PROFESSIONAL COMPONENTS

DATA HANDBOOK

Photomultipliers

BOOK PC04 1990

Philips Components

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PHOTOMULTIPLIERS

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GENERAL

SELECTION GUIDE

use	nominal diameter (note 1)	photocathode sensitivity	number of stages (note 2)	base material (note 3)	type number (note 4)	page	comments
general photometry and scintillation counting tubes	19 mm	blue	6 10	g g	+ XP1922 XP1911	57 41	
		UV	10	g	XP1918	49	
		red	9	g	XP1117	27	
	38 mm	blue	10 10 10	g, p g, p g, p	XP2012(B) XP2072(B) + XP2052(B)	65 149 141	 high PHR high gain
		UV	10	p	XP2018B	93	
		green extended	10	g, p	+ XP2081(B)	157	
		red	8 10	p p	XP2023B + XP2013B	115 73	
		extended red	10	p	XP2017B	85	
		infrared	10	p	+ XP2015B	79	
	51 mm	blue	10 10 vb 12	g, p g, p g, p	XP2202(B) XP2102(B) XP2212(B)	181 165 205	 high PHR, medium gain
		green extended	10	g, p	+ XP2201(B)	173	
		high temp.	10	g	+ XP2206	197	
		red	10	p	XP2203B	189	
	76 mm	blue	10 vb	g, p	XP2412(B)	279	high PHR, medium gain
	127 mm	blue	10 vb	p	XP2050	133	

use	nominal diameter (note 1)	photocathode sensitivity	number of stages (note 2)	base material (note 3)	type number (note 4)	page	comments
fast tubes	29 mm	blue	8	g	XP2962	311	
			10	g	XP2972	327	
			11	g	XP2982	343	
		UV	10	g	+ XP2978	335	
		red	8	g	XP2963	319	
	51 mm	blue	6	p	XP2242B	229	
			8	p	+ XP2282B	263	
			12	p	XP2262B	253	
		red	6	p	+ XP2243B	237	
			12	p	XP2233B	213	
		extended red	12	p	+ XP2237B	221	
	76 mm	blue	8	p	XP3462B	389	
			12	p	XP2312B	271	
		green extended	8	p	+ XP3461B	381	
	127 mm	blue	14	p	XP2041	123	
		UV	14	p	XP2041/Q	123	
very fast tubes	51 mm	blue	12	p	XP2020	101	
			12	p	+ XP4222B	397	high cathode sensitivity
		UV	12	p	XP2020/Q	101	
			12	p	+ XP4228B	413	high cathode sensitivity
		UV to red	12	p	XP2254B	243	
		extended red	12	p	+ XP4227B	405	

use	nominal diameter (note 1)	photocathode sensitivity	number of stages (note 2)	base material (note 3)	type number (note 4)	page	comments
high pulse height resolution, medium gain tubes	38 mm H	blue	10 8	g, p g	XP2072(B) + XP3062	149 351	
	51 mm	blue	10 vb 8	g, p p	XP2102(B) XP3102B	165 357	
	60 mm H H	blue	10 vb 10 vb 8 8	p p p p	XP2432B + XP2422B + XP3432B XP3422B	295 287 373 365	
	76 mm H	blue	10 vb 10 vb	g, p p	XP2412(B) + XP2442B	279 303	
multi-anode tubes	51 mm	blue	10 fl 10 fl	g g	XP4702 + XP4722	421 427	 fibre-optic window
photo tubes	29 mm	blue	0	g	AV29	435	photodiode
	80 mm	blue	1	g	+ XP1501	35	phototriode

Notes to selection guide

1. H indicates hexagonal shape, dimension is across the flats.
2. vb = venetian blind multiplier.
   fl = foil multiplier.
   no symbol = linear focused
3. g = glass base version.
   p = plastic base version.
4. + = newly listed type.

REPLACEMENT LIST

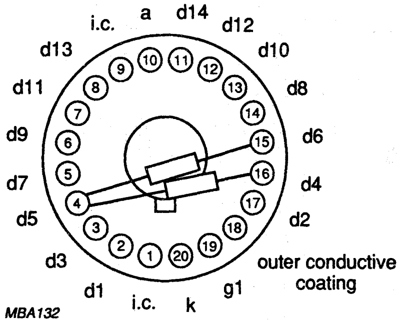
Our range of photomultiplier tubes is constantly improving and many types have been discontinued. The list below gives possible replacements, however, if in doubt, please consult your supplier.

Obsolete type	Replacement type
50AVP	XP2012B
51AVP	XP2012B
51UVP	XP2018B
52AVP	
53AVP	XP2202B
53DVP	XP2202B
53UVP	
54AVP	XP2050
54DVP	XP2050
54UVP	
56AVP	XP2262B*
56CVP	
56DUVP	XP2020/Q*
56DVP	XP2262B*
56SBUVP	
56TUVP	XP2254B*
56TVP	XP2233B*
56UVP	XP2020/Q*
57AVP	
58AVP	XP2041
58DVP	XP2041
58UVP	XP2041/Q
60AVP	
60DVP	
60DVP/H	
150AV	
150AVP	XP2012B
150CVP	XP2015B
150DVP	XP2012B
150UVP	XP2018B
152AVP	XP1911
153AVP	XP2012B

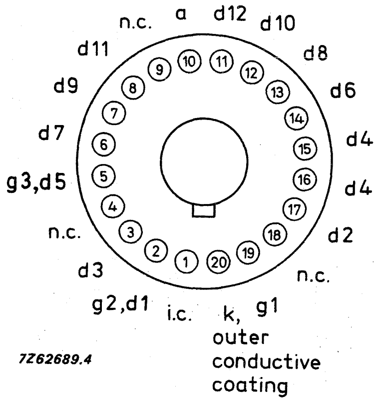
Obsolete type	Replacement type
PM1980	XP2972
PM1982	XP2982
PM2007	XP2017B
PM2054	XP2050
XP1000	XP2202B
XP1001	XP2202B
XP1002	XP2203B
XP1003	XP2254B
XP1004	
XP1005	
XP1006	XP2202B
XP1010	XP2012B
XP1011	
XP1015	
XP1016	XP2013B
XP1017	XP2017B
XP1020	XP2020
XP1023	XP2020/Q
XP1030	XP2412B
XP1031	XP2412B
XP1032	
XP1033	
XP1034	XP2412B
XP1040	XP2041
XP1041	XP2041
XP1110	XP1911
XP1113	XP1920
XP1114	
XP1115	XP1911
XP1116	
XP1118	XP1918
XP1119	XP1911

Obsolete type	Replacement type
XP1143	
XP1180	XP2972
XP1210	XP2020
XP1220	
XP1230	
XP1910	XP1911
XP2000	XP2102B
XP2000UB	XP2102
XP2008	XP2012B or XP2072B
XP2008UB	XP2012 or XP2072
XP2010	XP2012B or XP2072B
XP2011	XP2012 or XP2081
XP2011B	XP2012B or XP2081B
XP2030	XP2412B
XP2030UB	XP2412
XP2040	XP2041
XP2040/Q	XP2041/Q
XP2060	XP2052
XP2060B	XP2052B
XP2061	XP2052
XP2061B	XP2052B
XP2062	XP2052
XP2062B	XP2052B
XP2071	XP2072
XP2071B	XP2072B
XP2230B	XP2262B
XP2232B	XP2262B
XP2252B	XP2262B
XP2402	
XP2402B	
XP3202	XP3102
XP3202B	XP3102B

*These replacement types have 12-stage multipliers and are unilaterally interchangeable with the 56AVP family tubes. By connection of dynode d_4 to pins 15 and 16 of the plastic base, the resistors between d_4-d_5 and between d_5 d_6 are short-circuited in bleeders wired for the 56 AVP family tubes as indicated in figures below.



14-stage.



12-stage.

Definitions

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of this specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
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LIST OF SYMBOLS

Photocathode	k
Secondary emission electrode (dynode) n	dn
Anode	a
Focusing or accelerating electrode	g
Cathode luminous sensitivity	sk_v
Cathode spectral sensitivity	$sk_{e(\lambda)}$
Anode luminous sensitivity	sa_v
Anode spectral sensitivity	$sa_{e(\lambda)}$
Anode blue sensitivity	sa_v
Current amplification (gain)	G
Total supply voltage	V_{ht}
Anode current	I_a
Anode dark current	i_{da}
Cathode current	I_k
Wavelength	λ
Internal connection (do not use)	i.c.
Non-connected pin (may be used)	n.c.
Typical value*	typ.
Approximate value**	≈

* These values represent the median of the distribution curve based on the total population of tubes. The individual values are systematically measured and shown on the test ticket supplied with each tube.

** These values are measured on a sample of tubes during production.

GENERAL DESCRIPTION

A photomultiplier is a non-thermionic vacuum tube which converts light into an electrical signal and internally amplifies that signal to a useful level. As shown in Fig.1, a photomultiplier normally consists of

- a window to admit light
- a photocathode which emits electrons in response to light
- an electron-optical input system which focuses the emitted electrons
- a series of electrodes, called dynodes, which multiply the electrons by secondary emission
- an anode which collects the multiplied electrons.

An external voltage divider provides the potentials that accelerate the electrons from the photocathode to the first dynode, from dynode to dynode, and from the last dynode to the anode. Depending on the number of dynodes and the applied voltage, one electron emitted from the cathode may give rise to as many as 10^8 electrons at the anode.

The photocathode, consisting of a layer of photo-emissive material deposited on a substrate, may be opaque or semitransparent. Opaque cathodes, deposited on a metal plate inside the tube, are generally easier to manufacture; semitransparent cathodes, deposited on the inside of the window, are more versatile. All the photo-multipliers listed in this book have semitransparent cathodes.

The materials of the window and the photocathode together determine the spectral response of the tube (see Fig.2). Type S1 and ERMA (extended red multi-alkali) photocathode extend usefully into the near infrared. Cathode on fused silica window (dotted lines) extend usefully into the ultraviolet. Type S20 on fused silica window spans the range from near infrared to ultraviolet, peaking at about 420 nm.

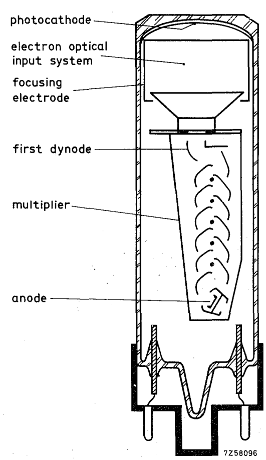


Fig.1 Photomultiplier tube

The response speed and other time characteristics of the tube depend mainly on the electron-optical input system and the electron-multiplier dynode structure. Of the several types of dynode structure in use, two predominate among the tubes listed here:

- linear focused dynodes, which progressively focus the electron paths as they advance through the multiplier. This minimizes electron transit time variations between stages and makes for very fast response.
- venetian blind dynodes, in which each dynode consists of numerous parallel strips slanted with respect to the tube axis. The large surface area the first dynode presents to the photocathode enables good collection efficiency to be obtained with a fairly simple electron-optical input system. Gain stability is good, but response is slow compared with linear focused dynodes.

Materials commonly used for dynodes are oxidized CuBe and alkali antimonide (i.e. the same material as photocathodes). The latter provide high secondary emission which is mainly for improving the single electron pulse height resolution. If dynode one has a secondary emission coefficient δ_1 and all the others δ, the gain of the multiplier is expressed as $\delta_1 \delta^{n-1}$, where n = the number of dynodes.

PHOTOMULTIPLIER CHARACTERISTICS

The characteristics described in photomultiplier data sheets relate to sensitivity, gain, response time, dark current, linearity and stability; and, for tubes intended for such applications as scintillation counting, energy resolution.

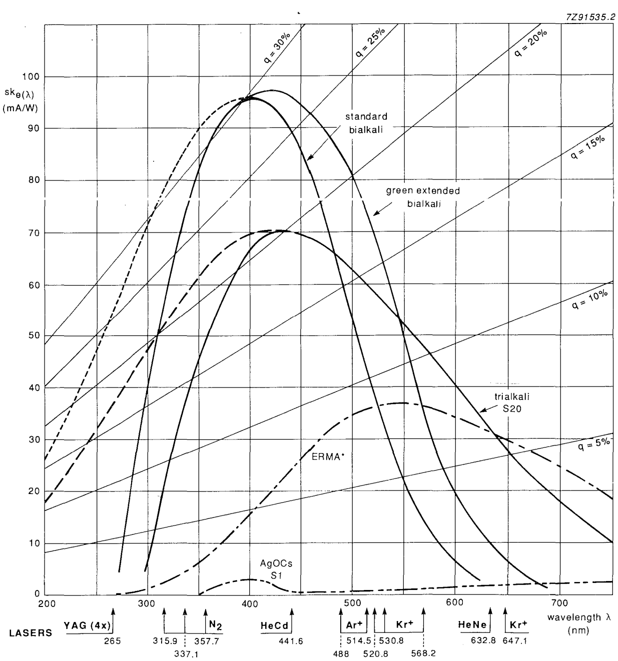


Fig.2(a) Spectral curves of standard photocathodes, with lines of constant quantum efficiency, q, overlaid for reference. Some characteristic laser wavelengths are indicated along the wavelength axis.

----- = Fused silica window
**ERMA = extended red multi-alkali*

SENSITIVITY CHARACTERISTICS

Sensitivity can be referred to the photocathode or the anode and can be expressed in photometric units or radiometric units. Sensitivities expressed in photometric units are called luminous sensitivities; the units are amperes per lumen. Sensitivities expressed in radiometric units are called radiant sensitivities; the units are amperes per watt.

Photocathode sensitivity

Photocathode luminous sensitivity is the ratio I_k/ϕ, where I_k is the cathode photocurrent due to an incident flux ϕ measured in lumens. In the data sheets it is given under the heading *General Characteristics,* subheading *Photocathode,* and called simply *luminous sensitivity.* For most photomultipliers it is of the order of several tens of microamperes per lumen. The light with which it is measured is from a tungsten-filament lamp with a colour temperature of 2856 K. The symbol for photocathode luminous sensitivity is sk_v.

A measure of cathode sensitivity that has particular relevance to scintillation counting is *cathode blue sensitivity* (also called simply *blue sensitivity* in the data sheets). This is the cathode luminous sensitivity measured with 2856 K tungsten light filtered through a Corning CS5-58 filter ground to half stock thickness. The symbol for cathode blue sensitivity is sk_F (the F standing for filtered).

Photocathode radiant sensitivity is the ratio I_k/ϕ, where ϕ is the radiant power measured in watts. Photocathode radiant sensitivity measured at a specific wavelength is called *photocathode **radiant** sensitivity* at that wavelength. Most of the data sheets state radiant sensitivity at one or more wavelengths and also state the wavelength at which radiant

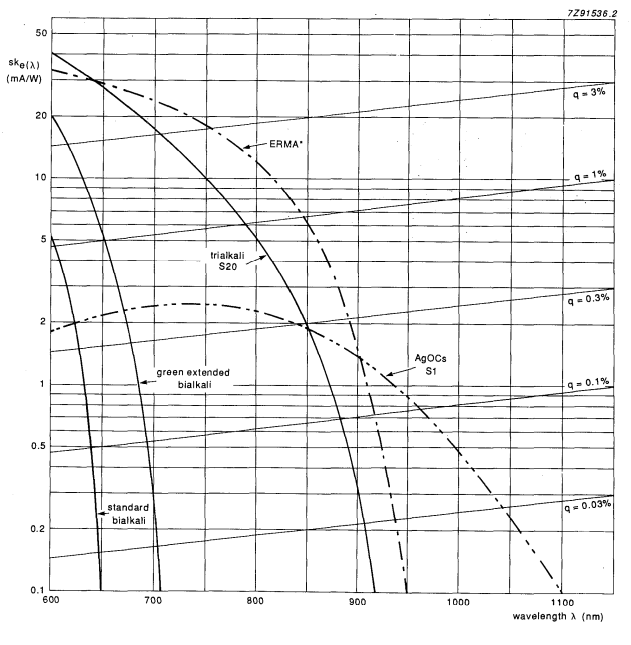


Fig.2(b) Photocathode spectral curves in the 600 ns to 1200 nm ranged expanded on semi-logarithmic coordinates.

sensitivity is maximum. Photocathode radiant sensitivities are commonly of the order of several tens of milliamperes per watt. The symbol for photocathode radiant sensitivity is $sk_{e(\lambda)}$.

Besides stating the photocathode luminous sensitivity and one or more values of radiant sensitivity, each data sheet includes a spectral curve: the variation of radiant sensitivity with wavelength.

Another measure of photocathode sensitivity is *quantum efficiency,* which is the ratio of the number of photoelectrons emitted to the number of incident photons, usually expressed in percent. In the data sheets it is given for a specified wavelength, usually 400 nm or 440 nm, under the heading *Quick Reference Data* or *General Characteristics.*

Quantum efficiency is related to radiant sensitivity by the equation

$$QE = sk_{e(\lambda)} \frac{h\nu}{e} = sk_{e(\lambda)} \frac{hc}{e\lambda}$$

where e is the electron charge, h is Planck's constant, and c is the speed of light in vacuum. Taking hc/e = 1,24 x 10^{-6} Wm/A,

$$QE = 124\ sk_{e(\lambda)} / \lambda$$

where $sk_{e(\lambda)}$ is expressed in milliamperes per watt and λ in nanometres. The lines of constant quantum efficiency in Fig.2 help visualize the quantum efficiency variation with wavelength of standard photocathodes.

Anode sensitivity

Anode luminous sensitivity is the ratio I_a/ϕ, where I_a is the anode current due to an incident flux ϕ on the photocathode measured in lumens. Anode luminous sensitivity is a function of the cathode luminous sensitivity and the gain, which itself is a function of the high voltage applied and the voltage divider configuration. When anode luminous sensitivity is given in the data sheets, under the heading *Typical Characteristics,* or *Output Characteristics,* it is therefore always stated in conjunction with a specific high voltage and voltage divider configuration. It is generally of the order of several amperes per lumen to several tens of amperes per lumen. The symbol for anode luminous sensitivity is sa_v.

Blue sensitivity is sometimes referred to the anode instead of the cathode and is then called *anode blue sensitivity.* It is generally of the order of several amperes per lumen; the symbol is sa_F.

Anode radiant sensitivity is the ratio I_a/ϕ, with the radiant power ϕ measured in watts. Anode radiant sensitivity measured at a specific wavelength is called *anode radiant sensitivity* at that wavelength. Anode radiant sensitivity is a function of the cathode radiant sensitivity and the gain; therefore it too is always stated in conjunction with a specific high voltage and voltage divider configuration, also under the heading *Typical Characteristics* or *Output Characteristics.* Anode radiant sensitivity is generally of the order of tens to hundreds of kiloamperes per watt. The symbol for it is $sa_{e(\lambda)}$.

Many of the data sheets include a graph of anode radiant sensitivity as a function of applied voltage. Unless otherwise stated, the plotted sensitivity is that measured at 400 nm or at the anode or cathode sensitivity wavelength (e.g. 440 nm) mentioned in the *Quick Reference Data* or *General Characteristics.*

Sensitivity characteristics measured at the anode correspond closely but not exactly to those measured at the cathode. Differences are due mainly to the different energies with which photoelectrons excited by different wavelengths are emitted by the cathode, and the different efficiencies with which they are consequently collected by the first dynode.

GAIN

The *gain* or *current amplification* of a photomultiplier is the ratio I_a/I_k, where I_a is the anode current due to a cathode photocurrent I_k. Within practical limits it varies as a power (usually >5) of the high voltage applied and depends also on how that voltage is distributed among the dynodes. When gain is given in the data sheets therefore it is always in conjunction with a specified high voltage and voltage divider configuration. Many of the data sheets also include a graph of gain as a function of applied voltage (V_{ht}).

Gain and anode sensitivity graphs in the data sheets are typical for each tube type but not representative of every specimen of the type; small differences occur from tube to tube. For that reason every tube is accompanied by a certificate stating the gain or anode sensitivity measured at one or more specified voltages and with one or more voltage dividers. To find the actual gain or anode sensitivity curves for the tube, transfer the measured points to the data sheet graph and shift the published curves up or down so that they pass through the transferred points. For most tube types the published curves are straight lines on log-log paper, so this is a simple matter of redrawing the lines at the same slope through the transferred points.

Within limits gain can be adjusted by adjusting individual dynode voltages. In addition to diagrams of recommended voltage dividers, therefore, some data sheets include a graph of the effect on gain of changes in certain dynode voltage ratios.

For the same reason that sensitivity characteristics at the anode do not correspond exactly to those at the cathode, gain also varies somewhat with wavelength.

TIME CHARACTERISTICS

Signal transit time is the interval between the arrival of a delta-function light pulse at the photomultiplier window and the time at which the corresponding output pulse reaches a stated value. Signal transit time values given in the data sheets are based on the interval separating the respective maxima of the light pulse and the anode pulse. The measurement is made using light pulses with a duration <1 ns (FWHM) to simulate delta-function pulses.

Signal transit time varies as $V_{ht}^{-1/2}$ and is always stated in conjunction with a specific V_{ht} value.

Transit time also depends on the part of the photocathode from which a photoelectron originates. In the data sheets this dependence is described in terms of the *transit time difference* between pulses originating from the centre of the photocathode and from a point at a specified distance from the centre.

Transit time jitter is the variation of signal transit time from pulse to pulse when each output pulse results from the emission of a single photoelectron. In the data sheets transit time jitter is specified in terms of σ, the standard deviation of the *signal transit time distribution,* at a specified V_{ht} value.

Signal transit time distribution varies as $N_k^{-1/2}$, where N_k is the number of photoelectrons per pulse. The single-photoelectron value is therefore a worst-case value.

Anode pulse rise time, as given in the data sheets, is the 10% to 90% rise time measured using simulated delta-function (<1 ns) light pulses.

Anode pulse duration at half height (FWHM) is the interval separating the half-amplitude points of the anode current pulse in response to a simulated delta-function light pulse at the photocathode.

Time characteristics are given in the data sheets under the heading *Typical Characteristics* or *Output Characteristics.* Anode pulse rise time is in many cases also given in the *Quick Reference Data or General Characteristics.*

DARK CURRENT AND NOISE

Dark current is the current measurable at the anode of a photomultiplier operating in total darkness. It comprises a d.c. component and a component consisting of very short duration (nanosecond range) random pulses ('dark pulses').

A significant part of the pulse component is due to thermionic emission of single electrons from the photocathode (see Table 2). This can be reduced by operating the tube at reduced temperature. At the lowest useful temperature the photocathode emission approaches a practical limit of about 1 electron/cm²s due at least partly to background radiation.

The number of dark pulses per second is called the *dark noise count rate* or simply *background noise.* It is more or less constant over a fairly wide range of V_{ht}; however, the amplitude of the dark pulses varies as the gain setting of the tube; that is, as a power of V_{ht}.

TABLE 2. THERMIONIC BEHAVIOUR OF COMMON PHOTOCATHODES

CATHODE TYPE	THERMIONIC EMISSION AT 20 °C (A/cm²)	TEMPERATURE RISE FOR WHICH THERMIONIC CURRENT DOUBLES (K)	LOWEST USEFUL TEMPERATURE (°C)
AgOCs (S1)	$10^{-13} - 10^{-11}$	5 – 7	–100
SbCs* (S11)	$10^{-16} - 10^{-15}$	6 – 15	–20
bi-alkaline	$10^{-19} - 10^{-17}$	4 – 5	–20
SbRbCs*	$10^{-19} - 10^{-16}$	5 – 10	–20
tri-alkaline (S20)	$10^{-19} - 10^{-15}$	4	–40
ERMA	$10^{-17} - 10^{-15}$	4	–40

* Old cathode types

The d.c. component of the dark current is due to leakage currents on the glass and insulating surfaces of the tube. It varies directly as V_{ht} and is not significantly temperature dependent. When a photomultiplier is operated at low gain or low temperature the d.c. component of the dark current is therefore the predominant one.

The data sheets do not distinguish the pulse and d.c. components of the dark current. The values given under *Typical Characteristics* or *Output Characteristics* and in graphs are total dark current values measured with an integration time constant which is long compared with the dark pulse durations. However, a typical level of noise count rate is often given for high-gain tubes and, especially, for fast-response tubes.

Like gain or anode sensitivity graphs, dark current graphs are typical of the tube type but not representative of every specimen. Each tube is therefore accompanied by a certificate stating the dark current measured on that tube under stated conditions. The actual dark current characteristic of the tube can be found by transferring the measured value to the data sheet graph and drawing a line through it parallel to the published line.

After long stabilization the actual dark current can become several times smaller than the value stated on the test certificate.

The dark current values given are for normal operating conditions. Under other conditions other causes of dark current come into play. At very high applied voltages, for instance, dark current is likely to increase out of proportion to the gain and become unstable. This is mainly due to primary and secondary effects of field emission from the dynodes and usually subsides after the high voltage has been applied for some hours. Another cause of anomalous dark current is persistent phosphorescence of the glass following exposure of the tube to ambient light; this too subsides after a time, though if the exposure has been long or the light intense the time may be as long as 48 hours. If an application necessitates operating the tube with the anode grounded and the cathode at high negative potential, the dark current will initially be many times its normal value and may take more than half an hour to settle down. Dust and high relative humidity increase the d.c. component of the dark current, the more so when the tube is operated at lower than ambient temperature.

Dark current is always present, whether or not the tube is in total darkness; the spurious signal it provides must be taken into account in many photomultiplier applications.

SHOT NOISE

Another effect to be taken into account is shot noise: the random fluctuation of the cathode photocurrent about a mean value $\bar{I}_k$ under conditions of constant illumination. If Δf is the bandwidth of the measuring equipment connected to a photomultiplier, the mean square value of this fluctuation is

$$\bar{i}_k^2 = 2\, e \bar{I}_k \Delta f$$

where e is the electron charge, $1{,}6 \times 10^{-19}$ C.

At a gain G the mean square value of the corresponding fluctuation of the anode current about its mean value $\bar{I}_a$ is

$$\bar{i}_a^2 = 2\, G\, e\, \bar{I}_a\, \Delta f \left\{ 1 + \frac{\delta}{\delta_1 (\delta - 1)} \right\}$$

and the signal-to-noise ratio at the anode is

$$\frac{S}{N} = \frac{\bar{I}_a}{i_a} = \frac{\bar{I}_a}{\sqrt{2\, G\, e\, \Delta f \left\{ 1 + \frac{\delta}{\delta_1 (\delta - 1)} \right\}}}$$

The term $\delta / \delta_1 (\delta - 1)$, in which δ is the average electron multiplication per stage and δ_1 the multiplication at the first dynode, takes account of additional noise due to random fluctuations in secondary emission. With typical values of $\delta_1 = 6$ and $\delta = 4$, these fluctuations decrease the signal-to-noise ratio by about 10%.

LINEARITY

As used in connection with photomultipliers, the term *linearity* refers to the direct proportionality between input illumination and output current under pulsed operating conditions. In the data sheets linearity is specified in terms of the maximum anode pulse current for which such a proportionality still applies within 2% (which is about the practical limit of accuracy with which it can be measured). The measurement is made using illumination pulses much longer (100 – 200 ns) than the pulse response of the tube; for pulses whose duration is comparable to the pulse response of the tube the linearity limit can be considerably higher than the value stated in the data sheets.

An important factor determining the linearity limit is the development of space charge in the last stages of the electron multiplier, which depends very much on the voltage division ratio there. Ratios which yield maximum linearity do not as a rule yield maximum gain, and vice versa; moreover, adjusting the ratio to raise the linearity limit generally entails a disproportionate sacrifice of gain. Under the heading *Typical*

Characteristics or *Output Characteristics* linearity limits are usually given for at least two V_{ht} values and voltage divider configurations, and graphs are given of the gain or anode sensitivity obtainable with those voltage dividers. With a given voltage divider the linearity limit varies approximately as V^{α}_{ht}, where α is between 2 and 3.

STABILITY

The term 'stability' refers to the constancy of anode sensitivity as a function of time, temperature, or mean anode current. Departures from stability are of two types: long-term drift under conditions of constant temperature and mean anode current; and short-term shift due to changes of temperature or mean anode current.

The 16-hour drift tests reported in the data sheets are made according to a widely recognized procedure recommended in ANSI N42.9-1972. An NaI(T1) scintillator is coupled to the photomultiplier window and a ^{137}Cs source is spaced in front of it so as to produce a count rate of about 10^4 counts per second; the tube is adjusted to give a mean anode current of about 300 nA at that count rate. After allowing the system to warm up for half-an-hour to an hour the amplitude of the ^{137}Cs 662 keV peak is recorded, and again measured and recorded every hour thereafter for 16 hours. The *mean anode sensitivity deviation,* in per cent, as reported in the data sheets is then calculated from

$$\frac{\sum_{i=1}^{17} | p - p_i |}{17p} \cdot 100$$

where p is the mean pulse amplitude averaged over the 17 readings, and p_i the amplitude of the *i*th reading.

Short-term shift due to mean anode current change (also called count rate stability) is also measured according to an ANSI 42.9-1972 procedure using a ^{137}Cs source and NaI(T1) scintillator. The distance from the source to the scintillator is first adjusted to give a count rate of about 10^4 counts per second and the amplitude of the 662 keV peak is recorded. After increasing the source distance sufficiently to reduce the count rate to about 10^3 per second the amplitude of the 662 keV peak is again measured. The percentage shift reported in the data sheets is $(\Delta p/p)100$, where p is the larger of the two amplitudes and Δp the difference between them. For the measurement the photomultiplier is usually adjusted to give a mean anode current of about 1 μA at 10^4 counts per second and 0.1 μA at 10^3 counts per second.
(Nowadays, stability tests are usually performed using light-emitting diodes instead of scintillators, for convenience).

Anode sensitivity changes are particularly troublesome in scintillation counting, for they degrade resolution by shifting the total absorption peaks. However, when the mean anode current is less then about 10 μA, as is usually the case, the anode sensitivity usually stabilizes sufficiently after 10 or 15 minutes for its long-term drift to be disregarded. Short-term shift, whether due to temperature or mean anode current changes, are usually reversible, though often with some hysteresis which may be slow to disappear.

An anode sensitivity change which is not reversible is that due to the length of time the tube has been in service. At high mean anode currents this appears to be a function of the total charge handled during the history of the tube. At a mean anode current of 30 μA, for instance, the gain of most photomultipliers will be halved after about 5000 hours of operation. At low anode currents (a few microamperes or less) the total charge handled does not appear to be relevant. Other effects, such as helium migration through the glass or internal migration and diffusion balances, then determine the end of useful life, which is measured in years and is independent of the mode of operation. Some users in fact have reported that uninterrupted low-current operation appears to result in better long-term stability of the operating characteristics than storage.

ENERGY RESOLUTION

Two energy resolution criteria commonly referred to in scintillation counting are *pulse amplitude resolution or pulse height resolution* (PHR) and *peak-to-valley ratio.* Both are defined with reference to the pulse amplitude distribution curve obtained with a multichannel pulse-height analyser for radiation of a known energy:

- pulse amplitude resolution is the ratio, expressed in percent, of the FWHM of the curve to the amplitude corresponding to its peak
- peak-to-valley ratio is the ratio of the peak value of the curve to the minimum value of the valley to the left of the peak.

Energy resolution is a characteristic of a scintillation counter as a whole, not of a photomultiplier alone; the contributions of the scintillator and the photomultiplier are not statistically independent and cannot be treated separately. In the data sheets therefore, when pulse amplitude resolutions or peak-to-valley ratios are given, under the heading *Typical Characteristics* or *Output Characteristics.* the particulars of the scintillator with which they were measured are also specified. The photomultiplier adjustment at which the measurements were made is also stated, usually in terms of a specified anode blue sensitivity. Radiation sources used for the measurements include ^{137}Cs (662 keV), ^{57}Co (122 keV) and ^{55}Fe (5.9 keV). At the higher energies the scintillator statistics, and at the lower energies the photomultiplier statistics, tend to be the dominant factor of energy resolution.

OPERATING NOTES

VOLTAGE SUPPLY

Gain varies as V_{ht}^{β}, where $\beta \gg 1$; a well stabilized supply is therefore essential. For, say, $\beta = 7$, which is typical for a 10-stage tube, a supply voltage variation of little more than 0,1% will cause a 1% gain variation.

The configuration of the voltage divider depends on the tube and its application. Four types of configuration are illustrated in the data sheets:

- *type A,* in which the interdynode voltages are all equal; this yields maximum gain for a given supply voltage and is particularly suitable for photometry and nuclear spectrometry applications
- *type A1,* in which, at some expense to the gain, a higher cathode/first-dynode voltage ensures good collection efficiency even at low supply voltages
- *type B,* in which the interdynode voltages increase progressively toward the anode, in some cases becoming as much as ten times as high in the last stages as in the first; gain is much lower than with type A division, but anode pulse linearity remains good up to much larger peak currents
- *type C* , in which the interdynode voltages increase only in the last stages; with fast photomultipliers this gives good time characteristics together with satisfactory gain and pulse linearity.

Whichever type is used it must be designed so that variations of cathode illumination do not cause dynode voltage variations, otherwise non-linearities will occur. To satisfy this requirement the divider current must always be much larger than the mean anode current.

When input illumination varies continuously the relative gain variation $\Delta G/G$ due to varying illumination is roughly proportional to the ratio of the mean anode current I_a to the divider current I_p:

$$\frac{\Delta G}{G} = \frac{I_k}{I_p}\left\{\delta^n - \frac{\delta^{n+1}}{(n+1)(\delta-1)}\right\}$$

$$\approx \frac{I_a}{I_p}\left\{1 - \frac{\delta}{(n+1)(\delta-1)}\right\}$$

Here, n is the number of dynodes and δ their secondary emission coefficient. A good rule is to design for a nominal divider current I_p at least a hundred times the anticipated peak anode current $\bar{I}_a$.

Example. An 8-stage photomultiplier is supplied at $V_{ht} = 1500$ V via a type B voltage divider with a progressive division ratio such that $V_{ht} = 18{,}25\ V_d$, where V_d is the basic interdynode voltage increment. The maximum anticipated mean anode current $\bar{I}_a = 10\ \mu A$; therefore assume a divider current $I_p = 100\bar{I}_a = 1$ mA. The total divider resistance is then $1500\ V/10^{-3}\ A = 1{,}5\ M\Omega$ and the incremental resistance value $1{,}5 \times 10^6/18{,}25 = 82\ k\Omega$.

The rule $I_p \geqslant 100\bar{I}_a$ is a minimum for good linearity. The maximum practical value of I_p depends on two other considerations:

- if the tube and the divider are closely coupled thermally, dissipation in the divider (I_p^2R) can increase the thermionic component of the dark current
- low divider current affords a measure of protection against accidental glare; as soon as glare increases the anode current to a level comparable with the divider current, the resulting decrease of gain automatically prevents the anode current from becoming excessive.

ZENER DIODES

Zener diodes can be substituted for some of the resistors in the divider to keep critical interdynode voltages constant.

They can be used between the first dynode and cathode to keep the collection efficiency constant regardless of supply voltage and gain setting, and between the dynodes of the first two multiplier stages to keep the gains of those stages constant. This is useful in nuclear spectrometry, where certain minimum voltages are necessary in the first stages but the overall gain need not be high. Note, however, that it cannot be done with fast-response tubes (e.g. XP2020) that incorporate an accelerating electrode internally connected to one of the higher-ranking dynodes; the potential of such an electrode must be kept in constant proportion to the voltage between the cathode and first dynode.

Zener dynodes in the last stages of the divider can stabilize the voltages there throughout a wider range of anode current variation and make it practical to design for a smaller $I_p/\overline{I}_a$ ratio than with a purely resistive divider.

In certain applications a drawback of using zener diodes is that they limit the freedom of gain adjustment. Altering the supply voltage to adjust the gain would also alter the overall voltage division ratio, for it would alter the voltages across the resistor stages but not the zener-stabilized ones. As linearity is dependent on the overall voltage distribution, a divider with zener diodes should be designed for a specific value of V_{ht} and that value should be closely adhered to. Departure from it invites the risk of over-linearity (increase of the proportionality factor between input illumination and anode current) or premature saturation (decreaese of the proportionality factor). The risk is considerably less if only the last stage is zener stabilized.

Whether zener diodes are used in the higher or lower stages of the divider, they should be shunted by resistors to protect those stages from being exposed to the full supply voltage in the event of a diode going open-circuit. The resistance values should be 2 to 3 times what they would be in a purely resistive divider.

Bear in mind that the temperature coefficients of zener diodes can cause significant variations of gain with temperature.

RESERVOIR CAPACITORS

When the input illumination is not continuous but pulsed, as in scintillation counting, design the voltage divider on the basis of the anticipated mean anode current $\overline{I}_a = I_a Nt$, where I_a is the peak amplitude of the anode pulses, N their repetition rate, and t their duration. Again, a good rule is to assume $I_p \geqslant 100\overline{I}_a$.

To supply the instantaneous current for individual pulses exceeding the mean value $\overline{I}_a$ it is now necessary to provide reservoir capacitors. These may be connected from dynode to dynode, shunting the individual divider resistors, or from each dynode to anode potential; the former arrangement is often preferable as it enables capacitors with lower voltage ratings to be used.

The capacitance required is largest between the last dynode and anode, where the pulse amplitudes are largest, and decreases from stage to stage in proportion to the gain per stage. If $q = I_a t$ is the maximum pulse charge to be delivered by the last dynode, and ΔV the maximum voltage change that can be tolerated at that dynode, the capacitance required between the last dynode and anode is $C = q/\Delta V$.

Example. The anode pulses expected in a given scintillation counting application have a maximum amplitude of 1 mA and a full width at half maximum of 0,3 μs; therefore,

$q = 10^{-3}$ A x 0,3 x 10^{-6} s = 0,3 x 10^{-9} coulomb.

If the voltage difference between the last dynode and anode is 100 V and its maximum tolerable change is 1%, the required capacitances is then

$C_n = 1$ V x 0,3 x 10^{-9} C = 0,3 nF.

Assuming a stage-to-stage gain of 3, the capacitances needed in the preceding stages are

C_{n-1} = 0,1 nF

C_{n-2} = 33 pF.

Stages in which the capacitance required is less than about 20 pF do not require reservoir capacitors; the stage-to-stage stray capacitance is usually sufficient.

If pulses occur in bursts there may be insufficient time between individual pulses to allow the reservoir capacitances to recharge fully. The effect of successive pulses is then cumulative and dynode voltages may change appreciably between the beginning and end of a burst, even though the long-term mean anode current is substantially less than $I_p/100$. In that case, the voltage divider will have to be redesigned for a larger value of I_p.

MEASUREMENT OF VERY SHORT PULSES

Where very short pulses are to be measured, observe good high-frequency wiring practice to avoid distorting the pulse shapes. Decouple the last two dynodes by connecting their reservoir capacitors direct to the sheath of the output coaxial cable; keep the capacitor leads as short as possible to minimize stray inductance and prevent ringing.

Many tubes intended for high-frequency pulse work have integral damping resistors in the base connected to the last one or two dynodes. If the tube you are using does not, connect non-inductive 51 Ω resistors externally between the last two dynodes and their reservoir capacitors.

SAFETY PRECAUTIONS

Normal safety precautions should be observed with regard to electrical shock hazards. These products should be installed, used and serviced only by qualified personnel. They must be operated strictly in accordance with the operating instructions. Eye protection must be worn when handling large tubes (diameter > 100 mm).

WARRANTY

Unless otherwise agreed, the Seller guarantees to the original Buyer to refund the price paid for, or at the Sellers discretion, to repair or replace, those tubes which proved to the Seller's reasonable satisfaction not to conform to the published specifications at the time of receipt by the Buyer, or to have failed by reason of faulty design, material or workmanship during a period of twelve months following the date of shipment.

This guarantee is subject to the following provisions.

1. Claims for damage in transit will be considered only if the Buyer promptly notifies the Seller upon receipt of the tubes.
2. The guarantee shall not extend to failures by reason of defects which ought reasonably to have been discovered by the Buyer upon inspection and testing of the tubes and were not reported to the Seller within thirty days.
3. The Buyer informs the Seller promptly on any alleged defect and, if and when requested, returns the tubes, carriage paid, as the Seller directs with a full written report of the defect together with the original test tickets of the tubes.
4. The tubes have been stored, installed, maintained and used properly having regard in particular to the applicable specifications and instructions for use as published by the Seller.
5. The Sellers liability in the case of tubes or components not of the Sellers manufacture shall in no circumstances extend beyond any corresponding liability to the Seller of the manufacturer of such tubes or components.

All expressed and implied conditions, warranties and other liabilities arising under common law or statute are expressly excluded. Save as in this guarantee hereinbefore expressed, the Seller shall be under no liability in contract, tort or otherwise for any personal injury, loss or damage of whatsoever kind, however caused, or for anything done or committed in connection with the tubes or any work in connection therewith.

INSTRUCTIONS FOR USE

Failure to observe these instructions will invalidate the guarantee.

Storage conditions

- Store in darkness.
- Store within the temperature range specified in the data sheet.
- Store in a dry atmosphere. Glass is hygroscopic and accumulated moisture (especially in the plastic base) will cause dark current when the tube is in use.
- Helium must not be in excess in the atmosphere, or it will penetrate the glass envelope and deteriorate the vacuum, especially for borosilicate glass tubes.

Cleaning

- The usual detergents and solvents (water, alcohol, trichloroethylene acetone etc.) may be used to clean glass envelopes and windows.
- UV transmitting glass windows must only be cleaned with alcohol and must be protected from water and acetone at all times.

Operating conditions

- Luminance.
  Protect tubes from ambient light when applying the supply voltage. 10^{-5} lm is sufficient to cause the anode to exceed its permissible limit.
- Voltages, currents and temperatures.
  Do not exceed the specified maximum ratings.
- Humidity.
  Operate in a dry atmosphere (see also storage conditions).
- Helium.
  Helium must not be in excess in the atmosphere (see also storage conditions).
- Pressure.
  Tubes can be operated in a vacuum or up to one atmosphere over-pressure. However, if a tube with a plastic base is to be used in a vacuum, a hole must be drilled into the base to allow trapped air to escape. The drilling depth must not exceed 2 mm.
- Window potential.
  The external surface of the glass tube, and any electrostatic or magnetic shield fitted to it, must be at the same potential as the cathode to prevent electrolysis, which will deteriorate the tube.
  The potential difference between the glass bulb and any close object must be kept at a minimum to prevent electrostatic discharge.
  To avoid both problems connect the cathode to ground and the anode to + HT. If the tube has to be operated with the cathode at − HT and the anode grounded, it must be supported by insulators of at least 10^{15} Ω. In this mode of operation, noise and dark current will generally increase and become erratic.
- Warm up.
  Before taking any accurate measurements, wait at least half an hour after the HT has been applied to allow the dark current to stabilize.

Connections

- Where the tubes have a glass base, use electric welding to make connections to the pins. Do not solder directly to the pins. The heat of soldering can crack the glass envelope.
- Only use Philips approved sockets.
- When inserting or removing a tube, always keep the axis of the tube parallel to the axis of the socket.
- Never make connections to pins identified in the data sheets as i.c. (internally connected).

PHOTOMULTIPLIER TUBES

9-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	S20
Useful diameter of the photocathode	> 15 mm
Radiant sensitivity of the photocathode at 700 nm	typ. 13 mA/W
Supply voltage for anode luminous sensitivity = 30 A/lm	1100 V
Anode pulse rise time (with voltage divider B)	≈ 3.5 ns
Linearity	
with voltage divider A (Fig. 2)	up to ≈ 6 mA
with voltage divider B (Fig. 3)	up to ≈ 30 mA

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

GENERAL CHARACTERISTICS

Window

Material	borosilicate
Shape	plano-plano
Refractive index at 550 nm	1.48

Photocathode

Semi-transparent, head-on	
Material	trialkaline
Useful diameter	> 15 mm
Radiant sensitivity characteristic	S20 (Fig.6)
Maximum radiant sensitivity	420 ± 30 nm
Luminous sensitivity	≈ 140 μA/lm
Radiant sensitivity at 630 nm	≈ 25 mA/W
Radiant sensitivity at 700 nm	typ. 13 mA/W min. 9 mA/W

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.

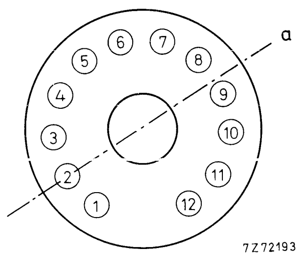


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

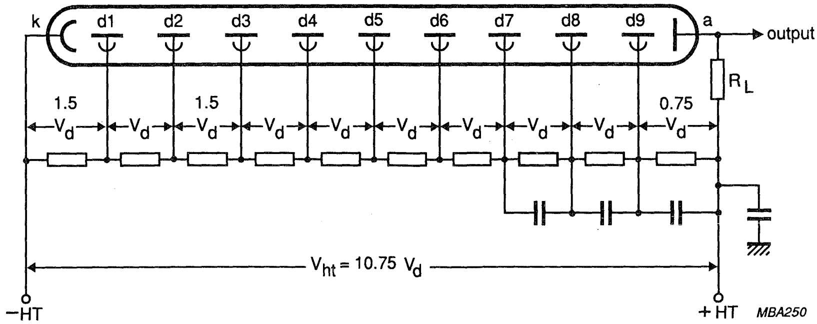


Fig. 2 Voltage divider A.

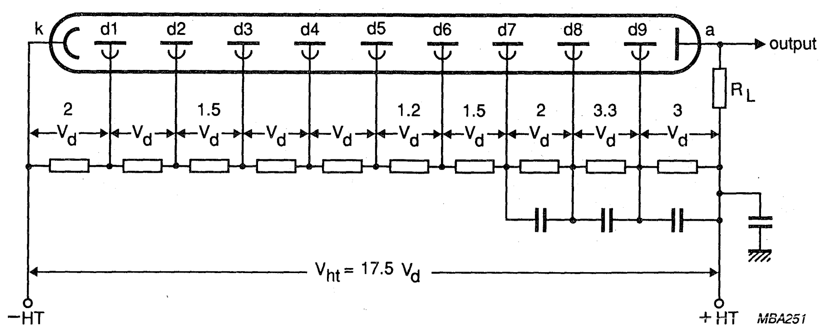


Fig. 3 Voltage divider B.

k = cathode
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)	max. 1400 V typ. 1100 V	
Gain at V_{ht} = 1100 V (Fig.8)	≈ 2×10^5	
Anode dark current at an anode luminous sensitivity of 30 A/lm (Fig.8)	max. 10 nA typ. 1 nA	2, 3
Anode current linear within 2% at V_{ht} = 1400 V	up to ≈ 6 mA	
With voltage divider B (Fig. 3)		1
Anode luminous sensitivity at V_{ht} = 1800 V (Fig. 8)	≈ 300 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)

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. + 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
3. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower value can be obtained after a longer stabilisation 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 reaches 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. 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 μA is recommended for applications requiring good stability.

MECHANICAL DATA

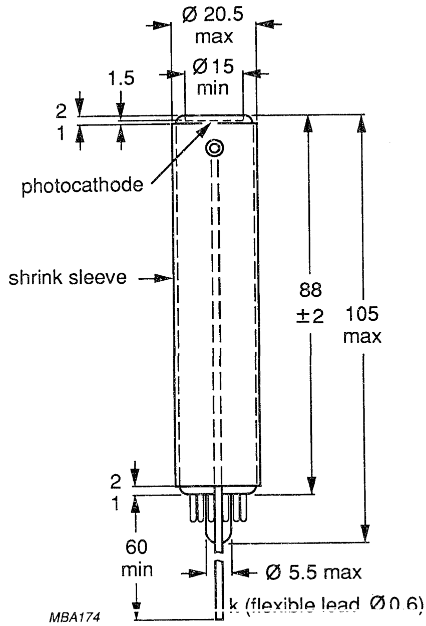


Fig. 4.

PIN CONNECTIONS

Base 12-pin all-glass

Net mass 25 g

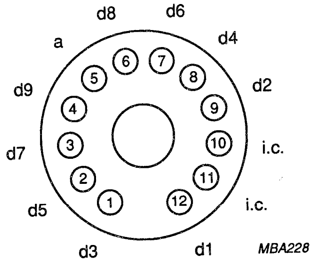


Fig. 5.

ACCESSORIES

Socket: type FE1004
Mu-metal shield type 56689

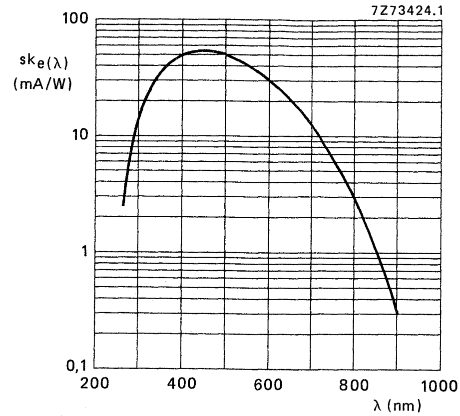


Fig. 6 Radiant sensitivity characteristic.

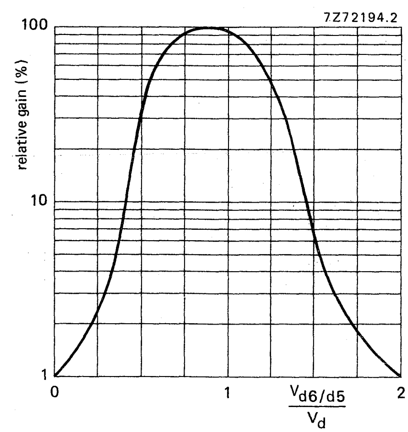


Fig. 7 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

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

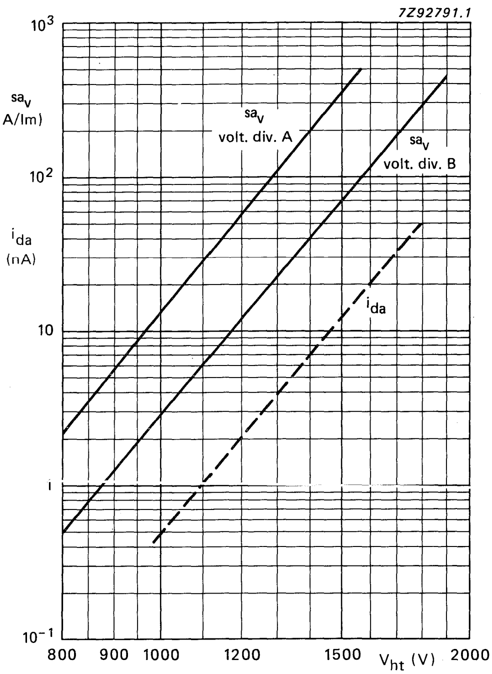


Fig. 8.

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

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP1501

80 mm diameter phototriode

APPLICATIONS

The XP1501 is a photomultiplier tube with one single dynode especially designed for operation in axial magnetic fields up to 1 Tesla.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – plano		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkali		1
useful diameter	min. 65	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 70	μA/lm	3
blue sensitivity	min. 8	μA/lmF	4
	typ. 9.5	μA/lmF	4
radiant sensitivity at 400 nm	≈ 75	mA/W	5
Multiplier			
number of stages	1		
dynode	high gain		
gain characteristics	see Fig.2		
capacitance anode to dynode	≈ 20	pF	
capacitance anode to dynode + cathode	≈ 25	pF	

80 mm diameter phototriode XP1501

OUTPUT CHARACTERISTICS

PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTES
Supply voltage	–	1200	–	V	6
Gain in an axial magnetic field B of: B = 0 B = 0.7 T	 20 8	 25 12			
Gain deviation in magnetic field (see Fig.2)					
Dark current in an axial field of: B = 0 B = 0.7 T	 – –	 100 50	 1000 300	 pA pA	 7,8 7,8

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Supply voltage	–	1500	V	
Continuous anode current	–	10	nA	
Ambient temperatures short operation (30 min. maximum) continuous operation and storage	 –30 –30	 80 50	 °C °C	

RECOMMENDED CIRCUIT

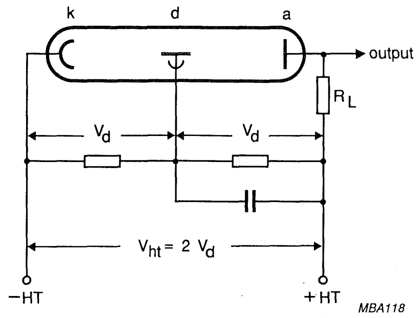
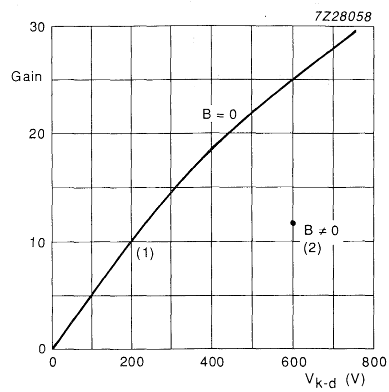


Fig.1 Typical voltage divider.

a = anode
d = dynode
k = cathode

Typical values of capacitor 1 nF.



(1) Gain as a function of voltage V_{k-d} between the cathode and the dynode in the absence of magnetic field.

(2) • = working point for use in an axial magnetic field of 0.7 T.

Fig.2

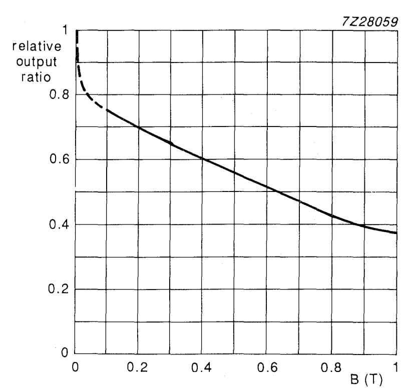


Fig.3 Relative output as a function of axial magnetic field B.

80 mm diameter phototriode XP1501

MECHANICAL DATA

Dimensions in mm

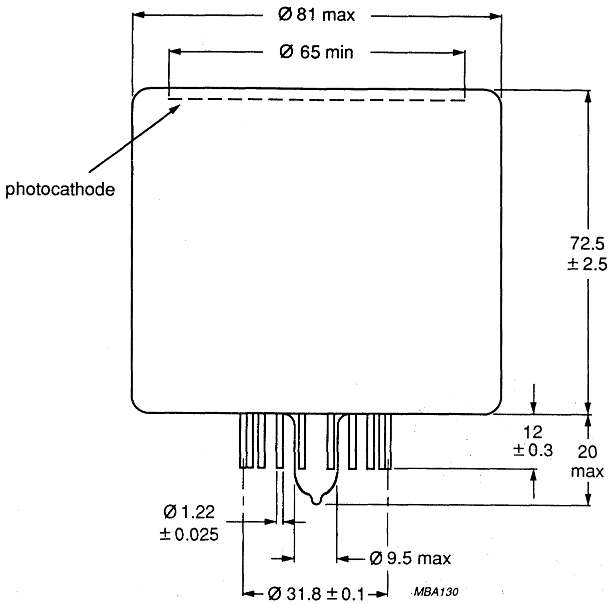


Fig.4 Mechanical outline.

