)

For use with 110 mm tubes XP2040(Q) and XP2041(Q), remove jumpers a-b and c-e and connect a new jumper c-d.

Potentiometer P1 is for adjusting the input optics; P2 is for gain adjustment. CAUTION: Beware of high voltage when adjusting either of these potentiometers.

The resistors of the last three stages (* in Fig. 3) may be replaced by zener diodes with 100 kΩ protection resistors in parallel.

Observe the limiting values given in the data sheet of the tube used.

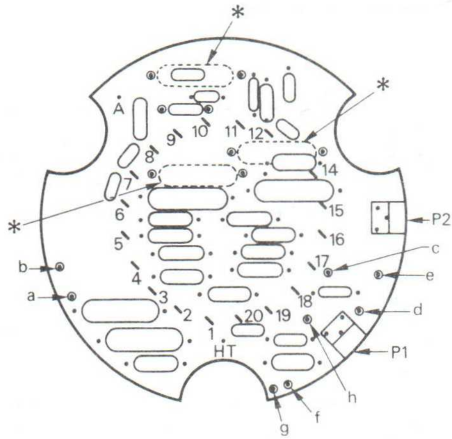


Fig. 3.

CONNECTIONS

A: anode output, 50 Ω BNC
B: dynode output, 50 Ω BNC
(to be terminated with 50 Ω
if not used)
C: H.T. supply input (socket SHV
R 317580; mating connector
R 317005**)
D: high-voltage indicator
E: housing lock

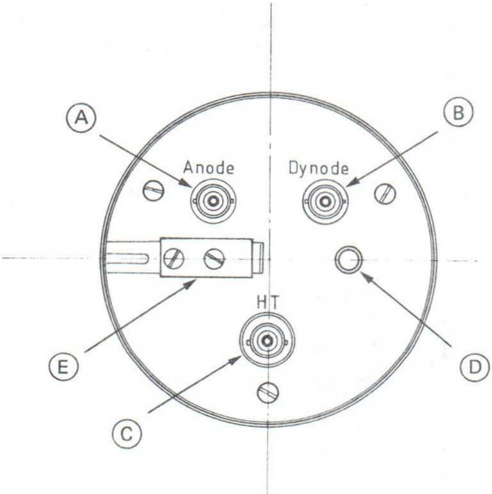


Fig. 4.

** Not supplied by the manufacturer of the base assembly.

ELECTRICAL PERFORMANCE

Pulse response

Figure 5 shows the anode pulse due to a very brief light pulse at the cathode. The peak amplitude into a 50 Ω load is 200 mA; 10% – 90% rise time, t_r, and full width at half maximum, t_W, are tabulated below.

Gain

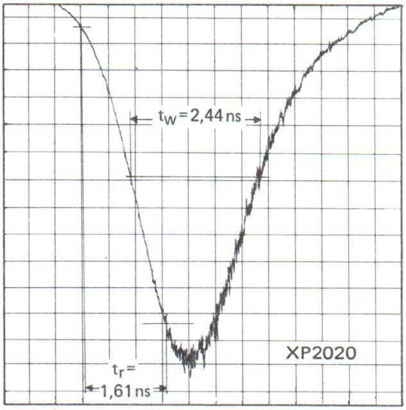
The voltage divider is of the semi-progressive type, similar to type B' for tubes XP2020(Q), XP2040(Q), XP2041(Q), XP2230B, XP2254B, and 56AVP family, type B for tubes XP2252B, XP2233B and XP2262B. It combines very fast response with a good compromise between gain and pulse linearity. Supply voltages for a gain of 10^7 are tabulated below.

Pulse response

tube	supply voltage V	t_r ns	t_W ns
XP2020(Q)	2800	1,6	2,5
XP2040(Q)	2200	2,4	3,3
XP2041(Q)	2200	2,4	3,3
XP2230B	2700	1,8	2,6
XP2252B	2100	2,1	3,1
XP2233B	2100	2,1	3,1
XP2262B	2100	2,1	3,1
XP2254B	2800	1,6	2,5
56DVP	2400	2,1	3,5

Gain

tube	supply voltage for G = 10^7 (V)
XP2020(Q)	2230
XP2040(Q)	2150
XP2041(Q)	2350
XP2230B	2330
XP2252B	2050
XP2233B	2200
XP2262B	1950
XP2254B	2350
56DVP	2060



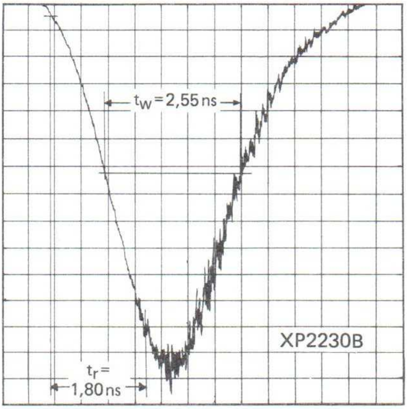


Fig. 5.

DEVELOPMENT SAMPLE DATA

NOTES

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