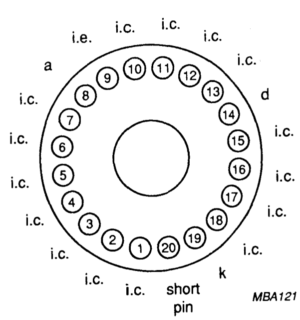


Fig.5 Pin connections.

Base 20-pin all glass
Net mass 200 g

ACCESSORIES

Socket FE2019

80 mm diameter phototriode XP1501

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at –30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8 x 10^3 for this type of tube.

6 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

7 Apply both supply voltage and magnetic field about 20 minutes before using the phototriode to allow the dark current to stabilize.

8 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

10-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bialkaline
Useful diameter of the photocathode	> 15 mm
Cathode blue sensitivity	10.5 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	bialkaline	
Useful diameter	> 15 mm	
Radiant sensitivity characteristic	see Fig.5	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 85 μA/lm	note 3
Blue sensitivity	typ. 10.5 μA/lmF	
	> 8.5 μA/lmF	note 1
Radiant sensitivity at 400 nm	≈ 85 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.

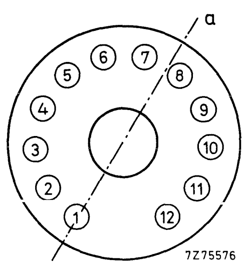


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

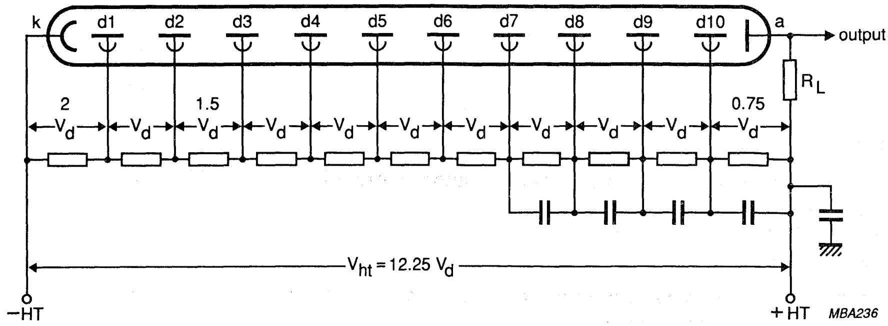


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; dn = dynode no.; a = anode; R_L = load resistor.

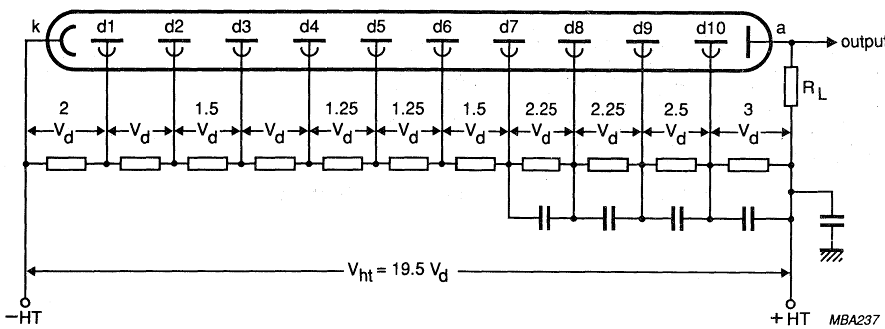


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; dn = dynode no.; a = anode; R_L = load resistor.

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
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	≈ 23 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)

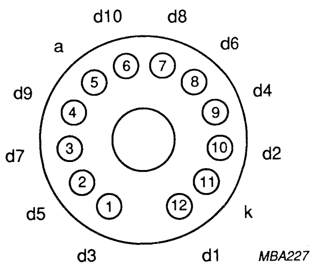
Supply voltage	max. 1900 V	note 11
Continuous anode current	max. 0.2 mA	note 12
Voltage between first dynode and photocathode	max. 350 V min. 100 V	note 13
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	note 14
Ambient temperature range		
operational (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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If used, the metal shield should be kept at the cathode potential.
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 $\approx$ 300 nA.

   Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an anode current of $\approx$ 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 reaches 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. 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



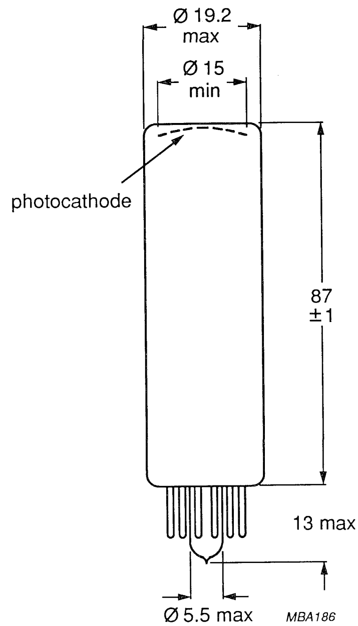


Fig. 4.

Base	12-pin all glass
Net mass	21 g

ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56689

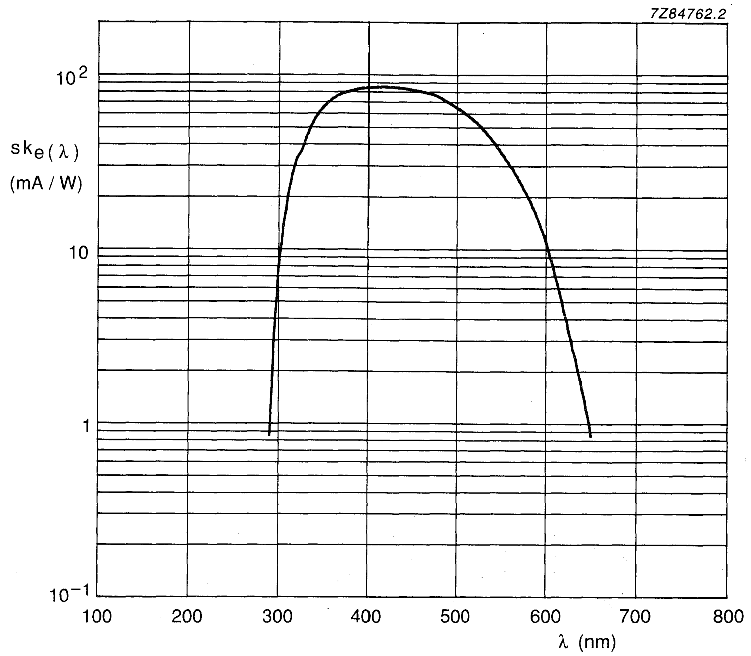


Fig. 5 Radiant sensitivity characteristic.

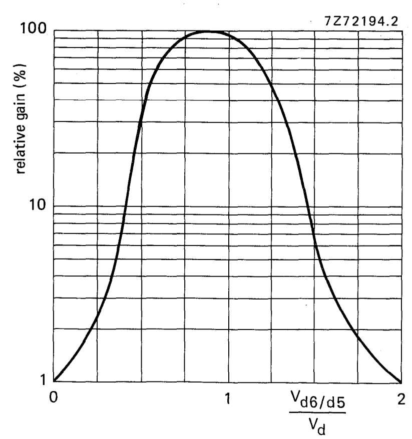


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

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

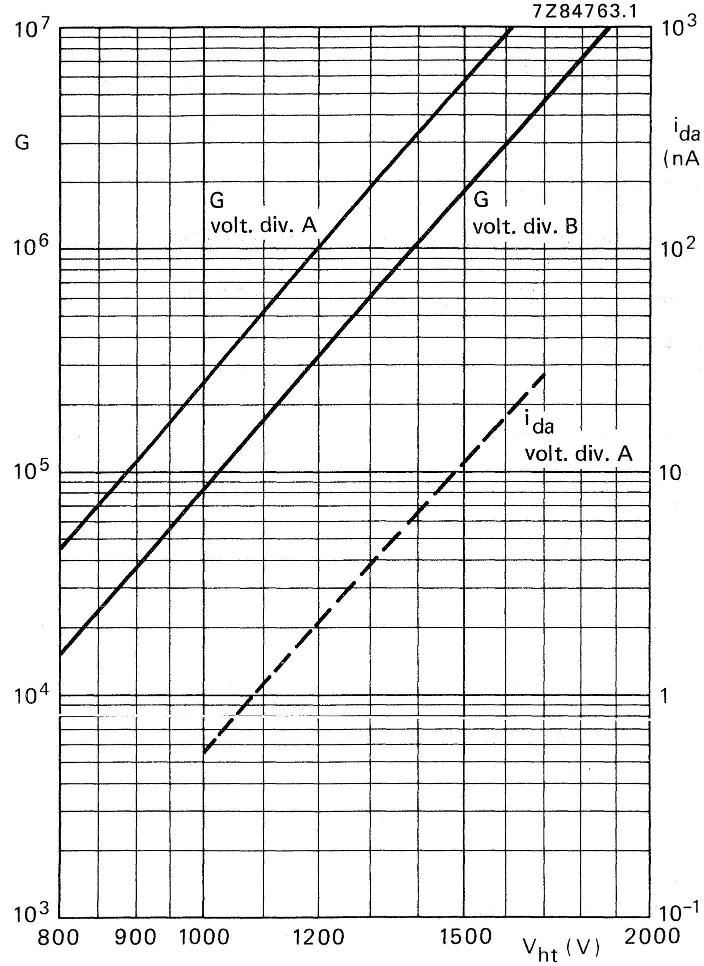


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}. i_{da} is given as a dotted line to indicate its principle behaviour only.

10-STAGE PHOTOMULTIPLIER TUBE

- 15 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline photocathode deposited on a fused silica window
- For high-energy physics and positron scanners
- Time of flight applications with BaF_2 scintillators under limited dimensional conditions

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bialkaline on fused silica
Useful diameter of the photocathode	> 15 mm
Cathode blue sensitivity	10.5 μA/lmF
Supply voltage for anode blue sensitivity = 10 A/lmF	1250 V
Anode pulse rise time (with voltage divider B)	≈ 3 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	fused silica	
Shape	plano-plano	
Refractive index at 400 nm	1.47	
at 250 nm	1.50	

Photocathode (note 2)

Semi-transparent, head-on		
Material	bialkaline	
Useful diameter	> 15 mm	
Radiant sensitivity characteristic	see Fig. 5	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 85 μA/lm	note 3
Blue sensitivity	typ. 10.5 μA/lmF	
	> 8.5 μA/lmF	note 1
Radiant sensitivity at 440 nm	≈ 85 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.

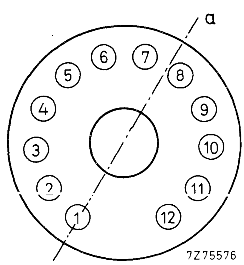


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

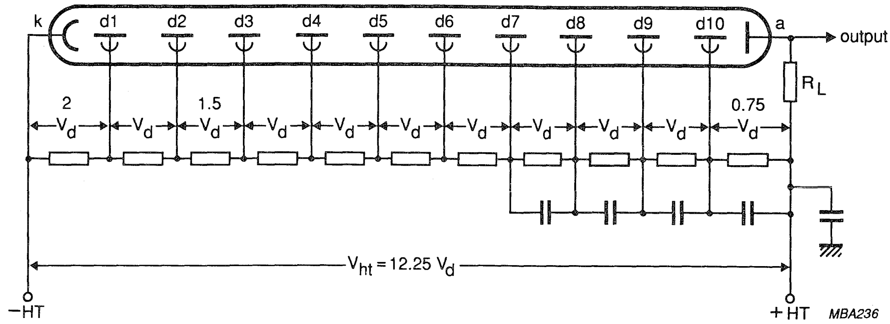


Fig. 2 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; dn = dynode no.; a = anode; R_L = load resistor.

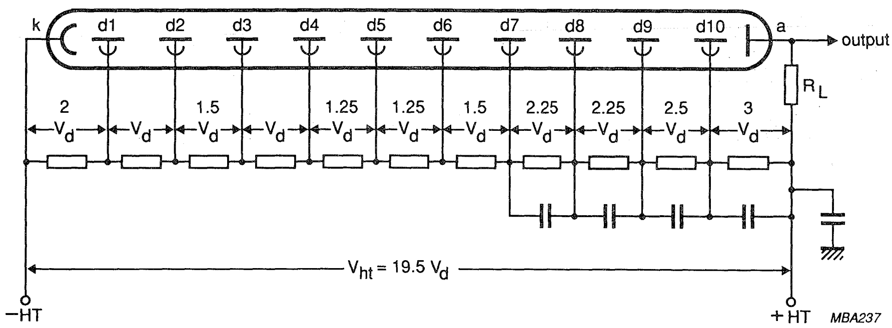


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF; k = cathode; dn = dynode no.; a = anode; R_L = load resistor.

TYPICAL CHARACTERISTICS

With voltage divider A (Fig. 2)

Supply voltage for an anode blue sensitivity of 10 A/lmF	< 1500 V typ. 1250 V	notes 1,5
Gain at V_{ht} = 1250 V (Fig. 7)	≈ 1 x 10^6	
Anode dark current at an anode blue sensitivity of 10 A/lmF	< 25 nA typ. 3 nA	notes 1,6,7
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) after change of count rate	 ≈ 1.5 % ≈ 1.5 %	note 9
Anode pulse rise time at V_{ht} = 1500 V	≈ 3 ns	note 10
Anode pulse duration at half height at V_{ht} = 1500 V	≈ 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)	≈ 3 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	≈ 23 ns	note 10
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈ 80 mA	

LIMITING VALUES (Absolute maximum rating system)

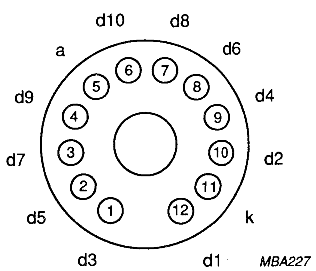
Supply voltage	max. 1900 V	note 11
Continuous anode current	max. 0.2 mA	note 12
Voltage between first dynode and photocathode	max. 350 V min. 100 V	note 13
Voltage between consecutive dynodes	max. 250 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	note 14
Ambient temperature range operational (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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage, the glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If used, the metal shield should be kept at the cathode potential.
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 $\approx$ 300 nA.

   Mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance of the scintillator such that the count rate can be changed from 10^4 c/s to 10^3 c/s corresponding to an anode current of $\approx$ 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 reaches 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. 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 XP1911.

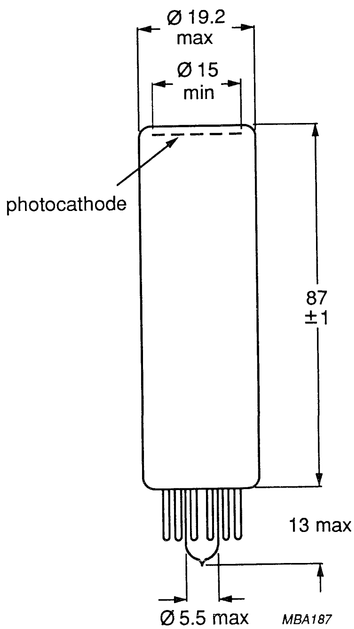


Fig. 4.

Base	12-pin all glass
Net mass	21 g

ACCESSORIES

Socket	type FE1004
Mu-metal shield	type 56689

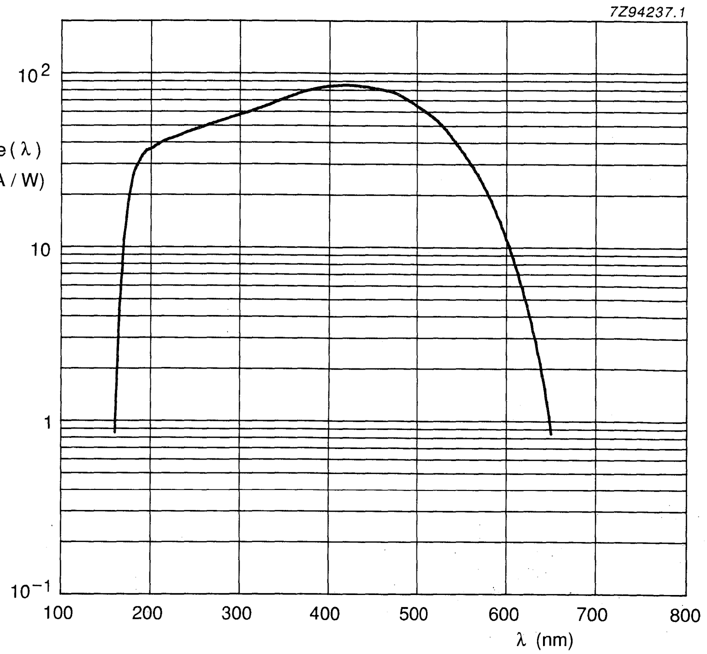


Fig. 5 Radiant sensitivity characteristic.

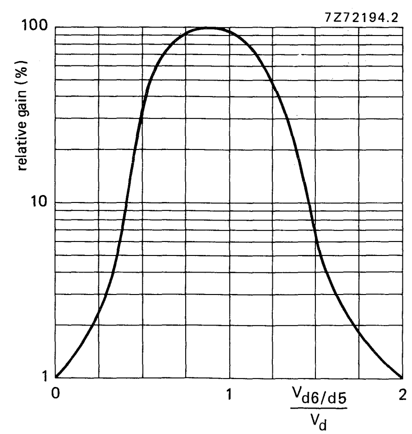


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

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

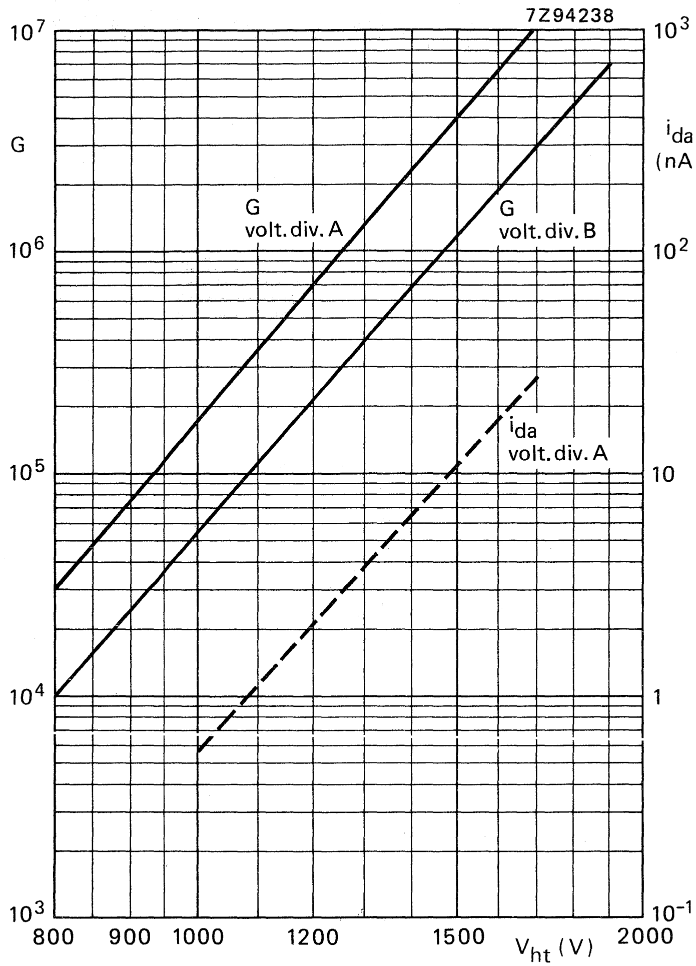


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}. i_{da} is given as a dotted line to indicate its principle behaviour only.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP1922

Low gain 19 mm (3/4″) diameter tube

APPLICATIONS

Photometry and scintillation counting.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano–concave		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 15	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 85	μA/lm	3
blue sensitivity	min. 8.5	μA/lmF	4
	typ. 10.5	μA/lmF	4
radiant sensitivity at 400 nm	≈ 85	mA/W	5
Multiplier			
structure	linear focused		
number of stages	6		
slope: log(gain)/log(supply voltage)	≈ 4.5		
capacitance anode to all	≈ 4	pF	

Low gain 19 mm (3/4″) diameter tube — XP1922

OUTPUT CHARACTERISTICS WITH VOLTAGE DIVIDER A

with voltage divider A, anode sensitivity 0.05 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	700	1200	V	
Gain x 10^3	–	≈ 4.8	–		
Anode dark current	–	0.5	5	nA	6,7
^{137}Cs pulse amplitude resolution	–	≈ 7.5	–	%	8
Mean anode sensitivity deviation					9
long term (greater than 16 hours)	–	≈ 1.5	–	%	
after change of count rate	–	≈ 1.5	–	%	
temperature 0 to 40 °C at 400 nm	–	≈ 0.3	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n"	–	≈ 0.3	–	mT	11
parallel with axis "n"	–	≈ 0.2	–	mT	11
parallel with the tube axis	–	≈ 0.6	–	mT	

see note 12

PARAMETER	VOLTAGE DIVIDER A	B	C	UNIT	NOTES
Supply voltage set at	1100	1200	–	V	
Gain x 10^3	≈ 35	≈ 10	–		
Anode current linear within 2% to	≈ 30	≈ 80	–	mA	
Anode pulse rise time	≈ 2.2	≈ 2	–	ns	13
Anode pulse duration at half height	≈ 3.6	≈ 3.2	–	ns	13
Signal transit time	≈ 17	≈ 16	–	ns	13

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Supply voltage	–	1500	V	
Continuous anode current	–	0.2	mA	15
Anode blue sensitivity	–	0.5	A/lmF	14
Voltage between first dynode and photocathode	100	350	V	16
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	400	V	17
Ambient temperatures				
short operation (30 min.maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

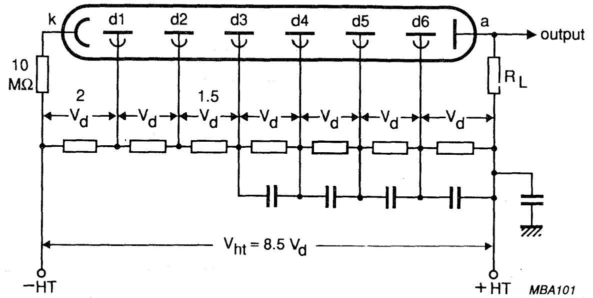


Fig.1 Voltage divider A.

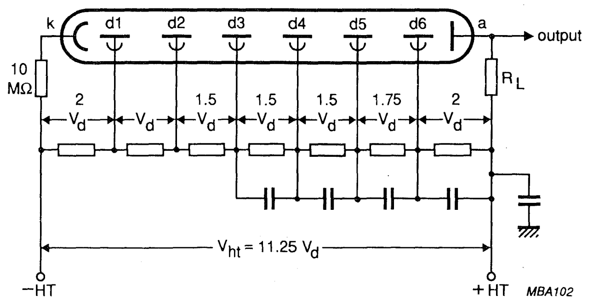


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

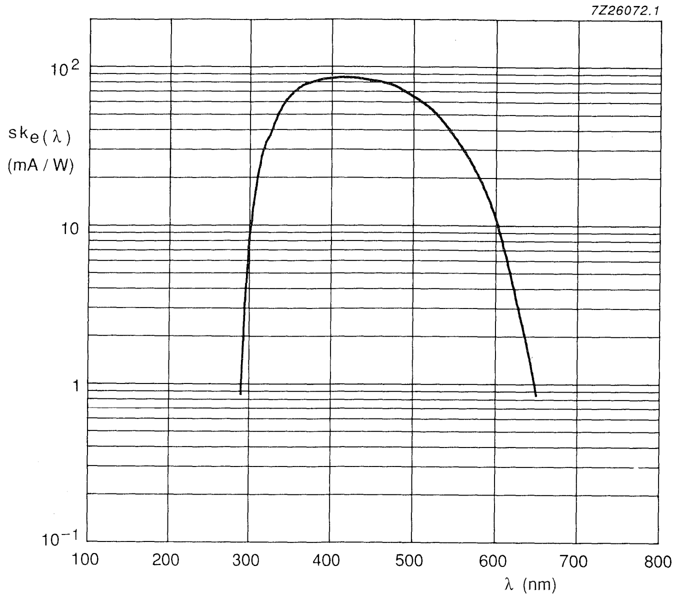


Fig.3 Cathode spectral characteristic.

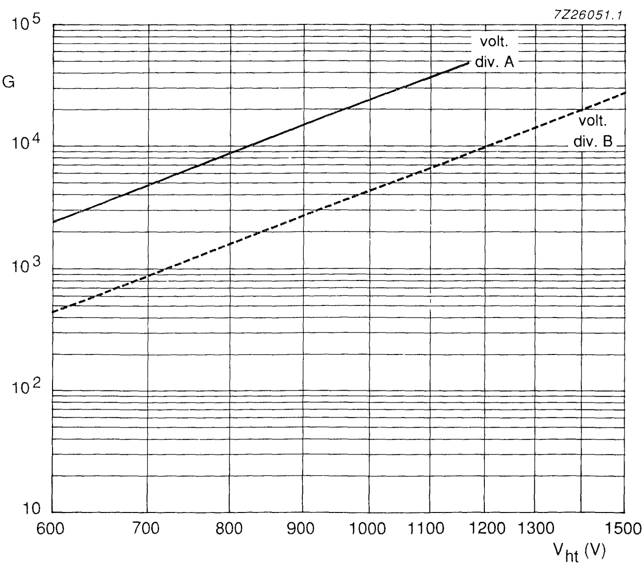


Fig.4 Gain as a function of supply voltage

Low gain 19 mm (3/4″) diameter tube

XP1922

MECHANICAL DATA

Dimensions in mm

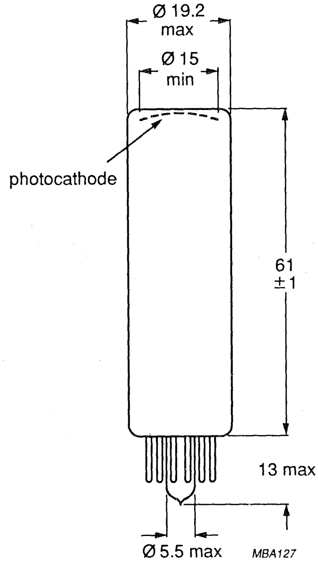
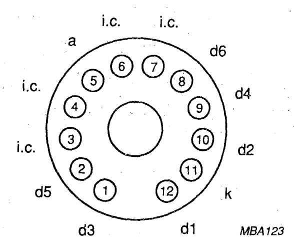


Fig.5 Mechanical outline.



i.c. = internally connected

Fig.6 Pin connections.

Base	12-pin all glass
Net mass	16 g

ACCESSORIES

Socket	FE1004
Mu-metal shield	56689

Low gain 19 mm (3/4″) diameter tube XP1922

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 12 mm and a height of 12 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pin 1.

Low gain 19 mm (3/4″) diameter tube XP1922

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 µs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.7 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 µA is recommended for applications requiring good stability.

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

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

10-STAGE PHOTOMULTIPLIER TUBES

- 34 mm useful diameter head-on type
- flat window
- semi-transparent bi-alkaline photocathode
- high stability
- good linearity
- for laboratory and industrial photometry
- XP2012 has a 14-pin all-glass base; XP2012B has a 12-pin plastic base

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bi-alkaline
Useful diameter of the photocathode	> 34 mm
Cathode blue sensitivity	11,5 μA/lmF
Supply voltage for anode blue sensitivity = 7,5 A/lmF	1350 V
Pulse amplitude resolution for ^{55}Fe	≈ 42%
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

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1,54	
Photocathode		1
Semi-transparent, head-on		
Material	bi-alkaline	
Useful diameter	> 34 mm	
Radiant sensitivity characteristic	see Fig. 6	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lm	
Blue sensitivity	typ. 11,5 μA/lmF > 10 μA/lmF	
Radiant sensitivity at 400 nm	≈ 90 mA/W	

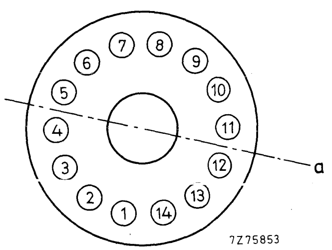
Multiplier system

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

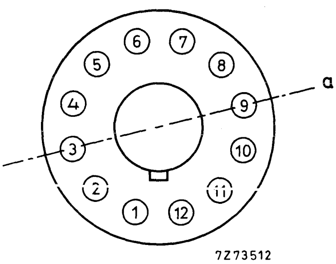
Magnetic field

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

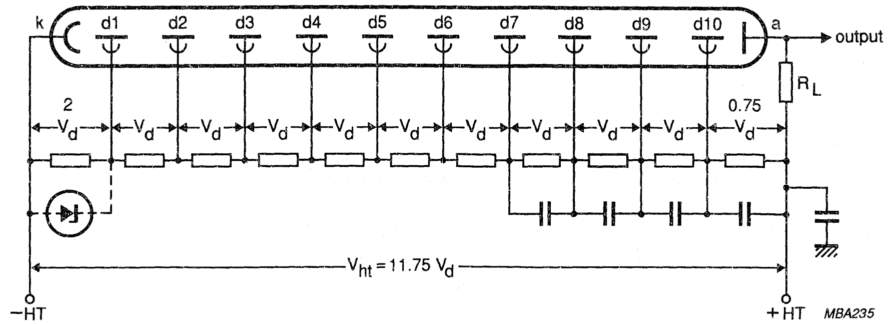


Fig. 2 Voltage divider A.

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.

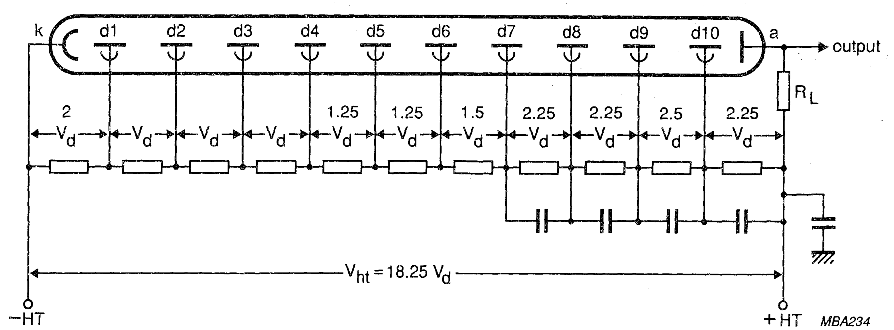


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

k = cathode

dn = dynode no

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				2
Supply voltage for an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		< typ.	1600 V 1350 V	
Gain at V_{ht} = 1350 V (Fig. 9)		≈	$6{,}5 \times 10^5$	
Anode dark current at an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		< typ.	10 nA 1 nA	3,4
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF		≈	7,2 %	5
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		≈	42 %	6
Peak-to-valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		≈	34	6
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	
Anode current linear within 2% at V_{ht} = 1350 V	up to	≈	65 mA	
With voltage divider B (Fig. 3)				2
Anode blue sensitivity at V_{ht} = 1700 V (Fig. 8)		≈	6,5 A/lmF	
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 100 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 operating 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, 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
4. Dark current is measured at ambient temperature, after the tube has been in darkness for approximatively 1 min. Lower value can be obtained after a longer stabilisation period in darkness (approx. 30 min.).
5. Pulse amplitude resolution for ^{137}Cs is measured with an NaI (Tl) cylindrical scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is ≈ 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 reaches 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. Or the voltage at which the tube has an anode spectral 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 the 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 types with plastic base this range of temperatures is limited principally by stresses in the sealing layer of the base to 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

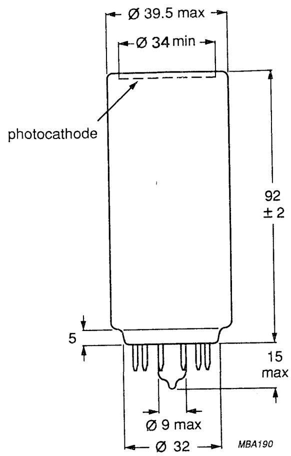
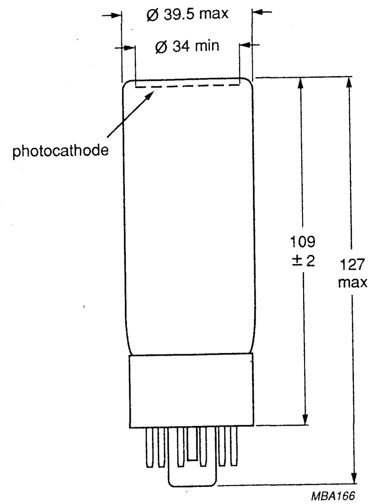


Fig. 4 XP2012

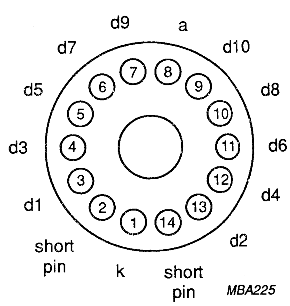


XP2012B

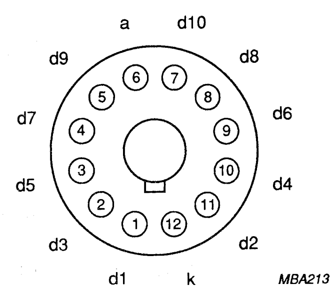
Base: 14-pin all-glass
Net mass: 54 g

Base: 12-pin (JEDEC B12-43)
Net mass: 72 g

PIN CONNECTIONS



XP2012



XP2012B

ACCESSORIES

Socket
- for XP2012 type FE1112
- for XP2012B type FE1012

Mu-metal shield type 56609

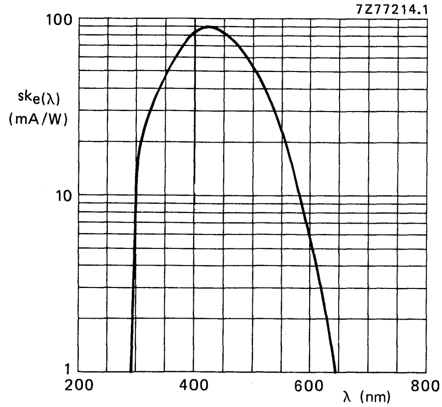


Fig. 6 Radiant sensitivity characteristic.

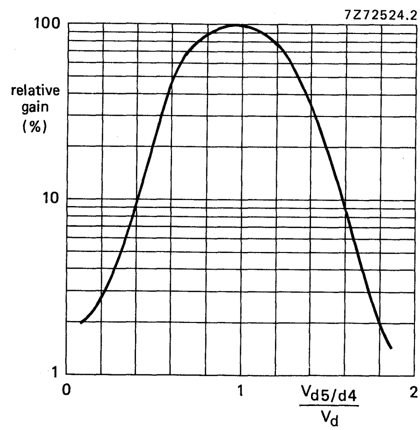


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

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

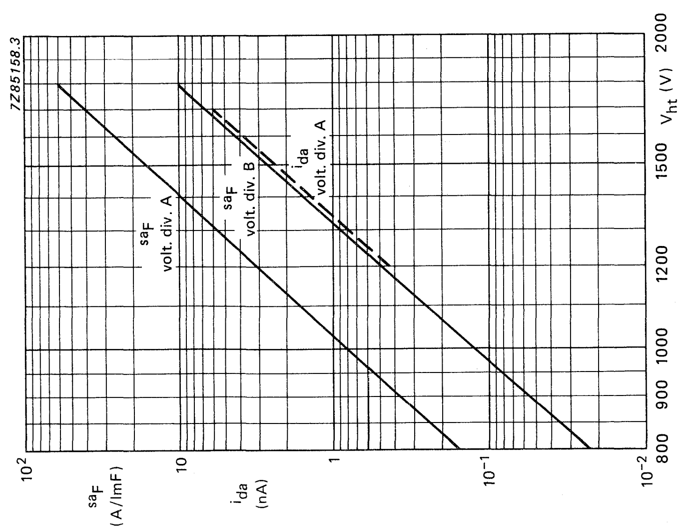


Fig. 8 Anode blue sensitivity, sa_F, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

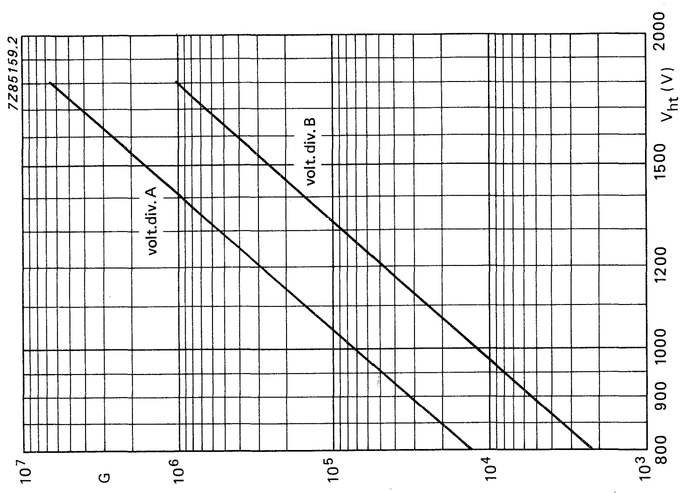


Fig. 9 Gain G as a function of supply voltage V_{ht}.

Philips Components

Data sheet	
status	Product specification
date of issue	November 1989

XP2013B

Red-sensitive 38 mm (1.5″) diameter tube

APPLICATIONS

For industrial applications such as laser reading.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	frosted borosilicate		
profile	plano – plano		
refractive index at 800 nm	1.48		
Photocathode	semi-transparent, head-on		
material	trialkali		
useful diameter	min. 34	mm	
spectral range	270 to 850	nm	1
wavelength for maximum radiant sensitivity	≈ 420	nm	
luminous sensitivity	≈ 200	µA/lm	2
radiant sensitivity at 700 nm	min. 10	mA/W	3
	typ. 20	mA/W	3
Multiplier			
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 5	pF	

Red-sensitive 30 mm (1.5″) diameter tube XP2013B

OUTPUT CHARACTERISTICS

With voltage divider A and an anode sensitivity of 60 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	-	1250	1600	V	
Gain x 10^3	-	≈ 300	-		
Anode dark current	-	2	50	nA	4,5
Mean anode sensitivity deviation					6
long term (16 hours)	-	≈ 1	-	%	
after change of count rate	-	≈ 1	-	%	
at a temperature between 0 and 40 °C at 450 nm	-	≈ 0.1	-	%/K	
Anode current halved for magnetic field of					7
perpendicular to axis ‘n’	-	≈ 0.35	-	mT	8
parallel with axis ‘n’	-	≈ 0.15	-	mT	8
parallel with the tube axis	-	≈ 0.6	-	mT	

see note 9

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	1350	1700	-	V	
Gain x 10^3	≈ 530	≈ 500	-		
Anode current linear within 2% up to	≈ 65	≈ 200	-	mA	
Anode pulse rise time	≈ 3	≈ 2.5	-	ns	10
Anode pulse duration at half height	≈ 7	≈ 6	-	ns	10
Signal transit time	≈ 28	≈ 26	-	ns	10

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode luminous sensitivity	-	600	A/lm	11
Supply voltage	-	1800	V	
Continuous anode current	-	0.2	mA	12
Voltage between first dynode and photocathode	100	500	V	13
Voltage between consecutive dynodes	-	300	V	
Voltage between anode and last dynode	30	300	V	14
Ambient temperatures				15
short operation (30 min. maximum)	−30	80	°C	
continuous operation and storage	−30	50	°C	

RECOMMENDED CIRCUITS

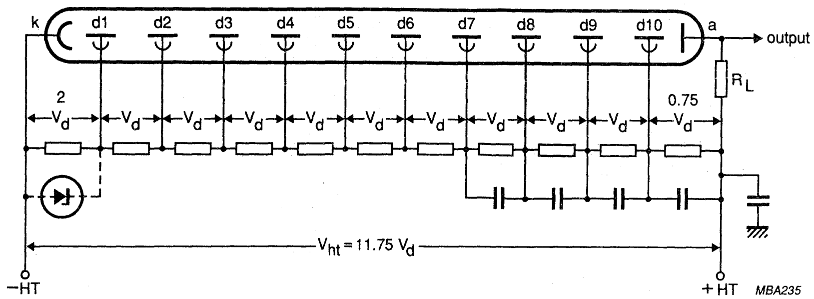


Fig.1 Voltage divider A.

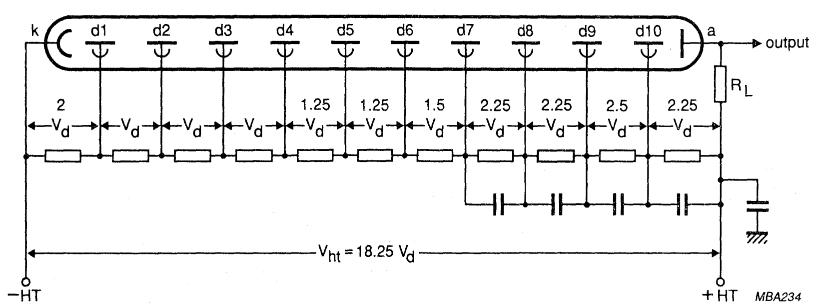


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

Red-sensitive 30 mm (1.5″) diameter tube XP2013B

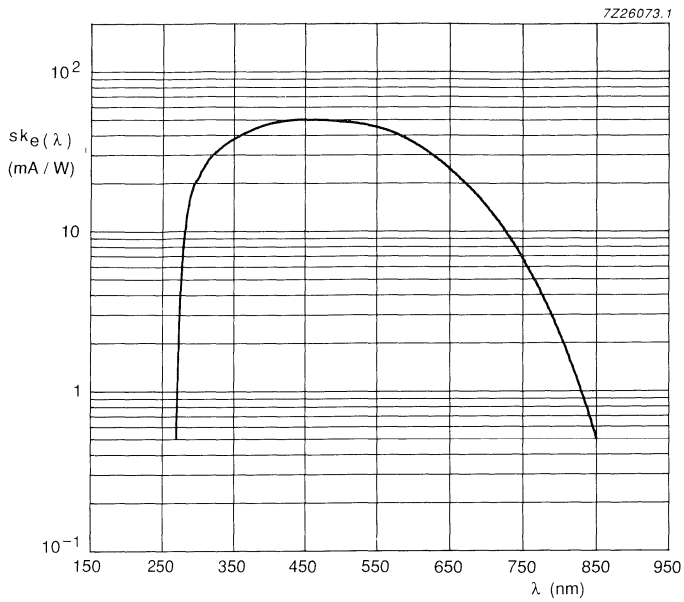


Fig.3 Cathode spectral sensitivity.

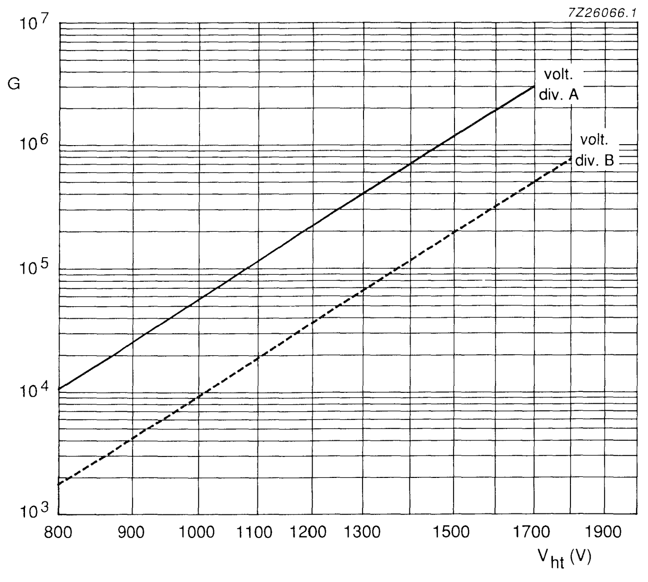


Fig.4 Gain as a function of supply voltage.

Red-sensitive 30 mm (1.5″) diameter tube XP2013B

MECHANICAL DATA

Dimensions in mm

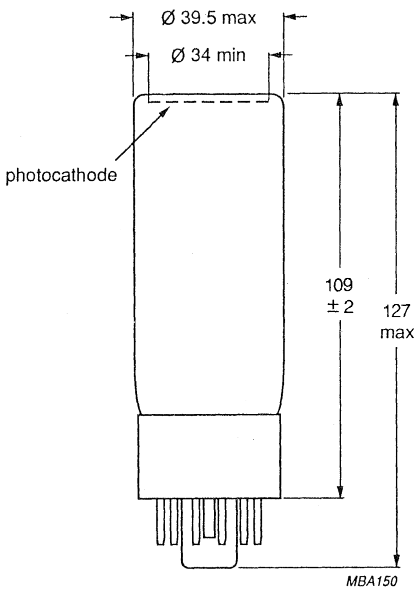


Fig.5 Mechanical outline.

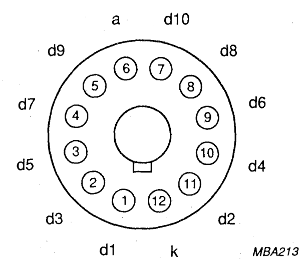


Fig.6 Pin connections.

Base	12-pin (JEDEC B12-43)
Net mass	72 g

ACCESSORIES

Socket	FE1012
Mu-metal shield	56609

Red-sensitive 30 mm (1.5″) diameter tube XP2013B

Notes

1 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

2 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

3 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter.

4 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

5 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

6 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

8 Axis 'n' belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 3 and 9.

9 To obtain a peak pulse current greater than that obtainable with divider 'A', it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

10 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.

11 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

12 A value less than 10 μA is recommended for applications requiring good 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.

15 For types with a plastic base this range of temperatures is limited principally by stresses in the sealing layer of the base to the glass bulb.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	November 1989

XP2015B

Near-infrared sensitive 38 mm (1.5″) diameter tube

APPLICATIONS

For industrial applications where a good sensitivity in the red and near infrared part of the spectrum is required such as laser detection and pollution monitoring.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	borosilicate		
profile	plano – concave		
refractive index at 800 nm	1.48		
Photocathode	semi-transparent, head-on		
material	AgOCs		1
useful diameter	min. 34	mm	
spectral range	270 to 1100	nm	2
wavelength for maximum radiant sensitivity	≈ 800	nm	
luminous sensitivity	min. 15	μA/lm	3
	typ. 20	μA/lm	3
infrared/white sensitivity ratio	≈ 0.1		5
radiant sensitivity at 1060 nm	≈ 0.12	mA/W	4
Multiplier			
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 5	pF	

Near-infrared sensitive 38 mm (1.5″) diameter tube XP2015B

OUTPUT CHARACTERISTICS

with voltage divider A

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1200	1500	V	
Gain x 10^3	–	≈ 500	–		
Anode dark current	–	2	10	μA	6,7
Anode current halved for magnetic field of					8
perpendicular to axis 'n'	–	≈ 0.35	–	mT	9
parallel with axis 'n'	–	≈ 0.15	–	mT	9
parallel with the tube axis	–	≈ 0.6	–	mT	

see note 10

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at		1550	1200	V	
Gain x 10^3		≈ 500	≈ 500		
Anode current linear within 2% up to		≈ 200	≈ 65	mA	
Anode pulse rise time		≈ 3	≈ 3	ns	11
Anode pulse duration at half height		≈ 4	≈ 4	ns	11
Signal transit time		≈ 24	≈ 25	ns	11

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Supply voltage	–	1600	V	
Continuous anode current	–	0.02	mA	12
Voltage between first dynode and photocathode	100	500	V	13
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	300	V	14
Ambient temperatures				15
short operation (30 min. maximum)	–30	50	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

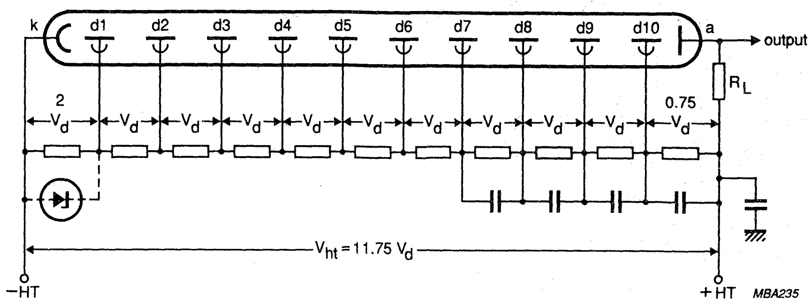


Fig.1 Voltage divider A.

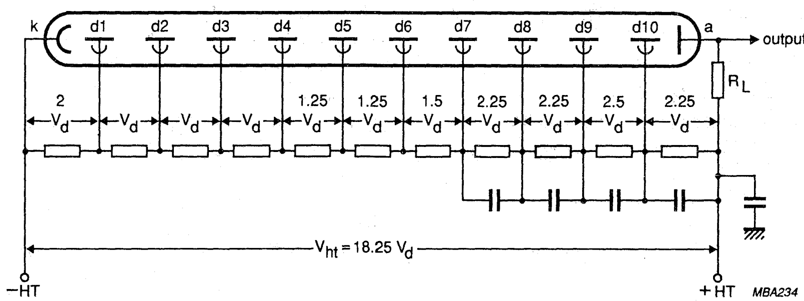


Fig.2 Voltage divider B.

Typical values of capacitors 1 nF.

a = anode
dn = dynode number
k = cathode

Near-infrared sensitive 38 mm (1.5″) diameter tube

XP2015B

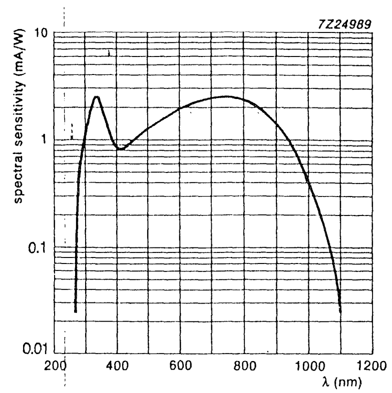


Fig.3 Cathode spectral sensitivity.

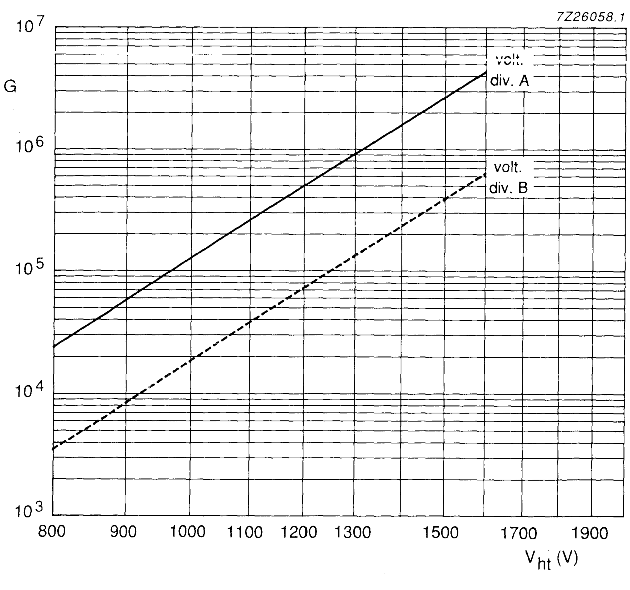


Fig.4 Gain as a function of supply voltage.

MECHANICAL DATA

Dimensions in mm

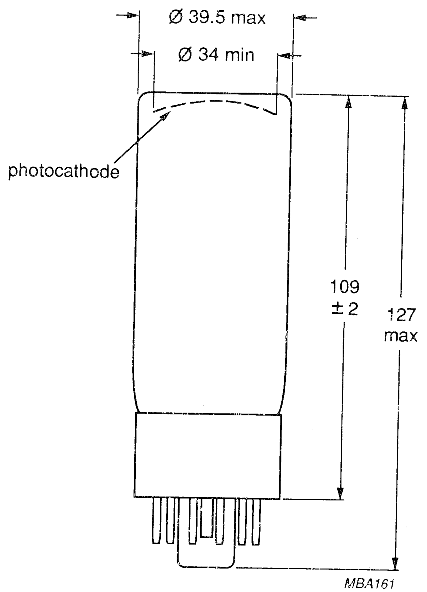


Fig.5 Mechanical outline.

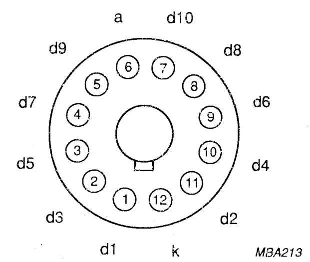


Fig.6 Pin connections.

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

ACCESSORIES

Socket	FE1012
Mu-metal shield	56609

Notes

1 This type of photocathode is known to show significant and unpredictable variations (positive or negative) of the IR sensitivity during storage (even when stored at 20 °C) and temperature cycling. These variations are generally reversible and should not be considered as signs of reduced life expectancy.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter.

5 This is the ratio of the photocathode sensitivity measured with a tungsten filament light source at a colour temperature of 2856 ± 5 K, transmitted through an IR filter (Corning CS 7-56) divided by the cathode sensitivity measured with the filter removed. The filter should have a cut-off of 5% at 850 nm and 50% at 1000 nm.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

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

9 Axis 'n' belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 3 and 9.

10 To obtain a peak pulse current greater than that obtainable with divider 'A', it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

11 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.

12 A value less than 10 μA is recommended for applications requiring good 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.

15 For types with a plastic base this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE PHOTOMULTIPLIER TUBE

- 34 mm useful diameter head-on type
- Flat window
- Semi-transparent multi-alkaline extended red photocathode
- For the red and near-infrared part of the spectrum

QUICK REFERENCE DATA

Radiant sensitivity characteristic		extended-red multi-alkaline		
Useful diameter of the photocathode		>	34	mm
Radiant sensitivity of the photocathode				
at 550 nm		≈	35	mA/W
at 700 nm		≈	23	mA/W
at 860 nm			6,5	mA/W
Supply voltage for anode luminous sensitivity = 60 A/lm			1200	V
Anode pulse rise time (with voltage divider B)		≈	2,5	ns
Linearity				
with voltage divider A	up to	≈	50	mA
with voltage divider B	up to	≈	200	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	tri-alkaline
Useful diameter	> 34 mm
Radiant sensitivity characteristic	see Fig.5
Maximum radiant sensitivity	550 ± 50 nm
Luminous sensitivity	typ. 210 μA/lm
Radiant sensitivity at 700 nm	≈ 23 mA/W
Radiant sensitivity at 860 nm	typ. 6,5 mA/W > 1,5 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.

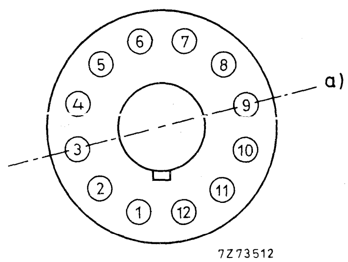


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

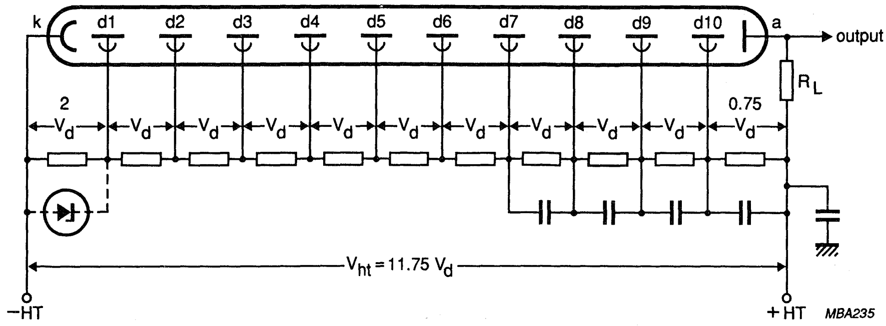


Fig. 2 Voltage divider A.

When operating at low voltage 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.

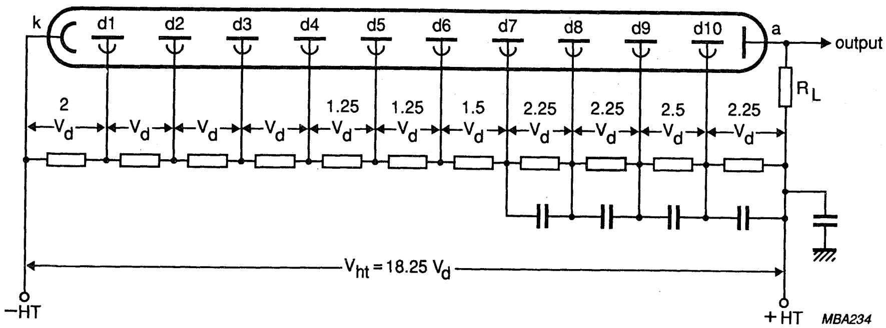


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

k = cathode

dn = dynode no

a = anode

R_L = load resistor

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				
Supply voltage for an anode luminous sensitivity of 60 A/lm, (Fig. 6)	<	1500	V	
	typ.	1200	V	
Gain at V_{ht} = 1200 V	≈	3×10^5		
Anode dark current at an anode luminous sensitivity of 60 A/lm	<	20	nA	2, 3
	typ.	2	nA	
Anode current linear within 2% at V_{ht} = 1400 V	up to ≈	50	mA	
With voltage divider B (Fig. 3)				1
Supply voltage for an anode luminous sensitivity at 60 A/lm	≈	1500	V	
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	

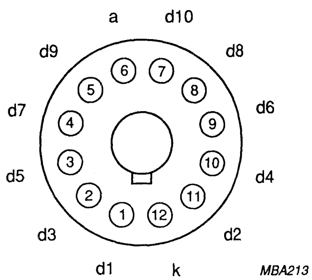
LIMITING VALUES (Absolute maximum rating system)

				notes
Supply voltage	max.	1800	V	5
Continuous anode current	max.	0,2	mA	9
Voltage between first dynode and photocathode	max.	500	V	6
	min.	100	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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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 supplier should be consulted.
9. A value of < 10 μA is recommended for applications requiring high stability.

MECHANICAL DATA



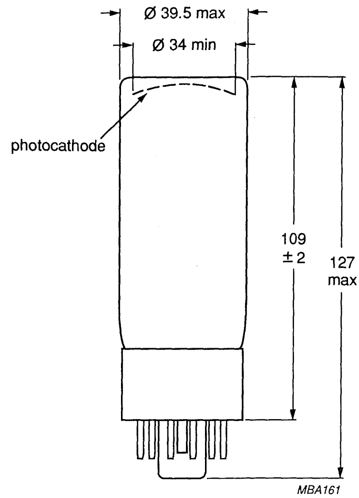


Fig. 4.

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

ACCESSORIES

Socket	type FE1012
Mu-metal shield	type 56609

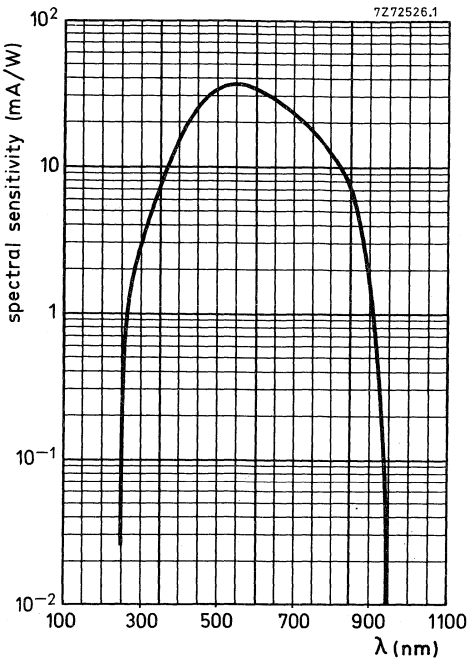


Fig. 5 Spectral sensitivity characteristic.

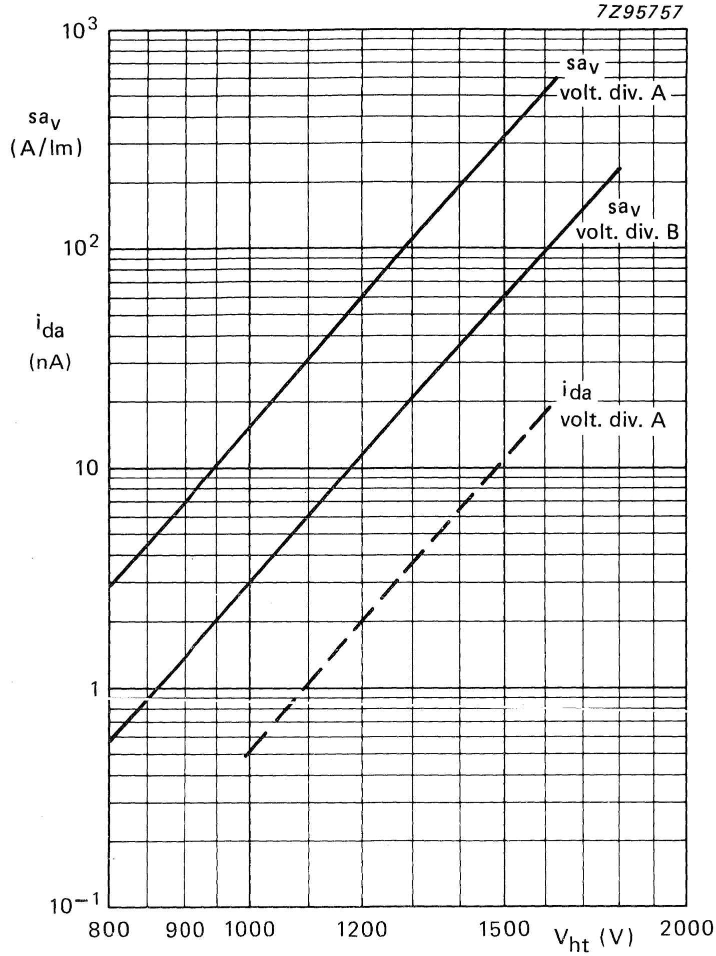


Fig. 6 Anode luminous sensitivity sa_v and anode dark current i_{da} as a function of the supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

10-STAGE PHOTOMULTIPLIER TUBE

The XP2018B is a 34 mm useful diameter head-on photomultiplier tube with a semitransparent bialkaline photocathode on a fused silica window. 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

Radiant sensitivity characteristic	bialkaline on fused silica
Useful diameter of the photocathode	> 34 mm
Cathode blue sensitivity	10 μA/lmF
Supply voltage for an anode blue sensitivity of 7.5 A/lmF	1350 V
Anode pulse rise time (with voltage divider B)	≈ 2.5 ns
Linearity with voltage divider A with voltage divider B	 up to ≈ 100 mA 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 at 400 nm	 1.50 1.47

Photocathode

Semi-transparent, head-on	
Material	bialkaline
Useful diameter	> 34 mm
Radiant sensitivity characteristic	See Fig.5
Maximum radiant sensitivity at	400 ± 30 nm
Luminous sensitivity	≈ 85 μA/lm
Blue sensitivity	typ. 10 μA/lmF min. 8.5 μA/lmF
Radiant sensitivity at 400 nm	≈ 80 mA/W

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.

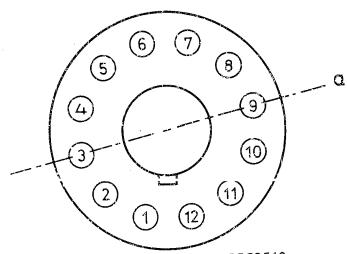


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

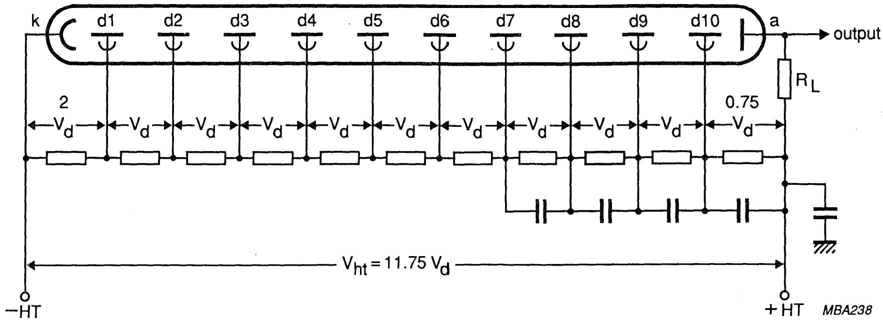


Fig. 2 Voltage divider A. Typical value of capacitors: 10 nF, k = cathode, dn = dynode no., a = anode, R_L = load resistor.

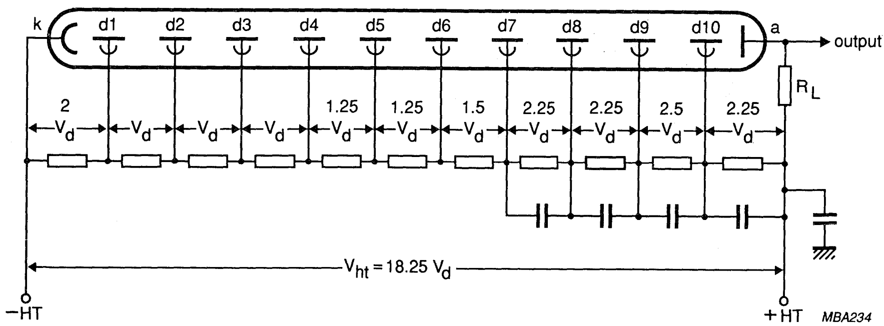


Fig. 3 Voltage divider B. Typical values of capacitors: 10 nF, k = cathode, dn = dynode no., a = anode, R_L = load resistor.

TYPICAL CHARACTERISTICS

				notes
With voltage divider A Fig. 2)				1
Supply voltage for an anode blue sensitivity of 7.5 A/lmF (Fig.7)	<	1600	V	
	typ.	1350	V	
Anode dark current at an anode blue sensitivity of 7.5 A/lmF	<	20	nA	2,3
	typ.	5	nA	
Anode current linear within 2% at V_{ht} = 1700 V	up to ≈	100	mA	
With voltage divider B (Fig. 3)				1
Anode radiant sensitivity at V_{ht} = 1700 V (Fig. 7)	≈	4.7	A/lmF	
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)

				notes
Supply voltage	max.	1800	V	5
Continuous anode current	max.	0.2	mA	9
Voltage between first dynode and photocathode	max.	500	V	6
	min.	150	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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
3. Dark current is measured at ambient temperature, after the tube has been in darkness for approximatively 1 min. Lower value can be obtained after a longer stabilisation 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 reaches 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 blue sensitivity of 75 A/lmF 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

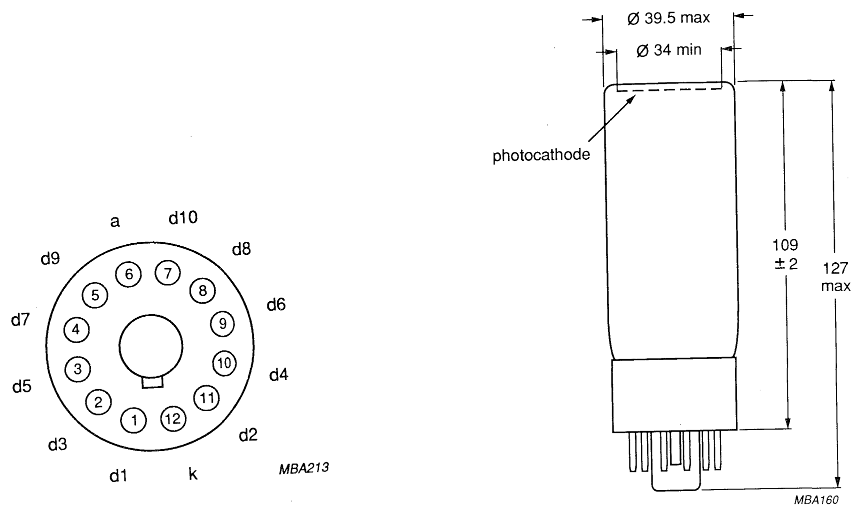


Fig. 4.

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

ACCESSORIES

Socket	type FE1012
Mu-metal shield	type 56609

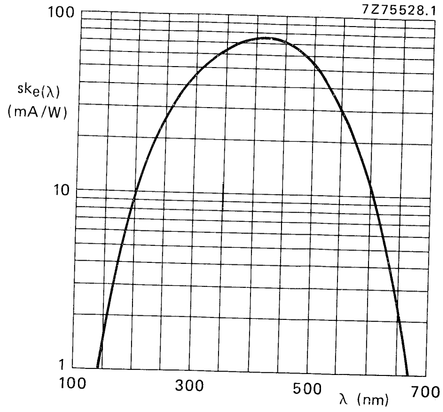


Fig. 5 Radiant sensitivity characteristic.

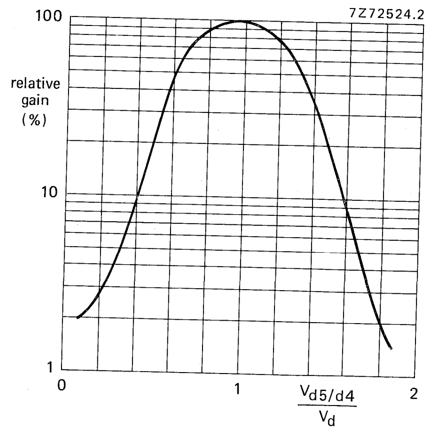


Fig. 6 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

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

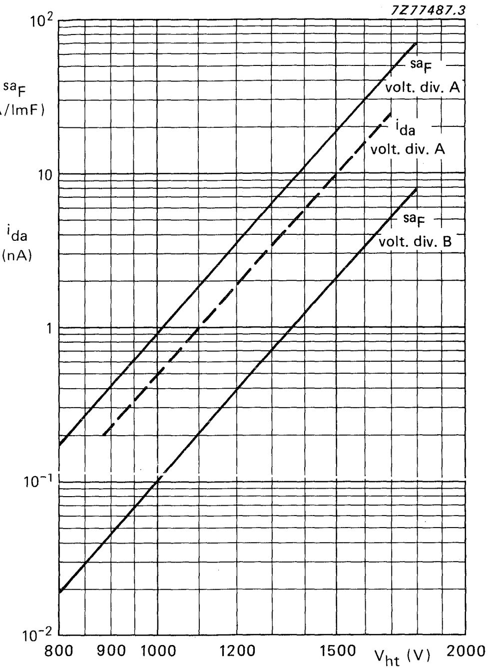


Fig. 7 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of the supply voltage V_{ht}.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2020 and XP2020/Q are 44 mm useful diameter head-on photomultiplier tubes with a plano-concave window and a semi-transparent bialkaline photocathode and a high gain 1st dynode from SN14007 onwards. 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 sensivity, a good linearity combined with a very low background noise, extremely good time characteristics and good single electron spectrum resolution. They are especially useful in high-energy physics experiments where ultimate time characteristics are needed, such as coincidence measurements, Cerenkov detection, etc. The XP2020/Q has a fused silica window enabling transmission at a wavelength of 160 nm and higher.

QUICK REFERENCE DATA

Radiant sensitivity characteristic	XP2020	bialkaline		
	XP2020/Q	bialkaline on fused silica		
Useful diameter of the photocathode		>	44	mm
Quantum efficiency at 400 nm			25	%
Blue sensitivity of the photocathode			10	μA/lmF
Single electron spectrum resolution			70	%
Supply voltage for a gain of 3×10^7			2200	V
Pulse amplitude resolution for ^{137}Cs		≈	7,2	%
Anode pulse rise time (with voltage divider C)		≈	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
XP2020/Q	fused silica
Shape	plano-concave
Refractive index	
XP2020, at 550 nm	1,48
XP2020/Q at 400 nm	1,47
XP2020/Q at 250 nm	1,50

Photocathode (note 1)

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

GENERAL CHARACTERISTICS (continued)

Radiant sensitivity characteristic		see Figs 6 and 7
Maximum radiant sensitivity at		400 ± 30 nm
Blue sensitivity	typ.	10 μA/lmF
	min.	7.5 μA/lmF
Luminous sensitivity		70 μA/lm
Quantum efficiency at 400 nm		25 %
Radiant sensitivity at 400 nm	≈	80 mA/W

Multiplier system

Number of stages		12
Dynode structure		linear focused
Dynode material		CuBe
Capacitances		
Grid 1 to $k + d_1 + d_5 + g_2$	≈	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.

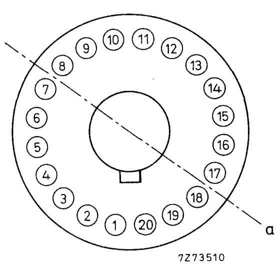


Fig.1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

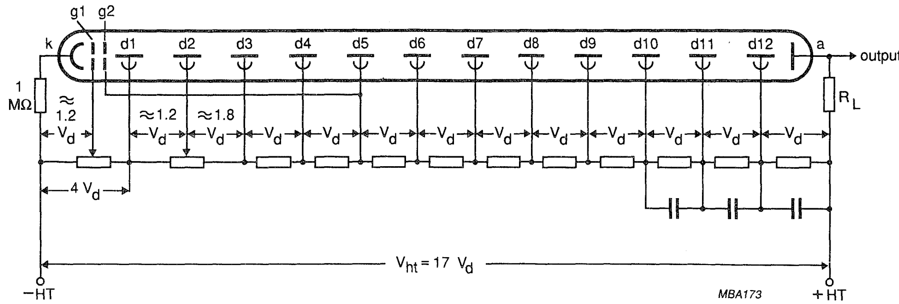


Fig. 2 Voltage divider type A.

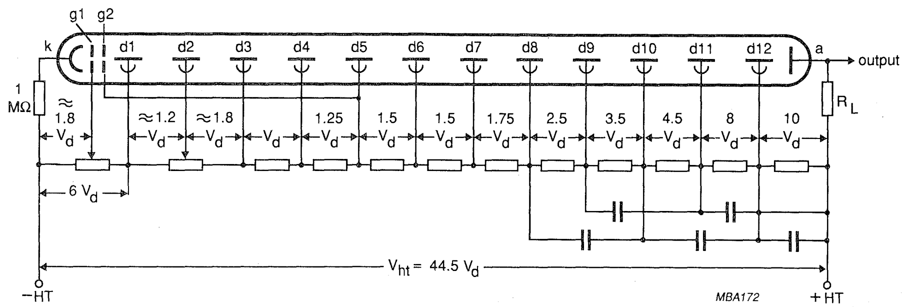


Fig. 3 Voltage divider type B.

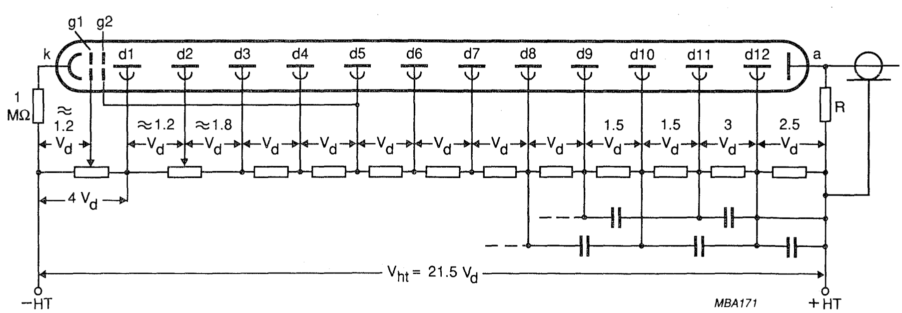


Fig. 4 Voltage divider type C.

k = cathode
g_1, g_2 = focusing and accelerating electrodes
d_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. 11-14)	5		typ.	900	c/s
			<	2500	c/s
Single electron spectrum at a gain of 3×10^7 (Fig. 15)					
resolution	15		≈	70	%
peak to valley ratio	16		≈	2,5	
Pulse amplitude resolution for ^{55}Fe at a gain of 3×10^7	6		≈	41	%
Peak to valley ratio for ^{55}Fe at a gain of 3×10^7			≈	34	
Pulse amplitude resolution for ^{137}Cs at V_b = 1500 V	6		≈	7,2	%
Anode pulse rise time at V_b = 2000 V	7,13		≈	1,6	ns
Anode pulse duration at half height at V_b = 2000 V	7,13		≈	3,7	ns
Signal transit time at V_b = 2000 V	7,13		≈	28	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. 3)	2				
Gain at V_b = 2800 V			≈	2×10^6	
Anode pulse rise time at V_b = 2800 V	7,13		≈	1,7	ns
Anode pulse duration at half height at V_b = 2800 V	7,13		≈	2,7	ns
Signal transit time at V_b = 2800 V	7,13		≈	31	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2800 V			≈	0,25	ns
Anode current linear within 2% at V_b = 2800 V		up to	≈	280	mA
Obtainable peak anode current			≈	0,5 to 1	A
With voltage divider C (Fig. 4)	2				
Gain at V_b = 2500 V			≈	2×10^7	
Anode pulse rise time at V_b = 2500 V	7,13		≈	1,5	ns
Anode pulse duration at half height at V_b = 2500 V	7,13		≈	2,4	ns
Signal transit time at V_b = 2500 V	7,13		≈	30	ns
Signal transit time distribution at V_b = 2500 V	12,13	σ	≈	0,25	ns
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_b = 2500 V			≈	0,25	ns
Anode current linear within 2% at V_b = 2500 V		up to	≈	70	mA
Obtainable peak anode current			≈	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.	800 V
		min.	300 V
Voltage between consecutive dynodes (except d_{11} and d_{12})		max.	400 V
Voltage between dynodes d_{11} and d_{12}	13	max.	600 V
Voltage between anode and final dynode	10	max.	700 V
		min.	80 V
Ambient temperature range	11		
operational (for short periods of time)		max.	+ 80 °C
		min.	−30 °C
continuous operation and storage		max.	+ 50 °C
		min.	−30 °C

Notes

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 voltage progressively. Divider circuit B and C 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 voltage ratio between two successive stages is less than 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 insulators with an insulation resistance of $> 10^{15}\ \Omega$.
4. Dark current is measured at ambient temperature, after the tube has been in darkness for approx. 1 min. Lower value can be obtained after a longer stabilization period in darkness (approx. 30 min.).
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 25 mm and a height of 1 mm provided with a beryllium window. 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 d_{11} and d_{12}. See also *General Operational Recommendations Photomultiplier Tubes.*
14. A value of $< 10\ \mu$A is recommended for applications requiring good stability.
15. The single electron spectrum resolution to be optimized by adjusting the dynode 2 voltage.
16. Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.

MECHANICAL DATA

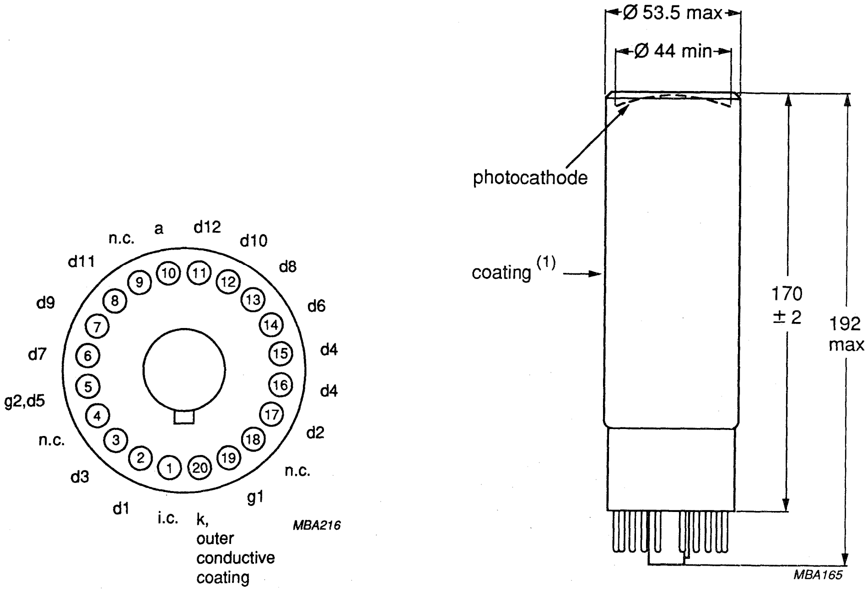


Fig.5.

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

ACCESSORIES

Socket	type FE1120
Mu-metal shield	type 56619
Base assembly	S563

(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.

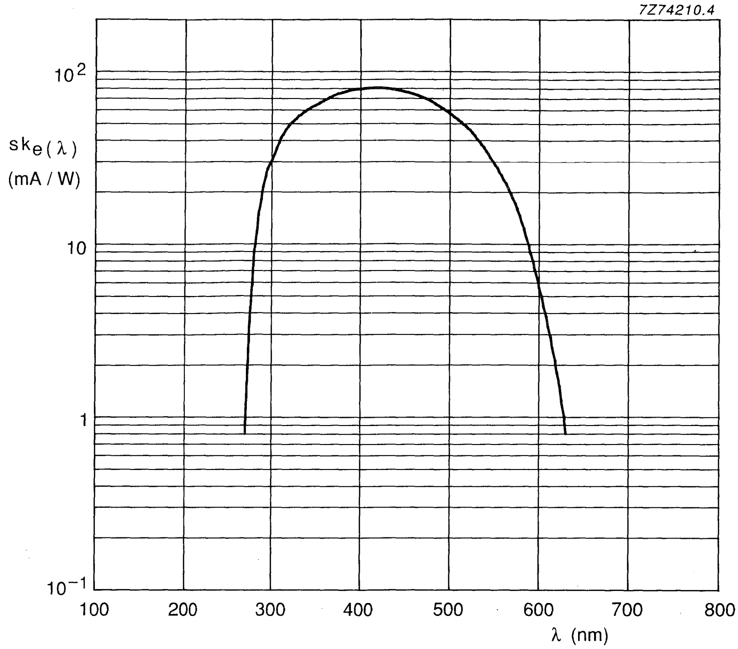


Fig. 6 Spectral sensitivity characteristic XP2020.

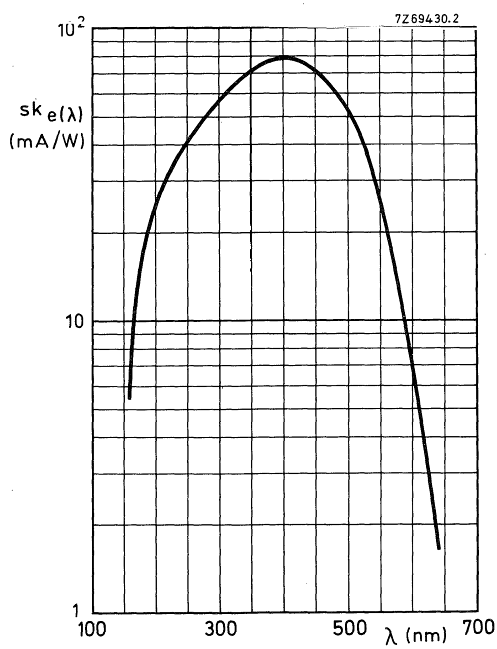


Fig. 7 Spectral sensitivity characteristic XP2020/Q.

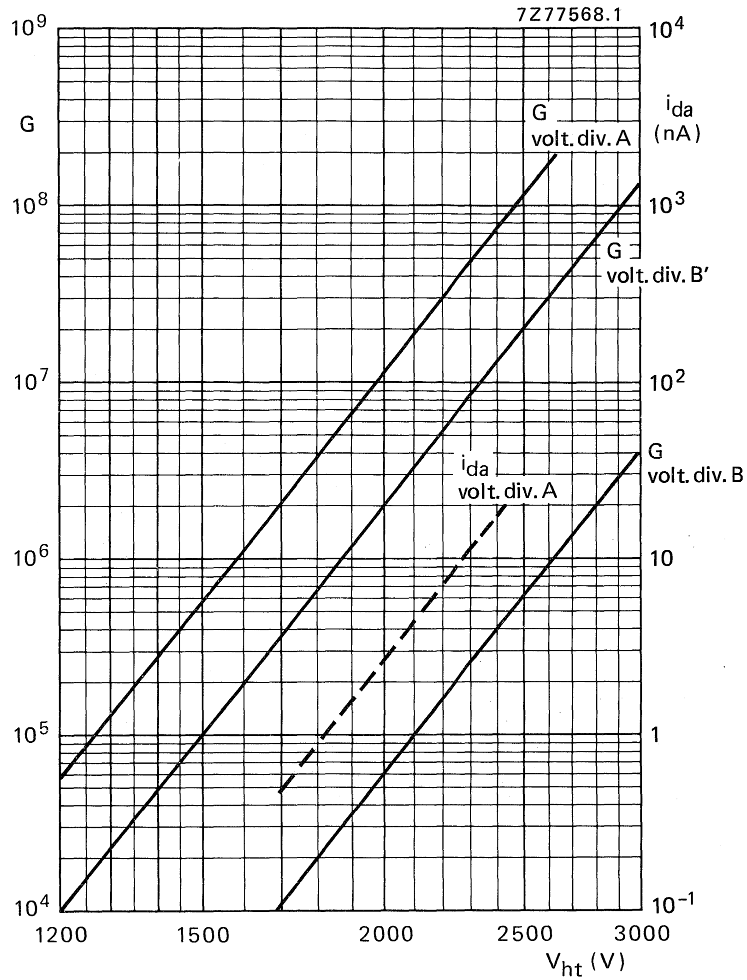


Fig. 8 Gain, G, and anode dark current, i_{da}, as a function of supply voltage V_b.

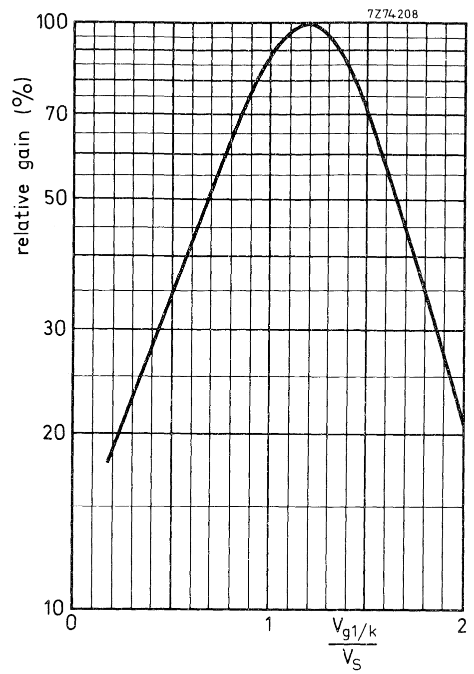


Fig. 9 Relative gain as a function of the voltage between grid 1 and cathode, normalized to V_S. $V_{S1/k}$ constant.

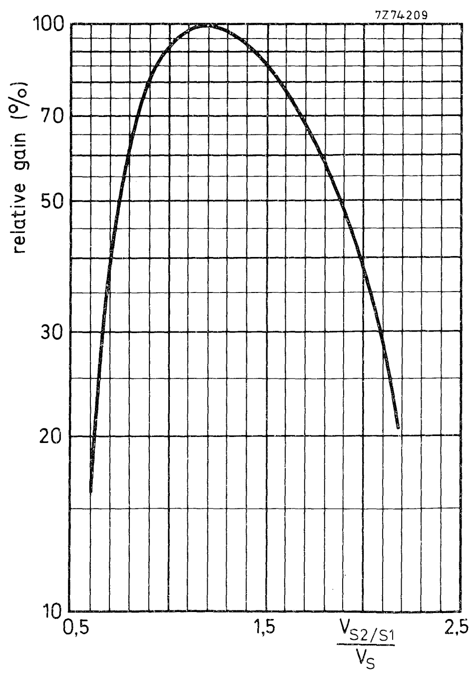


Fig. 10 Relative gain as a function of the voltage between S_2 and S_1, normalized to V_S. $V_{S3/S1}$ constant.

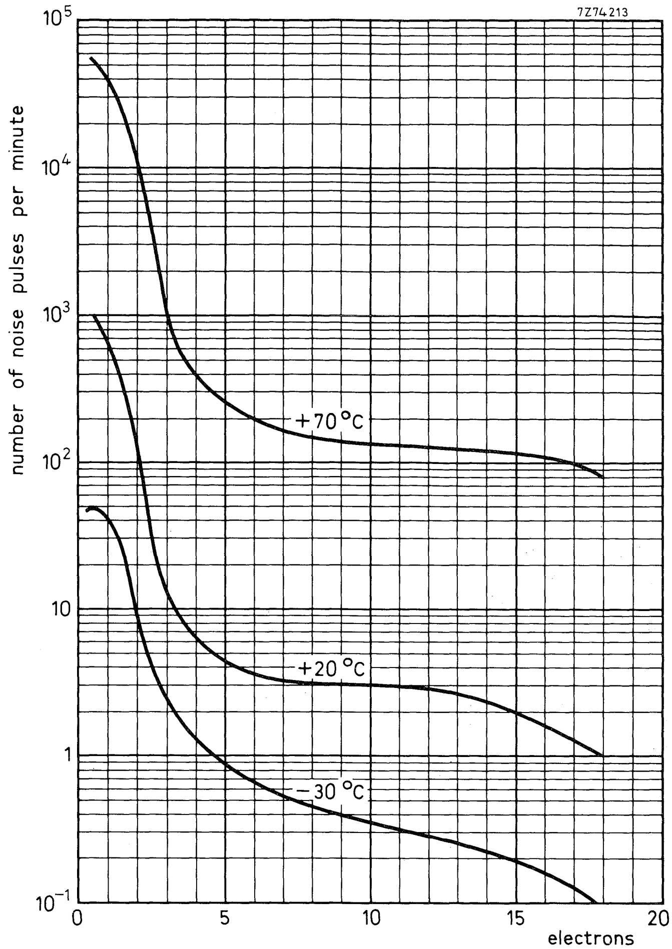


Fig. 11 Typical background spectrum from 0,1 to 18 equivalent photoelectrons, at a gain of 3×10^7 with voltage divider A.

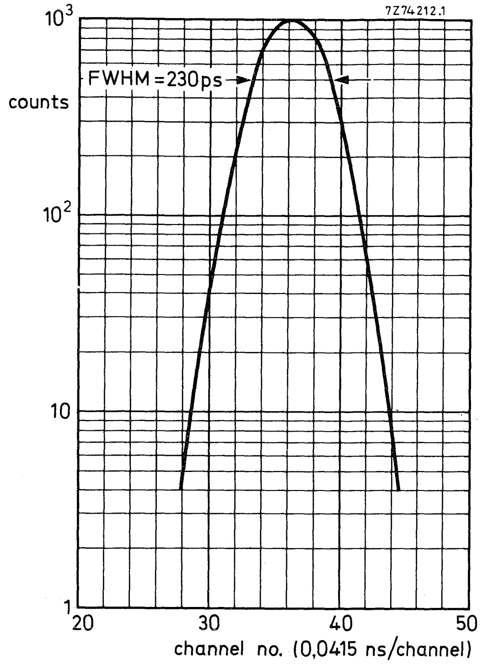


Fig. 12 Time resolution for 2 tubes XP2020 in coincidence. Measuring conditions:
Number of photoelectrons ≈ 1500
Supply voltage 2500 V
Constant fraction operation
Dynamic energy region 20%.

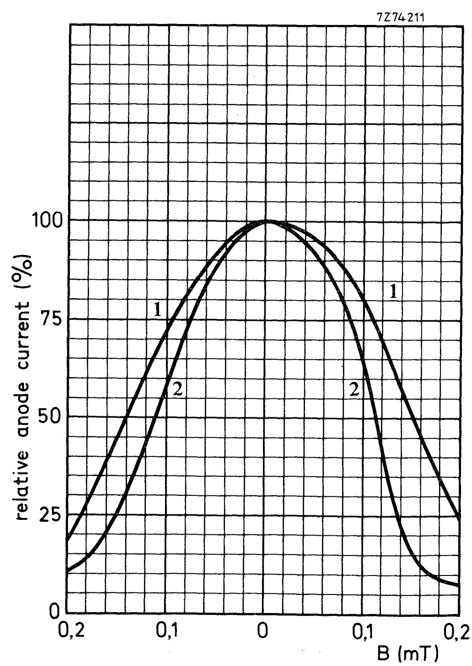


Fig. 13 Relative anode current as a function of the magnetic flux density B.
1. ⊥ axis a
2. // axis a

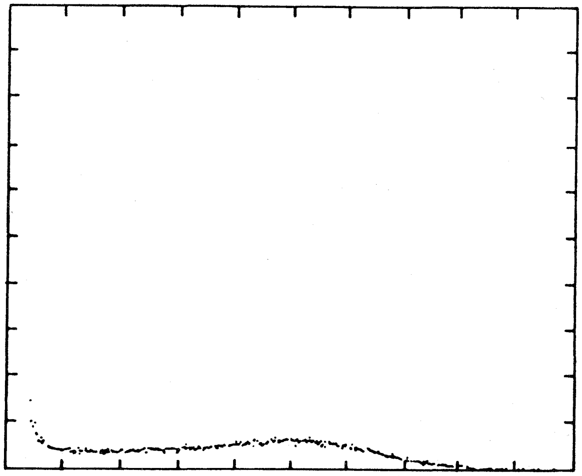


Fig. 14 Background noise spectrum, obtained with an XP2020 tube, series no. 13246. Gain: 3×10^7.

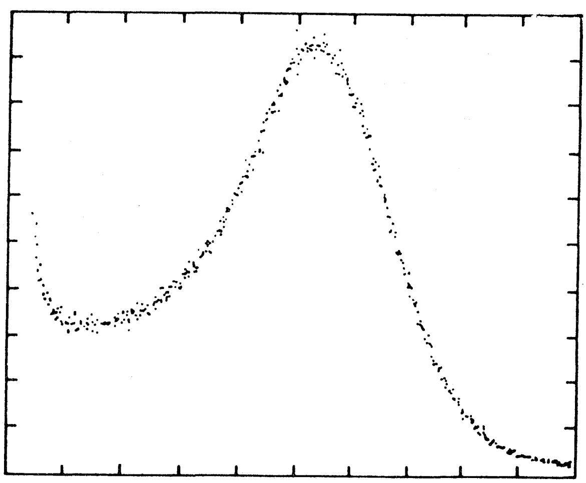


Fig. 15 Single electron spectrum obtained with an XP2020 tube, series no. 13246. Gain: 3×10^7. Resolution 67%. Peak to valley ratio: 2,8 (see Note 16).

8-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	S20
Useful diameter of the photocathode	> 34 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	trialkaline	
Useful diameter	> 34 mm	
Radiant sensitivity characteristic	see Fig.5	
Maximum spectral sensitivity	420 ± 30 nm	
Luminous sensitivity	≈ 200 μA/lm	note 1
Radiant sensitivity at 700 nm	typ. 20 mA/W > 10 mA/W	note 2
Radiant 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.

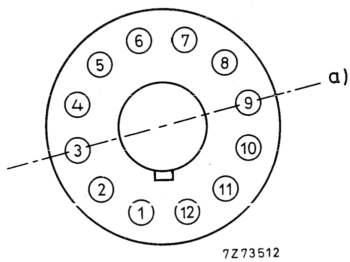


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

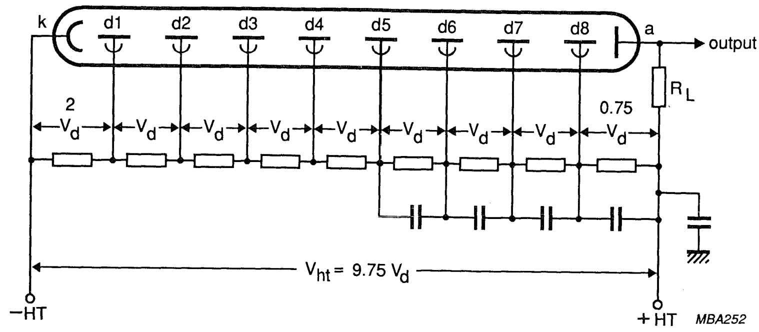


Fig. 2 Voltage divider A.

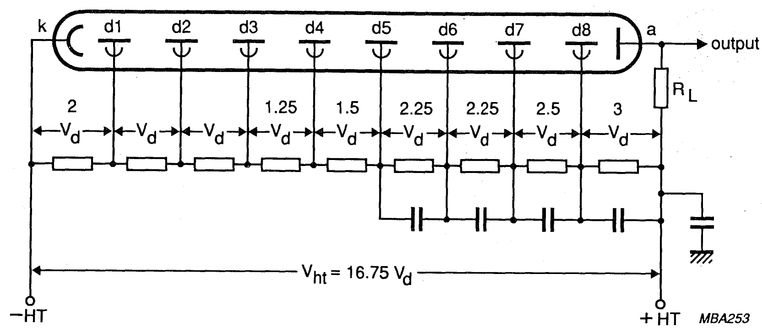


Fig. 3 Voltage divider B.

Typical value of capacitors: 10 nF

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

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 V < 1300 V	note 1
Anode dark current at an anode luminous sensitivity of 6 A/lm (Fig. 7)	typ. 1 nA < 5 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	

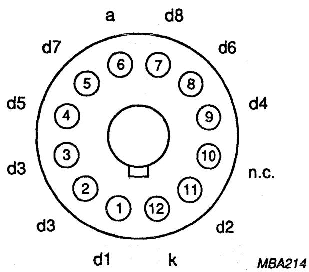
LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max. 1800 V	note 8
Continuous anode current	max. 0,2 mA	note 9
Voltage between first dynode and photocathode	max. 500 V min. 100 V	note 10
Voltage between consecutive dynodes	max. 300 V	
Voltage between anode and final dynode	max. 300 V min. 30 V	note 11
Ambient temperature range		note 12
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. Radiant 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than $10^{15}\ \Omega$. If used, the metal shield should be kept at the cathode potential.
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 reaches 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



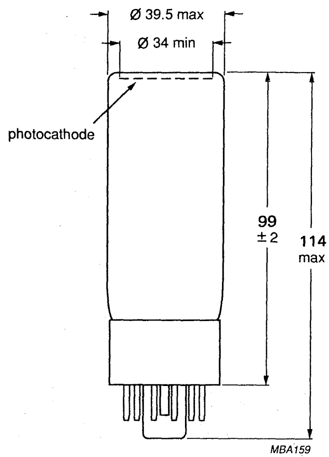


Fig. 4.

Base	12-pin (JEDEC B12-43)
Net mass	75 g
Socket	FE1012
Mu-metal shield	type 56609

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

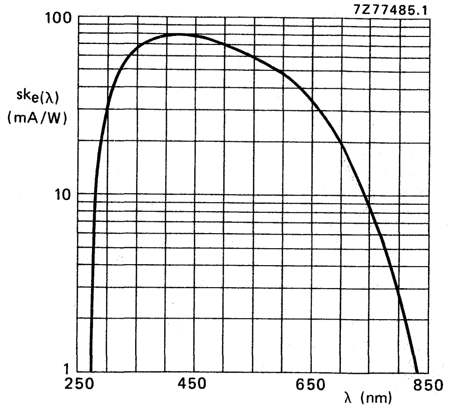


Fig. 5 Spectral sensitivity characteristic.

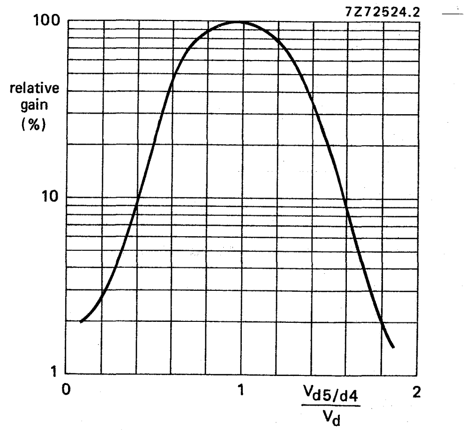


Fig. 6 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

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

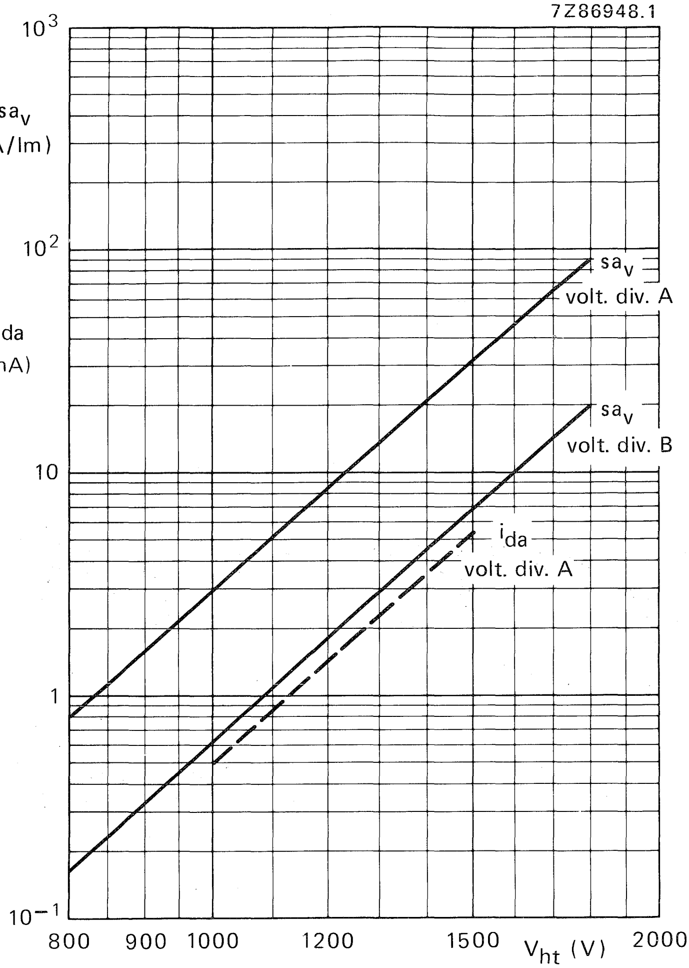


Fig. 7 Anode luminous sensitivity sa_v and anode dark current i_{da} as a function of the supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

14-STAGE PHOTOMULTIPLIER TUBE

- 110 mm useful diameter head-on type
- Concave-convex window
- Semi-transparent bi-alkaline photocathode on UV transmitting glass window
- 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) and a metal housing
- XP2041/Q is supplied with a plano-concave fused silica adapter (200 nm and up) and a metal housing
- XP2041/03 is supplied with a plastic adapter but without metal housing

QUICK REFERENCE DATA

Radiant sensitivity characteristic			bialkali, on UV transmitting glass	
Useful diameter of the photocathode		>	110	mm
Quantum efficiency at 400 nm			25	%
Cathode blue sensitivity			10	μA/lmF
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 C (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
Radiant sensitivity characteristic	see Fig.6
Maximum radiant sensitivity	400 ± 30 nm
Luminous sensitivity	≈ 55 μA/lm
Blue sensitivity	typ. 10 μA/lmF min. 8 μA/lmF
Radiant sensitivity at 400 nm	≈ 80 mA/W
Quantum efficiency at 400 nm	25 %

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 + 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.

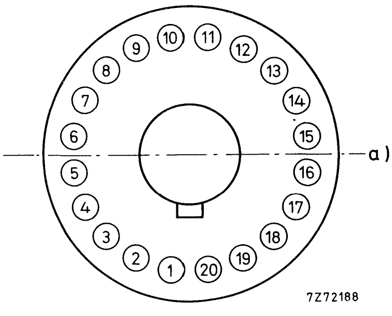


Fig.1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

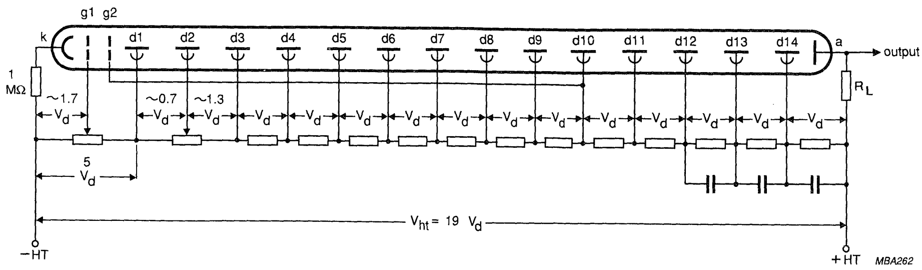


Fig. 2 Voltage divider A.

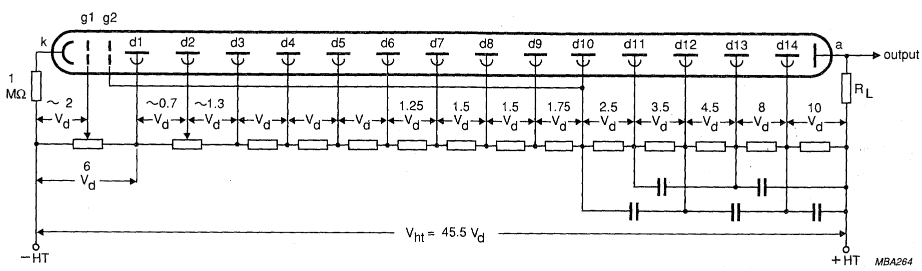


Fig. 3 Voltage divider B.

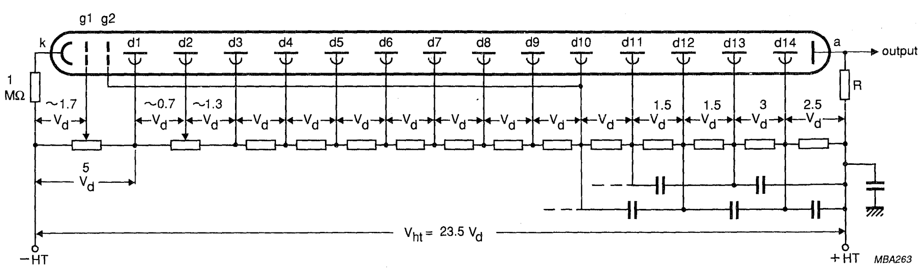


Fig. 4 Voltage divider C .

k = cathode; g1, g2 = focusing and accelerating electrodes; 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 C 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 C (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 ≈	80 mA	
Obtainable peak anode current	≈	500 mA	

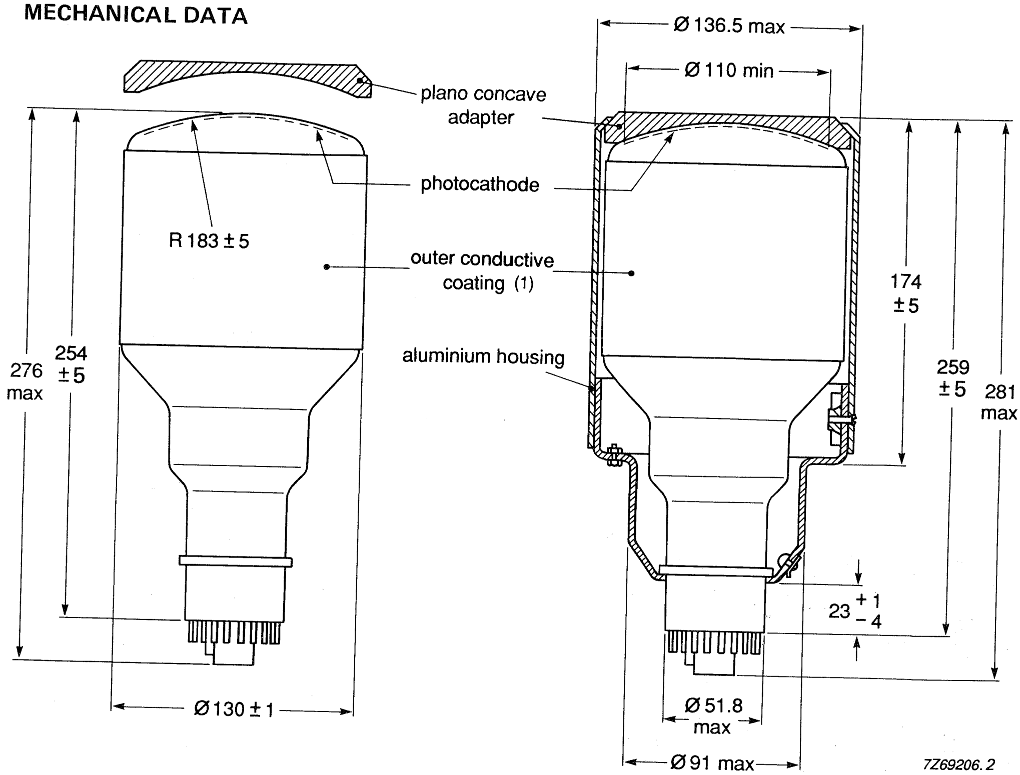
LIMITING VALUES (Absolute maximum rating system)

				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 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than $10^{15}\,\Omega$. If a metal shield is used, it should be kept at the cathode potential.
2. Dark current is measured at ambient temperature, after the tube has been in darkness for approximatively 1 min. Lower value can be obtained after a longer stabilisation period in darkness (approx. 30 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. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage progressively. Divider circuits B and C 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 voltage ratio between two successive stages is less than 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 <10μA 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



net mass: tube: 820 g
adaptor: 123 g

XP2041/03

net mass: 1340 g

XP2041
XP2041/Q

base: 20-pin (JEDEC B20-102)

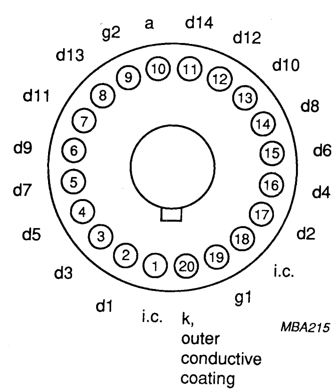


Fig.5 Mechanical details.

- Care should be taken in handling this larger diameter tube because of the risk of implosion.
- Optical coupling silicone grease is supplied with each tube. The grease should be applied to the adapter-photomultiplier interface before operation.

ACCESSORIES

Socket	FE1120
Base assembly	S563
Mu-metal shield	type 56658

(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.

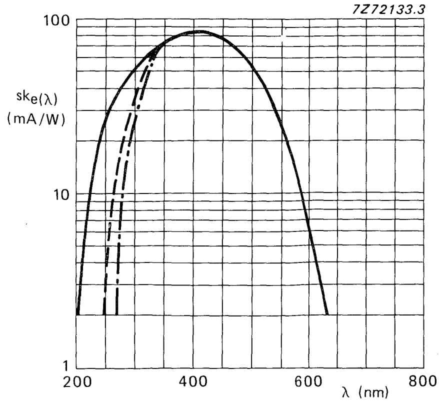


Fig. 6

Radiant sensitivity characteristic:
——— without adapter or with fused silica adapter
– – – with plastic adapter (centre)
– · – · with plastic adapter (edge)

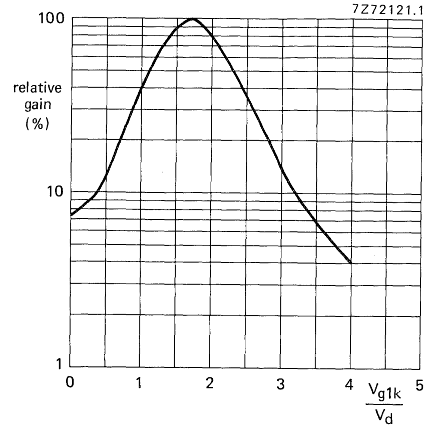


Fig. 7

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

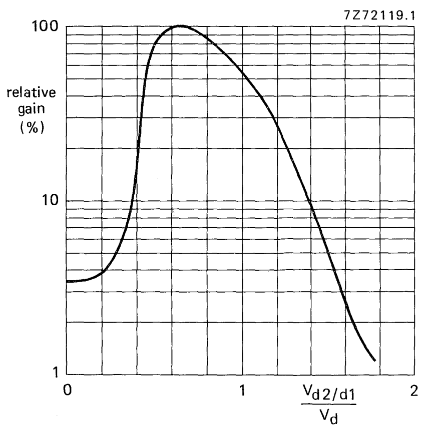


Fig. 8

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

$V_{d3/d1}$ constant.

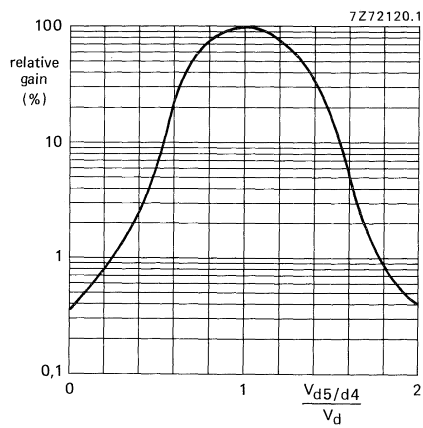


Fig. 9

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.

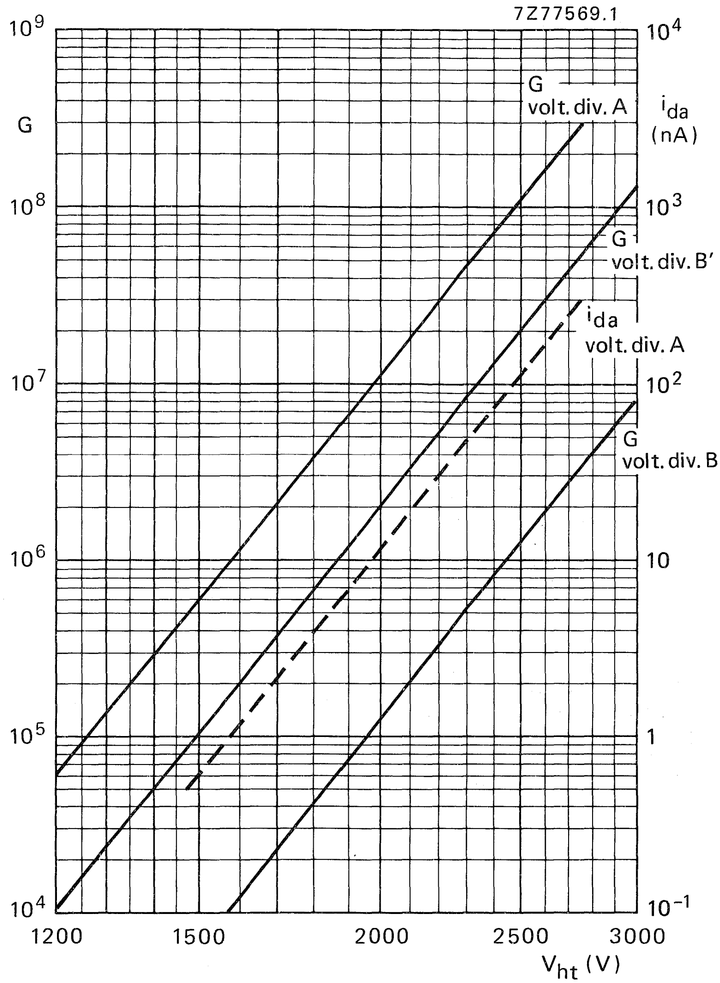


Fig. 10.

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 photocathode
- for high-energy physics, e.g. large dimensional Cerenkov counters, leadglass walls, etc.

QUICK REFERENCE DATA

Radiant sensitivity characteristic		bialkaline	
Useful diameter of the photocathode	>	110	mm
Cathode blue sensitivity		11	μA/lmF
Supply voltage for an anode blue sensitivity of 1.5 A/lmF		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

					notes
Material		borosilicate			
Shape		plano-plano			
Refractive index at 550 nm		1.48			

Photocathode

Semi-transparent, head-on

					notes
Material		bialkaline			1
Useful diameter	>	110		mm	
Radiant sensitivity characteristic		see Fig.4			
Maximum radiant sensitivity at		400 ± 30		nm	
Luminous sensitivity	≈		60	μA/lm	2
Blue sensitivity	typ.		11	μA/lmF	3
	min.		8	μA/lmF	
Radiant sensitivity at 400 nm	≈		85	mA/W	4

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

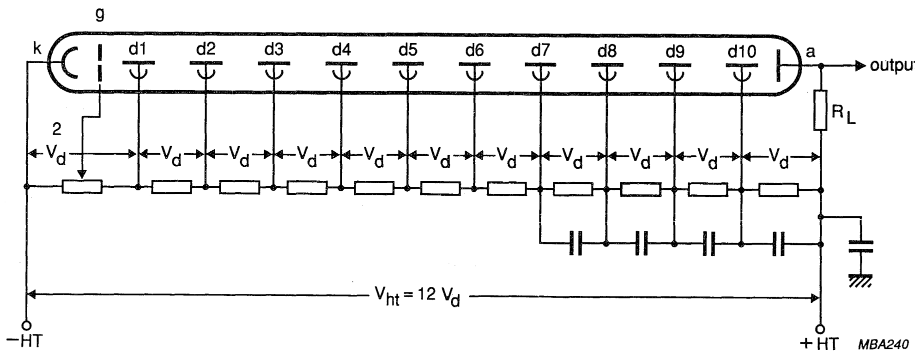


Fig. 1 Voltage divider A.

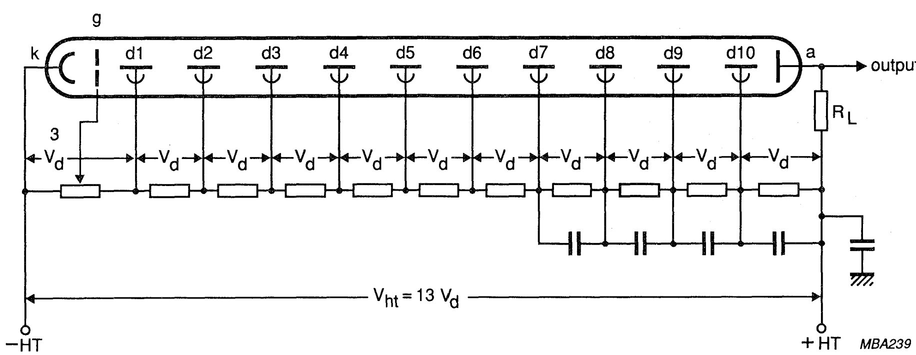


Fig. 2 Voltage divider A_1.

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 radiant sensitivities refer to a wavelength of 400 nm.

			notes
With voltage divider A (Fig. 1)			5
Supply voltage for an anode blue sensitivity of 1.5 A/lmF (Fig.7)	<	1500 V	
	typ.	1270 V	
Gain at V_{ht} = 1270 V	≈	1.4×10^5	
Anode dark current at an anode blue sensitivity of 1.5 A/lmF	<	5 nA	6
	typ.	0.5 nA	
Anode current linear within 2 % at V_{ht} = 1500 V up to	≈	10 mA	
With voltage divider A_1 (Fig. 2)			
Gain at V_{ht} = 1500 V (Fig.7)	≈	3.0×10^5	
Pulse amplitude resolution for ^{137}Cs at 1.5 A/lmF	≈	7.5 %	7
Anode current linear within 2% at V_{ht} = 1500 V up to	≈	10 mA	
Mean anode sensitivity deviation			8
long term (16 h)	≈	1 %	
after change of count rate	≈	1 %	
Anode pulse rise time at V_{ht} = 1500 V	≈	16 ns	9
Anode pulse width at half height at V_{ht} = 1500 V	≈	40 ns	9
Signal transit time at V_{ht} = 1500 V	≈	90 ns	9

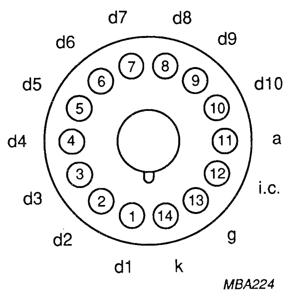
LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2000 V	10
Continuous anode current	max.	0.2 mA	11
Voltage between first dynode and photocathode	max.	500 V	12
	min.	150 V	
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	13
Ambient temperature range			14
operational (for short periods of time)	max.	+80 °C	
	min.	−30 °C	
continuous operation and storage	max.	+50 °C	
	min.	−30 °C	

Notes

1. This bialkaline photocathode has a significant resistance which increases rapidely 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 Ω to 10^7 Ω photo electrons without disturbance.
2. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ±5 K.
3. Blue sensitivity, expressed in μA/ImF, 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.
4. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ±5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/ImF, by 8×10^3 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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. 4170 or equivalent) with a diameter of 75 mm and a height of 75 mm. The count rate used is ≈ 10^4 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 ≈ 10^4 c/s, corresponding to an anode current of ≈ 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 ≈ 10^4 c/s to ≈ 10^3 c/s, corresponding to anode currents of ≈ 1 μA and ≈ 0.1 μA 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 reaches 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 blue sensitivity of 30 A/ImF, 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.
13. When calculating the anode voltage the voltage drop across the load resistor should be taken into account.
14. This range of temperatures is limited by stresses in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA



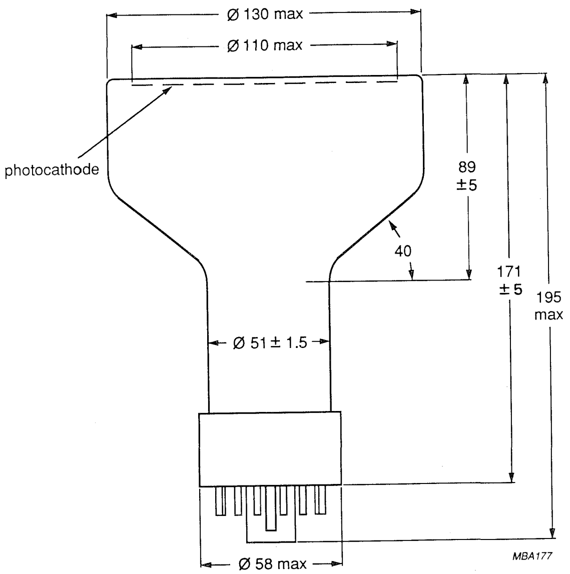


Fig. 3 Mechanical details.

Base: IEC 67–1–16a (Jedec B14–38)

Net mass: 460 g

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

ACCESSORIES

Socket	type FE1014
Mu-metal shield	type 56659

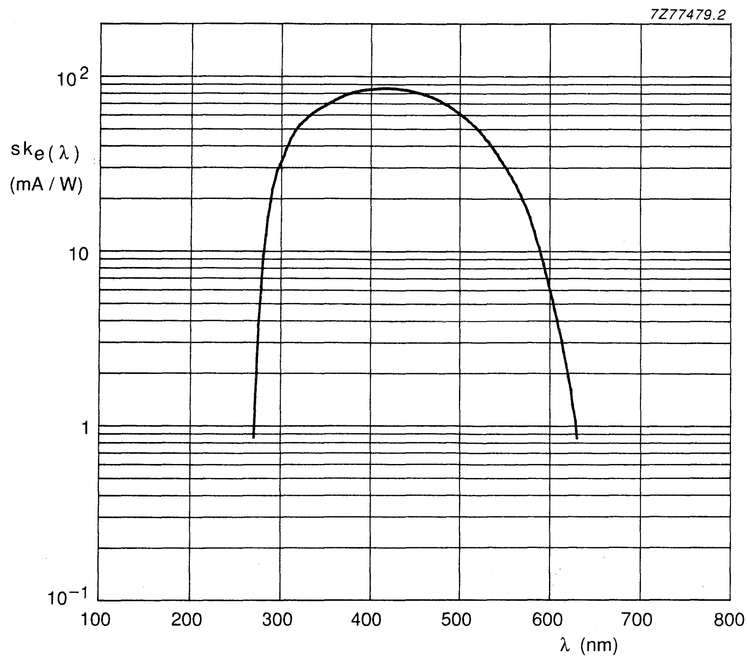


Fig. 4 Radiant sensitivity characteristic.

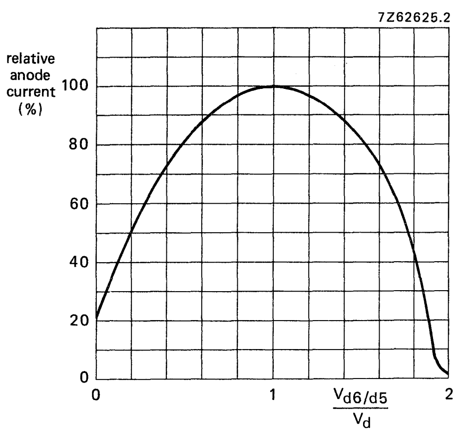


Fig. 5 Relative gain as a function of the voltage between d6 and d5 normalized to $V_d \cdot V_{d7/d5}$ constant. V_d = 90 V.

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

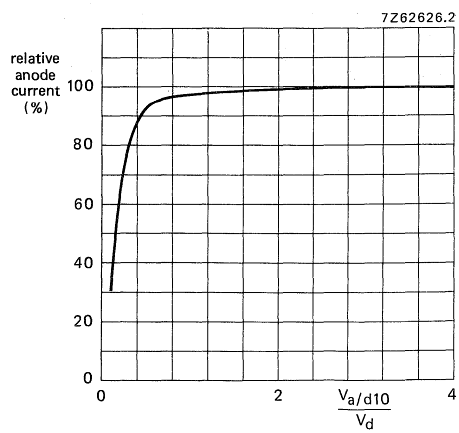


Fig. 6 Relative anode current as a function of the voltage between anode and final dynode. V_d = 90 V.

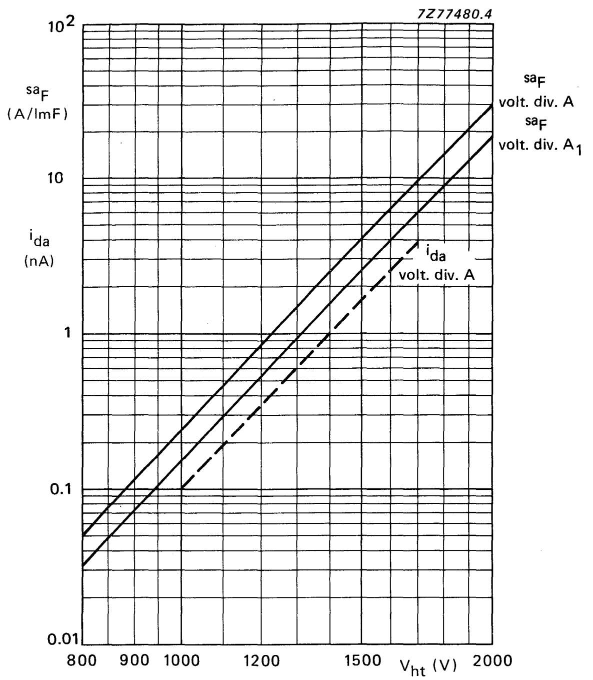


Fig.7 Anode blue sensitivity sa_F and anode dark current i_{da} as a function of the supply voltage V_{ht}.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2052/XP2052B
High gain 38 mm (1.5″) diameter tubes

APPLICATIONS

All photometry and scintillation counting applications where high gain is required.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – plano		
refractive index at 420 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 34	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 420	nm	
luminous sensitivity	≈ 90	µA/lm	3
blue sensitivity	min. 10	µA/lmF	4
	typ. 11.5	µA/lmF	4
radiant sensitivity at 420 nm	≈ 90	mA/W	5
Multiplier			
first dynode	high gain		
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, anode sensitivity 7.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	810	1000	V	
Gain x 10^3	–	≈ 650	–		
Anode dark current	–	2	10	nA	6,7
^{137}Cs pulse amplitude resolution	–	≈ 7.5	–	%	8
^{55}Fe pulse amplitude resolution	–	≈ 39	–	%	9
^{55}Fe peak to valley ratio	–	≈ 40	–		
Mean anode sensitivity deviation					10
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					11
perpendicular to axis "n"	–	≈ 0.3	–	mT	12
parallel with axis "n"	–	≈ 0.12	–	mT	12
parallel with the tube axis	–	≈ 0.5	–	mT	

see note 13

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	800	1000	–	V	
Gain x 10^3	≈ 600	≈ 1000	–		
Anode current linear within 2% up to	≈ 30	≈ 80	–	mA	
Anode pulse rise time	≈ 3	≈ 3	–	ns	14
Anode pulse duration at half height	≈ 7	≈ 6	–	ns	14
Signal transit time	≈ 36	≈ 34	–	ns	14

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Supply voltage	–	1400	V	
Continuous anode current	–	0.2	mA	16
Anode blue sensitivity	–	75	A/lmF	15
Voltage between first dynode and photocathode	100	400	V	17
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	20	300	V	18
Ambient temperatures				19
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

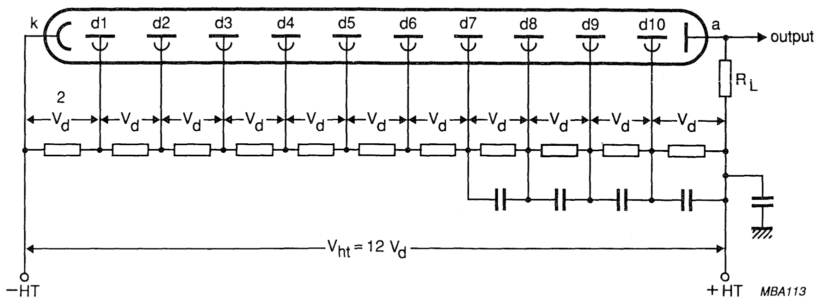


Fig.1 Voltage divider A.

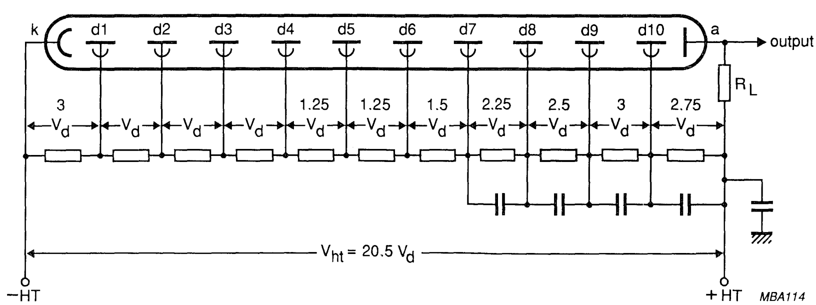


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

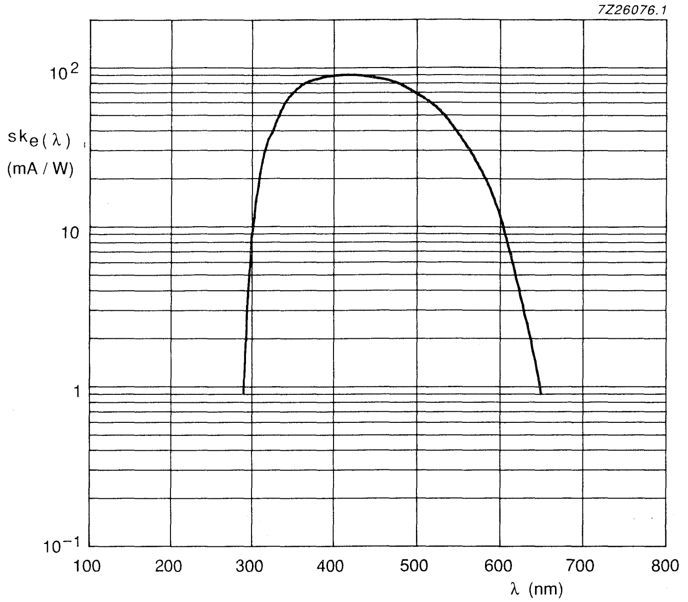


Fig.3 Cathode spectral characteristic.

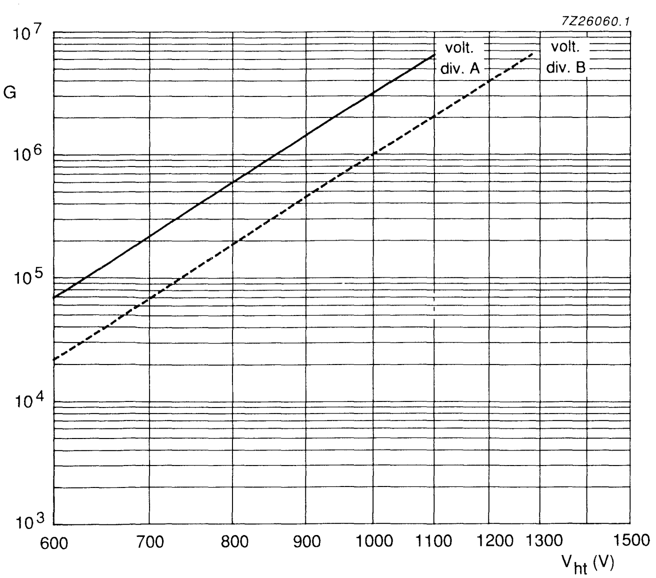


Fig.4 Gain as a function of supply voltage.

High gain 38 mm (1.5″) diameter tubes XP2052/XP2052B

MECHANICAL DATA

Dimensions in mm

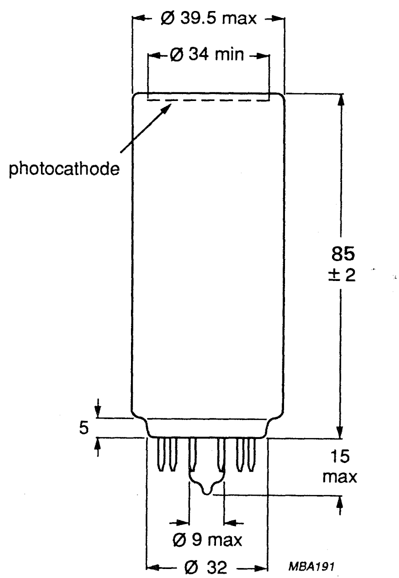


Fig.5 Mechanical outline XP2052.

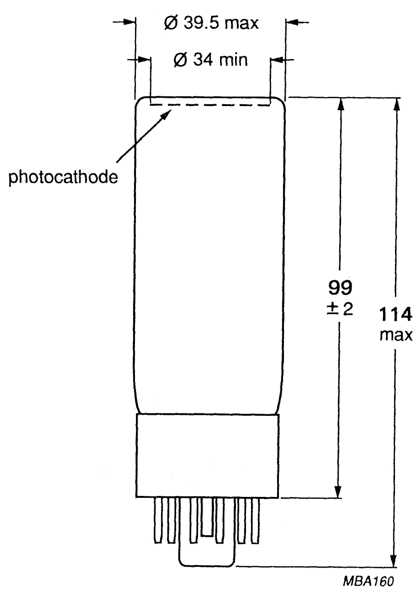
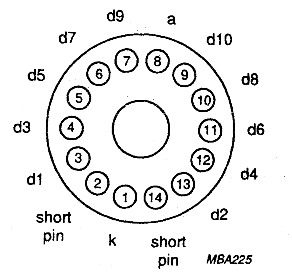


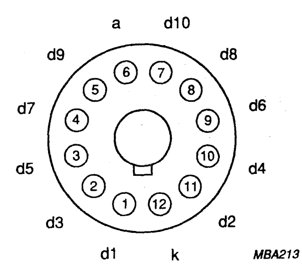
Fig.6 Mechanical outline XP2052B.

PINNING



Base	14-pin all glass
Net mass	54 g

Fig.7 Pin connections XP2052.



Base	12-pin (JEDEC B12-43)
Net mass	72 g

Fig.8 Pin connections XP2052B.

ACCESSORIES

	XP2052	XP2052B
Socket	FE1112	FE1012
Mu-metal shield	56609	56609

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 420 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is ≈ 10^4 counts per second.

9 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.

10 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

12 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 2 and 3 for XP2052 and on pins 3 and 9 for XP2052B.

Notes continued

13 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

14 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

15 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

16 A value less than 10 μA is recommended for applications requiring good stability.

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

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

19 For types with a plastic base this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE PHOTOMULTIPLIER TUBE

Features

- 34 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline photocathode
- High gain
- High energy resolution
- For high-energy physics experiments, scintillation counting, laboratory and industrial photometry
- XP2072 has a 14-pin all-glass base; XP2072B has a 12-pin plastic base

QUICK REFERENCE DATA

Radiant sensitivity characteristics	bi-alkaline
Useful diameter of the photocathode	min. 34 mm
Cathode blue sensitivity	13 μA/lmF
Supply voltage for anode blue sensitivity = 7.5 A/lmF	1100 V
Pulse amplitude resolution for ^{137}Cs	≈ 7.2%
Pulse amplitude resolution for ^{55}Fe	typ. 38%
Mean anode sensitivity deviation	≈ 1%
Anode pulse rise time	≈ 2.8 ns
Linearity (with voltage divider B)	up to ≈ 150 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	bi-alkaline	
Useful diameter	min. 34 mm	
Radiant sensitivity characteristics	see Fig.6	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 100 μA/lm	3
Blue sensitivity	typ. 13 μA/lmF min. 11 μA/lmF	2
Radiant sensitivity at 400 nm	≈ 100 mA/W	4

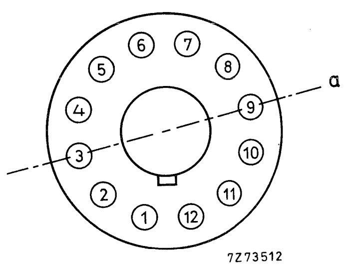
Multiplier system

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

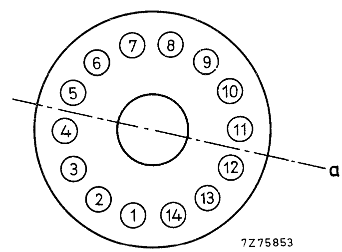
Magnetic field

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.



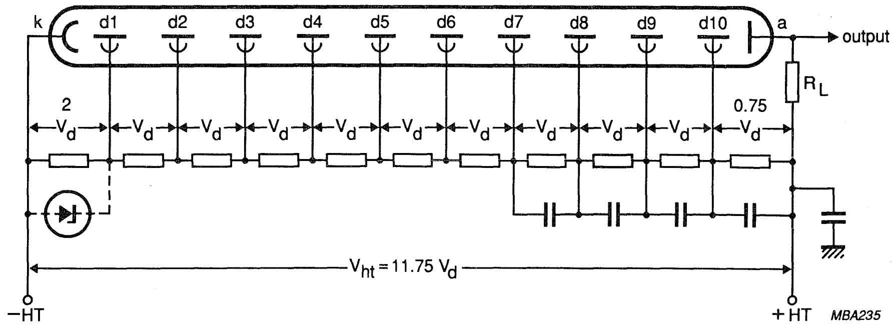
XP2072B



XP2072

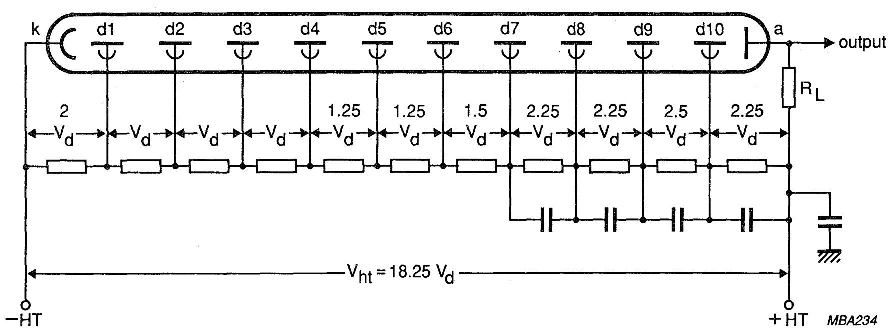
Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS



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 A.



Typical values of capacitors: 10 nF

k = cathode;

dn = dynode no.;

a = anode;

R_L = load resistor.

Fig.3 Voltage divider B.

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				5
Supply voltage for an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		max. typ.	1250 V 1100 V	2
Gain at V_{ht} = 1100 V (Fig. 9)		≈	6×10^5	
Anode dark current at an anode blue sensitivity of 7,5 A/lmF (Fig. 8)		max. typ.	10 nA 2 nA	6,7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 1,5 A/lmF			11,2 %	8
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF		≈	7,2 %	8
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		max. typ.	40 % 38 %	9
Peak-to-valley ratio for ^{55}Fe at an anode blue sensitivity of 7,5 A/lmF		min. typ.	30 43	
Mean anode sensitivity deviation				10
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 pulse rise time at V_{ht} = 1100 V		≈	2,8 ns	11
Anode pulse duration at half height at V_{ht} = 1100 V		≈	7 ns	11
Signal transit time at V_{ht} = 1100 V		≈	34 ns	11
Anode current linear within 2% at V_{ht} = 1100 V	up to	≈	70 mA	
With voltage divider B (Fig. 3)				5
At anode blue sensitivity at V_{ht} = 1500 V (fig. 8)		≈	3,5 A/lmF	
Anode pulse rise time at V_{ht} = 1500 V		≈	2,8 ns	11
Anode pulse duration at half height at V_{ht} = 1500 V		≈	7 ns	11
Signal transit time at V_{ht} = 1500 V		≈	29 ns	11
Anode current linear within 2% at V_{ht} = 1500 V	up to	≈	150 mA	

LIMITING VALUES (Absolute maximum rating system)

Supply voltage	max.	1600 V	12
Continuous anode current	max.	0,2 mA	13
Voltage between first dynode and photocathode	max. min.	500 V 100 V	14
Voltage between consecutive dynodes	max.	300 V	
Voltage between anode and final dynode	max. min.	300 V 30 V	15
Ambient temperature range			
Operational (for short periods of time)	max. min.	+80 °C −30 °C	16
Continuous operating and storage	max. min.	+50 °C −30 °C	

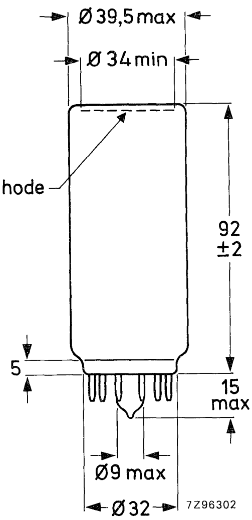
Notes

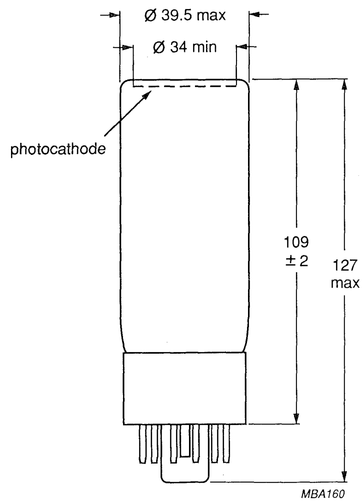
1. The bi-alkaline photocathode has a significant resistance which increases rapidly with reducing temperature. It is thus recommended that it should not be subjected to light of too great an intensity; the cathode current should be limited, for example, to 1 nA at room temperature or 0,1 nA at −30 °C. 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. 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).
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant 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. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If used, the metal shield should be kept at the cathode potential.
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 and ^{57}Co 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 ≈ 10^4 c/s.
9. 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 ≈ 2×10^3 c/s.
10. The mean anode sensitivity deviation is measured by coupling an NaI (Tl) scintillator to the window of the tube. Long term (16 h) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 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.
11. 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 reaches its maximum. Rise time, pulse duration and transit time vary as a function of high tension supply voltage V_{ht}, approximately as $V_{ht}^{-1/2}$.

Notes (continued)

12. 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.
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 XP2072B 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

Net mass 54 g

Base 12-pin (JEDEC B12-43)

Net mass 72 g

PIN CONNECTIONS

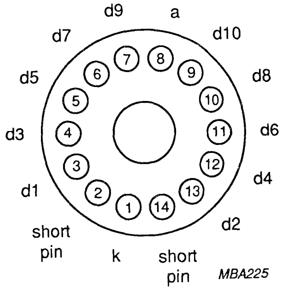


Fig. 4 XP2072.

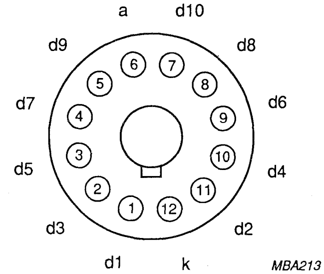


Fig. 5 XP2072B.

ACCESSORIES

Socket

for XP2072	FE1112
for XP2072B	FE1012
Mu-metal shield	56609

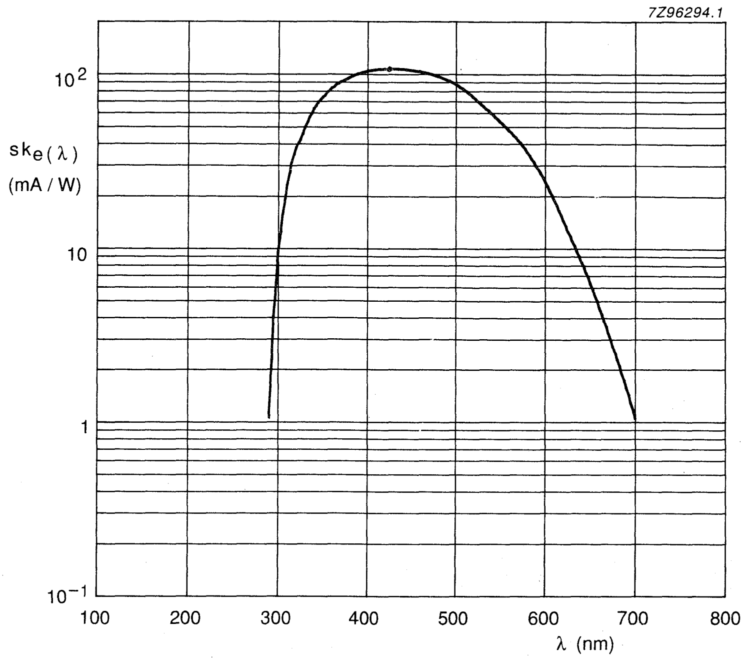


Fig. 6 Spectral sensitivity characteristic.

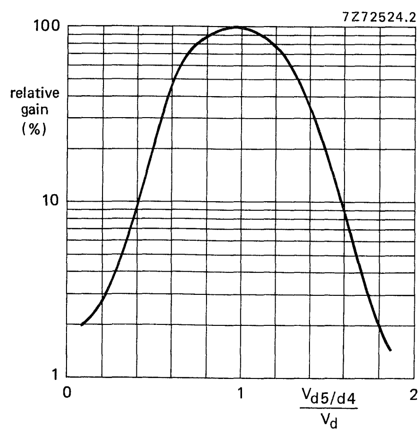


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

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

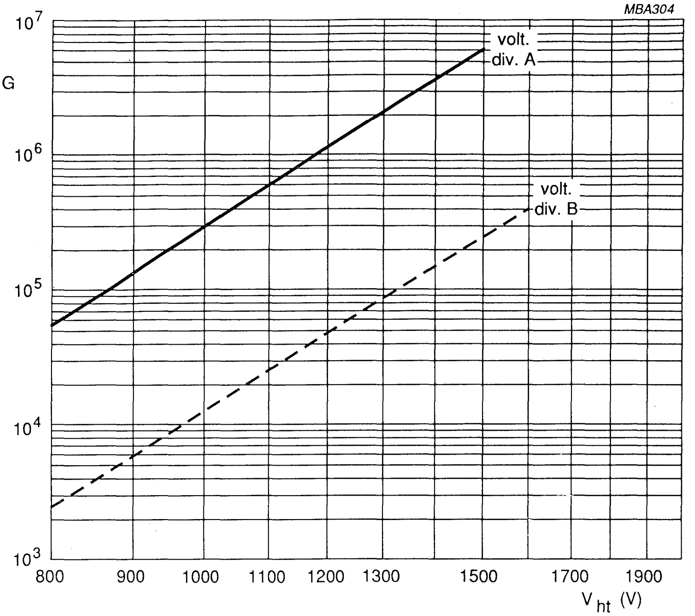


Fig. 8 Gain G as a function of supply voltage V_{ht}.

Philips Components

Data sheet	
status	Product specification
date of issue	October 1989

XP2081/XP2081B

Green-extended sensitive 38 mm (1.5″) diameter tube

APPLICATIONS

Scintillation counting with green-emitting scintillators or wavelength shifters such as CsI(Tl), BGO, BBQ.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – plano		
refractive index at 440 nm	1.54		
Photocathode			
material	semi-transparent, head-on green extended bialkaline		1
useful diameter	min. 34	mm	
spectral range	300 to 690	nm	2
wavelength for maximum radiant sensitivity	≈ 440	nm	
luminous sensitivity	min. 100	µA/lm	3
	typ. 135	µA/lm	3
blue sensitivity	≈ 13	µA/lmF	4
radiant sensitivity at 440 nm	≈ 100	mA/W	5
Multiplier			
first dynode	high gain		
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 5	pF	

Green-extended sensitive 38 mm (1.5″) diameter tube

XP2081/XP2081B

OUTPUT CHARACTERISTICS

with voltage divider A, anode sensitivity 7.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1100	1250	V	
Gain x 10^3	–	≈ 580	–		
Anode dark current	–	5	30	nA	6,7
^{137}Cs pulse amplitude resolution	–	≈ 7.2	–	%	8
^{55}Fe pulse amplitude resolution	–	≈ 39	–	%	9
^{55}Fe peak to valley ratio	–	≈ 30	–		
Mean anode sensitivity deviation					10
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 440 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					11
perpendicular to axis "n"	–	≈ 0.35	–	mT	12
parallel with axis "n"	–	≈ 0.15	–	mT	12
parallel with the tube axis	–	≈ 0.6	–	mT	

see note 13

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at	1100	1500	–	V	
Gain x 10^3	≈ 580	≈ 850	–		
Anode current linear within 2% up to	≈ 70	≈ 150	–	mA	
Anode pulse rise time	≈ 2.8	≈ 2.8	–	ns	14
Anode pulse duration at half height	≈ 7	≈ 7	–	ns	14
Signal transit time	≈ 34	≈ 29	–	ns	14

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Supply voltage		1600	V	
Continuous anode current		0.2	mA	16
Anode blue sensitivity		75	A/lmF	15
Voltage between first dynode and photocathode	100	500	V	17
Voltage between consecutive dynodes		300	V	
Voltage between anode and last dynode	30	300	V	18
Ambient temperatures				19
short operation (30 min. maximum)	−30	80	°C	
continuous operation and storage	−30	50	°C	

Green-extended sensitive 38 mm (1.5″) diameter tube

XP2081/XP2081B

RECOMMENDED CIRCUITS

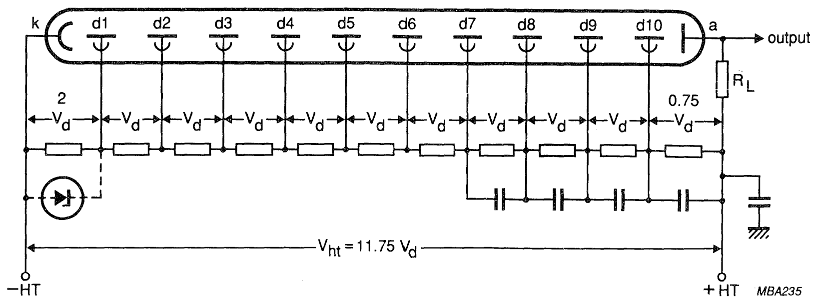


Fig.1 Voltage divider A.

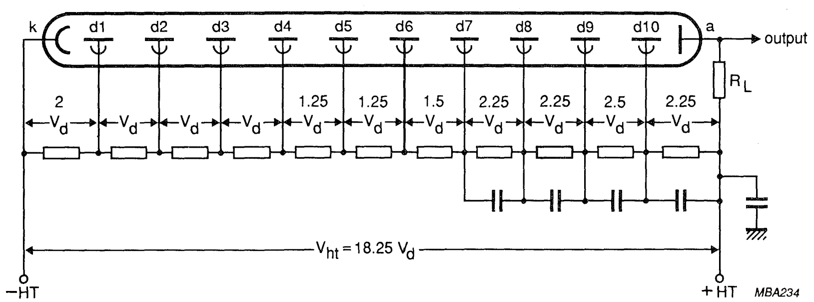


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

Green-extended sensitive 38 mm (1.5″) diameter tube

XP2081/XP2081B

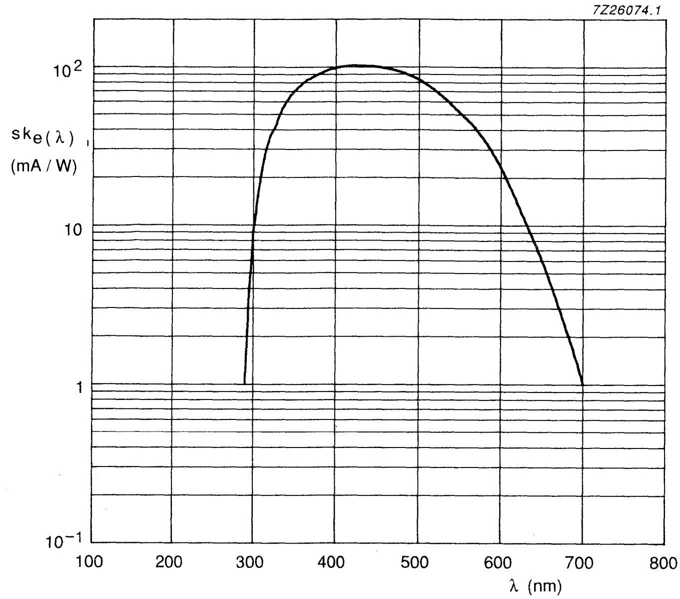


Fig.3 Cathode spectral characteristic.

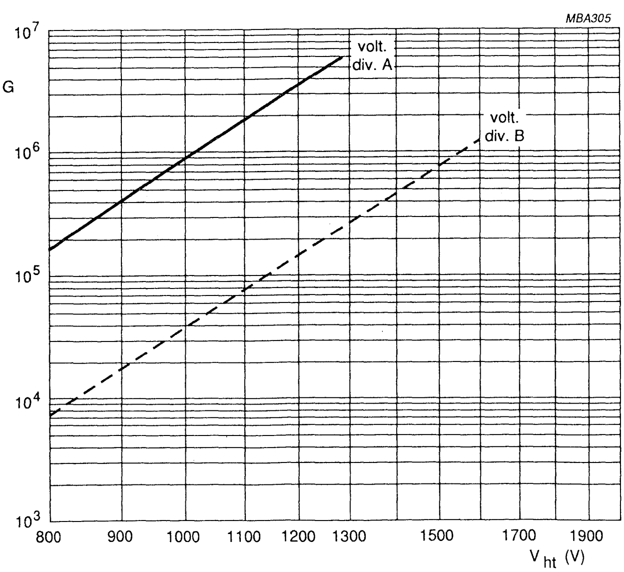


Fig.4 Gain as a function of supply voltage

MECHANICAL DATA

Dimensions in mm

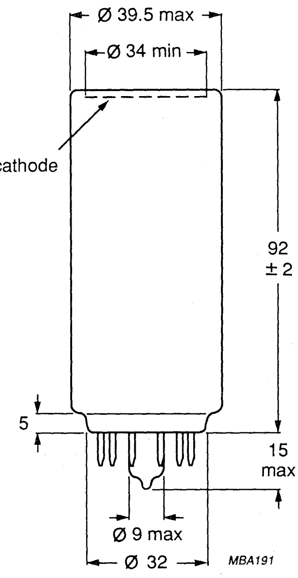


Fig.5 Mechanical outline XP2081.

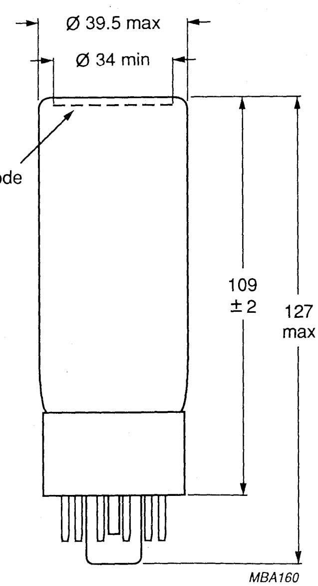
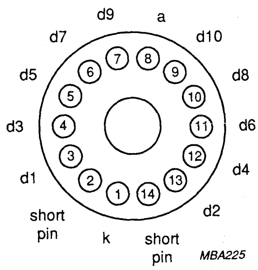


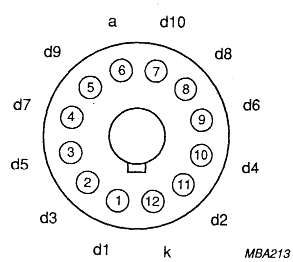
Fig.6 Mechanical outline XP2081B.

PINNING



Base	14-pin all glass
Net mass	54 g

Fig.7 Pin connections XP2081.



Base	12-pin (JEDEC B12-43)
Net mass	72 g

Fig.8 Pin connections XP2081B.

ACCESSORIES

	XP2081	XP2081B
Socket	FE1112	FE1012
Mu-metal shield	56609	56609

Green-extended sensitive 38 mm (1.5″) diameter tube

XP2081/XP2081B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at –30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 440 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.7×10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 32 mm and a height of 32 mm. The count rate used is ≈ 10^4 counts per second.

9 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 2×10^3.

10 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

12 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 2 and 3 for XP2081, and on pins 3 and 9 for XP2081B.

13 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

14 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

15 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

16 A value less than 10 μA is recommended for applications requiring good stability.

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

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

19 For types with a plastic base this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBES

- 46 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline 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

Radiant sensitivity characteristic	bialkaline
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	1 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	bialkaline	
Useful diameter	> 46 mm	
Radiant sensitivity characteristic	see Fig.2	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 95 μA/lm	3
Blue sensitivity	typ. 11.5 μA/lmF > 9.0 μA/lmF	1
Radiant 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	≈ 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 0.4 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

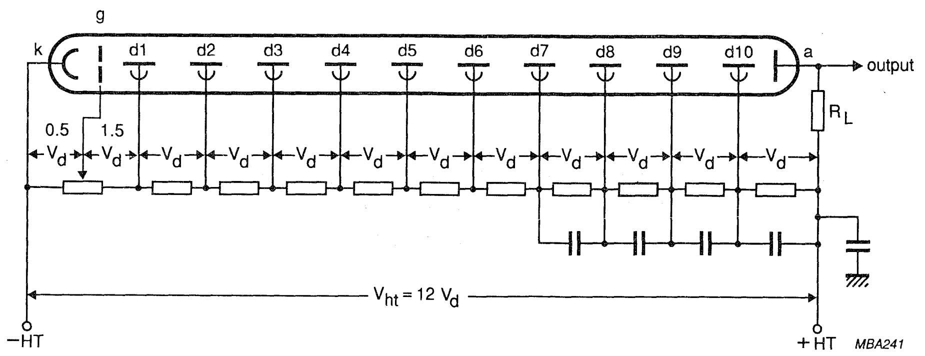


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

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

		notes
With voltage divider A (Fig. 1)		5
Supply voltage for an anode blue sensitivity of 1.5 A/lmF (Fig. 5)	max. 1400 V typ. 1250 V	1
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)	max. 20 nA typ. 1 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	max. 10% typ. 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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant 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, noise and dark current will generally increase and become erratic, particulary after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than $10^{15}\,\Omega$. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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 ratio between two successive stages is less than 2.

Notes (continued)

12. Or the voltage at which the tube has an anode blue sensitivity of 15 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.

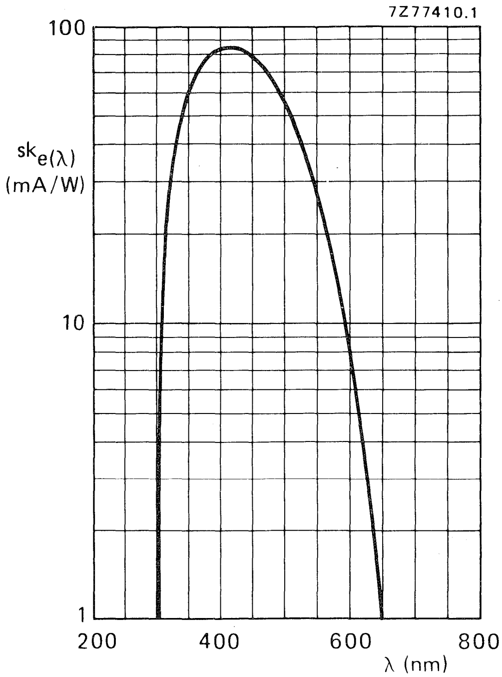


Fig. 2 Radiant sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm

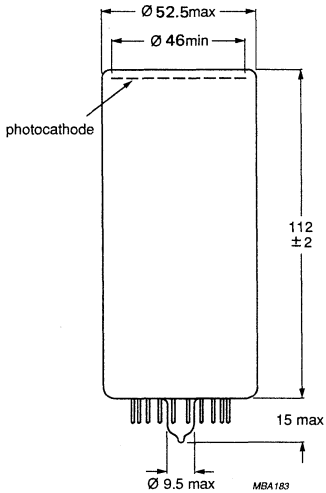


Fig.3 XP2102.

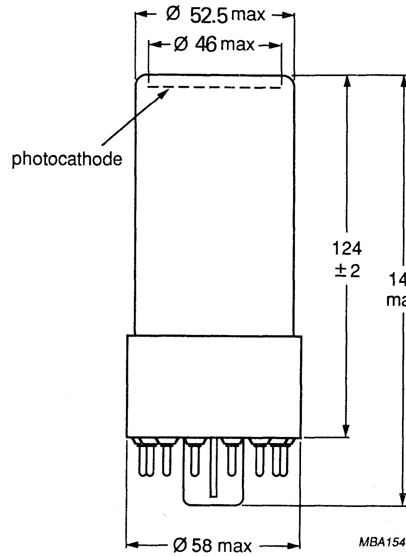
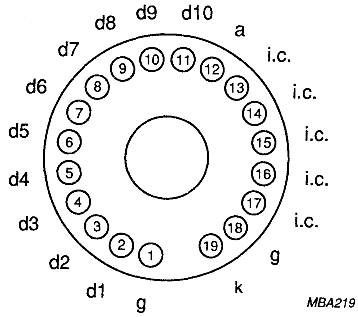


Fig.4 XP2102B.

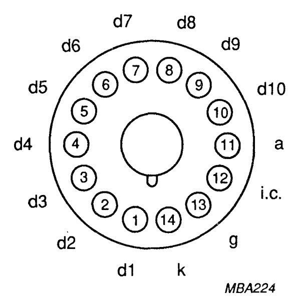
Base	19-pin all-glass
Net mass	120 g

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
Mu-metal shield	type 56629

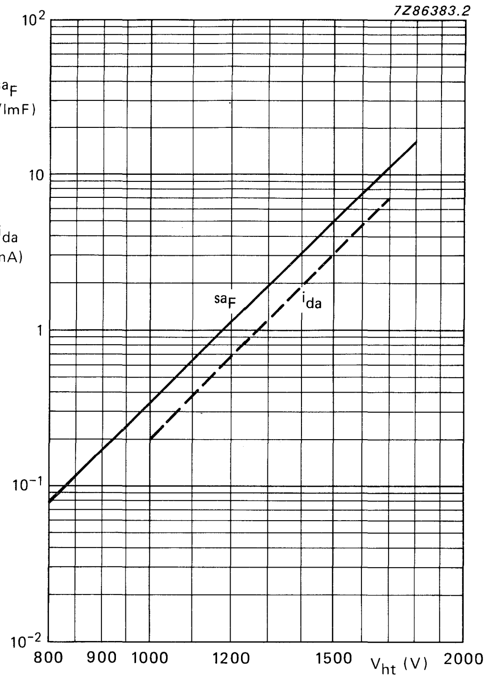


Fig. 5 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.
i_{da} is given as a dotted line to indicate its principle behaviour only.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2201/XP2201B

Green-extended 51 mm (2″) diameter tube

APPLICATIONS

Scintillation counting with green-emitting scintillators or wavelength shifters such as CsI(Tl),BGO and BBQ.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – plano		
refractive index at 440 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 44	mm	
spectral range	300 to 690	nm	2
wavelength for maximum radiant sensitivity	≈ 440	nm	
luminous sensitivity	min. 85	µA/lm	3
	typ. 120	µA/lm	3
blue sensitivity	≈ 12.5	µA/lmF	4
radiant sensitivity at 440 nm	≈ 95	mA/W	5
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, anode sensitivity 7.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1400	1700	V	
Gain x 10^3	–	≈ 600	–		
Anode dark current	–	10	40	nA	6,7
^{137}Cs pulse amplitude resolution	–	≈ 7.5	–	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.4	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n'	–	≈ 0.2	–	mT	11
parallel with axis "n'	–	≈ 0.1	–	mT	11

see note 12

PARAMETER	VOLTAGE DIVIDER A	B	C	UNIT	NOTES
Supply voltage set at	1700	1700	–	V	
Gain x 10^3	≈ 260	≈ 600	–		
Anode current linear within 2% up to	≈ 100	≈ 150	–	mA	
Anode pulse rise time	≈ 4	≈ 4	–	ns	13
Anode pulse duration at half height	≈ 8	≈ 8	–	ns	13
Signal transit time	≈ 34	≈ 35	–	ns	13

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
anode blue sensitivity	–	75	A/lmF	14
supply voltage	–	1800	V	
continuous anode current	–	0.2	mA	15
voltage between first dynode and photocathode	150	600	V	16
voltage between consecutive dynodes	–	300	V	
voltage between anode and last dynode	30	300	V	17
Ambient temperatures				18
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

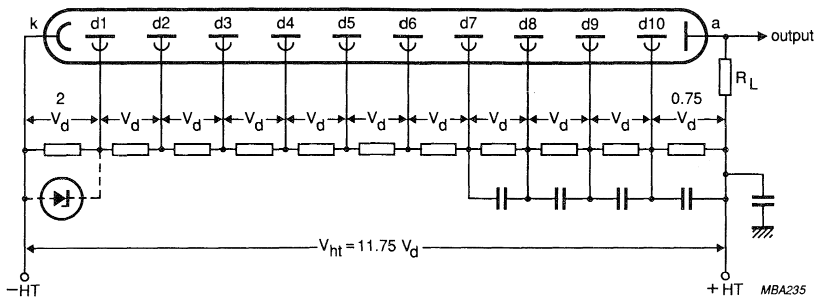


Fig.1 Voltage divider A.

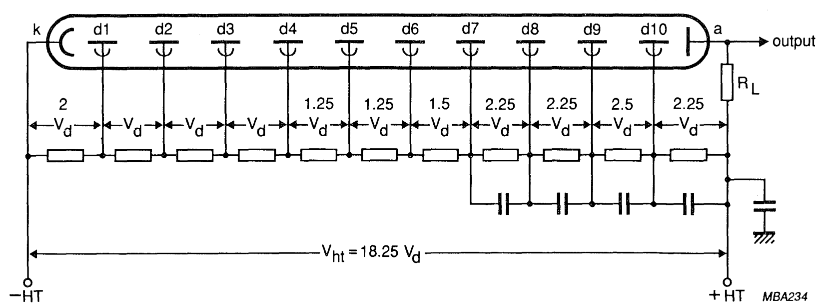


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

Green-extended 51 mm (2″) diameter tube XP2201/XP2201B

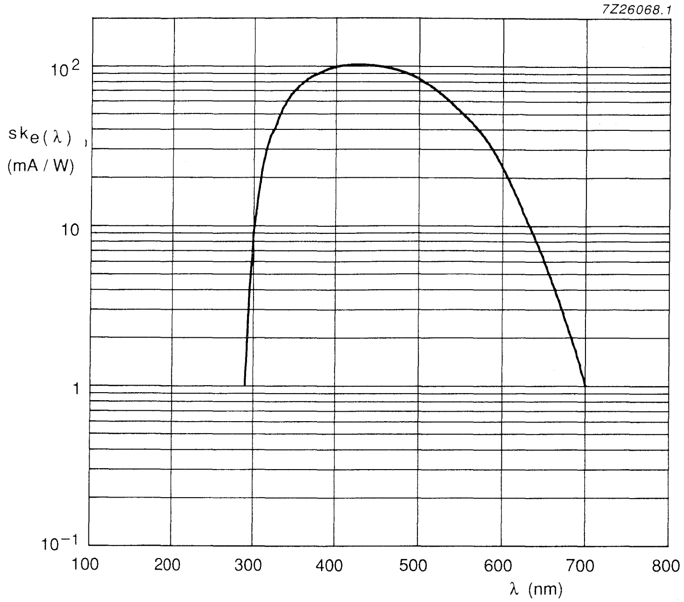


Fig.3 Cathode spectral characteristic.

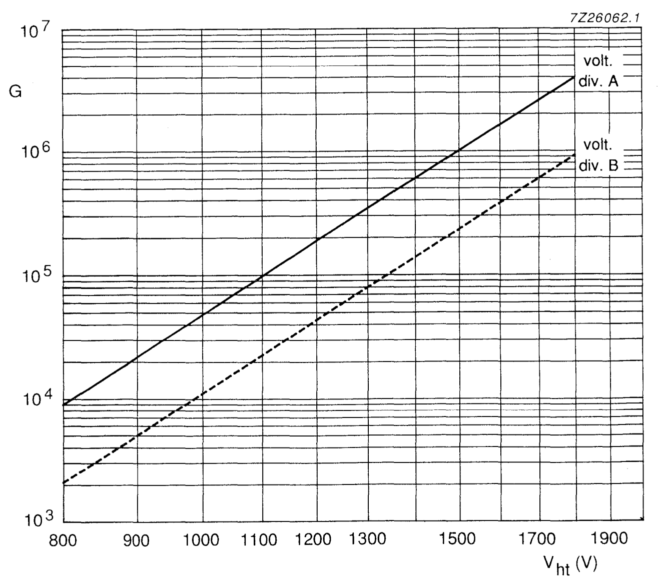


Fig.4 Gain as a function of supply voltage.

Green-extended 51 mm (2″) diameter tube XP2201/XP2201B

MECHANICAL DATA

Dimensions in mm

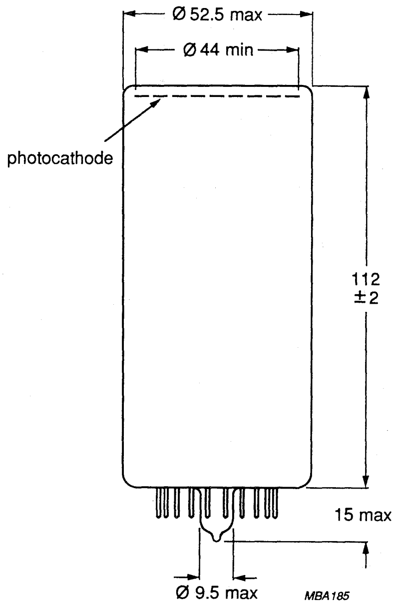


Fig.5 Mechanical outline XP2201.

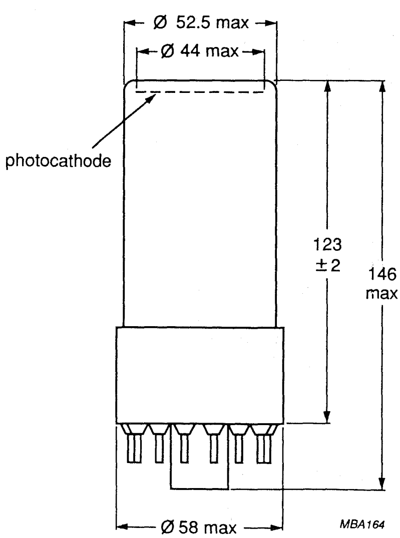
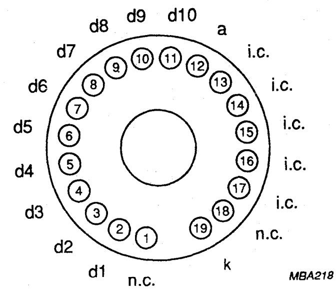


Fig.6 Mechanical outline XP2201B.

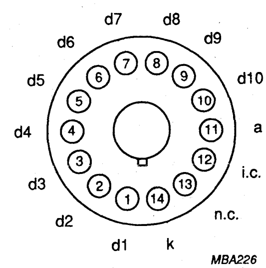
PINNING



Base	19-pin all glass
Net mass	110 g

i.c. = internally connected

Fig.7 Pin connections XP2201.



Base	12-pin (JEDEC B14-38)
Net mass	153 g

i.c. = internally connected

Fig.8 Pin connections XP2201B.

ACCESSORIES

	XP2201	XP2201B
Socket	FE2019	FE1014
Mu-metal shield	56629	56629

Notes

1 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 to 1 nA at room temperature to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 440 nm is expressed in A/W and can be estimated by multiplying the blue **sensitivity (expressed in A/lmF) by 7.7 x 10^3 for this type of tube.**

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than $10^{15}\ \Omega$. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator with a diameter of 44 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 4 and 14 for XP2201 and on pins 4 and 11 for XP2201B.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 µA is recommended for applications requiring good stability.

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

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

18 For types with a plastic base this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-plano window
- semi-transparent bi-alkaline 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

Radiant sensitivity characteristic		bialkaline		
Useful diameter of the photocathode		min.	44	mm
Cathode blue sensitivity			10	μA/lmF
Supply voltage for an anode radiant 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	bialkaline			
Useful diameter	>	44	mm	
Radiant sensitivity characteristic	see Fig.6			
Maximum radiant sensitivity		400 ± 30	nm	
Luminous sensitivity	≈	70	μA/lm	
Blue sensitivity	typ.	10	μA/lmF	
	min.	8.5	μA/lmF	
Radiant sensitivity at 400 nm	≈	75	mA/W	2

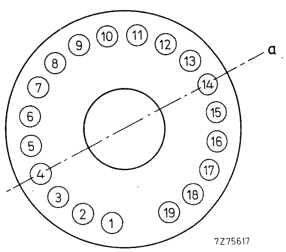
Multiplier system

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

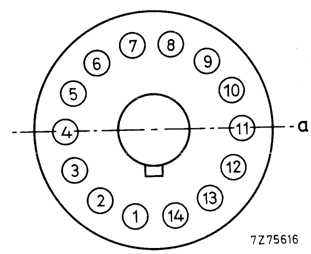
Magnetic field

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

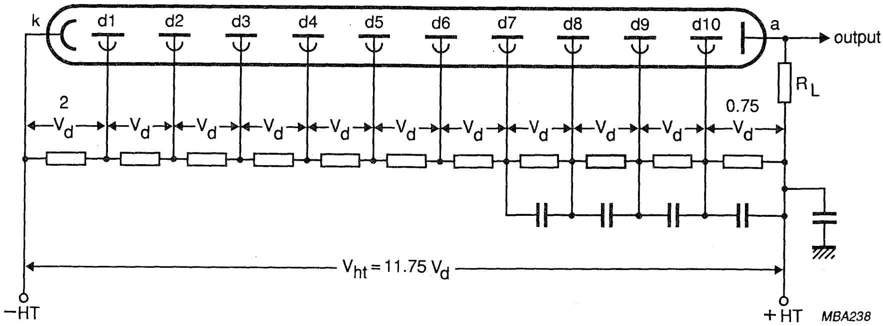


Fig. 2 Voltage divider A.

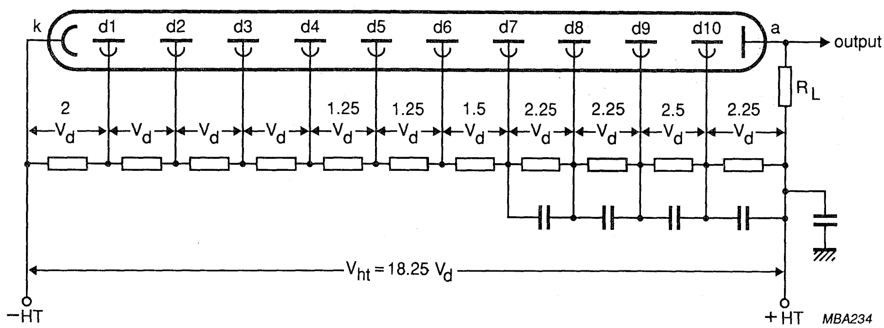


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

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

TYPICAL CHARACTERISTICS

				notes
With voltage divider A (Fig. 2)				3
Supply voltage for an anode blue sensitivity of 7.5 A/lmF (Fig.8)		<	1700 V	
		typ.	1400 V	
Anode dark current at an anode blue sensitivity of 7.5 A/lmF (Fig.8)		<	30 nA	4,5
		typ.	3 nA	
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1.5 A/lmF		≈	7.2 %	6
Pulse amplitude resolution for ^{55}Fe at an anode blue sensitivity of 7.5 A/lmF		≈	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
Gain at V_{ht} = 1700 V (Fig.8)		≈	8×10^5	
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. Radiant 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 driver A, it is necessary to increase the inter-dynode voltage 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 ≈ 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 x 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 ≈ 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.
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 reaches 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. Or the voltage at which the tube has an anode blue sensitivity of 75 A/lmF, whichever is lower.
11. A value of < 10 μA 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

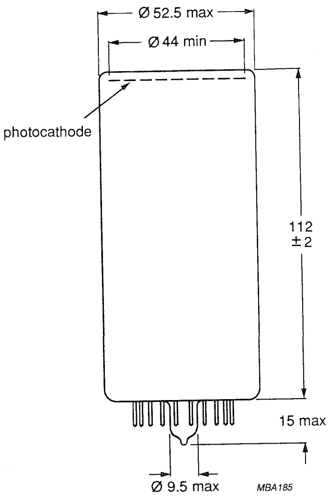


Fig. 4 XP2202.

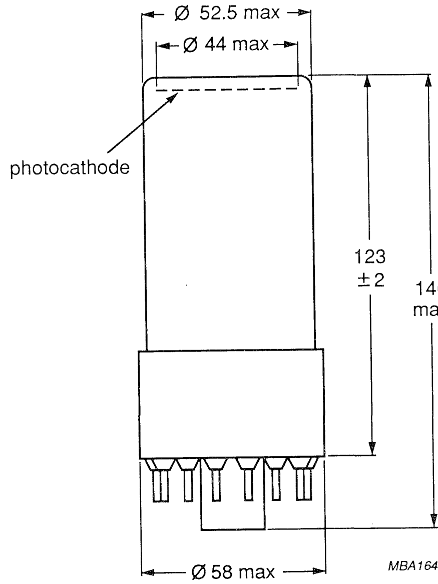
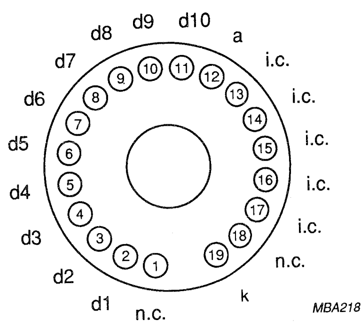


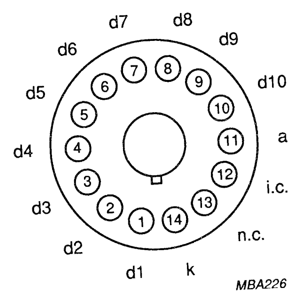
Fig. 5 XP2202B.

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
Mu-metal shield type 56629

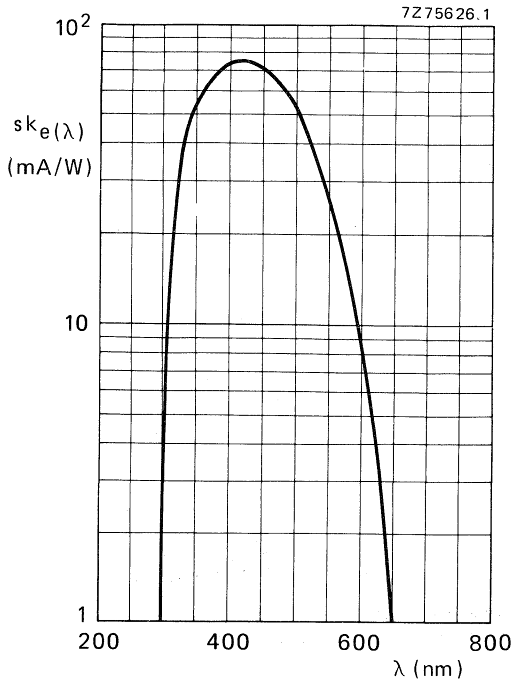


Fig. 6 Radiant sensitivity characteristic.

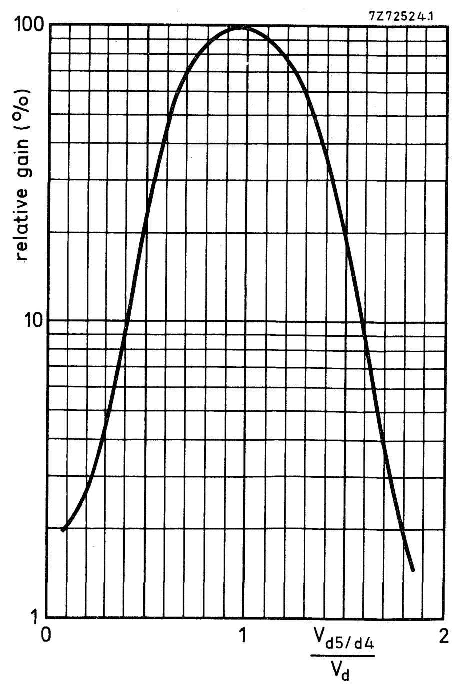


Fig. 7 Relative gain as a function of the voltage between d5 and d4, normalized to V_d; $V_{d6/d4}$ constant.

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

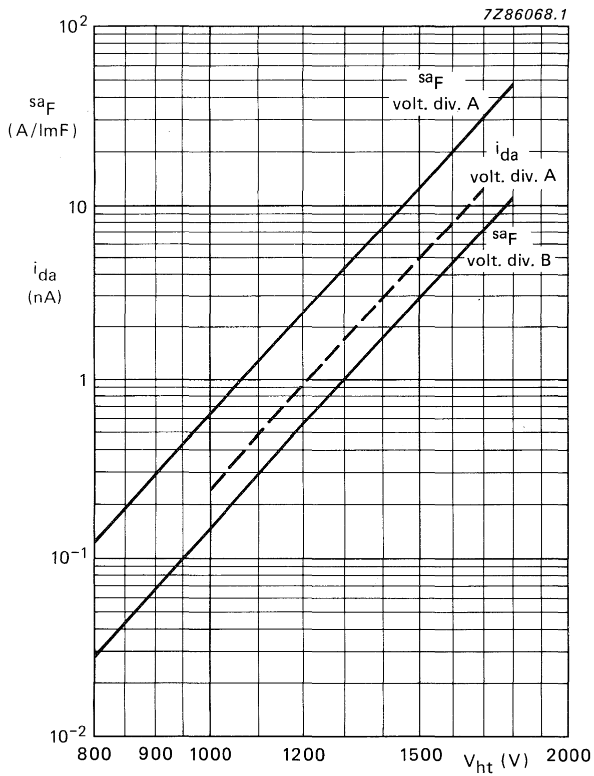


Fig. 8 Anode blue sensitivity sa_F and anode dark current i_{da} as a function of supply voltage V_{ht}.

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

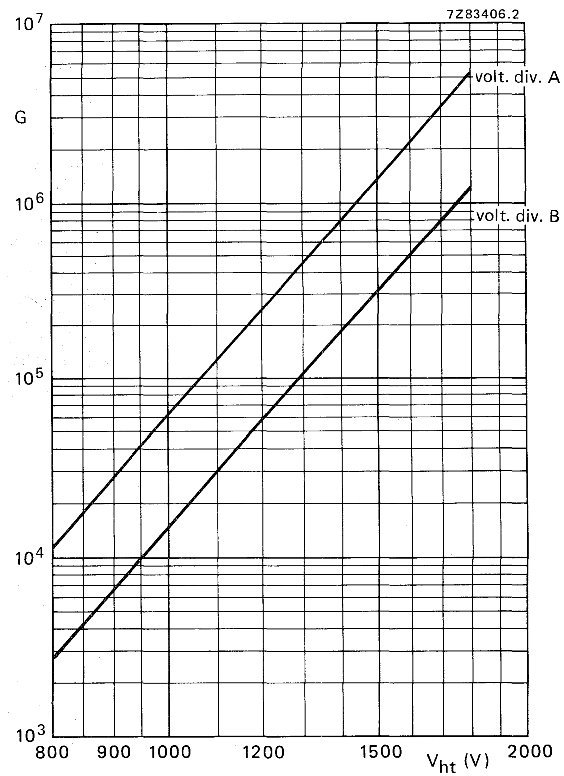


Fig. 9 Gain G as a function of supply voltage V_{ht}.

10-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	S20
Useful diameter of the photocathode	> 44 mm
Radiant 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)	≈ 3.5 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	borosilicate
Shape	plano-plano
Refractive index at 550 nm	1.48

Photocathode

Semi-transparent, head-on	
Material	tri alkaline
Useful diameter	> 44 mm
Radiant sensitivity characteristic	see Fig. 5
Maximum radiant sensitivity	420 ± 30 nm
Luminous sensitivity	≈ 165 μA/lm
Radiant sensitivity at 700 nm	typ. 16 mA/W > 7 mA/W
at 630 nm	≈ 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.

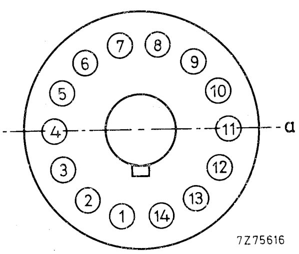


Fig. 1 Axis a with respect to base pins (botton view).

RECOMMENDED CIRCUITS

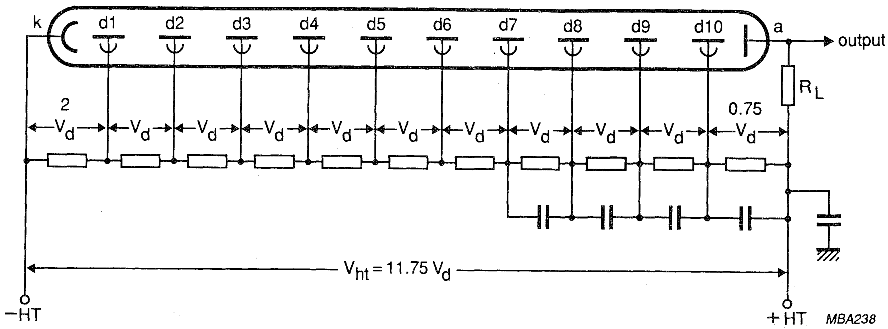


Fig. 2 Voltage divider A.

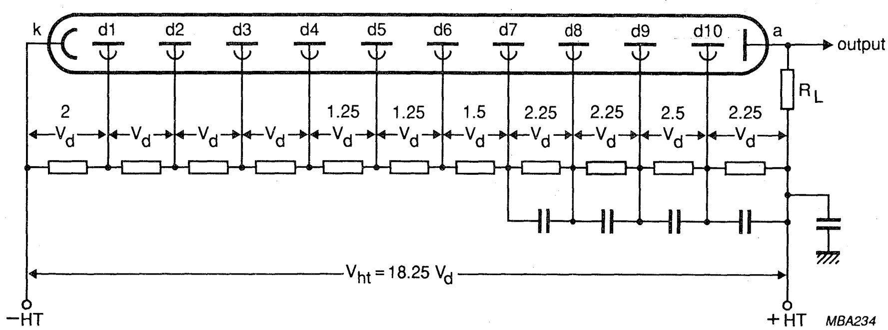


Fig. 3 Voltage divider B.

Typical values of capacitors: 10 nF

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

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	

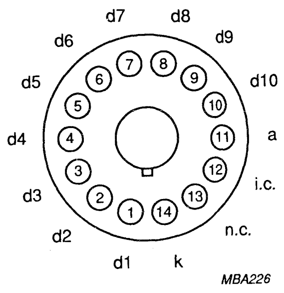
LIMITING VALUES (Absolute maximum rating system)

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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage, the glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If used, the metal shield should be kept at the cathode potential.
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 reaches 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. 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



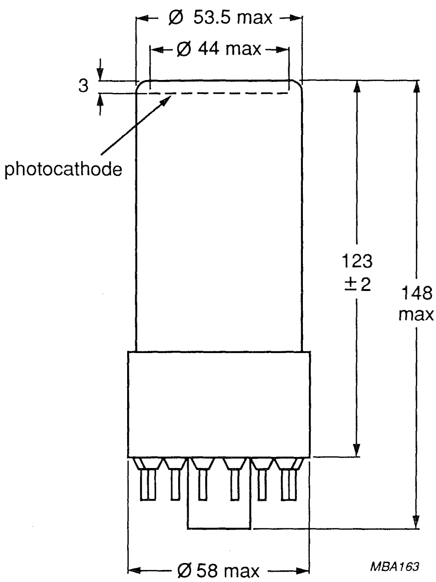


Fig. 4.

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

ACCESSORIES

Socket	type FE1014
Mu-metal shield	type 56629

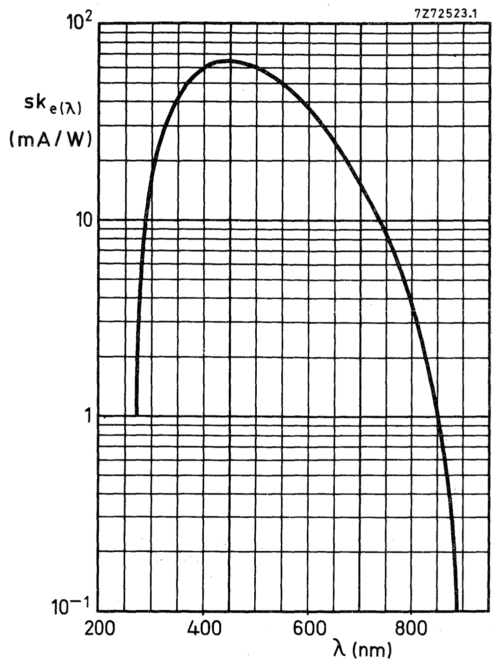


Fig. 5 Radiant sensitivity characteristic.

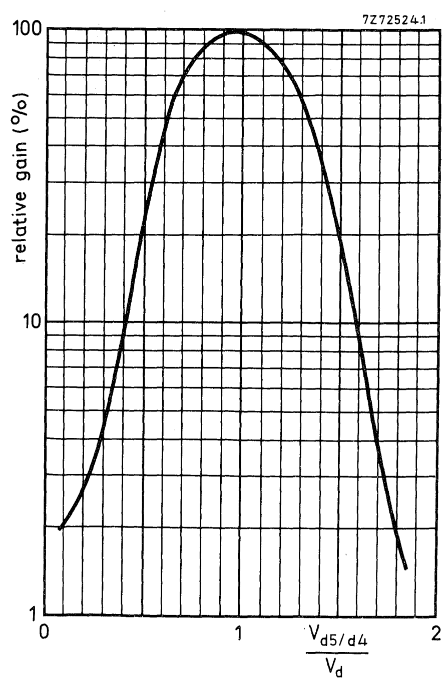


Fig. 6 Relative gain as a function of the voltage between d5 and d4 normalized to V_d; $V_{d6/d4}$ constant.

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

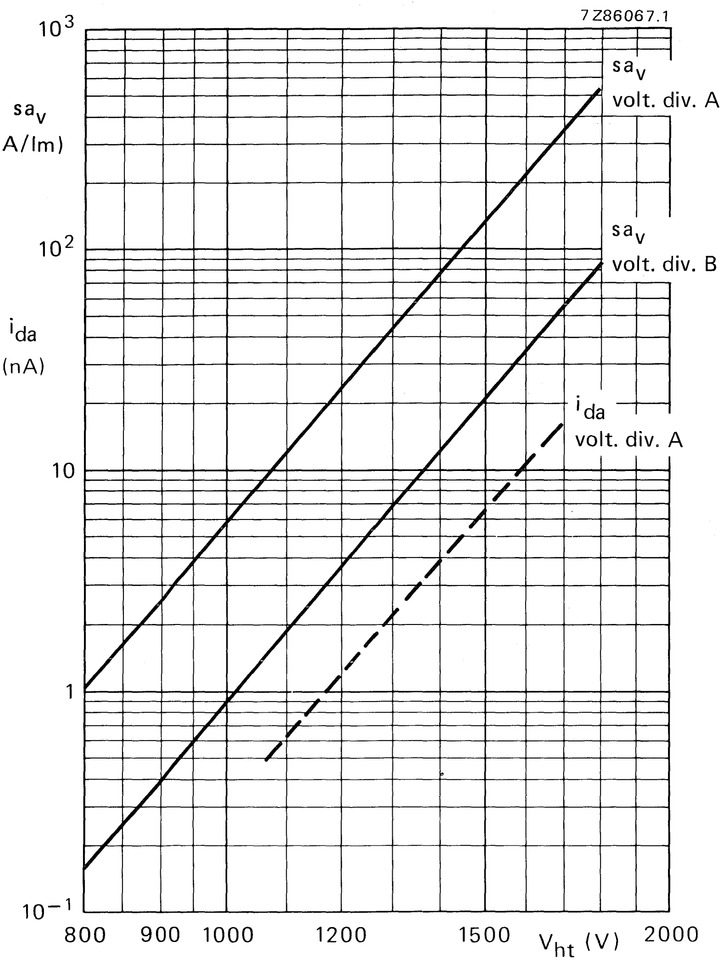


Fig. 7 Anode luminous sensitivity, sa_V, and anode dark current i_{da} as a function of supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2206

High temperature 51 mm (2″) diameter tube

APPLICATIONS

Scintillation counting and industrial photometry in high temperature environments up to 130 °C.

GENERAL CHARACTERISTICS

Unless otherwise stated, all characteristics are given at 20 °C.

			NOTES
Window			
material	borosilicate		
profile	plano – plano		
refractive index at 400 nm	1.48		
Photocathode	semi-transparent, head-on		
material	high – temperature bialkaline		1
useful diameter	min. 44	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 40	μA/lm	3
blue sensitivity	min. 5	μA/lmF	4
	typ. 7	μA/lmF	
blue sensitivity at 130 °C	≈ 5.5	μA/lmF	
radiant sensitivity at 400 nm	≈ 50	mA/W	5
Multiplier			
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS WITH VOLTAGE DIVIDER A

with voltage divider A, anode sensitivity 1.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1300	1700	V	
Gain x 10^3	–	≈ 210	–		
Anode dark current	–	1	10	nA	6,7
Anode dark current at 130 °C	–	≈ 15	–	nA	
^{137}Cs pulse amplitude resolution	–	8.5	–	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.1	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n'	–	≈ 0.2	–	mT	11
parallel to axis "n"	–	≈ 0.1	–	mT	11

see note 12

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at	1300	1700	–	V	
Gain x 10^3	≈ 210	≈ 210	–		
Anode current linear within 2% up to	≈ 100	≈ 200	–	mA	
Anode pulse rise time	≈ 4	≈ 3.5	–	ns	13
Anode pulse duration at half height	≈ 8	≈ 7	–	ns	13
Signal transit time	≈ 36	≈ 35	–	ns	13

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	15	A/lmF	14
Supply voltage	–	1700	V	
Continuous anode current	–	0.2	mA	15
Voltage between first dynode and photocathode	150	600	V	16
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	300	V	17
Ambient temperatures				
short operation (30 min. maximum)	–30	130	°C	
continuous operation and storage	–30	130	°C	

RECOMMENDED CIRCUITS

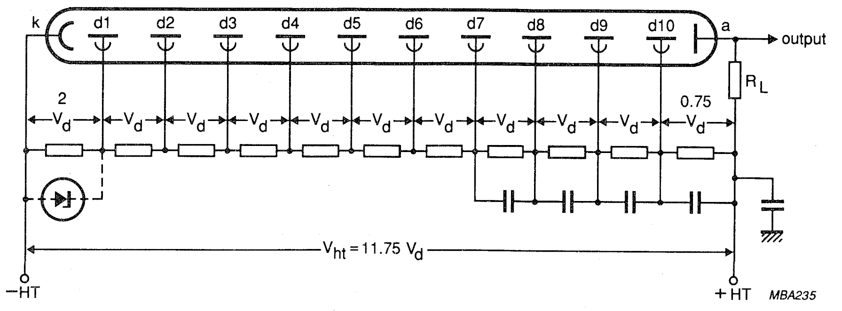


Fig.1 Voltage divider A.

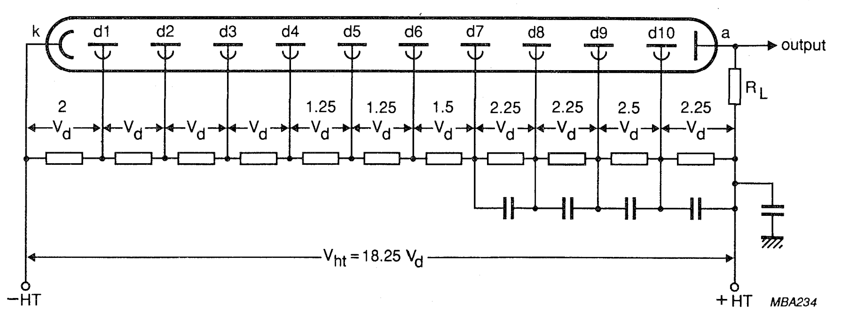


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

High temperature 51 mm (2″) diameter tube **XP2206**

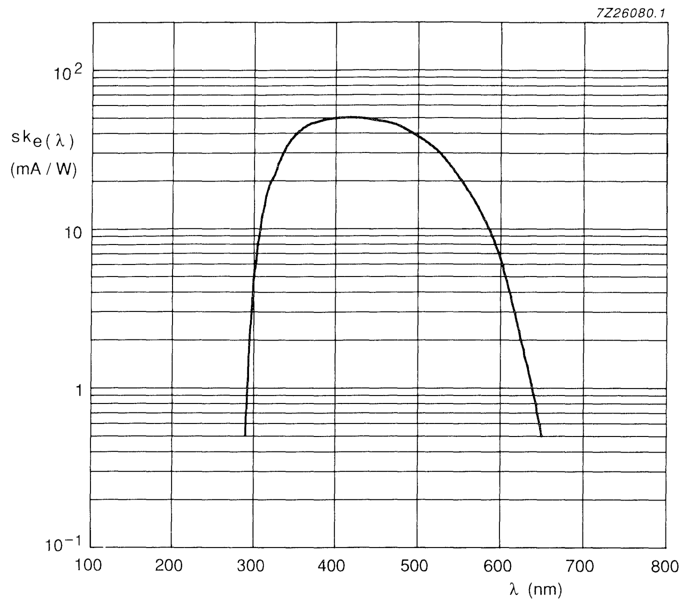


Fig.3 Cathode spectral characteristic.

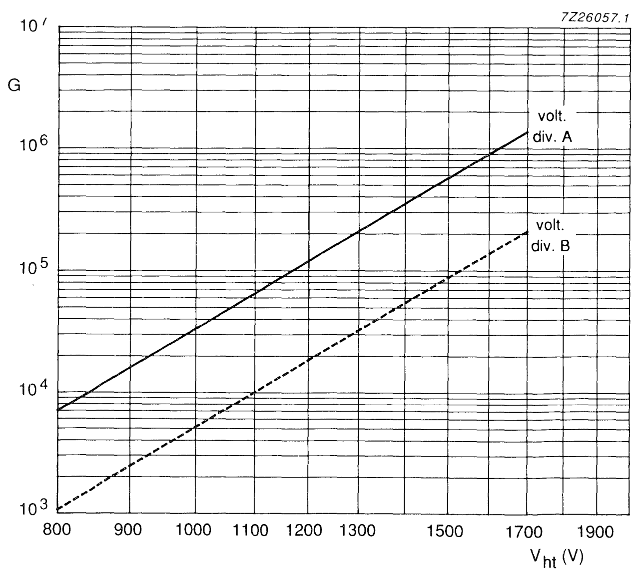


Fig.4 Gain as a function of supply voltage.

High temperature 51 mm (2″) diameter tube XP2206

MECHANICAL DATA

Dimensions in mm

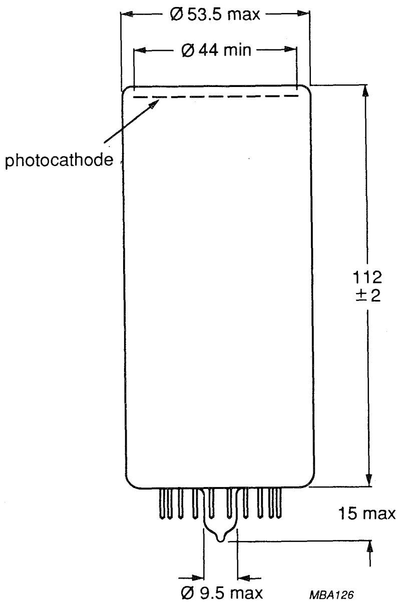
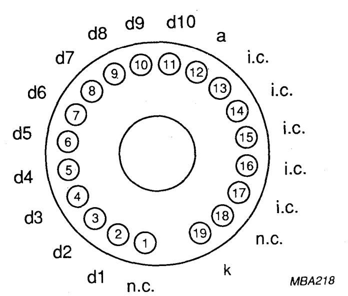


Fig.5 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.6 Pin connections.

Base	19-pin all glass
Net mass	110 g

ACCESSORIES

Socket	FE2019
Mu-metal shield	56629

High temperature 51 mm (2″) diameter tube XP2206

Notes

1 The high temperature bialkaline photocathode has a much lower resistance than the standard bialkaline photocathode and it can be used up to a peak current in the order of 10^{-6} A at room temperature without affecting linearity.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.7 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator with a diameter of 44 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 4 and 14.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

High temperature 51 mm (2″) diameter tube XP2206

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 µA is recommended for applications requiring good stability.

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

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

12-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on types
- plano-plano window
- semi-transparent bi-alkaline 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.

QUICK REFERENCE DATA

Radiant sensitivity characteristic		bi-alkaline		
Useful diameter of the photocathode		min.	44	mm
Quantum efficiency at 400 nm			23	%
Cathode blue spectral sensitivity			10	μA/lmF
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	bi-alkaline			
Useful diameter	min.	44	mm	
Radiant sensitivity characteristic	see Fig.4			
Maximum radiant sensitivity		400 ± 30	nm	
Luminous sensitivity	≈	70	μA/lm	
Blue sensitivity	typ.	10	μA/lmF	
	min.	8,5	μA/lmF	
Quantum efficiency at 400 nm		23	%	
Radiant sensitivity at 400 nm	≈	75	mA/W	2

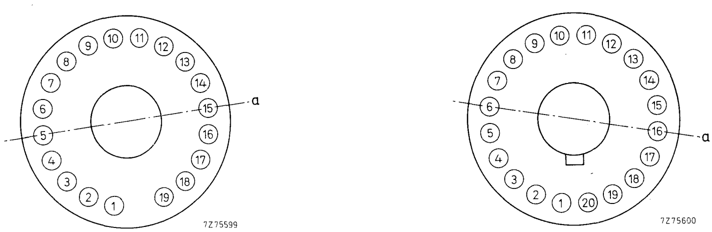
Multiplier system

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

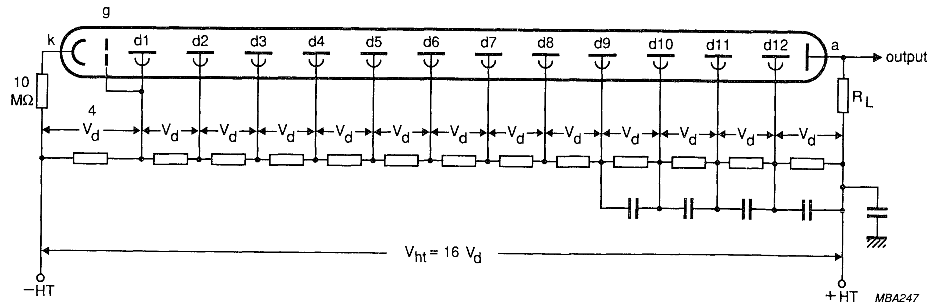


Fig. 2 Voltage divider A.

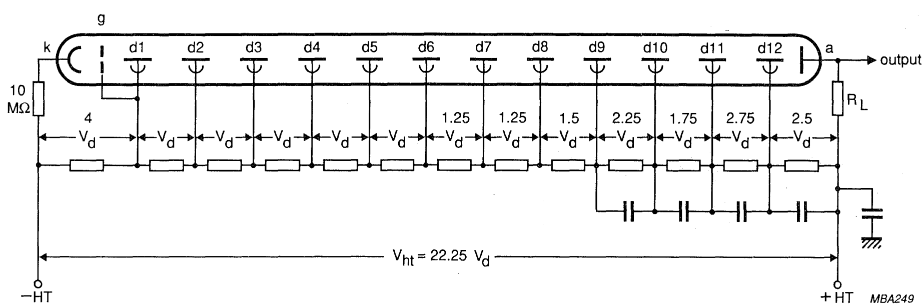


Fig. 3 Voltage divider B.

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)		< 2400 V typ. 1900 V	
Anode dark current at a gain of 3×10^7 (Fig. 8)		≈ 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		≈ 7,2 %	6
Anode current linear within 2% at V_{ht} = 1900 V	up to	≈ 100 mA	
Mean anode sensitivity deviation			7
long term (16 h)		≈ 1 %	
after change of count rate		≈ 1 %	
versus temperature between 0 and + 40 °C at 450 nm		≈ 0,2 %/K	
Single electron spectrum, peak to valley ratio, at a gain of 3×10^7		≈ 2	8
With voltage divider B (Fig. 3)			3
Gain at V_{ht} = 2000 V (Fig. 8)		≈ 7×10^6	
Anode pulse rise time at V_{ht} = 2000 V		≈ 4 ns	9
Anode pulse duration at half height at V_{ht} = 2000 V		≈ 8 ns	9
Signal transit time at V_{ht} = 2000 V		≈ 36 ns	9
Signal transit time difference between the centre of the photocathode and 18 mm from the centre at V_{ht} = 2000 V		≈ 5 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	10
Continuous anode current	max. 0,2 mA	11
Voltage between first dynode and photocathode	max. 800 V min. 300 V	12
Voltage between consecutive dynodes	max. 400 V	
Voltage between anode and final dynode	max. 600 V min. 80 V	13
Ambient temperature range		
operational (for short periods of time)	max. +80 °C min. −30 °C	14
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.
2. Radiant 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly 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 countrate 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 ≈ 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 ≈ 1 μA and ≈ 0,1 μA 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 reaches 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. 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.

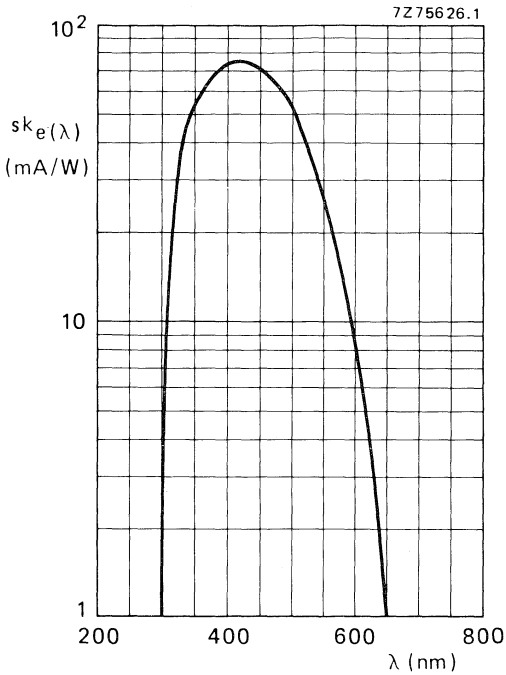


Fig. 4 Spectral sensitivity characteristic.

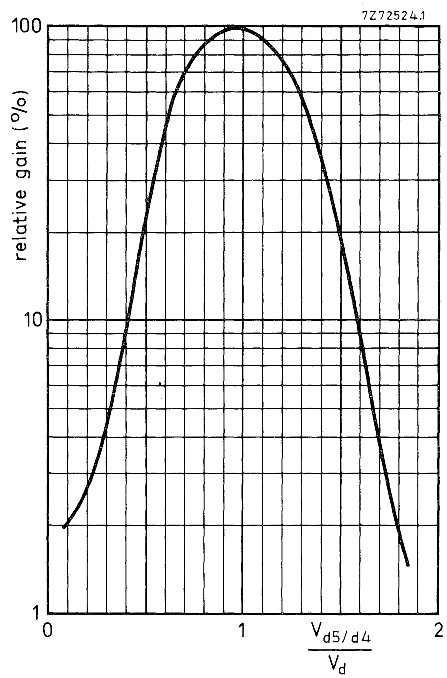


Fig. 5 Relative gain as a function of the voltage between d5 and d4 normalized to V_d. $V_{d6/d4}$ constant.

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

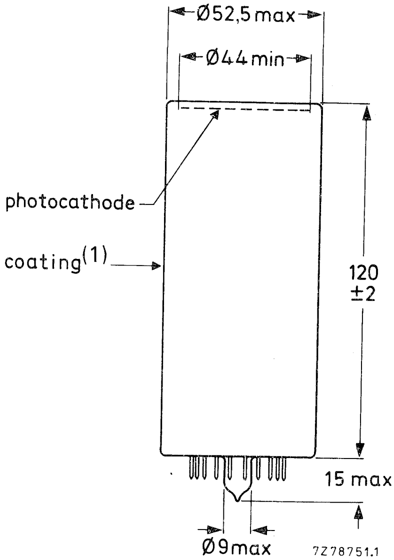


Fig. 6 XP2212.

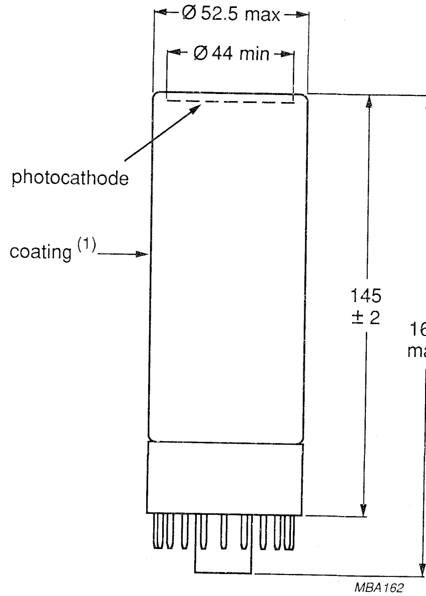
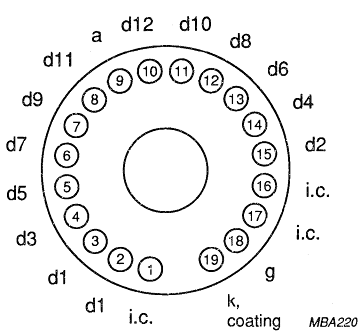


Fig. 7 XP2212B.

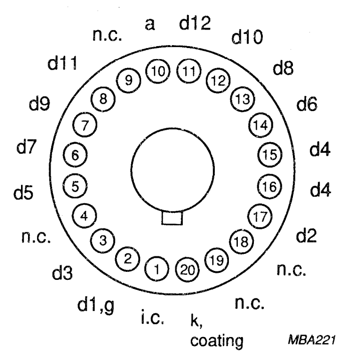
Base	19-pin all glass
Net mass	111 g

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 FE1120
Mu-metal shield		type 56629

(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.

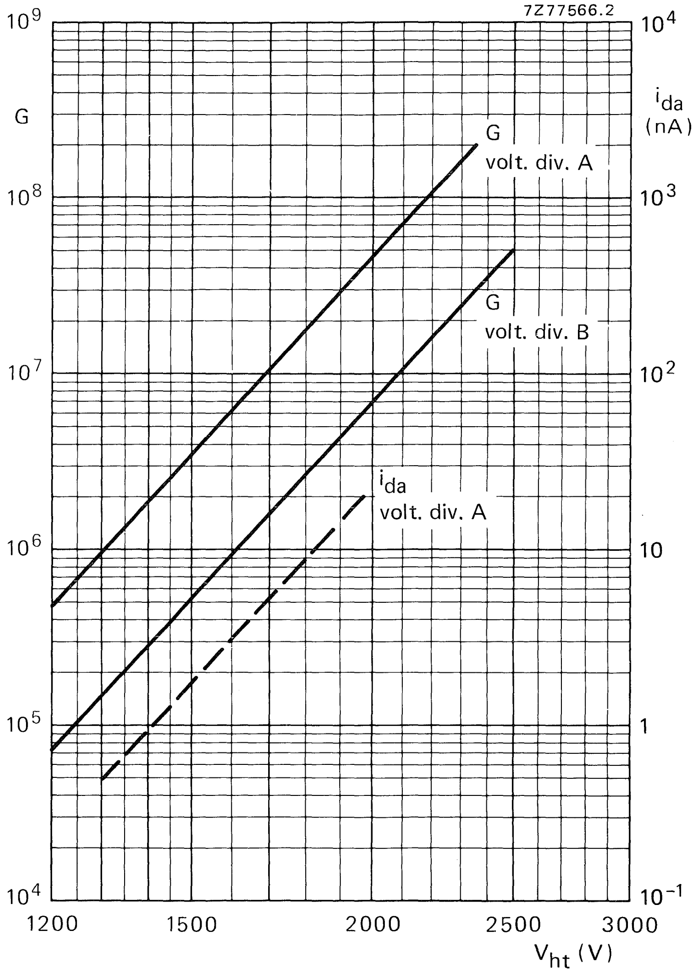


Fig. 8 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

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

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 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.

QUICK REFERENCE DATA

Radiant sensitivity characteristic		S20		
Useful diameter of the photocathode		min.	44	mm
Cathode radiant sensitivity at 700 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	trialkaline		
Useful diameter	>	44	mm
Radiant sensitivity characteristic	see Fig. 5		
Maximum radiant sensitivity at		420 ± 30	nm
Radiant sensitivity	typ.	15	mA/W
at 700 nm	>	7	mA/W
at 630 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.

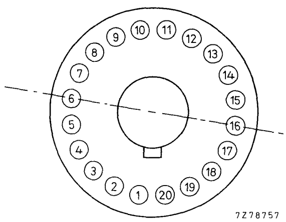


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

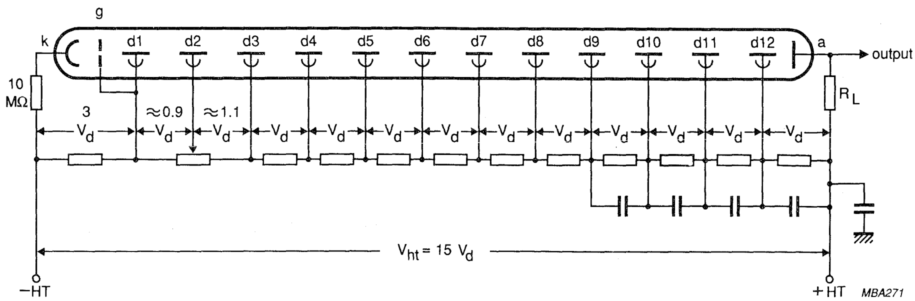


Fig. 2 Voltage divider A.

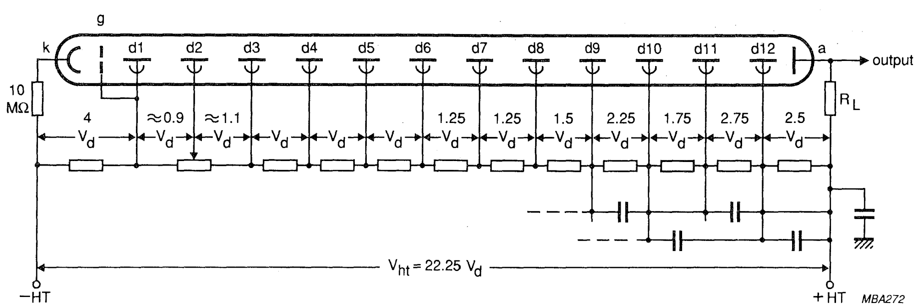


Fig. 3 Voltage divider B.

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)

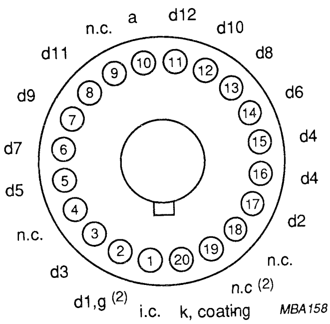
	notes		
Supply voltage	5	max.	2500 V
Continuous anode current	9	max.	0.2 mA
Voltage between accelerating electrode, g, and photocathode		max.	800 V
Voltage between first dynode and photocathode	6	max.	800 V
		min.	300 V
Voltage between consecutive dynodes		max.	400 V
Voltage between anode and final dynode	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

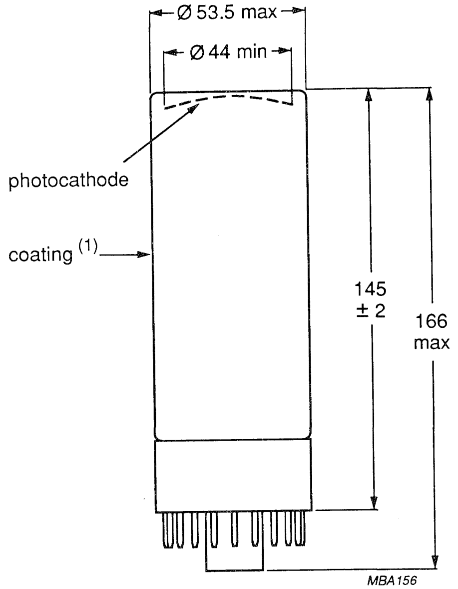
Notes

1. To obtain a peak pulse current greater than that obtainable with divider A, it is necessary to increase the inter-dynode voltage 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 ratio between two successive stages is less than 2.
2. Wherever possible, the power supply should be arranged so that the cathode is earthed and the anode is at + HT, however, it is sometimes necessary to supply the tube with the anode earthed and the cathode at −HT. Under these circumstances, erratic noise and dark current are generally increased and unstable, particularly immediately after application of voltage. The tube is provided with a conductive coating connected to the cathode. It is recommended that, if a metal shield is used this be kept at photocathode potential. This implies safety precautions tc 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 (≈ 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. 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 μA is recommended for applications requiring good stability.

MECHANICAL DATA

Dimensions in mm





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

Fig.4.

(1) Except for tubes with serial numbers between 1606 and 11576, where g is connected to pin 19 instead of d1.

(2) The envelope of the tube is covered with a conductive coating which is connected to the photocathode. Over 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.

ACCESSORIES

Socket	type FE1020
Mu-metal shield	type 56629

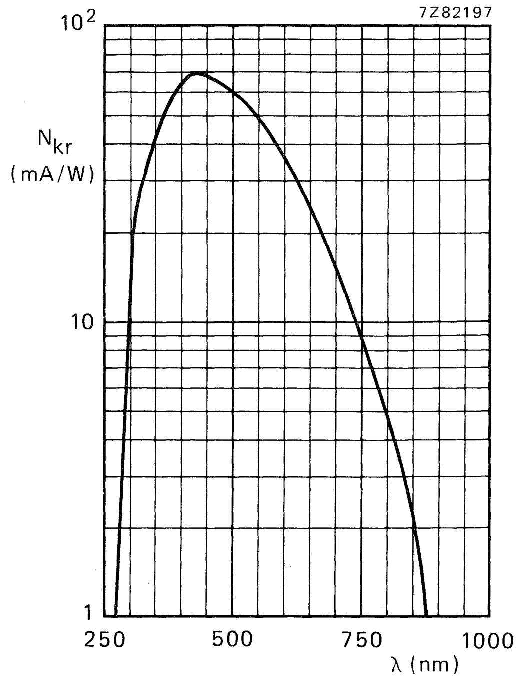


Fig. 5 Radiant sensitivity characteristic.

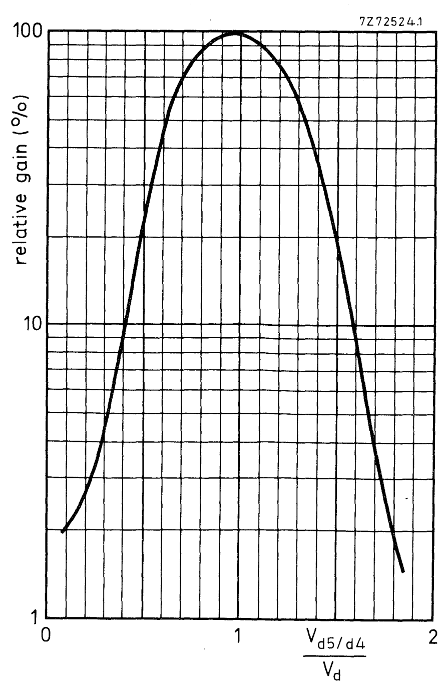


Fig. 6 Relative gain as a function of the voltage between S5 and S4, normalized to V_S. $V_{S6/S4}$ constant.

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

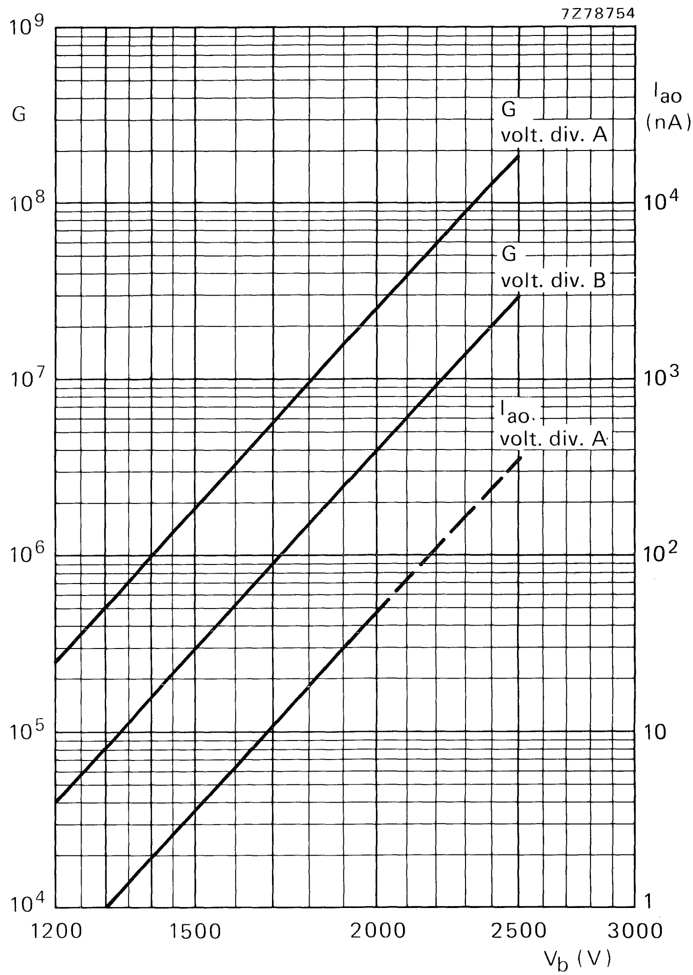


Fig. 7 Gain G, and anode dark current I_{ao}, as a function of supply voltage V_b.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2237B

Fast, extended-red-sensitive, 51 mm (2″) diameter tube

APPLICATIONS

For optical applications in the red part of the spectrum requiring good timing characteristics.

GENERAL CHARACTERISTICS

			NOTES
Window material profile refractive index at 550 nm	 borosilicate plano – concave 1.48		
Photocathode material useful diameter spectral range wavelength for maximum radiant sensitivity luminous sensitivity radiant sensitivity at 800 nm radiant sensitivity at 850 nm Quantum efficiency at 850 nm	semi-transparent, head-on extended red multialkaline min. 44 300 to 900 ≈ 550 ≈ 160 ≈ 15 min. 3 typ. 8 1	 mm nm nm μA/lm mA/W mA/W mA/W %	 1 2 3 3
Multiplier first dynode structure number of stages slope: log(gain)/log(supply voltage) capacitance anode to all	 high – gain linear focused 12 ≈9 ≈5	 pF	

OUTPUT CHARACTERISTICS

with voltage divider A, gain = 3 x 10^7

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	2050	2500	V	
Anode dark current		500	5000	nA	4,6
Background noise (x 10^3)	–	100	1000	c/s	5,6
Single electron spectrum			–		
resolution	–	≈ 70	–	%	7
peak to valley ratio	–	≈ 2.5	–		8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n"	–	≈ 0.2	–	mT	11
parallel to axis "n"	–	≈ 0.1	–	mT	11

see note 12

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at	2050	2400	2200	V	
Gain x 10^6	≈ 30	≈ 20	≈ 30		
Anode current linear within 2% up to	≈ 100	≈ 250	≈ 150	mA	
Anode pulse rise time	≈ 2.2	≈ 2	≈ 2	ns	13
Anode pulse duration at half height	≈ 3.6	≈ 3.2	≈ 3.2	ns	13
Signal transit time	≈ 30	≈ 30	≈ 30	ns	13
Transit time difference between centre of photocathode and 18 mm from it	–	≈ 0.7	–	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6	–	200		14
Supply voltage	–	2500	V	
Continuous anode current	–	0.2	mA	15
Voltage between first dynode and photocathode	300	800	V	16
Voltage between consecutive dynodes	–	400	V	
Voltage between anode and last dynode	80	600	V	17
Ambient temperatures				18
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

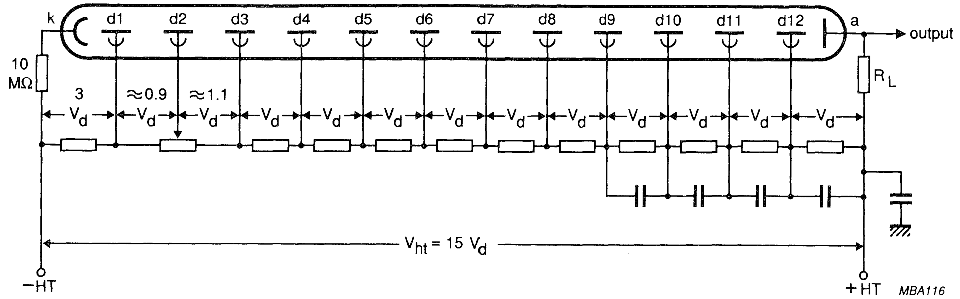


Fig.1 Voltage divider A.

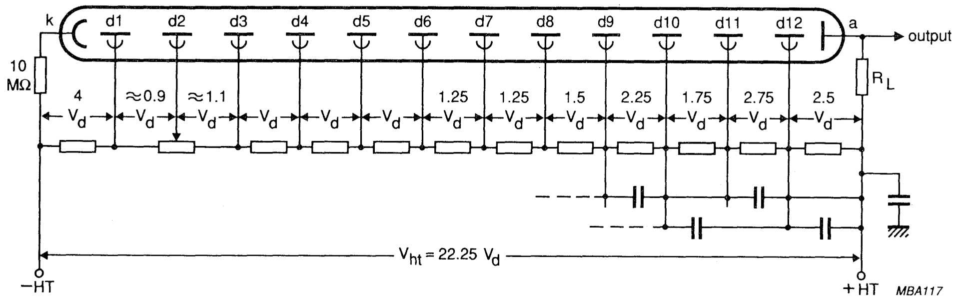


Fig.2 Voltage divider B.

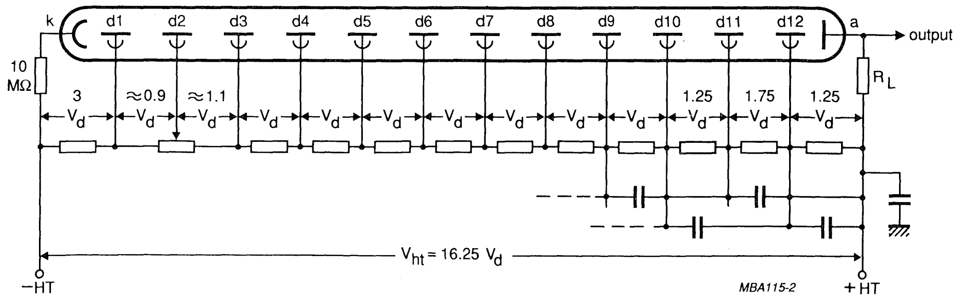


Fig.3 Voltage divider C.

a = anode

dn = dynode number

k = cathode

Typical values of capacitors 1 nF.

Fast, extended-red-sensitive, 51 mm (2″) diameter tube

XP2237B

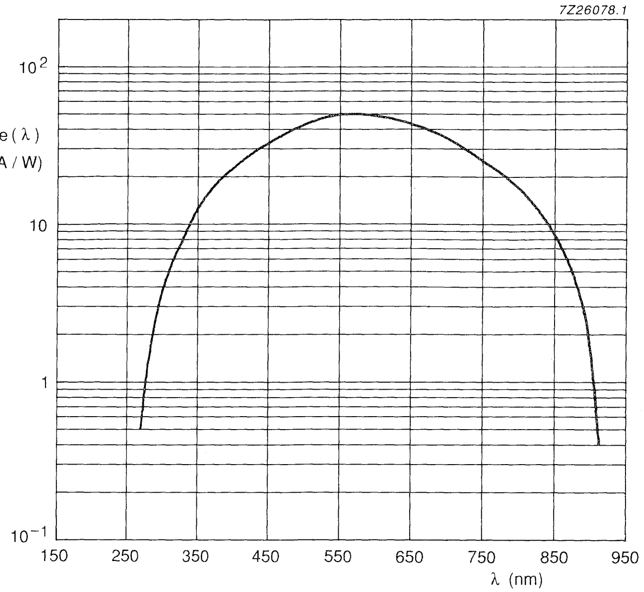


Fig.4 Cathode spectral characteristic.

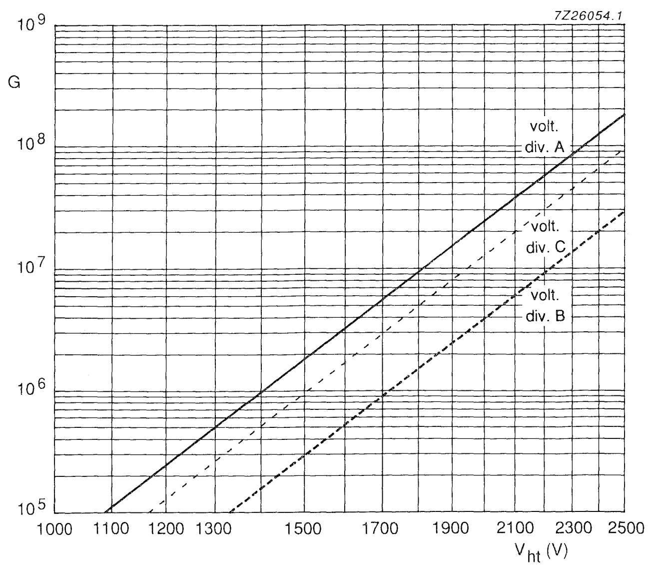


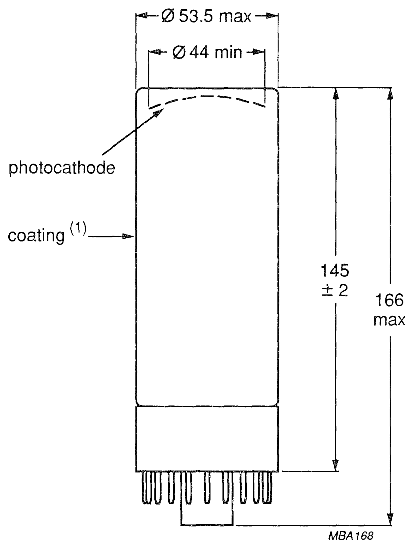
Fig.5 Gain as a function of supply voltage

Fast, extended-red-sensitive, 51 mm (2″) diameter tube

XP2237B

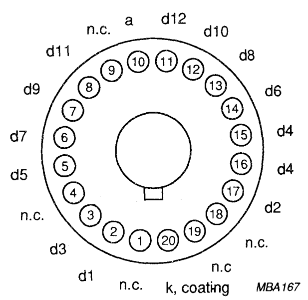
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.7 Pin connections.

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

ACCESSORIES

Socket	FE1120
Mu-metal shield	56629

Fast, extended-red-sensitive, 51 mm (2″) diameter tube XP2237B

Notes

1 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

2 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

3 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter.

4 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

5 After having been stored with its protection hood, the tube is placed in darkness with Vd 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 pC (corresponding to 0.2 photoelectron) are recorded.

6 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at – HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

7 The single electron spectrum resolution will be optimized by adjusting the d2 voltage.

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 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 6 and 16.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.2 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 μA is recommended for applications requiring good stability.

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

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

18 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

6-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic		bialkaline		
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 x 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	bialkaline			
Useful diameter	>	44	mm	
Radiant sensitivity characteristic	see Fig.5			
Maximum spectral sensitivity		400 ± 30	nm	
Luminous sensitivity	≈	90	μA/lm	3
Blue sensitivity	typ.	10,5	μA/lmF	1
	>	8,0	μA/lmF	
Radiant 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.

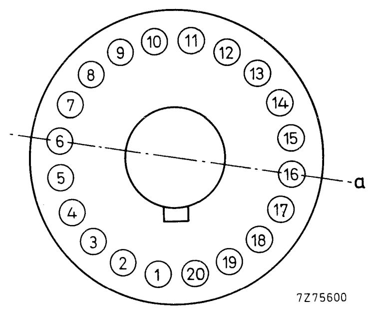


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

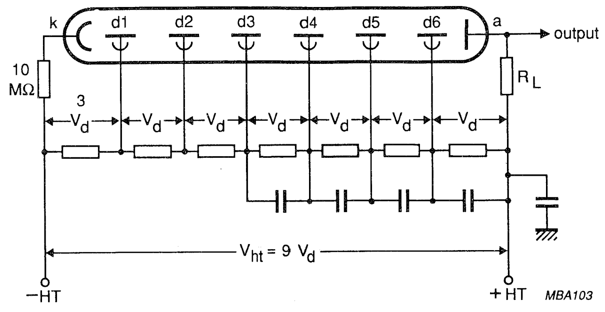


Fig. 2 Voltage divider A.

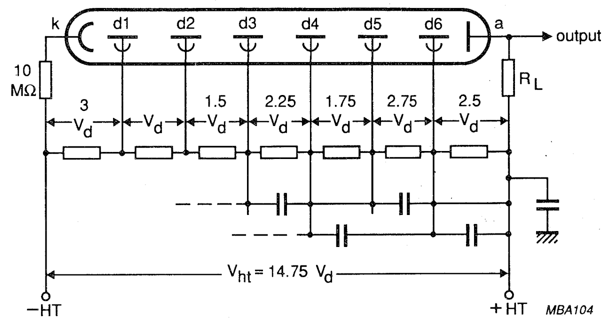


Fig. 3 Voltage divider B.

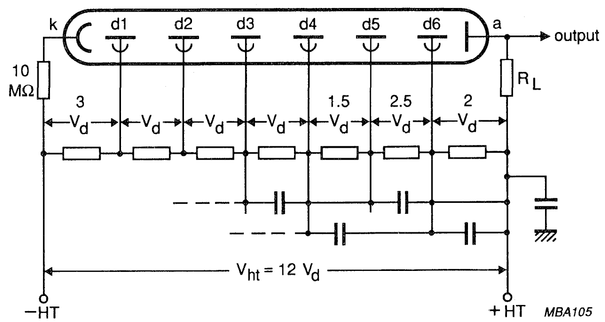


Fig. 4 Voltage divider C.

k = cathode;

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		<	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	
With voltage divider C (Fig. 4)				
Supply voltage for a gain of 10^5 (Fig. 6)			2500 V	
Anode pulse rise time at V_{ht} = 2500 V			1.3 ns	
Anode pulse duration at half height at V_{ht} = 2500 V			1.9 ns	
Signal transit time at V_{ht} = 2500 V			14 ns	
Anode current linear within 2% at V_{ht} = 2500 V			200 mA	

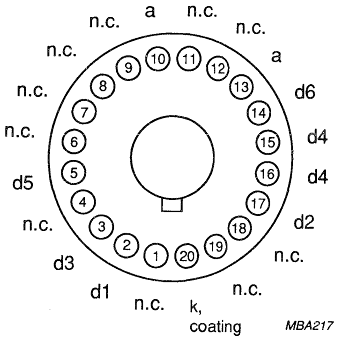
LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2500 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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Radiant 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 progressively. Divider circuits B and C are examples of progressive dividers, giving a compromise between gain, speed and linearity. Other dividers can be conceived to achieve other compromises. It is generally recommended that the voltage ratio between two successive stages is less than 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 reaches 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



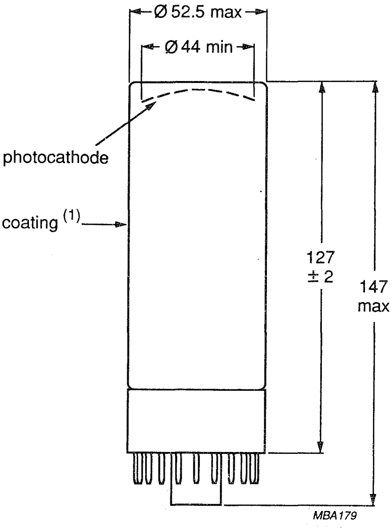


Fig. 5.

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 FE1120
Mu-metal shield	type 56629

(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.

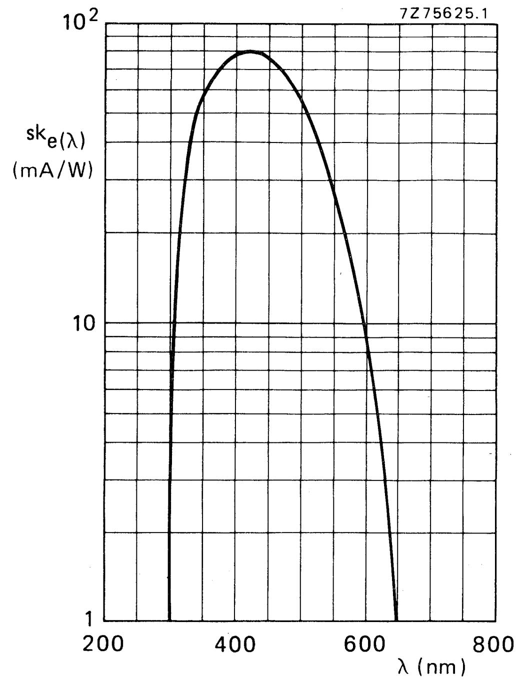


Fig. 6 Spectral sensitivity characteristic.

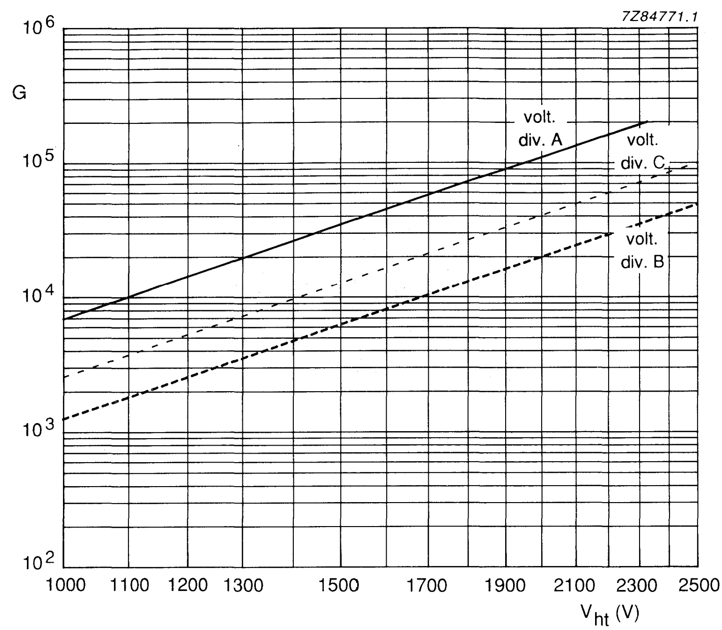


Fig. 7 Gain G as a function of supply voltage V_{ht}.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2243B

Fast, 6-stage, red sensitive, 51 mm (2") diameter tube

APPLICATIONS

High energy physics principally.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	borosilicate		
profile	plano – concave		
refractive index at 420 nm	1.48		
Photocathode	semi-transparent, head-on		
material	trialkaline		
useful diameter	min. 44	mm	
spectral range	300 to 850	nm	1
wavelength for maximum radiant sensitivity	≈ 420	nm	
luminous sensitivity	≈ 160	μA/lm	2
radiant sensitivity at 700 nm	min. 9	mA/W	3
	typ. 15	mA/W	3
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	6		
slope: log(gain)/log(supply voltage)	≈ 4		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, gain = 10^4

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1100	1600	V	
Anode dark current	–	2	10	nA	4,5
Mean anode sensitivity deviation					6
long term (16 hours)	–	≈ 1		%	
after change of count rate	–	≈ 1		%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2		%/K	
Anode current halved for magnetic field of					7
perpendicular to axis "n"	–	≈ 0.2		mT	8
parallel to axis "n"	–	≈ 0.1		mT	8
parallel with the tube axis	–	≈ 0.3		mT	

see note 9

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	2000	2000	2500	V	
Gain x 10^3	≈ 110	≈ 20	≈ 100		
Anode current linear within 2% up to	≈ 100	≈ 200	≈ 200	mA	
Anode pulse rise time	≈ 1.7	≈ 1.6	≈ 1.3	ns	10
Anode pulse duration at half height	≈ 2.6	≈ 2.4	≈ 1.9	ns	10
Signal transit time	≈ 16	≈ 16	≈ 14	ns	10
Transit time difference between centre of photocathode and 18 mm from it		≈ 0.7		ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^3	–	200		11
Supply voltage	–	2500	V	
Continuous anode current	–	0.2	mA	12
Voltage between first dynode and photocathode	200	750	V	13
Voltage between consecutive dynodes	–	600	V	
Voltage between anode and last dynode	50	600	V	14
Ambient temperatures				15
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Fast, 6-stage, red sensitive, 51 mm (2″) diameter tube XP2243B

RECOMMENDED CIRCUITS

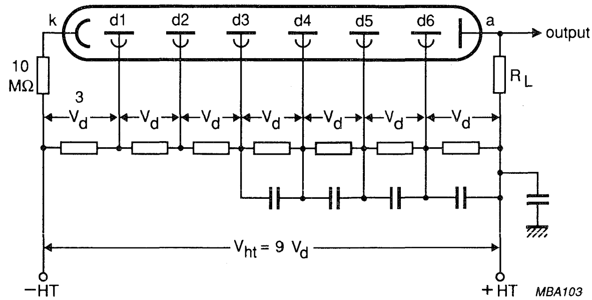


Fig.1 Voltage divider A.

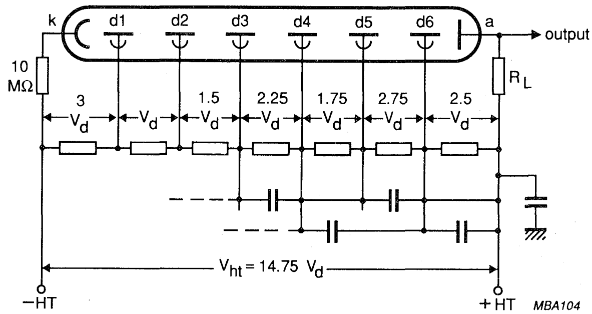


Fig.2 Voltage divider B.

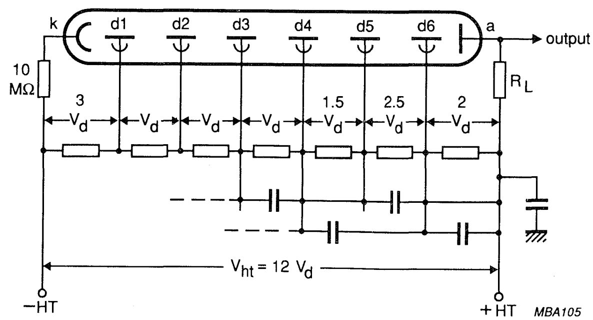


Fig.3 Voltage divider C.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

Fast, 6-stage, red sensitive, 51 mm (2″) diameter tube XP2243B

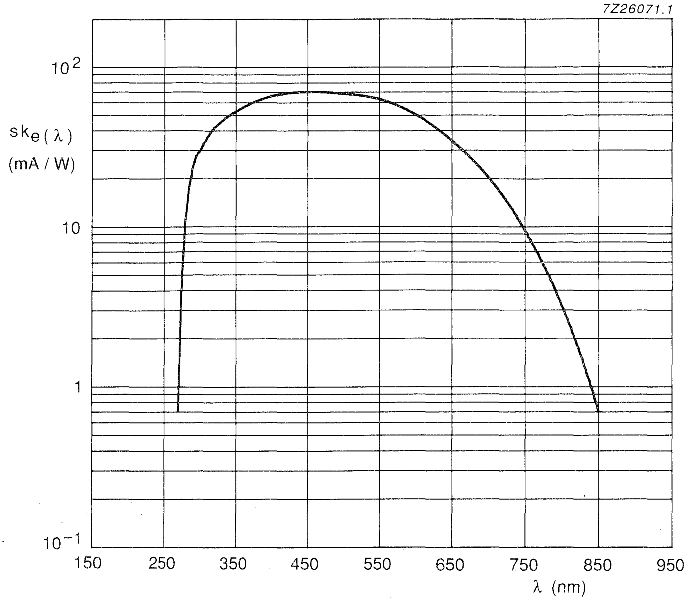


Fig.4 Cathode spectral characteristic.

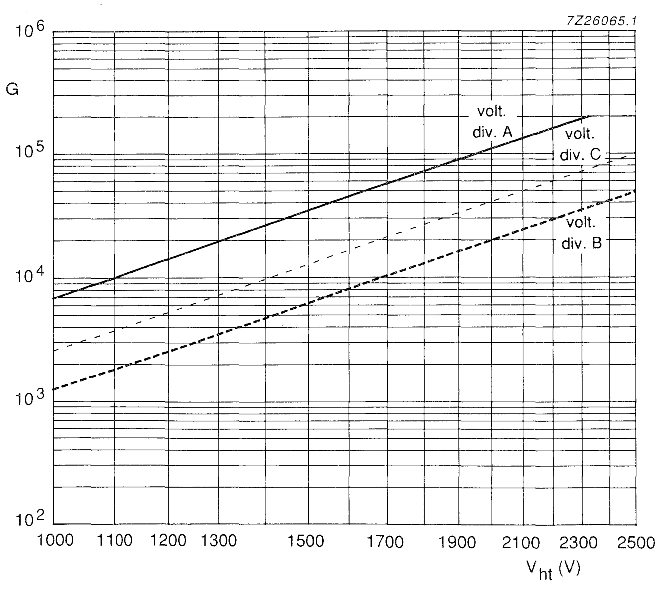


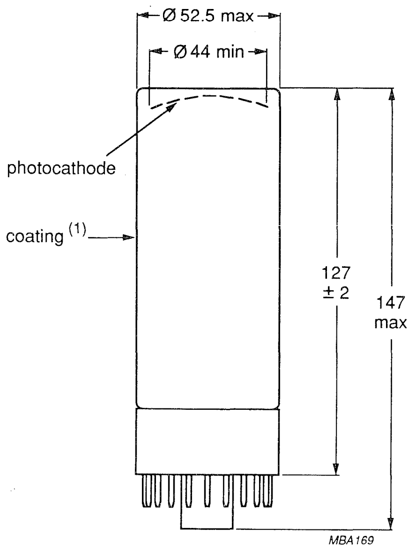
Fig.5 Gain as a function of supply voltage

Fast, 6-stage, red sensitive, 51 mm (2″) diameter tube

XP2243B

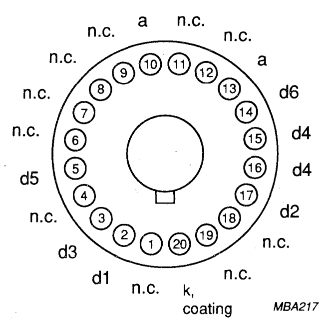
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



n.c. = not connected

Fig.7 Pin connections.

Base 20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass 151 g

ACCESSORIES

Socket	FE1120
Mu-metal shield	56629

Fast, 6-stage, red sensitive, 51 mm (2″) diameter tube XP2243B

Notes

1 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

2 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

3 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter.

4 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

5 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

6 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

8 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 6 and 16.

9 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

10 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

11 The voltage corresponding to this maximum anode blue sensitivity is equal to 2.1 times the voltage indicated on the test ticket of the tube.

12 A value less than 10 μA is recommended for applications requiring good 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.

15 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2254B is a 44 mm diameter head-on photomultiplier tube with a plano-concave fused silica window and a semi-transparent trialkaline S20 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.

QUICK REFERENCE DATA

Radiant sensitivity characteristic			S20 on fused silica	
Useful diameter of the photocathode		>	44	mm
Radiant 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 C)		≈	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	trialkali		
Useful diameter	>	44	mm
Radiant sensitivity characteristic	see Fig.6		
Maximum radiant sensitivity at		420 ± 30	nm
Radiant 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 + d5 + g2	≈	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.

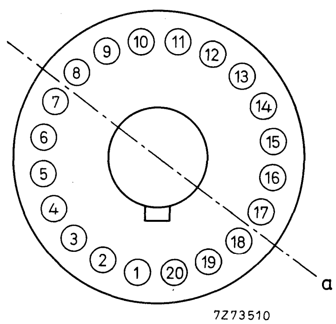


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

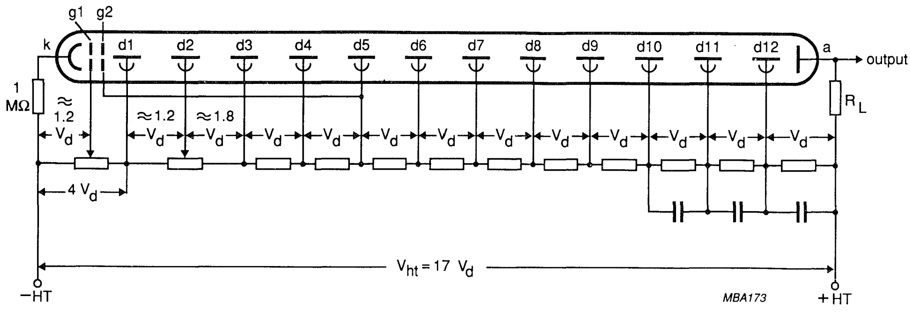


Fig. 2 Voltage divider type A.

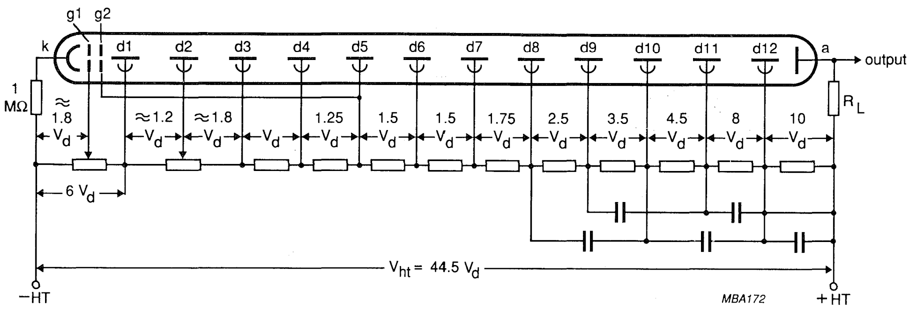


Fig. 3 Voltage divider type B.

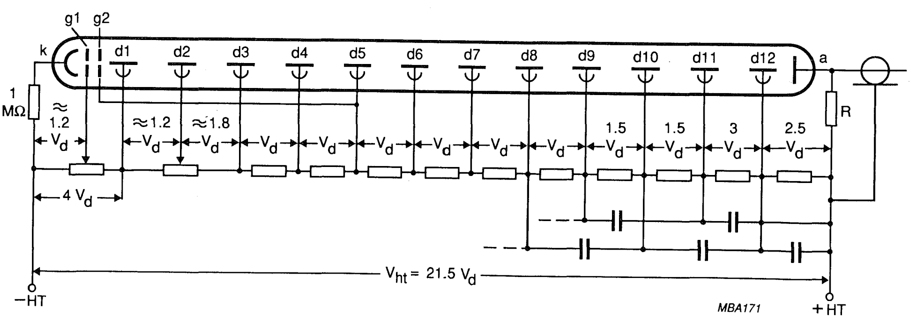


Fig. 4 Voltage divider type C.

k = cathode
g1, g2 = focusing and accelerating electrodes
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	

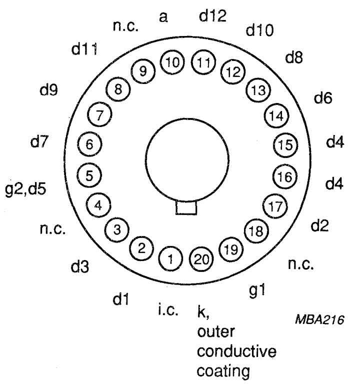
LIMITING VALUES (Absolute maximum rating system)

				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.	800	V	9
	min.	210	V	
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.	700	V	10
	min.	80	V	
Ambient temperature range				11
operational (for short periods of time)	max.	+ 80	°C	
	min.	−30	°C	
continuous operation and storage	max.	+ 50	°C	
	min.	−30	°C	

Notes

1. To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuit "B" and "C " 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 voltage ratio between successive stages 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 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 $V_{ht}^{-½}$.
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. Or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
8. A value of < 10 μA 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



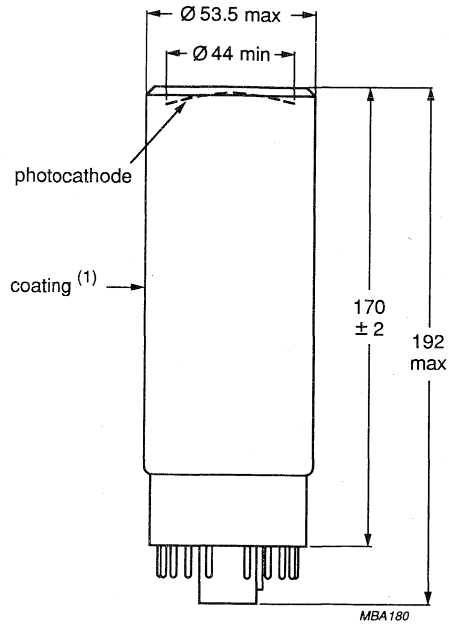


Fig. 5.

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

ACCESSORIES

Socket	type FE1120
mu-metal shield	type 56619

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

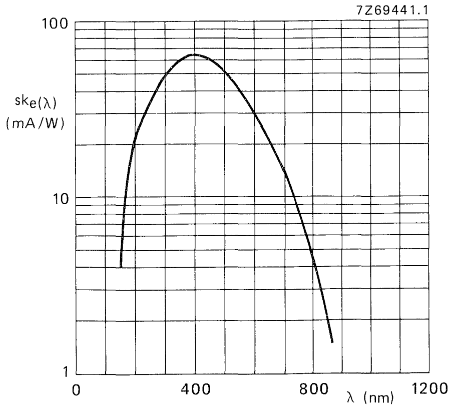


Fig. 6 Spectral sensitivity characteristic.

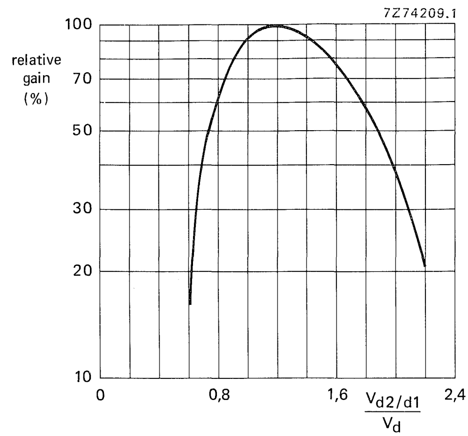


Fig. 7 Relative gain as a function of the voltage between d2 and d1, normalized to V_d $V_{d3/d1}$ constant.

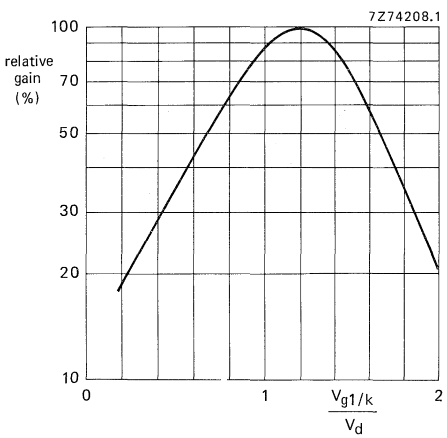


Fig. 8 Relative gain as a function of the voltage between grid 1 and cathode, normalized to V_d. $V_{d1/k}$ constant.

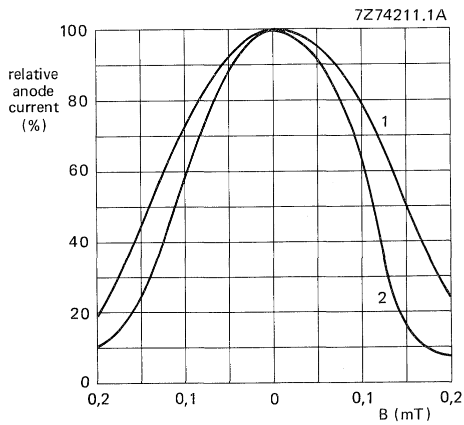


Fig. 9 Relative anode current as a function of the magnetic flux density B.
1. ⊥ axis a
2. // axis a

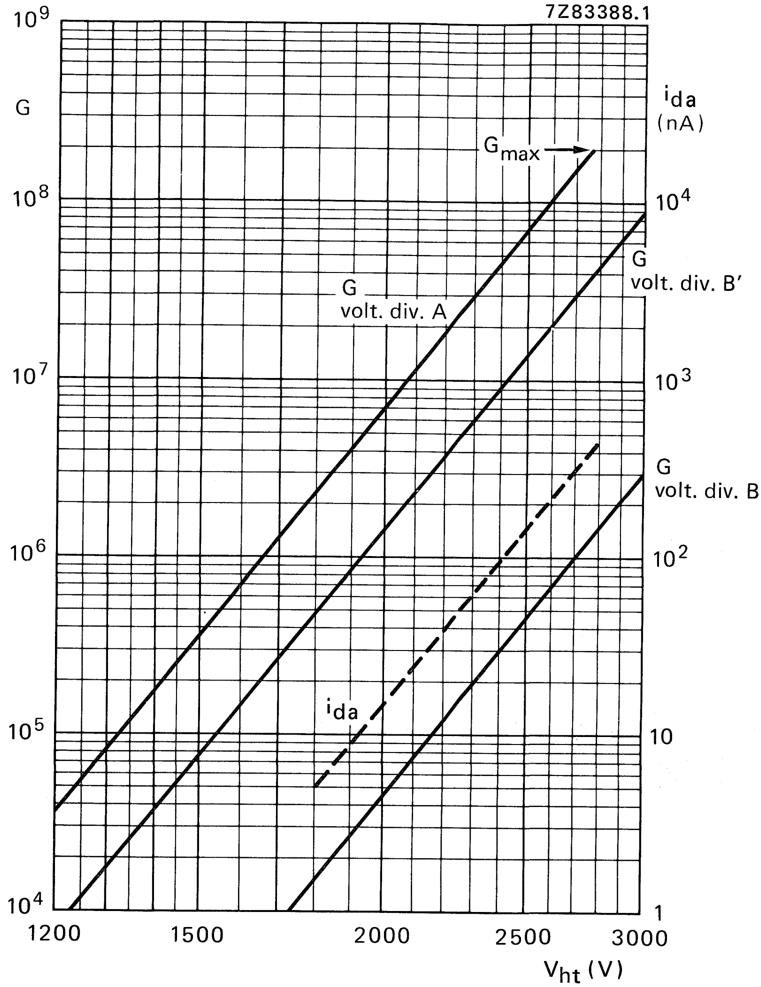


Fig. 10 Gain, G, and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

DEVELOPMENT DATA

12-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- plano-concave window
- semi-transparent bi-alkaline photocathode
- high cathode sensitivity
- very good linearity and time characteristics
- good single electron spectrum resolution
- for high-energy physics experiments

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bialkaline
Useful diameter of the photocathode	> 44 mm
Quantum efficiency at 400 nm	25%
Cathode blue sensitivity	11,2 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	lime-glass
Shape	plano-concave
Refractive index at 400 nm	1,54

Photocathode		notes
Semi-transparent, head-on		2
Material	bialkaline	
Useful diameter	> 44 mm	
Radiant sensitivity characteristic	see Fig.5	
Maximum spectral sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lm	3
Blue sensitivity	typ. 11.2 μA/lmF > 9.0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 90 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 anode to all	 ≈ 3 pF ≈ 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.

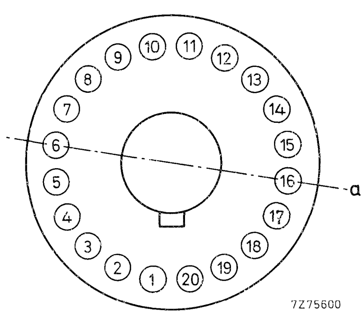


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

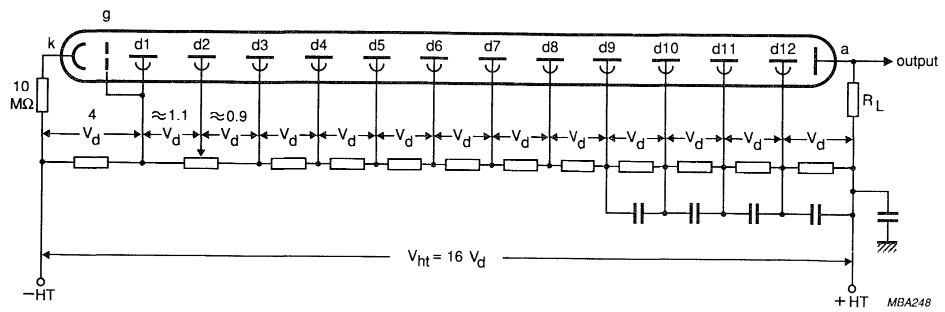


Fig. 2 Voltage divider A.

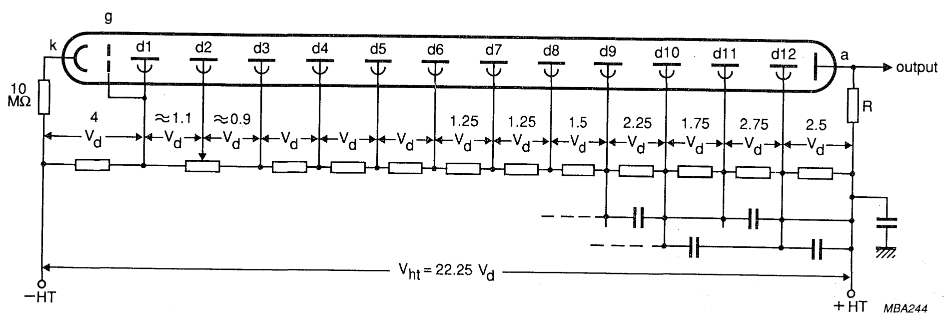


Fig. 3 Voltage divider B.

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. 7)	< 2400 V typ. 1850 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 c/s < 6×10^3 c/s	7
Single electron spectrum at a gain of 3×10^7 (Fig. 6)		
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
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	

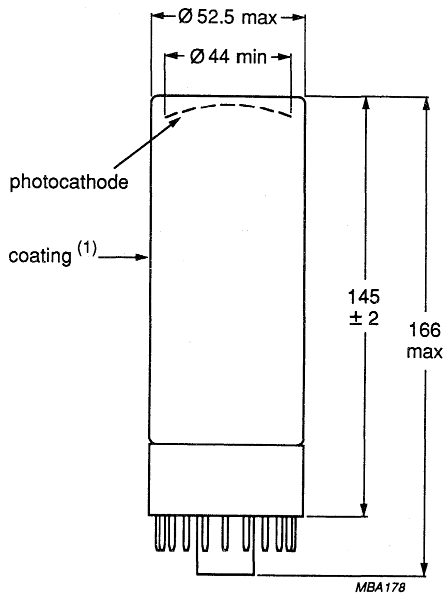
NOTES

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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 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 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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 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 ≈ 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 $\approx$ 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.
13. Or the voltage at which the tube has a gain of 2×10^8, whichever is lower.
14. A value of $< 10\ \mu$A 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. This range of temperatures is limited principally by stress in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm



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

PIN CONNECTIONS

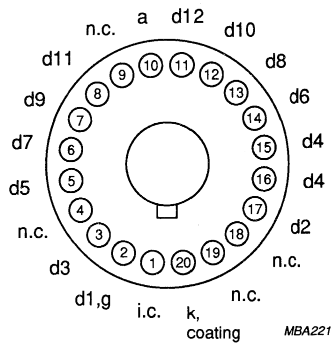


Fig.4.

ACCESSORIES

Socket	type FE1120
Mu-metal shield	type 56629

(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 not isolating.
Care should be taken to avoid electric shock.

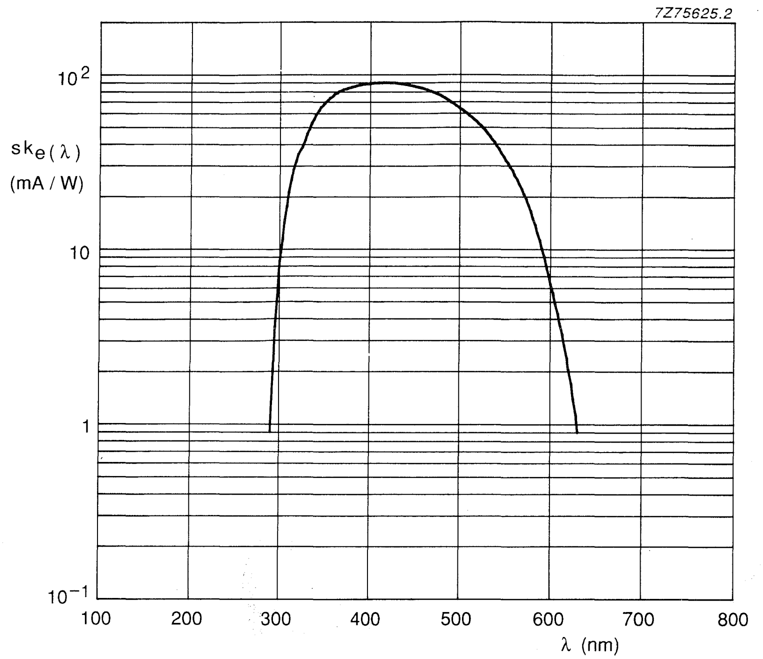


Fig. 5 Spectral sensitivity characteristic.

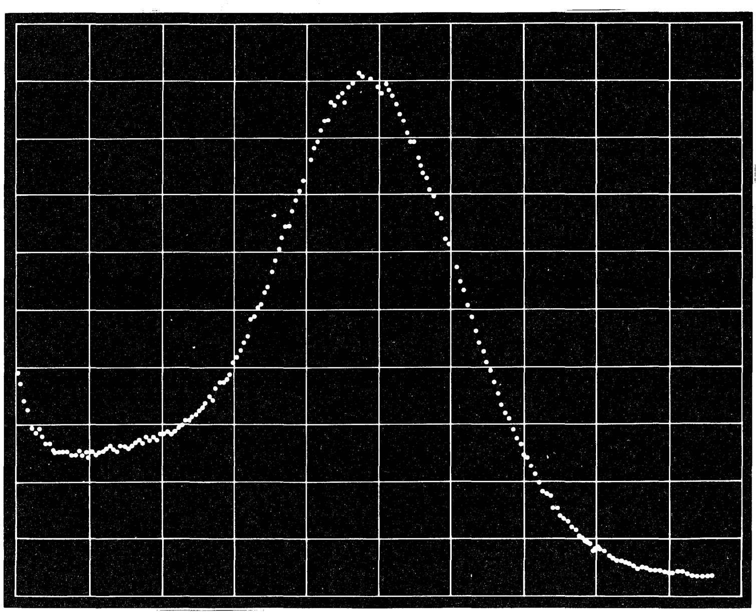


Fig. 6 Single electron spectrum obtained with an XP2262 tube.

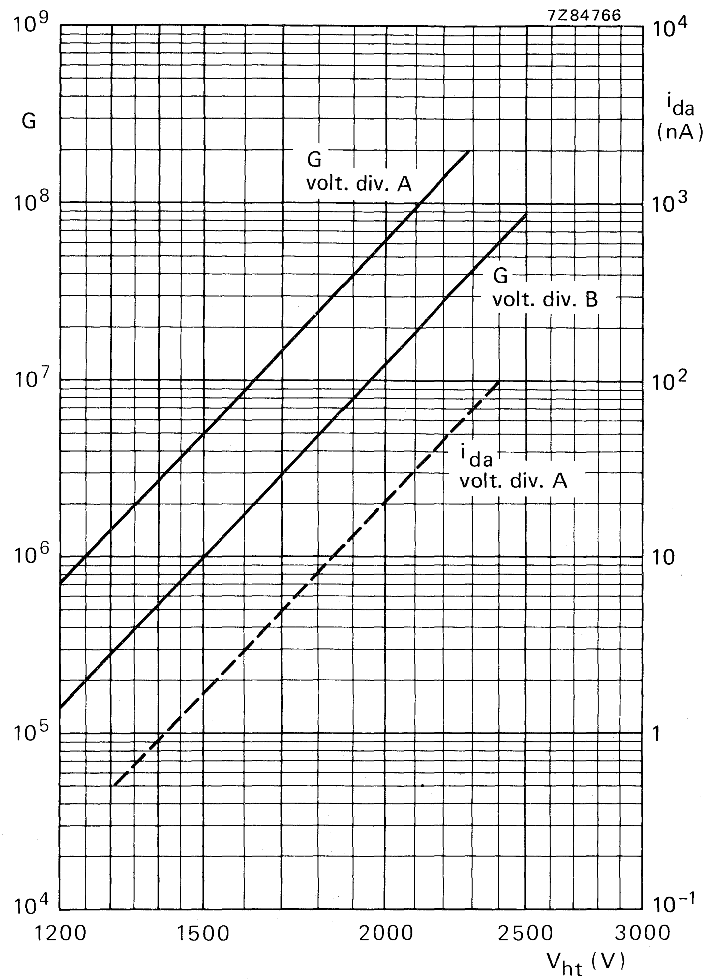


Fig. 7 Gain G and anode dark current, i_{da}, as a function of supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2282B

Fast, 8-stage, 51 mm (2″) diameter tube

APPLICATIONS

High energy physics and all applications where both medium gain and good timing characteristics are requested.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – concave		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 44	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 90	µA/lm	3
blue sensitivity	min. 9	µA/lmF	4
	typ. 11	µA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Quantum efficiency at 400 nm	≈ 28	%	
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	8		
slope: log(gain)/log(supply voltage)	≈ 5.6		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, gain = 10^6

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1900	2200	V	
Anode dark current	–	5	20	nA	6,7
^{137}Cs pulse amplitude resolution	–	≈ 7.2	–	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n'	–	≈ 0.2	–	mT	11
parallel with axis "n'	–	≈ 0.1	–	mT	11
parallel with the tube axis	–	≈ 0.3	–	mT	

see note 12

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	2500	2500	2500	V	
Gain x 10^6	≈ 4.5	≈ 1	≈ 3		
Anode current linear within 2% up to	≈ 100	≈ 180	≈ 180	mA	
Anode pulse rise time	≈ 1.6	≈ 1.6	≈ 1.5	ns	13
Anode pulse duration at half height	≈ 2.4	≈ 2.4	≈ 2.2	ns	13
Signal transit time	≈ 19	≈ 20	≈ 19	ns	13
Transit time difference between centre of photocathode and 18 mm from it	–	≈ 0.7	≈ 0.5	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6		5		14
Supply voltage		3000	V	
Continuous anode current		0.2	mA	15
Voltage between first dynode and photocathode	200	750	V	16
Voltage between consecutive dynodes		500	V	
Voltage between anode and last dynode	30	500	V	17
Ambient temperatures				18
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Fast, 8-stage, 51 mm (2″) diameter tube XP2282B

RECOMMENDED CIRCUITS

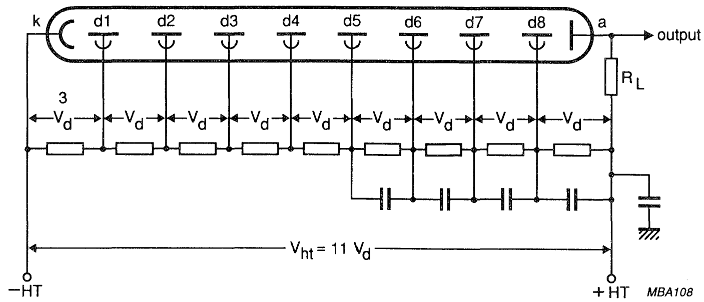


Fig.1 Voltage divider A.

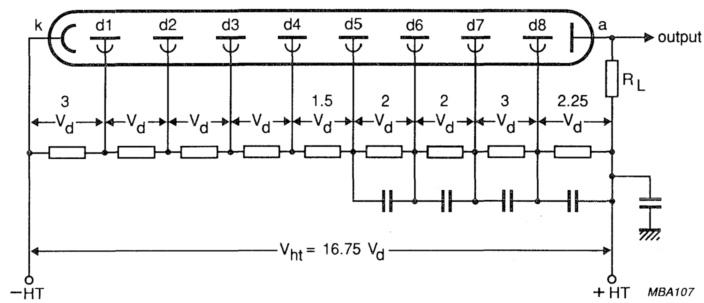


Fig.2 Voltage divider B.

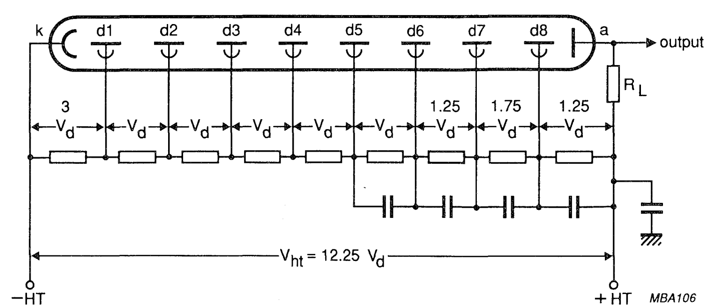


Fig.3 Voltage divider C.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

Fast, 8-stage, 51 mm (2″) diameter tube XP2282B

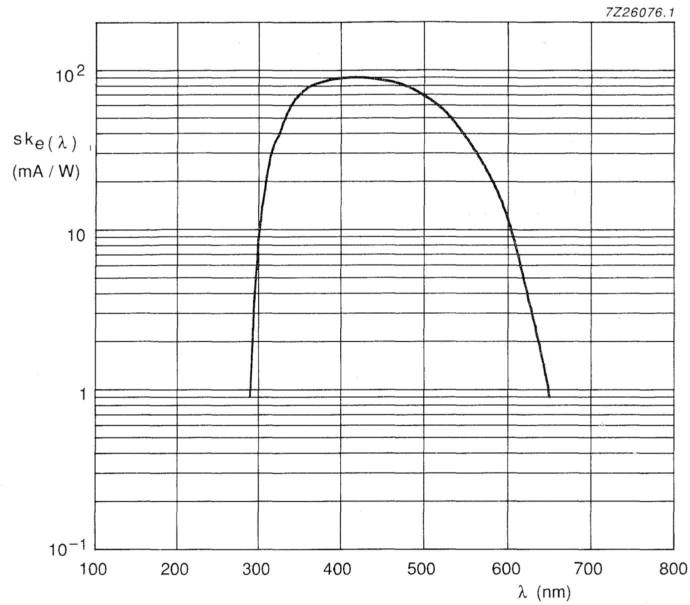


Fig.4 Cathode spectral characteristic.

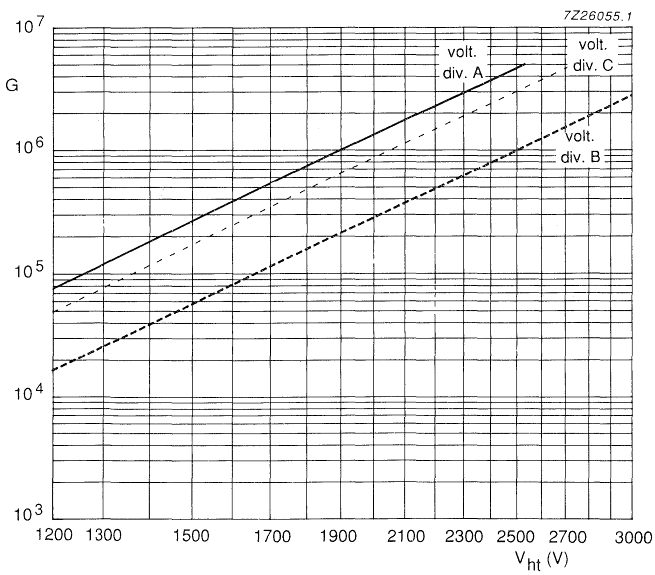
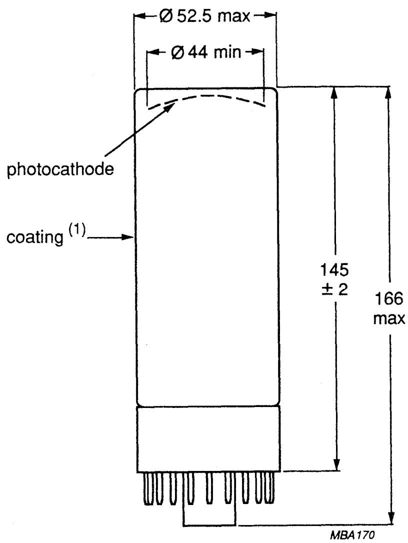


Fig.5 Gain as a function of supply voltage

Fast, 8-stage, 51 mm (2″) diameter tube XP2282B

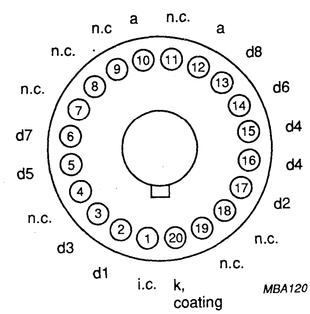
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.7 Pin connections.

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

ACCESSORIES

Socket	FE1120
Mu-metal shield	56629

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 44 mm and a height of 50 m. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pins 4 and 14.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

Fast, 8-stage, 51 mm (2″) diameter tube XP2282B

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.3 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 μA is recommended for applications requiring good stability.

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

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

18 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

12-STAGE PHOTOMULTIPLIER TUBE

The XP2312B is a 68 mm useful diameter head-on photomultiplier tube with a plano-concave window and a semi-transparent bialkaline photocathode. The tube is intended for use in nuclear physics where the number of photons to be detected is very low and where good time characteristics and a good linearity are required (coincidence measurements, Cerenkov counters).

QUICK REFERENCE DATA

Radiant sensitivity characteristic		bialkaline		
Useful diameter of the photocathode		>	68	mm
Quantum efficiency at 400 nm			23	%
Cathode blue sensitivity at 400 nm			9	μA/lmF
Supply voltage for a gain of 3×10^7			2000	V
Pulse amplitude resolution for ^{137}Cs		≈	8,0	%
Anode pulse 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

Semi-transparent, head-on			
Material	bialkaline		
Useful diameter	>	68	mm
Radiant sensitivity characteristic	see Fig.5		
Maximum spectral sensitivity at	400 ± 30 nm		
Luminous sensitivity	≈	60	μA/lm
Blue sensitivity	typ.	9	μA/lmF
	min.	7,5	μA/lmF
Quantum efficiency at 400 nm	≈	23	%
Radiant sensitivity at 400 nm	≈	75	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.

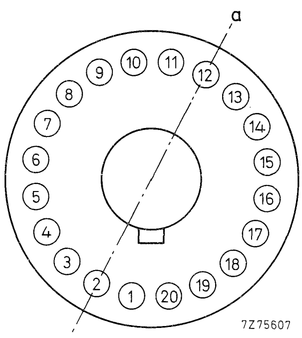


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

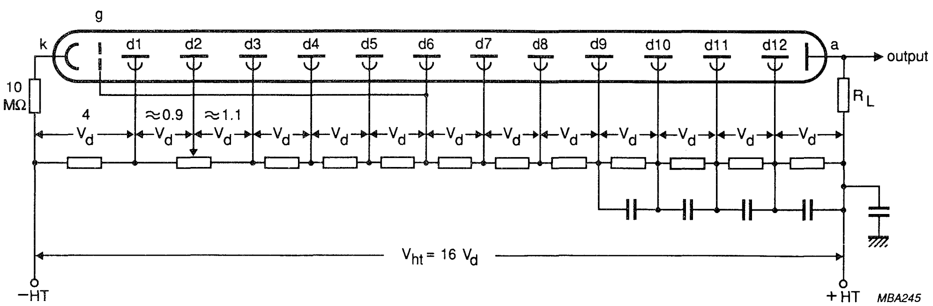


Fig. 2 Voltage divider A.

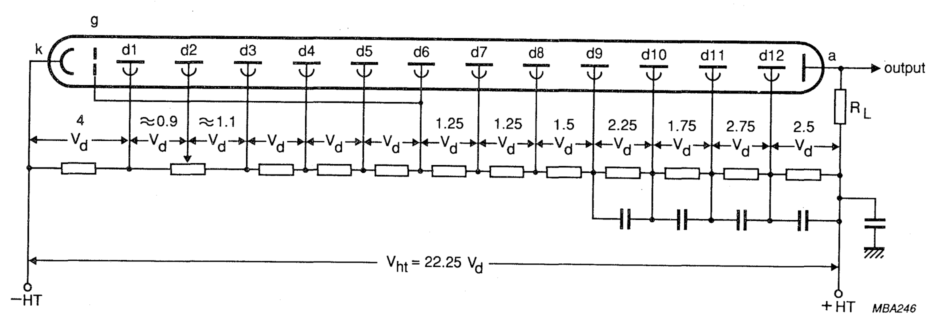


Fig. 3 Voltage divider B.

Typical value of capacitors: 1 nF; k = cathode; g = accelerating electrode; 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. 6)		typ. <	2000 V 2500 V	
Anode dark current at a gain of 3×10^7 (Fig. 6)		typ. <	25 nA 250 nA	3, 4
Background noise at a gain of 3×10^7 (Fig. 6)		≈	2000 c/s	5
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1,5 A/lmF		≈	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	

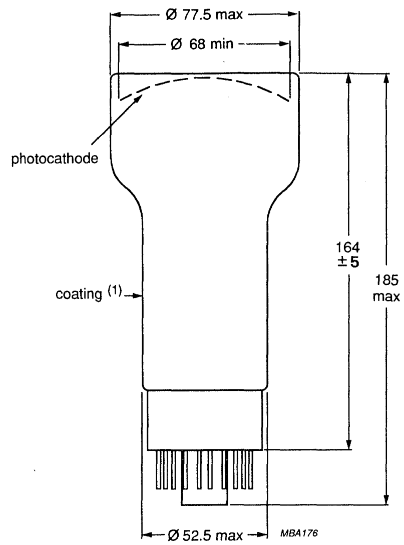
Notes

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 voltage 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 ratio between two successive stages is less than 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, noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only by insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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.
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 ≈ 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 reaches 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 to d11 and d12.
   See also *General Operational Recommendations Photomultiplier Tubes.*
8. 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 stress in the sealing layer of the base to the glass bulb. Where low temperature operation is contemplated, the supplier should be consulted.

MECHANICAL DATA

Dimensions in mm



Base	20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass	252 g

PIN CONNECTIONS

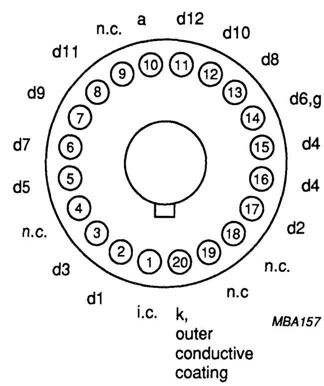


Fig.4.

(1) From serial number 1276 onwards, 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.

ACCESSORIES

Socket	type FE1120
Mu-metal shield	type 56639

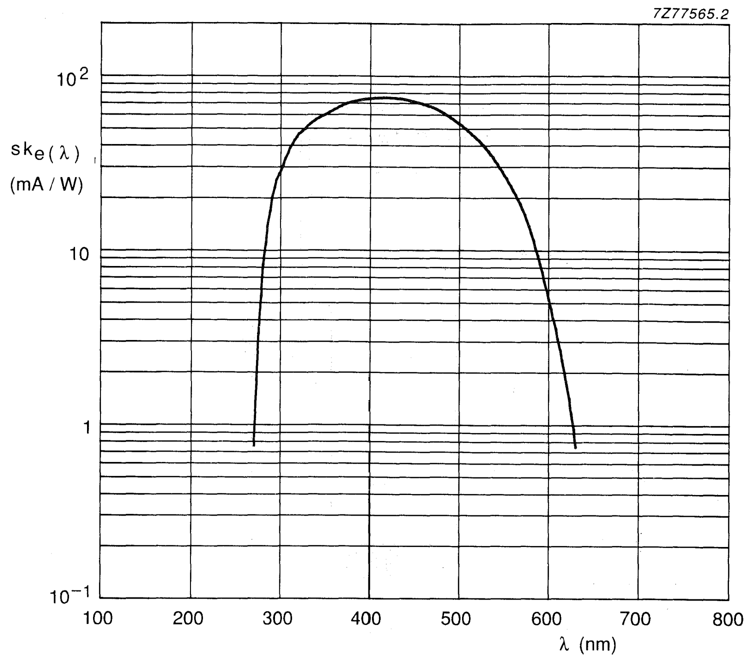


Fig. 5 Spectral sensitivity characteristic.

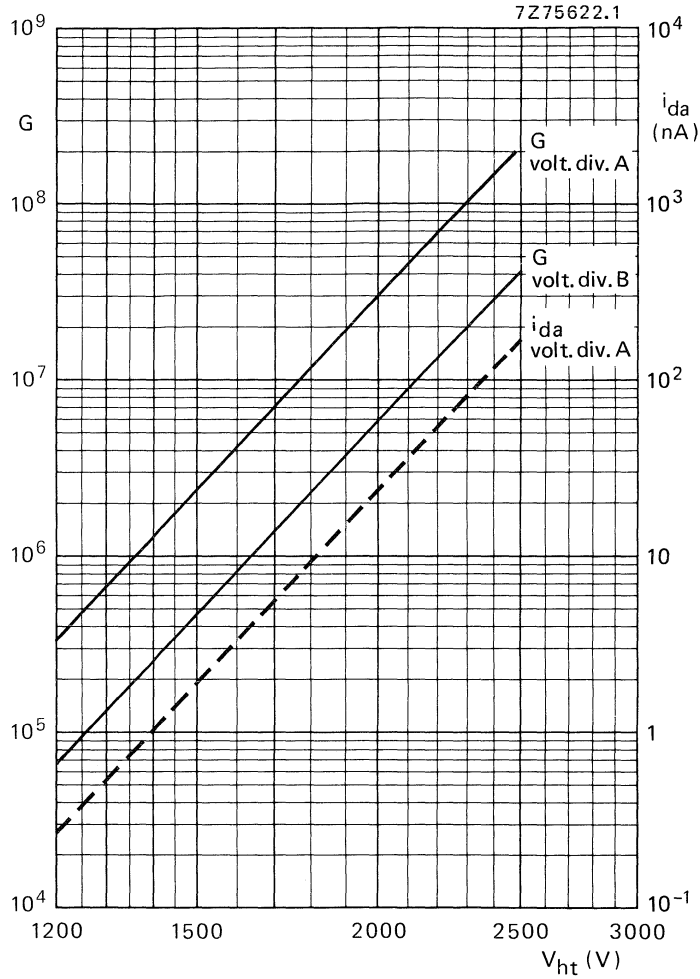


Fig. 6 Gain G, and anode dark current i_{da} as a function of the supply voltage V_{ht}.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBES

- 70 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline 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

Radiant sensitivity characteristic	bialkaline
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	1 nA
Pulse amplitude resolution (^{57}Co)	≈ 10%
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

		notes
Photocathode		2
Semi-transparent, head-on		
Material	bialkaline	
Useful diameter	> 70 mm	
Radiant sensitivity characteristic	see Fig.2	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 95 μA/lm	3
Blue sensitivity	typ. 13 μA/lmF > 10 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 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

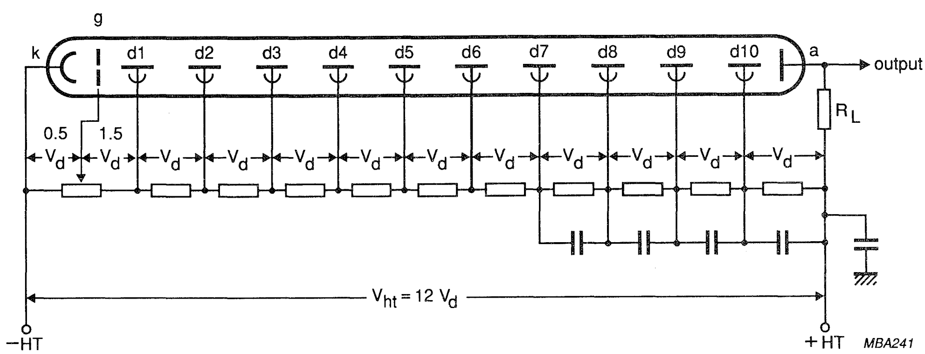


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

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)	max. 1400 V typ. 1250 V	1
Gain at V_{ht} = 1250 V	≈ 1.2×10^5	
Anode dark current at an anode blue sensitivity of 1.5 A/lmF (Fig. 5)	max. 20 nA typ. 1 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 photocatnode	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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 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. The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 ≈ 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. Or the voltage at which the tube has an anode blue sensitivity of 15 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.

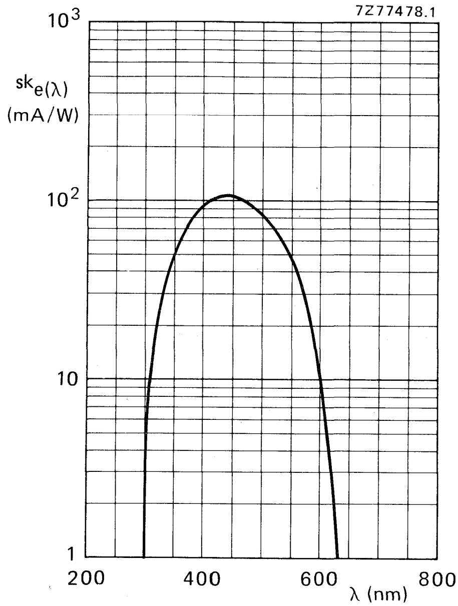


Fig.2 Radiant sensitivity characteristic.

MECHANICAL DATA

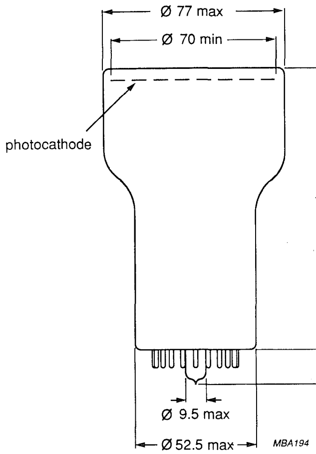


Fig. 3 XP2412.

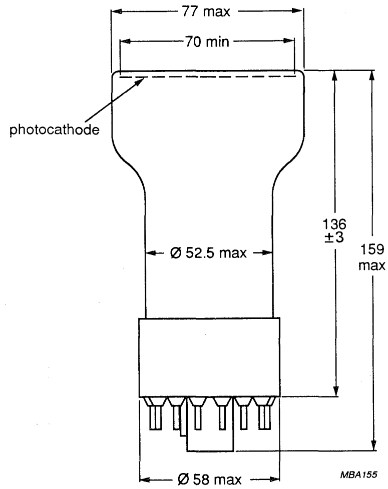
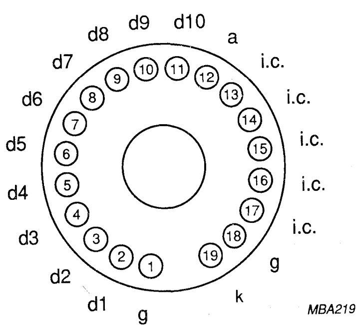


Fig. 4 XP2412B.

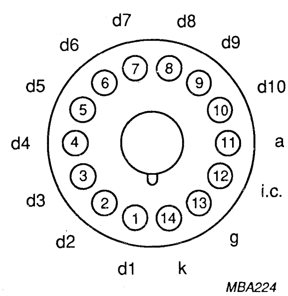
Base	19-pin all-glass
Net mass	163 g

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
Mu-metal shield	type 56639

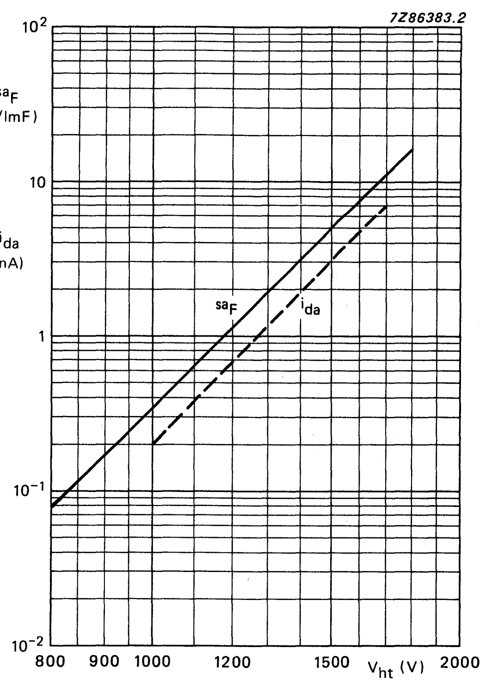


Fig. 5 Anode blue sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Product specification
date of issue	October 1989

XP2422B

High pulse height resolution, venetian blind, hexagonal 60 mm tube

APPLICATIONS

Principally for gamma cameras.

GENERAL CHARACTERISTICS

			NOTES
Window			
shape	hexagonal		
material	lime glass		
profile	plano – plano		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent head-on		
material	bialkaline		1
useful size between flats	min. 56	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 95	μA/lm	3
blue sensitivity	min. 9	μA/lmF	4
	typ. 12	μA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Multiplier			
structure	venetian blind		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 6.2		
capacitance anode to all	≈ 8.5	pF	

High pulse height resolution, venetian blind, hexagonal 60 mm tube

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OUTPUT CHARACTERISTICS

anode sensitivity 1.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1250	1400	V	
Anode dark current	–	1	20	nA	6,7
Gain x 10^3	–	≈ 130	–		
^{57}Co pulse amplitude resolution	–	8.9	9.2	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 0.5	–	%	
after change of count rate	–	≈ 0.5	–	%	
at a temperature between 0 and 40 °C at 400 nm	–	≈ 0.1	–	%/K	
Anode sensitivity deviation for a magnetic field of 0.05 mT	–	3	–	%	10
Anode current linear within 2% up to	–	≈ 10	–	mA	
Anode pulse rise time	–	≈ 10	–	ns	11
Anode pulse duration at half height	–	≈ 20	–	ns	11
Signal transit time	–	≈ 46	–	ns	11

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	15	A/lmF	12
Supply voltage	–	2000	V	
Continuous anode current	–	0.2	mA	13
Voltage between first dynode and photocathode	150	500	V	14
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	300	V	15
Ambient temperatures				16
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

High pulse height resolution, venetian blind, hexagonal 60 mm tube

XP2422B

RECOMMENDED CIRCUITS

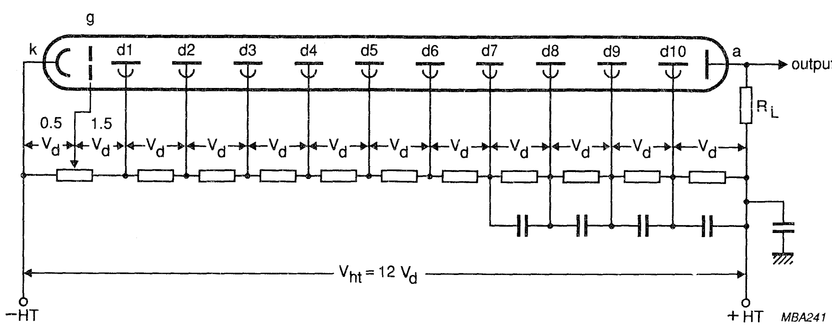


Fig.1 Voltage divider.

a = anode
dn = dynode number
g = accelerating electrode
k = cathode

Typical values of capacitors 1 nF.

High pulse height resolution, venetian blind, hexagonal 60 mm tube

XP2422B

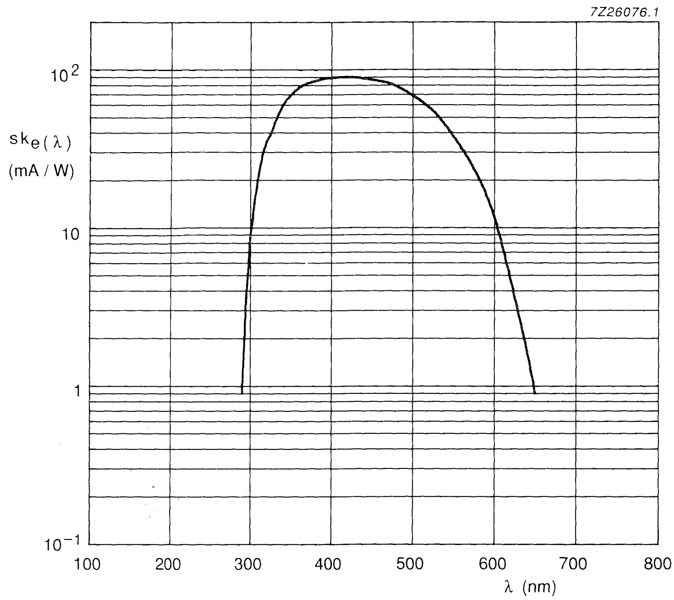


Fig.2 Cathode spectral characteristic.

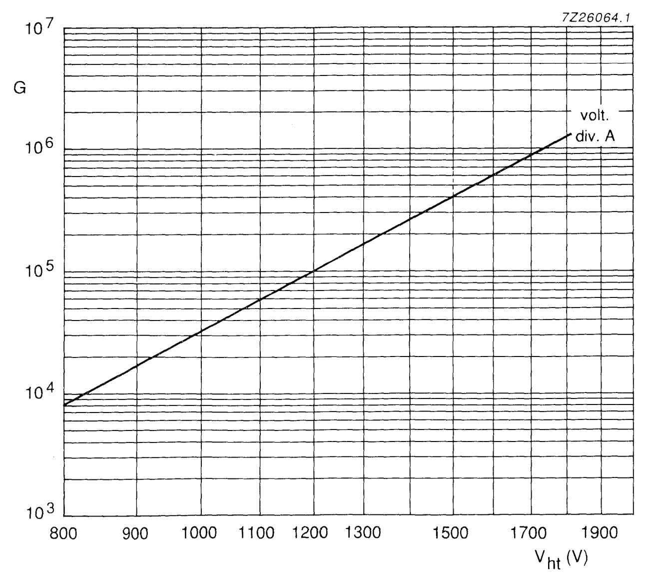


Fig.3 Gain as a function of supply voltage.

High pulse height resolution, venetian blind, hexagonal 60 mm tube

XP2422B

MECHANICAL DATA

Dimensions in mm

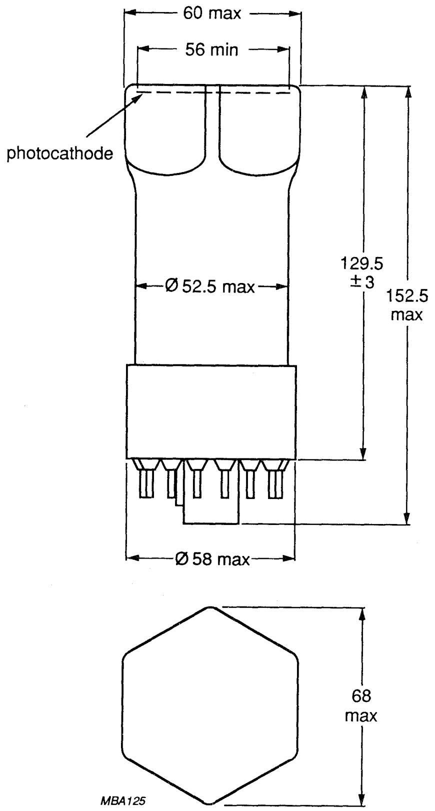
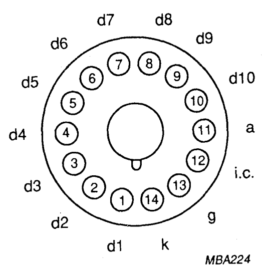


Fig.4 Mechanical outline.



i.c. = internally connected

Fig.5 Pin connections.

Base	14pin IEC67116a (JEDEC B14-38)
Net mass	191 g

ACCESSORIES

Socket	FE1014

High pulse height resolution, venetian blind, hexagonal 60 mm tube

XP2422B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in nonlinearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 558) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.5 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator with a diameter of 50 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSIN4291972 of IEEE recommendations.

10 It is recommended that the tube is screened from magnetic fields by a mumetal shield protruding at least 15 mm beyond the photocathode.

High pulse height resolution, venetian blind, hexagonal 60 mm tube

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11 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

12 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

13 A value less than 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 types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE VENETIAN BLIND PHOTOMULTIPLIER TUBE

- 56 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline 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

Radiant sensitivity characteristic	bi-alkaline
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	1 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	bi-alkaline	
Useful diameter	> 56 mm	
Radiant sensitivity characteristic	see Fig.2	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 95 μA/lm	3
Blue sensitivity	typ. 12 μA/lmF > 9,0 μA/lmF	1
Radiant 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

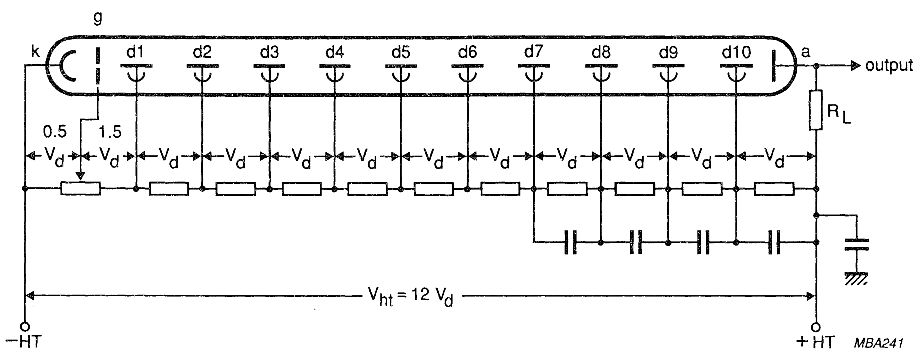


Fig. 1 Voltage divider A. Typical values of capacitors: 10 nF; k = cathode; g = accelerating electrode; dn = dynode no.; a = anode; R_L = load resistor.

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

With voltage divider A (Fig. 1)

		notes
With voltage divider A (Fig. 1)		5
Supply voltage for an anode blue sensitivity of 1,5 A/lmF (Fig.4)	max. 1400 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.4)	max. 20 nA typ. 1 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	max. 9,2% typ. 8,9%	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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.5×10^3 for this type of tube.
5. The power supply should be arranged such that the cathode is at earth potential and the anode is at + HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than $10^{15}\,\Omega$. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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. Or the voltage at which the tube has an anode blue sensitivity of 15 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. 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.

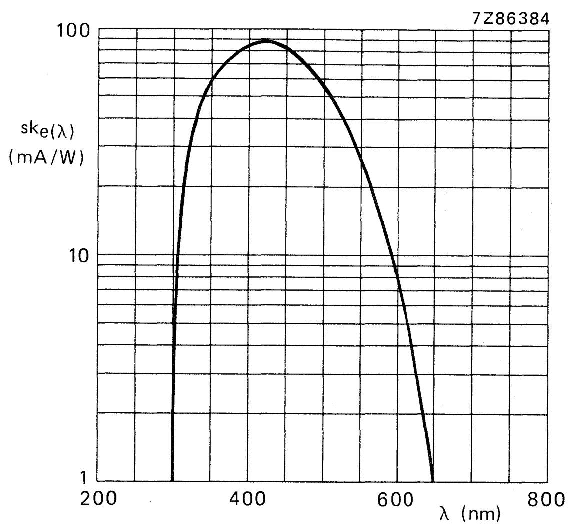
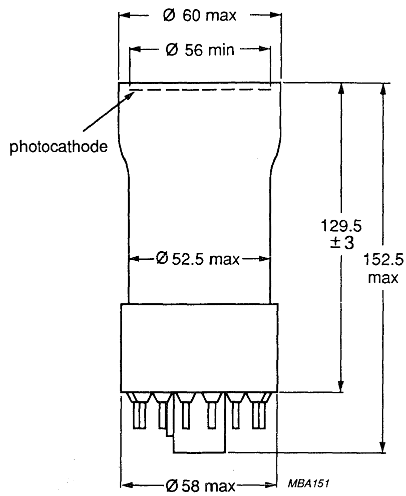


Fig. 2 Spectral sensitivity characteristic.

MECHANICAL DATA



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

PIN CONNECTIONS

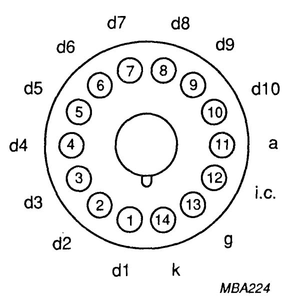


Fig. 3.

ACCESSORIES

Socket type FE1014

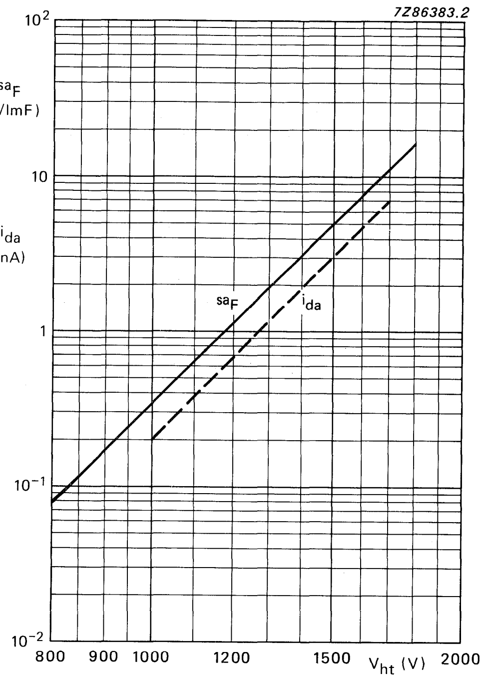


Fig. 4 Anode spectral sensitivity sa_F, and anode dark current i_{da} as a function of supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Product specification
date of issue	October 1989

XP2442B

High pulse height resolution, venetian blind, hexagonal 76 mm (3″) tube

APPLICATIONS

Principally for gamma-cameras.

GENERAL CHARACTERISTICS

			NOTES
Window			
shape	hexagonal		
material	lime glass		
profile	plano – plano		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful size between flats	min. 70	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 95	μA/lm	3
blue sensitivity	min. 9	μA/lmF	4
	typ. 12	μA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Multiplier			
structure	venetian blind		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 6.2		
capacitance anode to all	≈ 8.5	pF	

OUTPUT CHARACTERISTICS

anode sensitivity 1.5 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1250	1400	V	
Anode dark current	–	1	20	nA	6,7
Gain x 10^3	–	≈ 130	–		
^{57}Co pulse amplitude resolution	–	9.5	10	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 0.5	–	%	
after change of count rate	–	≈ 0.5	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.1	–	%/K	
Anode sensitivity deviation for a magnetic field of 0.05 mT	–	4	–	%	10
Anode current linear within 2% up to	–	≈ 10	–	mA	
Anode pulse rise time	–	≈ 10	–	ns	11
Anode pulse duration at half height	–	≈ 20	–	ns	11
Signal transit time	–	≈ 46	–	ns	11

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	15	A/lmF	12
Supply voltage	–	2000	V	
Continuous anode current	–	0.2	mA	13
Voltage between first dynode and photocathode	150	500	V	14
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	300	V	15
Ambient temperatures				16
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

High pulse height resolution, venetian blind, hexagonal 76 mm (3″) tube

XP2442B

RECOMMENDED CIRCUITS

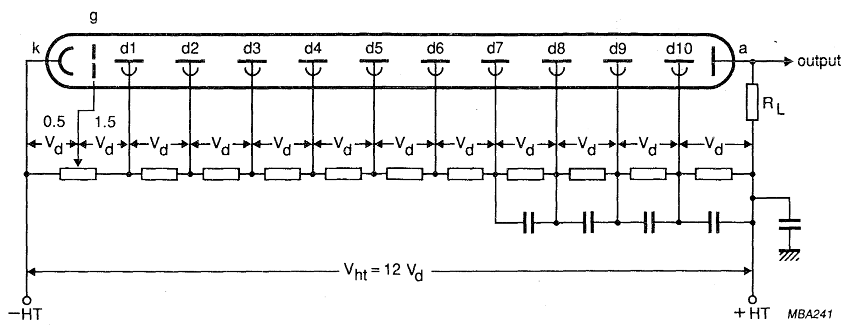


Fig.1 Voltage divider.

a = anode
dn = dynode number
g = accelerating electrode
k = cathode

Typical values of capacitors 1 nF.

High pulse height resolution, venetian blind, hexagonal 76 mm (3″) tube

XP2442B

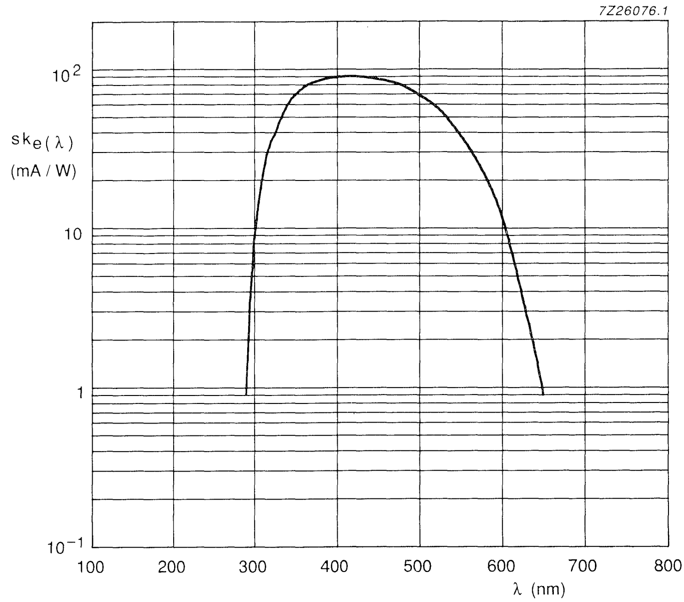


Fig.2 Cathode spectral characteristic.

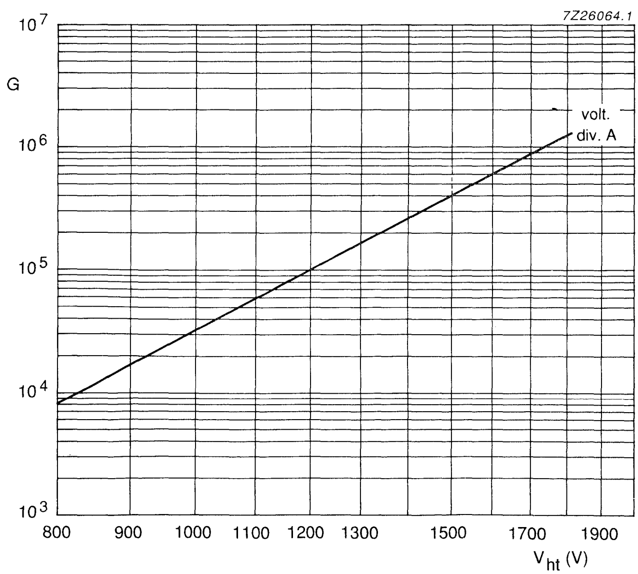


Fig.3 Gain as a function of supply voltage.

High pulse height resolution, venetian blind, hexagonal 76 mm (3″) tube

XP2442B

MECHANICAL DATA

Dimensions in mm

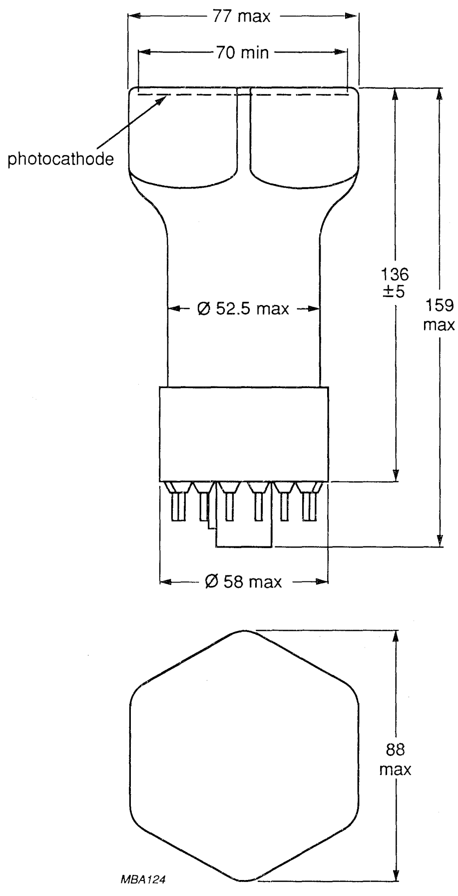
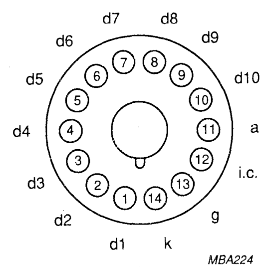


Fig.4 Mechanical outline.



i.c. = internally connected

Fig.5 Pin connections.

Base	14-pin IEC67-1-16a (JEDEC B14-38)
Net mass	228 g

ACCESSORIES

Socket	FE1014

High pulse height resolution, venetian blind, hexagonal 76 mm (3″) tube

XP2442B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.5 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator with a diameter of 75 mm and a height of 75 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

12 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

13 A value less than 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 types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

8-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bi-alkaline
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	bi-alkaline	
Useful diameter	> 23 mm	
Radiant sensitivity characteristic	see Fig.5	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 90 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 85 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.

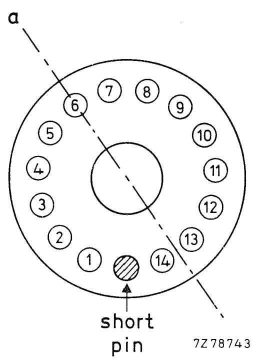


Fig. 1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

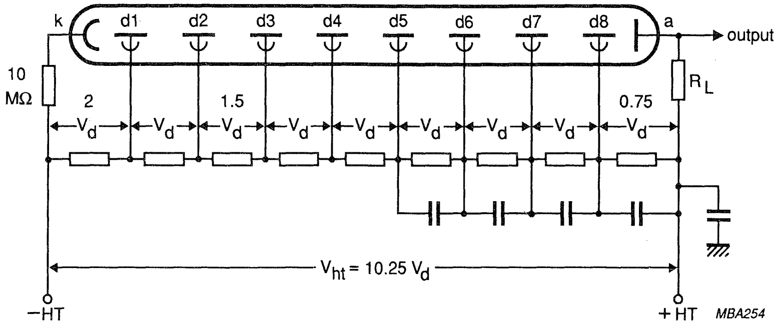


Fig. 2 Voltage divider A.

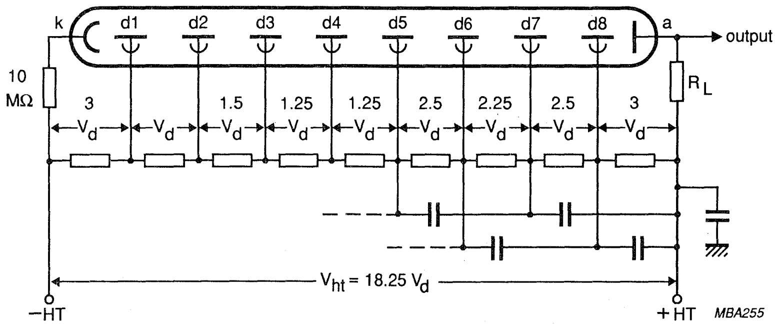


Fig. 3 Voltage divider B.

Typical value of capacitors: 1 nF

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

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	

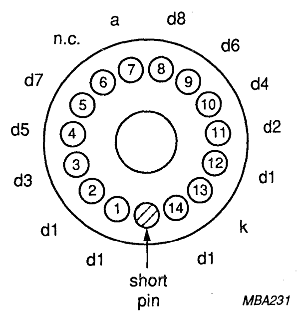
LIMITING VALUES (Absolute maximum rating system)

		notes
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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.9×10^3 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 $> 10^{15}\ \Omega$. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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



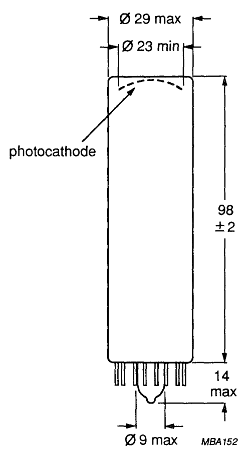


Fig. 4.

Base	14-pin all-glass
Net mass	34 g

ACCESSORIES

Socket	type FE1114
Mu-metal shield	type 56699

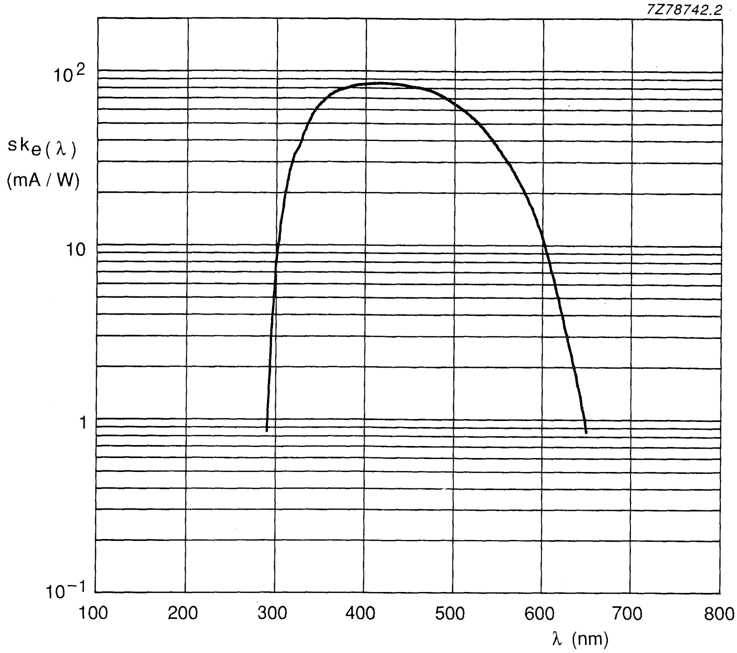


Fig. 5 Spectral sensitivity characteristic.

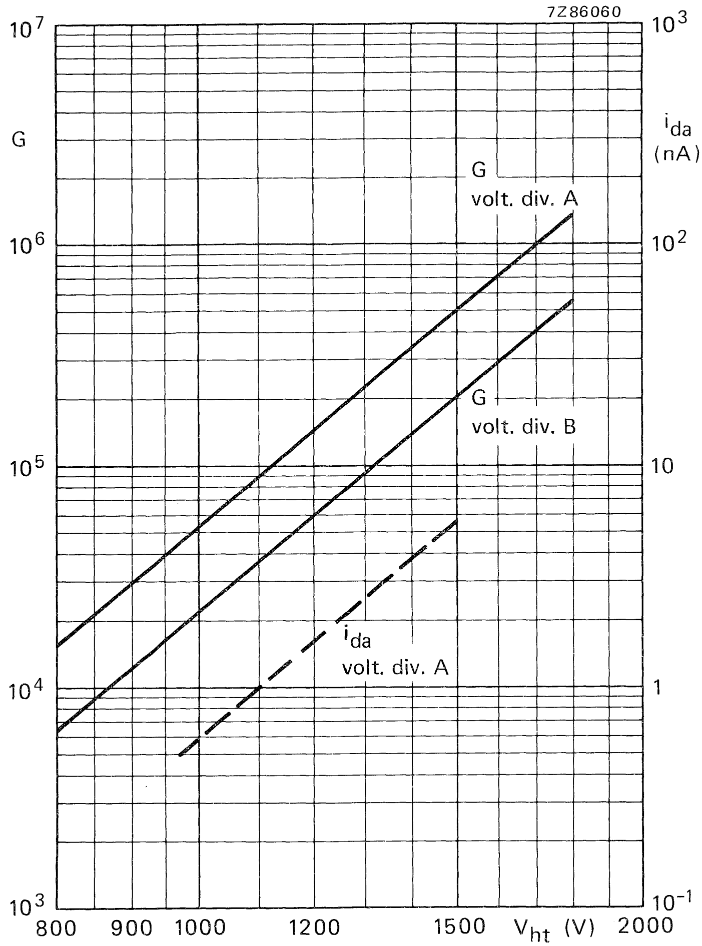


Fig. 6 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

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 photocathode
- Very good time characteristics
- For industrial applications, e.g. laser reading

QUICK REFERENCE DATA

Radiant sensitivity characteristic	S20
Useful diameter of the photocathode	> 23 mm
Radiant 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	tri-alkaline	
Useful diameter	> 23 mm	
Radiant sensitivity characteristic	S20, see Fig.4	
Maximum radiant sensitivity	420 ± 30 nm	
Luminous sensitivity	≈ 200 μA/lm	1
Radiant sensitivity at 700 nm	typ. 20 mA/W > 10 mA/W	2
Radiant 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.

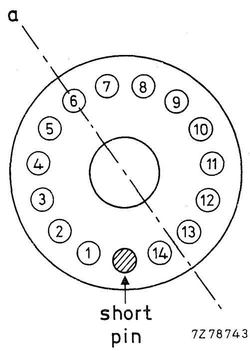


Fig. 1 Axis with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

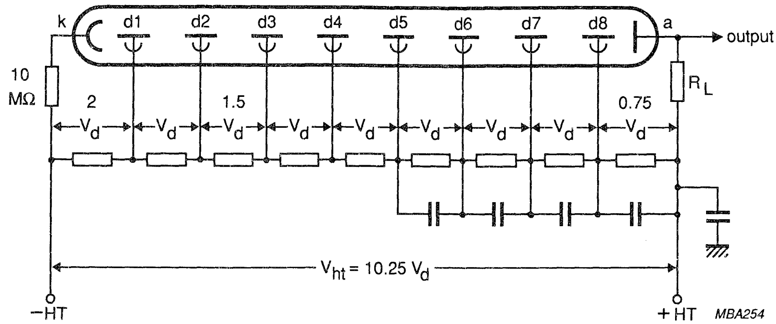


Fig. 2 Voltage divider A.

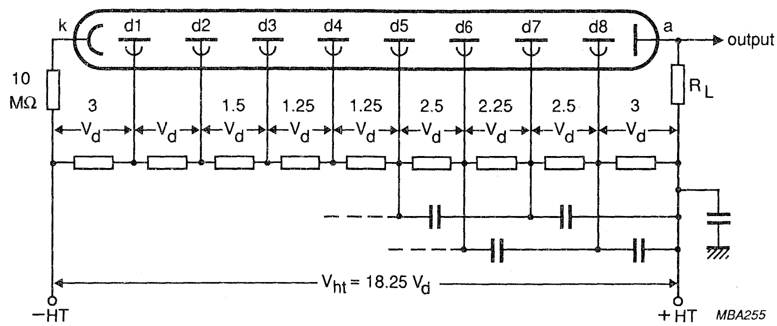


Fig. 3 Voltage divider B.

Typical value of capacitors: 1 nF

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

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. Radiant 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 $> 10^{15}\,\Omega$. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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 μA 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.

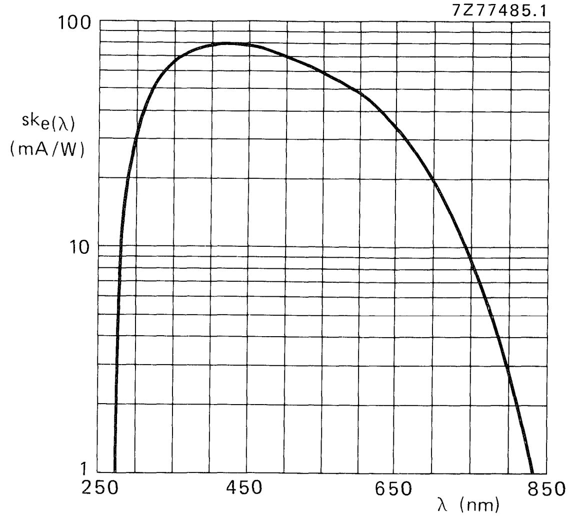


Fig. 4 Spectral sensitivity characteristic.

MECHANICAL DATA

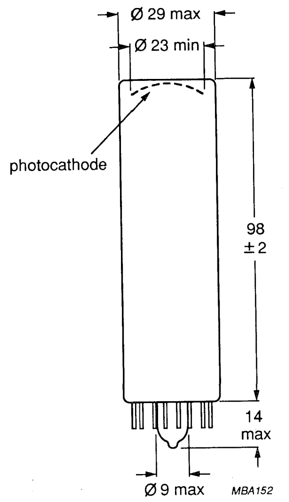
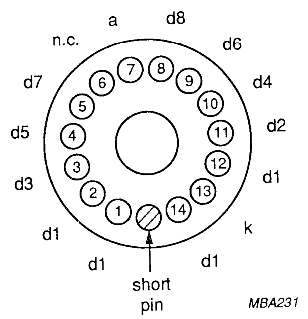


Fig. 5

Base	14-pin all-glass
Net mass	32 g

PIN CONNECTIONS



ACCESSORIES

Socket	type FE1114
Mu-metal shield	type 56699

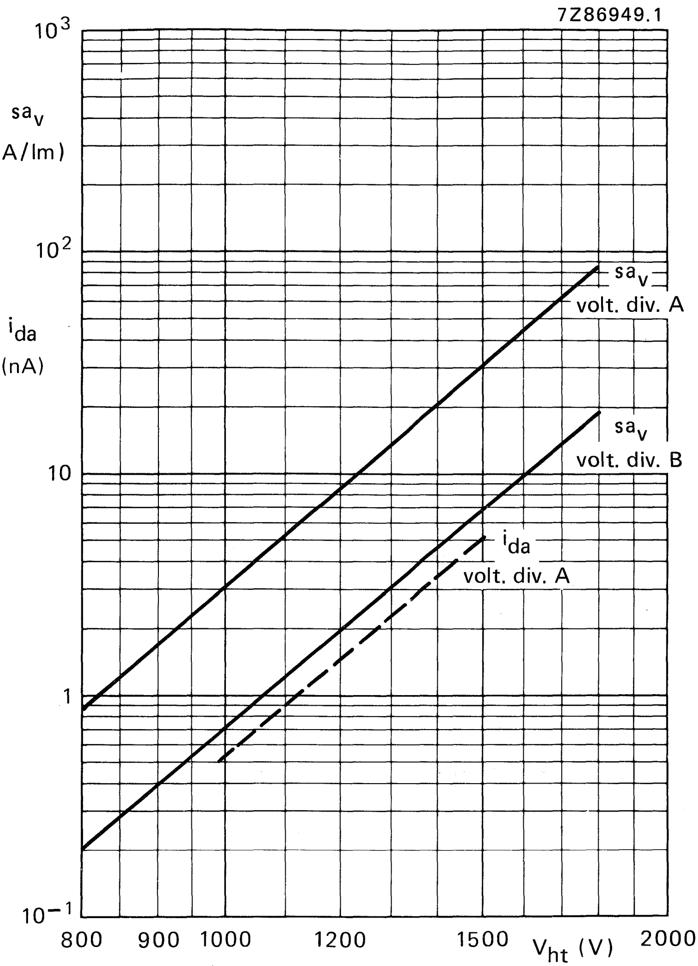


Fig. 6 Anode luminous sensitivity sa_V and anode dark current i_{da} as a function of the supply voltage V_{ht}; i_{da} is given as a dotted line to indicate its principle behaviour only.

10-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bi-alkaline
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	bi-alkaline	
Useful diameter	> 23 mm	
Radiant sensitivity characteristic	see Fig.5	
Wavelength for maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 90 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 85 mA/W	4

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

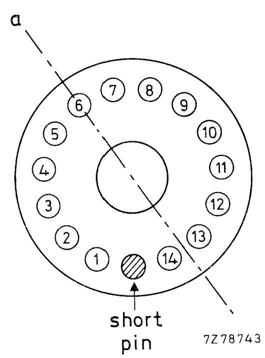


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

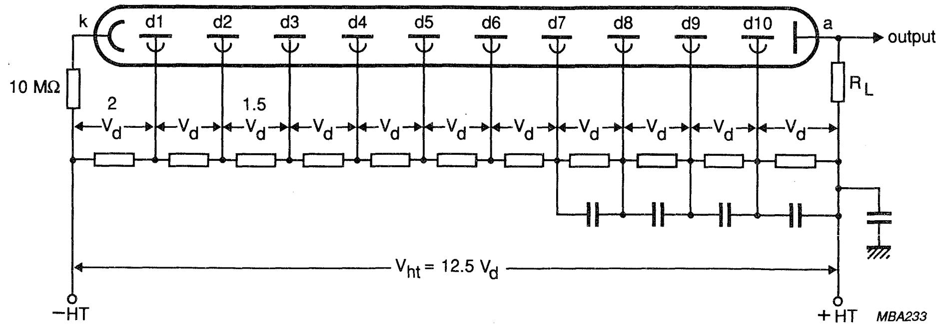


Fig. 2 Voltage divider A.

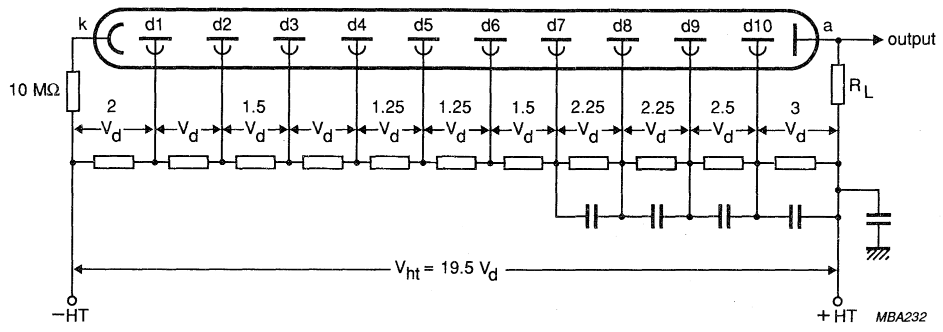


Fig. 3 Voltage divider B.

Typical value of capacitors: 1 nF

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

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)	≈ $0{,}9 \times 10^6$	
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)	≈ 3×10^6	
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)

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 7.9×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.
6. The power supply should be arranged such that the cathode is at earth potential and the anode is at + HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than $10^{15}\,\Omega$. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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. 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

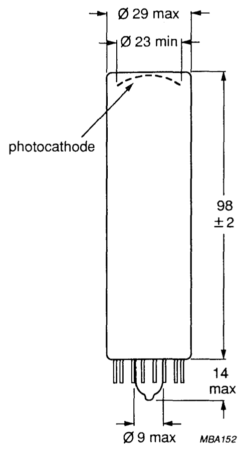
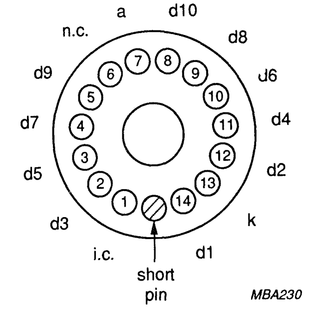


Fig. 4.

Base	14-pin all-glass
Net mass	34 g

PIN CONNECTIONS



i.c. = internally connected
n.c. = not connected

ACCESSORIES

Socket	type FE1114
Mu-metal shield	type 56699

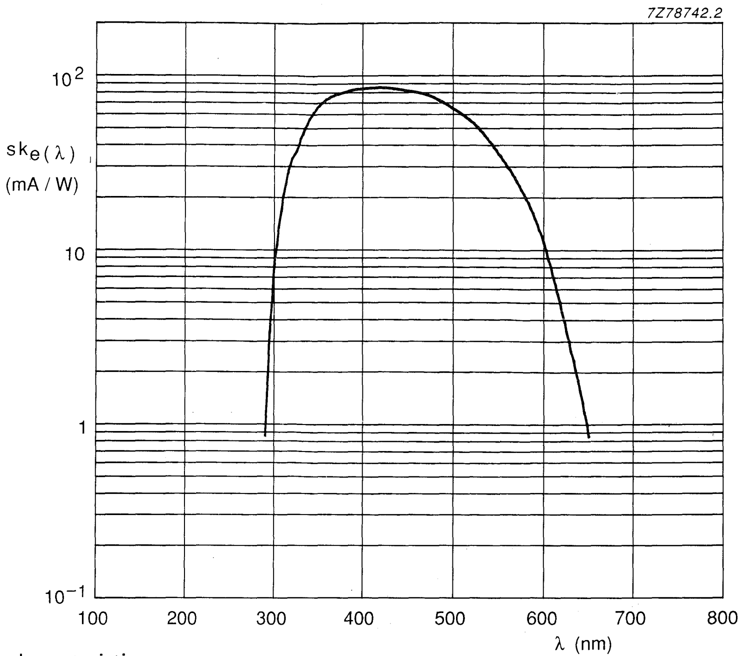


Fig. 5 Spectral sensitivity characteristic.

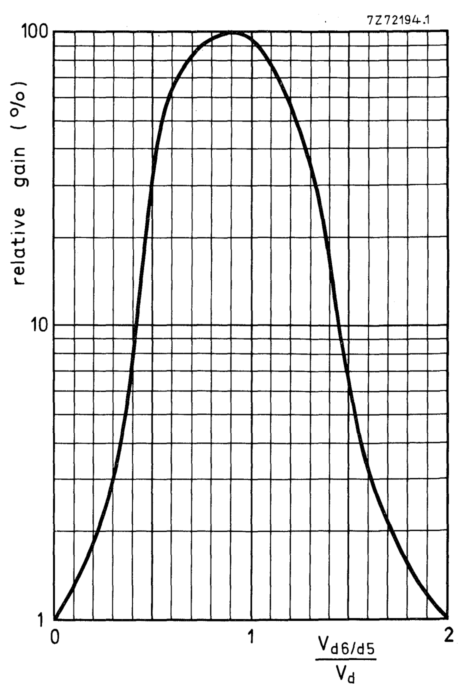


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

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

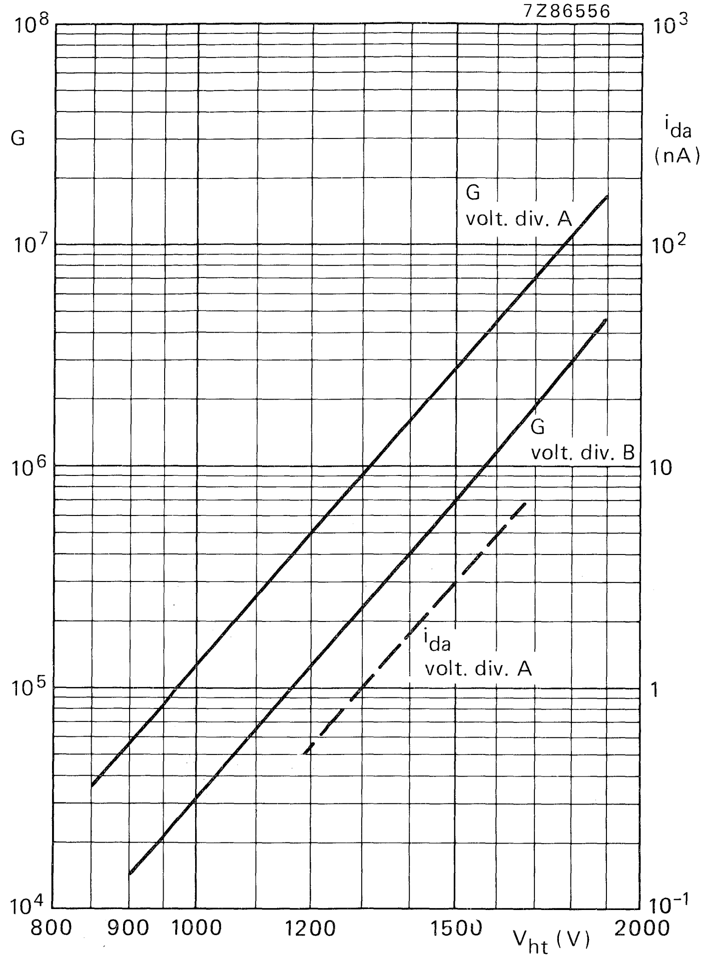


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP2978

Fast, UV sensitive 29 mm (1 1/8″) diameter tube

APPLICATIONS

Scintillating counting with BaF2, UV photometry.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	fused silica		
profile	plano – concave		
refractive index at 250 nm	1.50		
refractive index at 400 nm	1.47		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 23	mm	
spectral range	150 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 90	µA/lm	3
blue sensitivity	min. 8	µA/lmF	4
	typ. 10.5	µA/lmF	4
radiant sensitivity at 400 nm	≈ 80	mA/W	5
Multiplier			
structure	linear focused		
number of stages	10		
slope: log(gain)/log(supply voltage)	≈ 7.5		
capacitance anode to all	≈ 4	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, anode blue sensitivity 10 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1300	1600	V	
Anode dark current	–	1	20	nA	6,7
Gain x 10^3	–	≈ 950	–		
^{137}Cs pulse amplitude resolution	–	7.8	–	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 2	–	%	
after change of count rate	–	≈ 2	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.4	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n'	–	≈ 0.4	–	mT	11
parallel to axis "n"	–	≈ 0.2	–	mT	11

see note 12

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	1500	1800	–	V	
Gain x 10^3	≈ 3000	≈ 3000	–		
Anode current linear within 2% up to	≈ 30	≈ 80	–	mA	
Anode pulse rise time	≈ 2.1	≈ 1.9	–	ns	13
Anode pulse duration at half height	≈ 3.5	≈ 3	–	ns	13
Signal transit time	≈ 23	≈ 23	–	ns	13
Transit time difference between centre of cathode and 11 mm from it	–	≈ 0.8	–	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	100	A/lmF	14
Supply voltage	–	1900	V	
Continuous anode current	–	0.2	mA	15
Voltage between first dynode and photocathode	150	350	V	16
Voltage between consecutive dynodes	–	250	V	
Voltage between anode and last dynode	30	300	V	17
Ambient temperatures				18
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

RECOMMENDED CIRCUITS

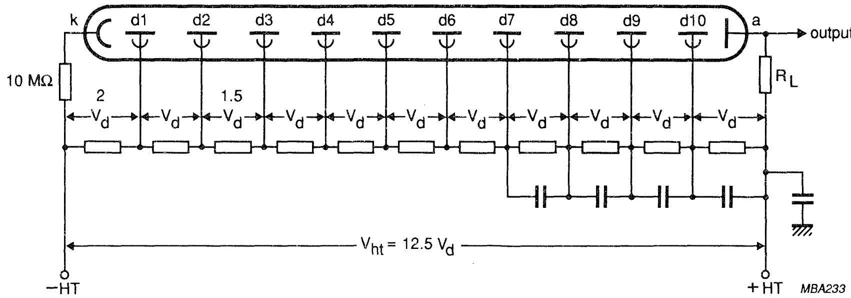


Fig.1 Voltage divider A.

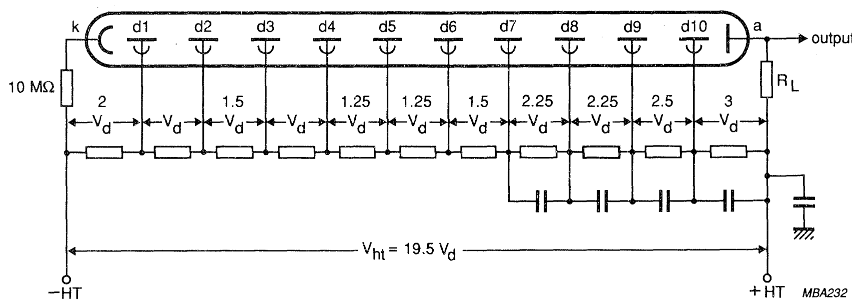


Fig.2 Voltage divider B.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

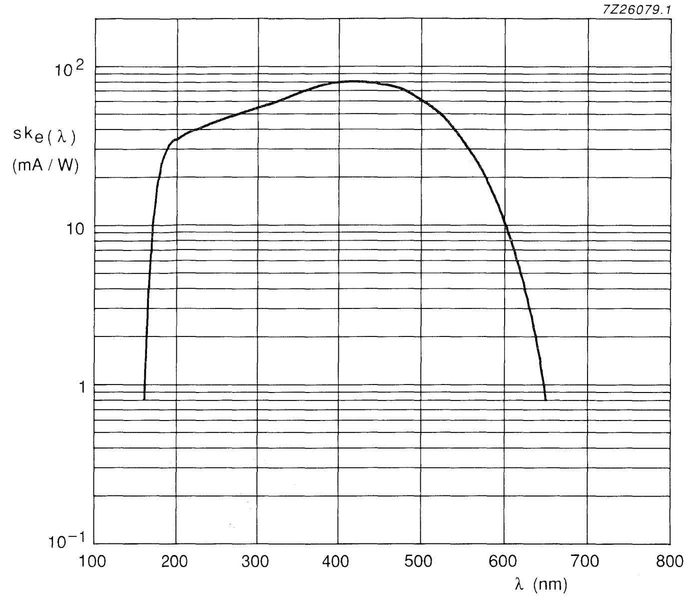


Fig.3 Cathode spectral characteristic.

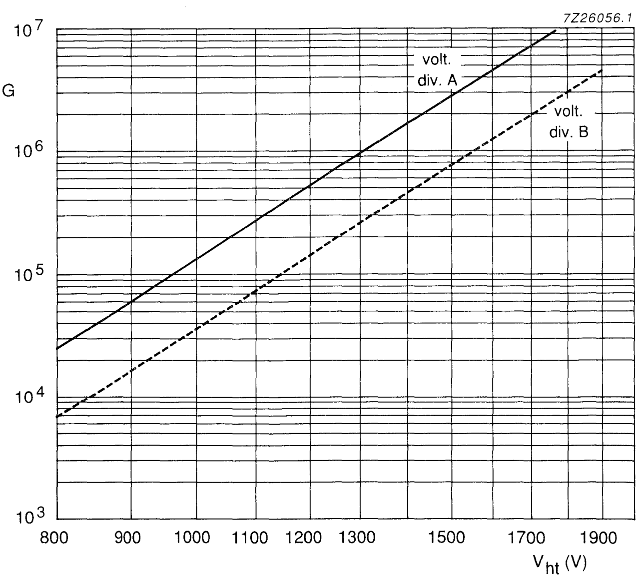


Fig.4 Gain as a function of supply voltage

Fast, UV sensitive 29 mm (1 1/8″) diameter tube XP2978

MECHANICAL DATA

Dimensions in mm

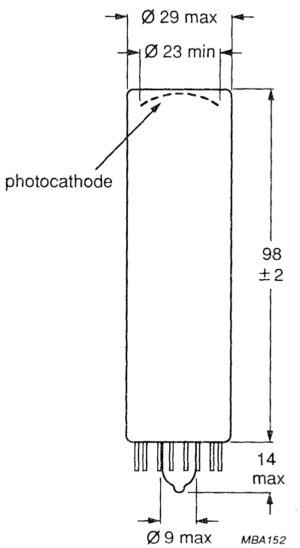
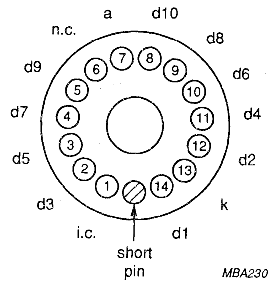


Fig.5 Mechanical outline



i.c. = internally connected
n.c. = not connected

Fig.6 Pin connections.

Base 14-pin all glass
Net mass 34 g

ACCESSORIES

Socket	FE1112
Mu-metal shield	56699

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity, expressed in μA/lmF, is measured with a tungsten 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.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.6 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs is measured with an NaI(Tl) cylindrical scintillator with a diameter of 22 mm and a height of 6 mm. The count rate used is approximately 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base on pin 6.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than 2.

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

14 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.4 times the voltage indicated on the test ticket of the tube.

15 A value less than 10 μA is recommended for applications requiring good stability.

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

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

18 For types with a plastic base this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

11-STAGE PHOTOMULTIPLIER TUBE

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

QUICK REFERENCE DATA

Radiant sensitivity characteristic	bi-alkaline
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	bi-alkaline	
Useful diameter	> 23 mm	
Radiant sensitivity characteristic	see Fig.5	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 70 μA/lm	3
Blue sensitivity	typ. 10,8 μA/lmF > 8,0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 85 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.

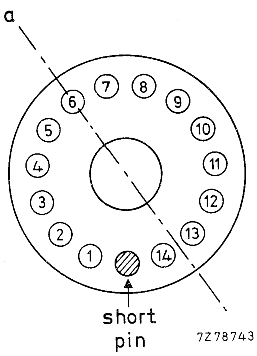


Fig. 1 Axis a with respect to base pins (bottom view).

RECOMMENDED CIRCUITS

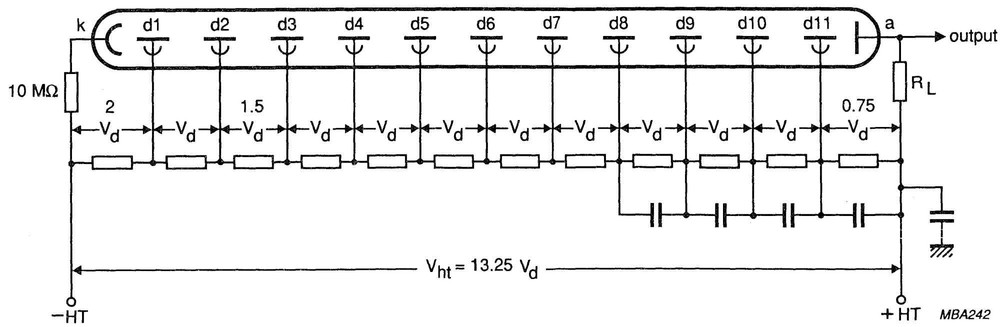


Fig. 2 Voltage divider A.

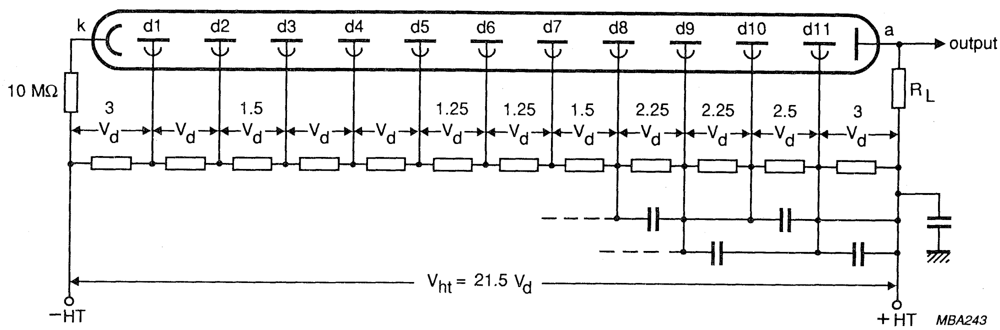


Fig. 3 Voltage divider B.

DEVELOPMENT SAMPLE DATA

Typical value of capacitors: 1 nF

k = cathode
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

			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	

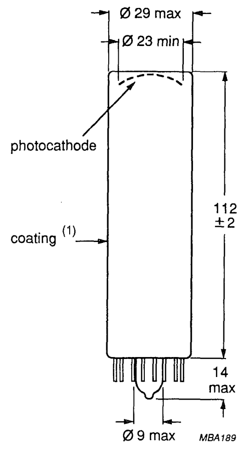
LIMITING VALUES (Absolute maximum rating system)

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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.9×10^3 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 reaches 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. 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



Base 14-pin all-glass
Net mass 37 g

PIN CONNECTIONS

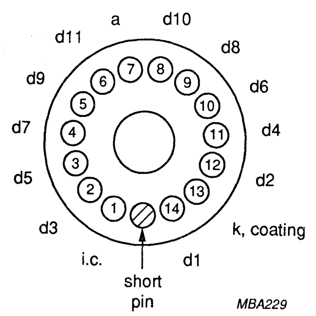


Fig. 4.

ACCESSORIES

Socket	type FE1114
Mu-metal shield	type 56699

(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.

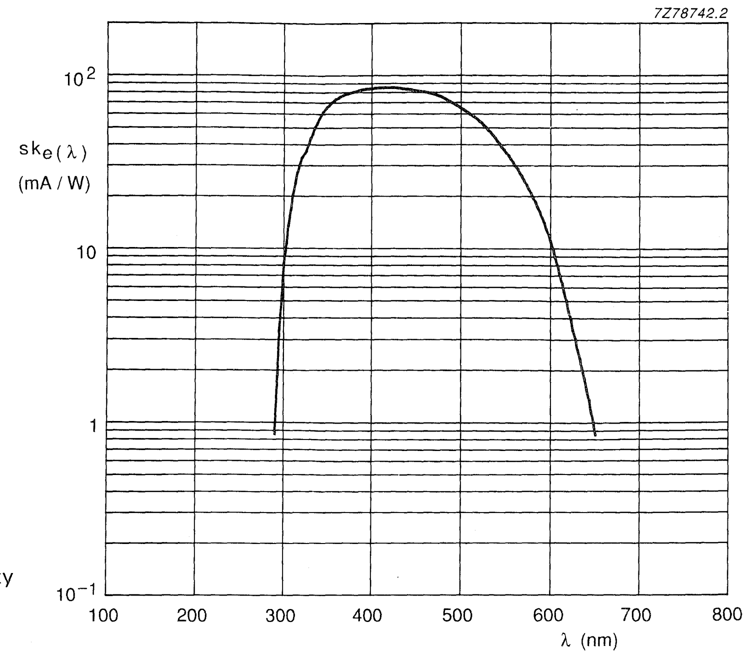


Fig. 5 Spectral sensitivity characteristic.

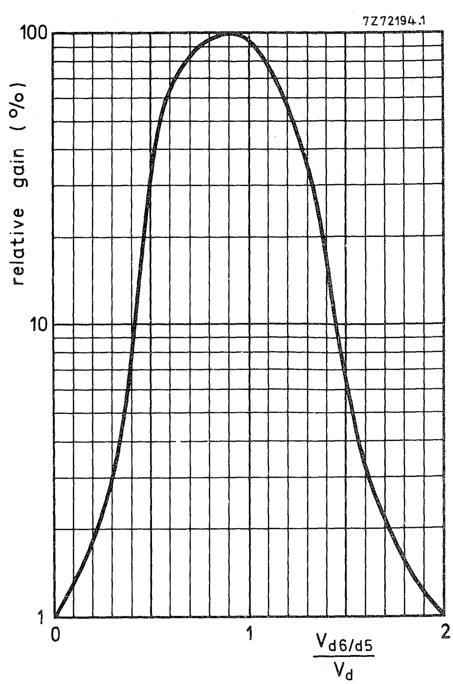


Fig. 6 Relative gain as a function of the voltage between d6 and d5, normalized to V_d; $V_{d7/d5}$ constant.

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

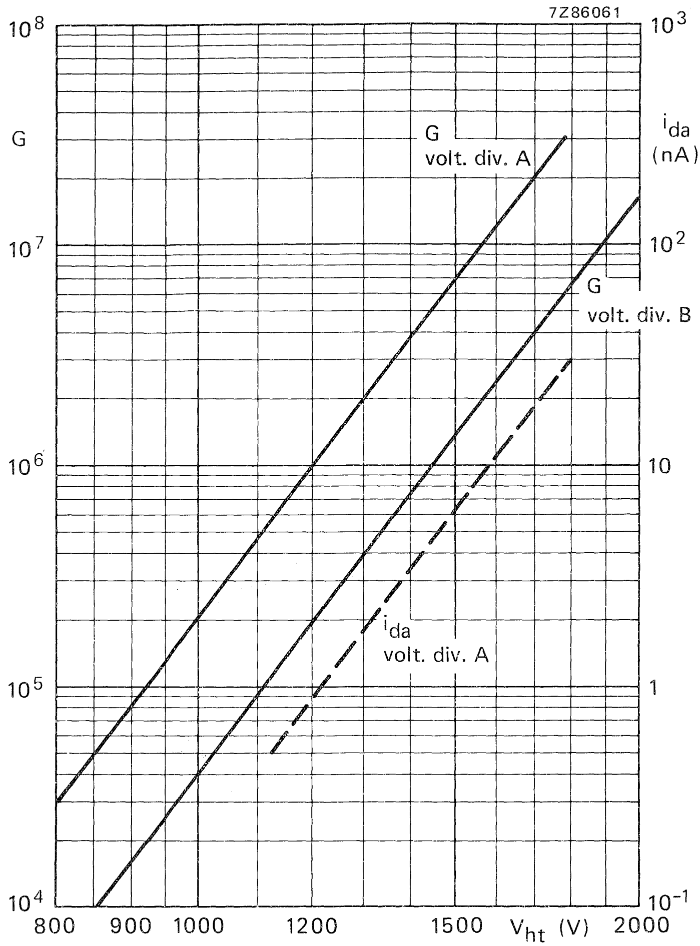


Fig. 7 Gain G and anode dark current i_{da} as a function of the supply voltage V_{ht}.

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

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP3062
High pulse amplitude resolution, 8-stage, hexagonal, 38 mm (1.5") tube

APPLICATIONS

Principally for small gamma-camera heads (e.g. heart cameras).

GENERAL CHARACTERISTICS

			NOTES
Window			
shape	hexagonal		
material	lime glass		
profile	plano – plano		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful size between flats	min. 35	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 90	μA/lm	3
blue sensitivity	min. 9	μA/lmF	4
	typ. 11.5	μA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	8		
slope: log(gain)/log(supply voltage)	≈ 5.8		
capacitance anode to all	≈ 5	pF	

High pulse amplitude resolution, 8-stage, hexagonal, 38 mm (1.5″) tube

XP3062

OUTPUT CHARACTERISTICS

anode blue sensitivity 3 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1100	1400	V	
Anode dark current	–	1	20	nA	6,7
Gain x 10^3	–	≈ 260	–		
^{57}Co pulse amplitude resolution	–	12	12.5	%	8
^{55}Fe pulse amplitude resolution	–	≈ 38	–	%	9
^{55}Fe peak to valley ratio	–	≈ 30	–		
Mean anode sensitivity deviation long term (16 hours) after change of count rate at a temperature between 0 and 40 °C at 400 nm	 – – –	 ≈ 1.5 ≈ 1 ≈ 0.2	 – – –	 % % %/K	10
Anode sensitivity deviation for a magnetic field of 0.05 mT	–	10	–	%	11
Anode current linear within 2% up to	–	≈ 100	–	mA	
Anode pulse rise time	–	≈ 3	–	ns	12
Anode pulse duration at half height	–	≈ 4.5	–	ns	12
Signal transit time	–	≈ 30	–	ns	12

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	15	A/lmF	13
Supply voltage	–	1600	V	
Continuous anode current	–	0.2	mA	14
Voltage between first dynode and photocathode	150	500	V	15
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	30	300	V	16
Ambient temperatures short operation (30 min. maximum) continuous operation and storage	 –30 –30	 80 50	 °C °C	17

RECOMMENDED CIRCUITS

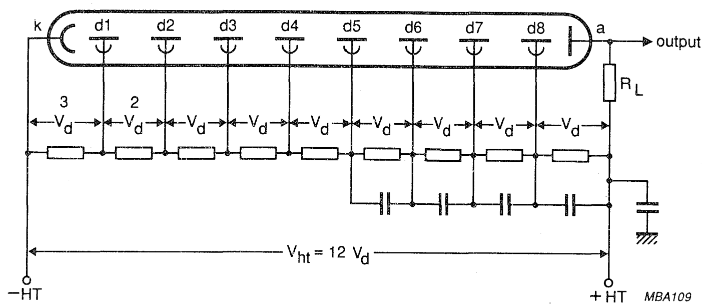


Fig.1 Voltage divider.

a = anode
dn = dynode number
k = cathode

Typical values of capacitors 1 nF.

High pulse amplitude resolution, 8-stage, hexagonal, 38 mm (1.5″) tube

XP3062

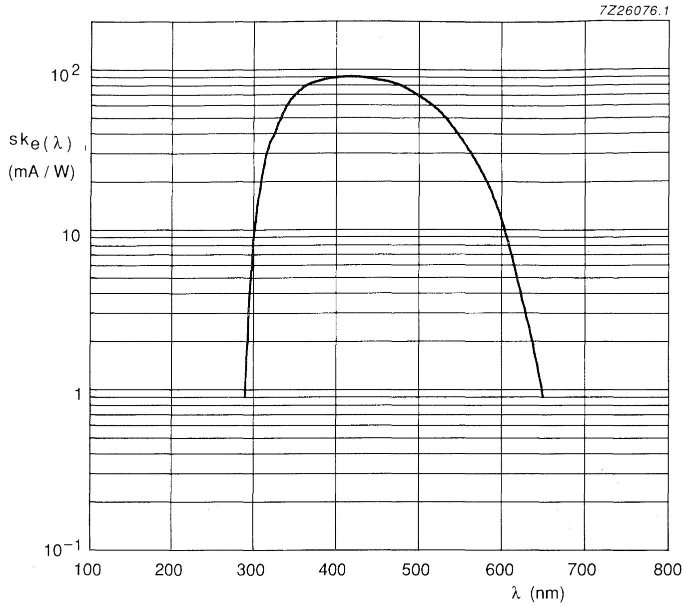


Fig.2 Cathode spectral sensitivity.

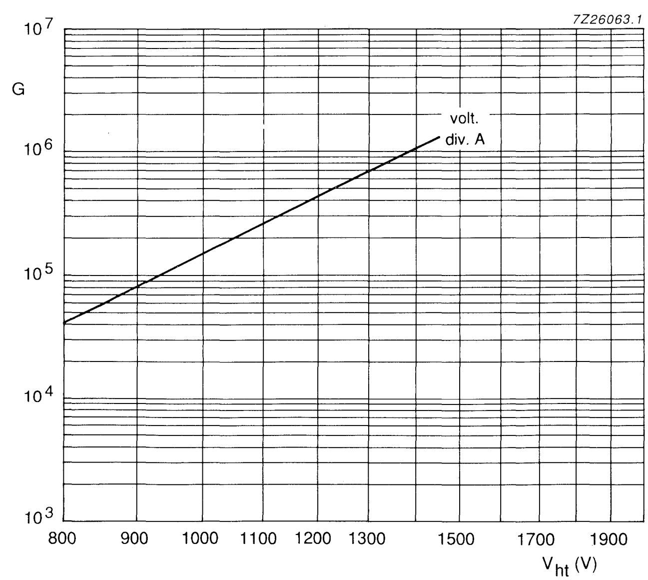


Fig.3 Gain as a function of supply voltage.

High pulse amplitude resolution, 8-stage, hexagonal, 38 mm (1.5″) tube

XP3062

MECHANICAL DATA

Dimensions in mm

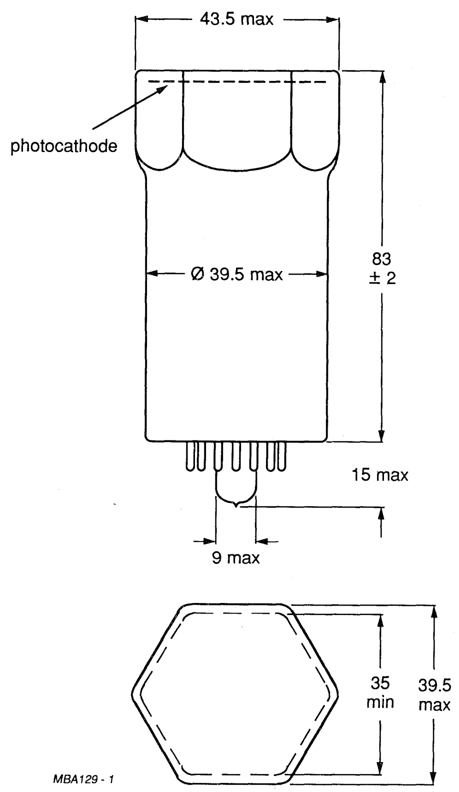


Fig.4 Mechanical outline.

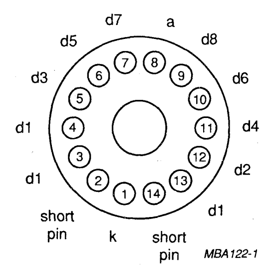


Fig.5 Pin connections.

Base	14-pin all glass
Net mass	50 g

ACCESSORIES

Socket	FE1112

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at –30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.8 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than $10^{15}\ \Omega$. If a metal shield is used, it should be kept at the cathode potential.

8 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 ≈ 10^4 counts per second.

9 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.

10 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

12 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

8-STAGE PHOTOMULTIPLIER TUBE

- 44 mm useful diameter head-on type
- Flat window
- Semi-transparent bi-alkaline 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

Radiant sensitivity characteristic	bi-alkaline
Useful diameter of the photocathode	> 46 mm
Cathode blue sensitivity	11.8 μA/lmF
Supply voltage for anode blue sensitivity = 3 A/lmF	1150 V
Anode dark current at anode blue sensitivity = 3 A/lmF	1 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

		notes
Window		
Material	lime glass	
Shape	plano-plano	
Refractive index at 400 nm	1.54	
Photocathode		2
Semi-transparent, head-on		
Material	bi-alkaline	
Useful diameter	> 46 mm	
Radiant sensitivity characteristic	see Fig.4	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 95 μA/lm	3
Blue sensitivity	typ. 11.8 μA/lmF > 9.0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 90 mA/W	4

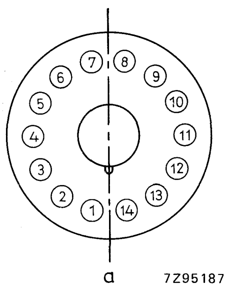
Multiplier system

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.



XP3102B.

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

RECOMMENDED CIRCUITS

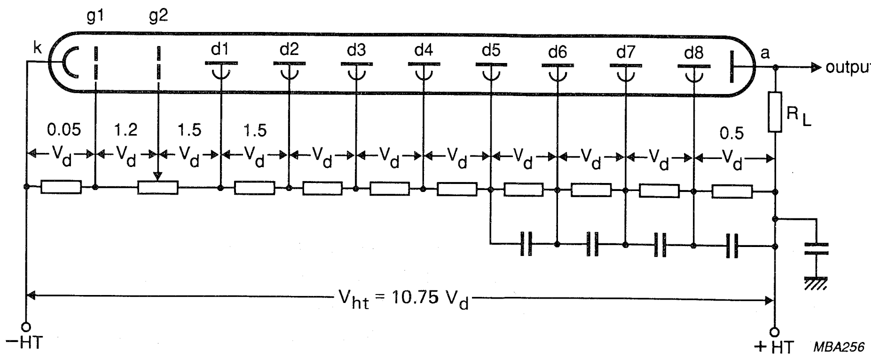


Fig. 2 Voltage divider A.

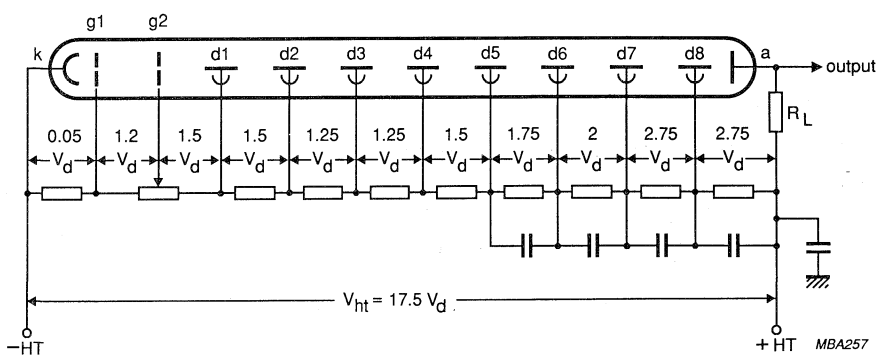


Fig. 3 Voltage divider B.

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 3 A/lmF (Fig.6)	max. 1300 V typ. 1150 V	1
Gain at V_{ht} = 1150 V	≈ 2.5×10^5	
Anode dark current at an anode blue sensitivity of 3 A/lmF (Fig.6)	min. 20 nA typ. 1 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 3 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 3 A/lmF	max. 9.5% typ. 9.1%	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} = 1400 V	≈ 4 A/lmF	
Anode current linear within 2% at V_{ht} = 1400 V	up to ≈ 150 mA	

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max. 1500 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	

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. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.6×10^3 for this type of tube.
5. The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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. Or the voltage at which the tube has an anode blue sensitivity of 7.5 A/lmF, (voltage for 3 A/lmF given on the test certificate, multiplied by 1.2), 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 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 with 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.

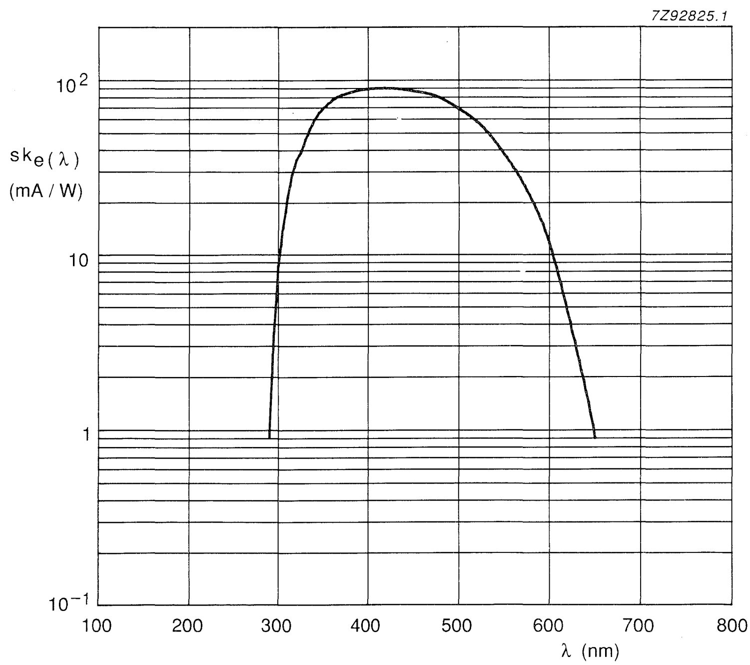
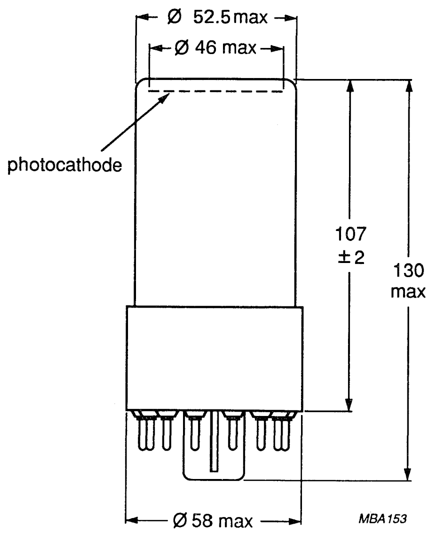


Fig. 4 Radiant sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm



Base	14-pin IEC67-1-16a (JEDEC B14-38)
Net mass	145 g

PIN CONNECTIONS

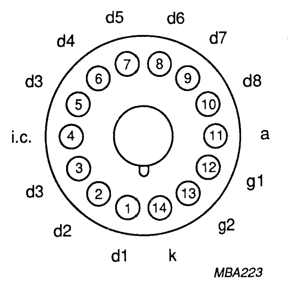


Fig.5.

ACCESSORIES

Socket	type FE1014
Mu-metal shield	type 56629

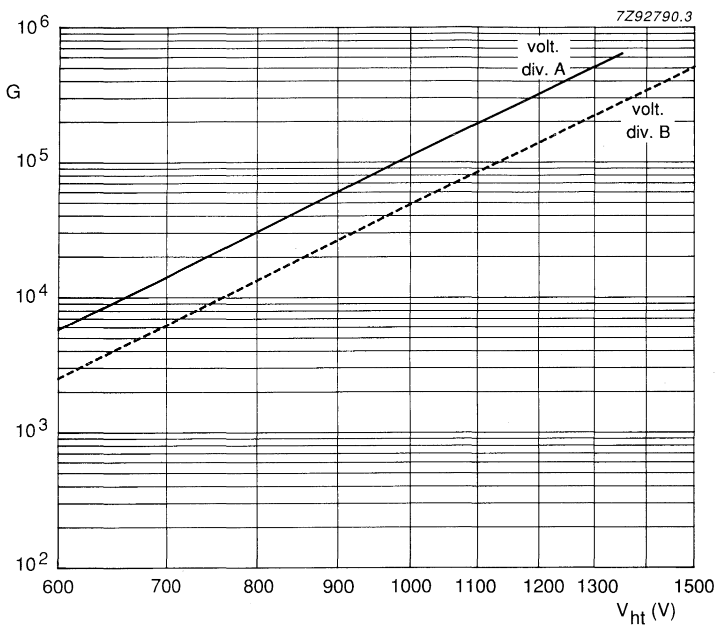


Fig.5 Gain G as function of supply voltage V_{ht}.

8-STAGE PHOTOMULTIPLIER TUBE

- Hexagonal head-on type; useful size 56 mm across flats
- Flat window
- Semi-transparent bi-alkaline 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

Radiant sensitivity characteristic	bi-alkaline
Useful size of the photocathode	> 56 mm across flats
Cathode blue sensitivity	12 μA/lmF
Supply voltage for anode blue sensitivity = 3 A/lmF	1150 V
Anode dark current at anode blue sensitivity = 3 A/lmF	1 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

		notes
Window		
Material	lime glass	
Shape	hexagonal, plano-plano	
Refractive index at 400 nm	1.54	
Photocathode		
Semi-transparent, head-on		2
Material	bi-alkaline	
Useful size	> 56 mm across flats	
Radiant sensitivity characteristic	see Fig.3	
Maximum radiant sensitivity	400 ± 30 nm	
Luminous sensitivity	≈ 95 μA/lm	3
Blue sensitivity	typ. 12 μA/lmF > 9.0 μA/lmF	1
Radiant sensitivity at 400 nm	≈ 90 mA/W	4

Multiplier system

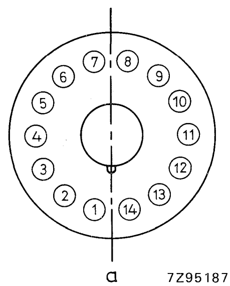
Number of stages	8
Dynode structure	linear focused
Dynode material	CuBe
Capacitances	
anode to final dynode	≈ 3 pF
anode to all	≈ 5 pF

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.



XP3422B.

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

RECOMMENDED CIRCUIT

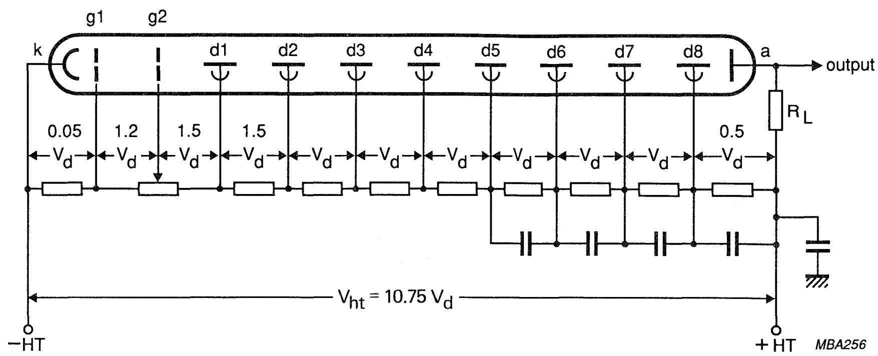


Fig. 2 Voltage divider A.

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 3 A/lmF (Fig.5)	max. 1300 V typ. 1150 V	1
Gain at V_{ht} = 1150 V	≈ 2.5 x 10^5	
Anode dark current at an anode blue sensitivity of 3 A/lmF (Fig. 5)	min. 20 nA typ. 1 nA	1, 6
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 3 A/lmF	≈ 7%	1, 7
Pulse amplitude resolution for ^{57}Co at an anode blue sensitivity of 3 A/lmF	max. 9.1% typ. 8.7%	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	≈ 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. 500 V min. 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. + 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 7.5×10^3 for this type of tube.
5. The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 reaches 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 7.5 A/lmF, (voltage for 3 A/lmF given on the test certificate, multiplied by 1.2), 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. 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.

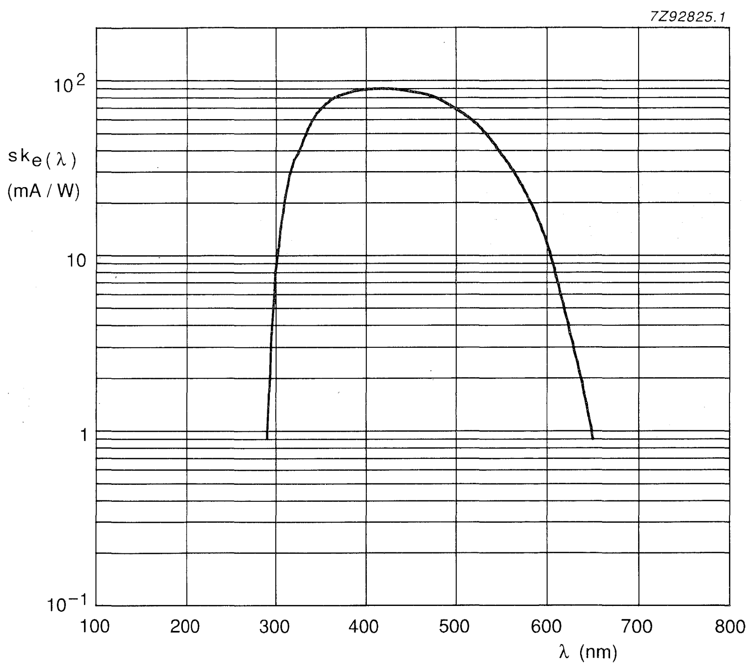
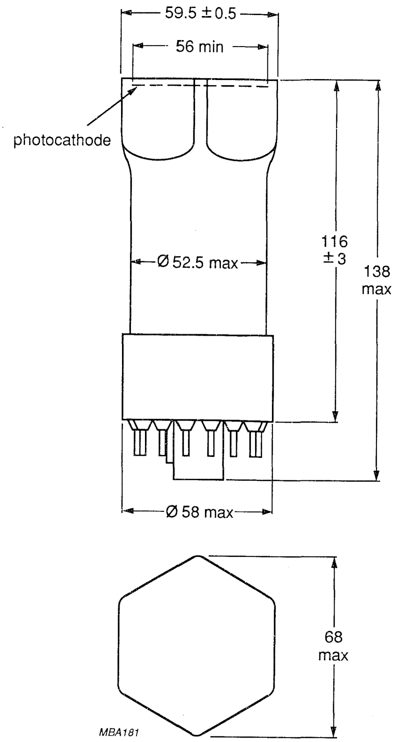


Fig.3 Radiant sensitivity characteristic.

MECHANICAL DATA

Dimensions in mm



Base 14-pin IEC67-1-16a (JEDEC B 14-38)

Net mass 165 g

PIN CONNECTIONS

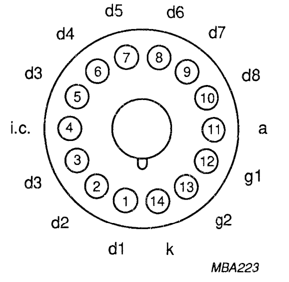


Fig.4.

ACCESSORIES

Socket type FE1014

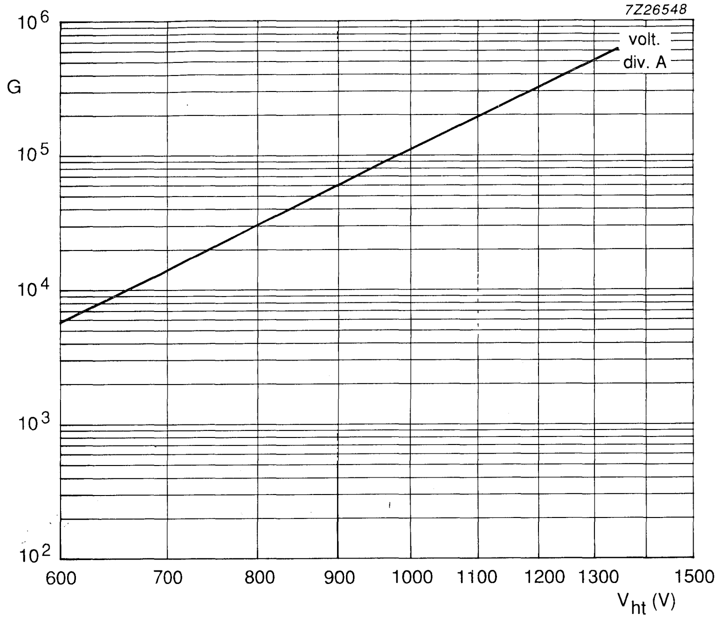


Fig.5 Gain G as function of supply voltage V_{ht}.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP3432B

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

APPLICATIONS

Principally for gamma-cameras.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – plano		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 56	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 95	μA/lm	3
blue sensitivity	min. 9	μA/lmF	4
	typ. 12	μA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	8		
slope: log(gain)/log(supply voltage)	≈ 5.8		
capacitance anode to all	≈ 5	pF	

OUTPUT CHARACTERISTICS

anode blue sensitivity 3 A/lmF

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1150	1300	V	
Anode dark current	–	1	20	nA	6,7
Gain x 10^3	–	≈ 250	–		
^{57}Co pulse amplitude resolution	–	8.7	9.1	%	8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.1	–	%/K	
Anode sensitivity deviation for a magnetic field of 0.05 mT	–	10	–	%	10
Anode current linear within 2% up to	–	≈ 100	–	mA	
Anode pulse rise time	–	≈ 3	–	ns	11
Anode pulse duration at half height	–	≈ 5	–	ns	11
Signal transit time	–	≈ 37	–	ns	11

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Anode blue sensitivity	–	7.5	A/lmF	12
Supply voltage	–	1500	V	
Continuous anode current	–	0.2	mA	13
Voltage between g1 and photocathode	–	20	V	
Voltage between g2 and photocathode	–	500	V	
Voltage between first dynode and photocathode	150	500	V	14
Voltage between consecutive dynodes	–	300	V	
Voltage between anode and last dynode	40	300	V	15
Ambient temperatures				16
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

XP3432B

RECOMMENDED CIRCUITS

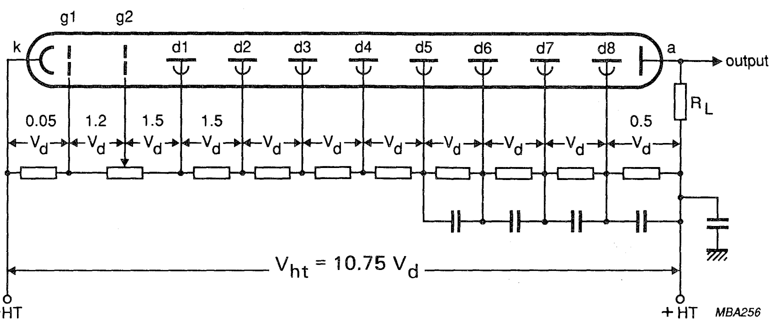


Fig.1 Voltage divider.

a = anode
dn = dynode number
g = accelerating electrode
k = cathode

Typical values of capacitors 1 nF.

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

XP3432B

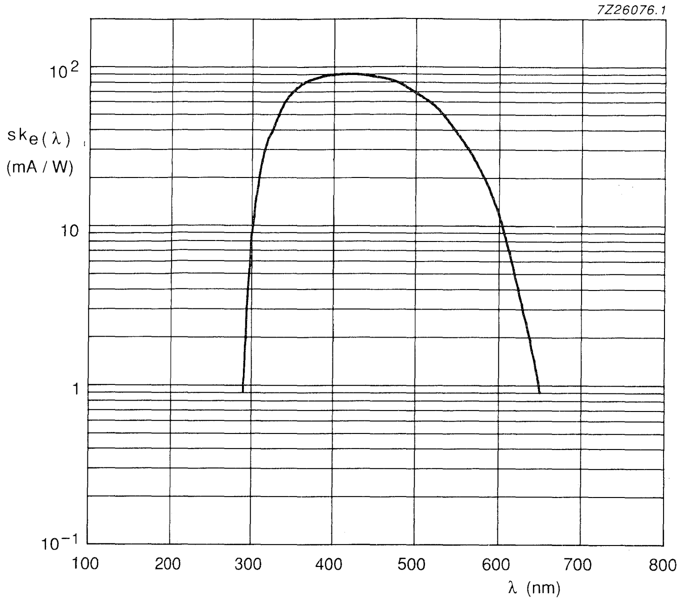


Fig.2 Cathode spectral characteristic.

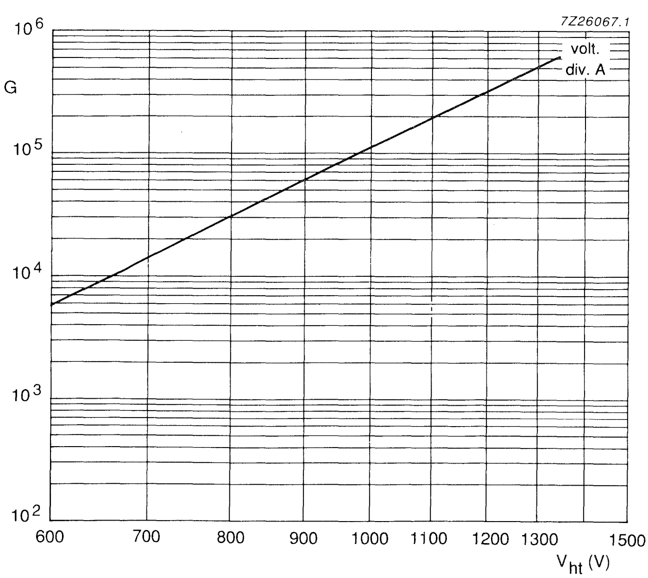


Fig.3 Gain as a function of supply voltage.

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

XP3432B

MECHANICAL DATA

Dimensions in mm

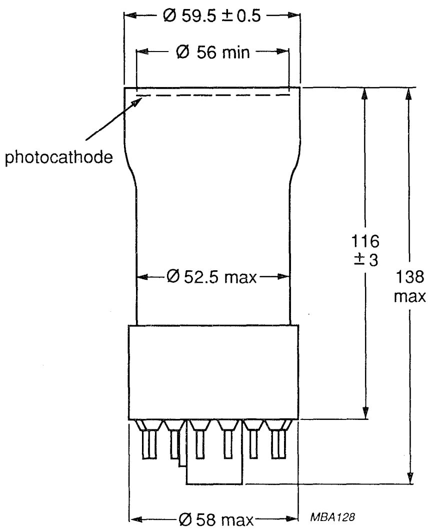
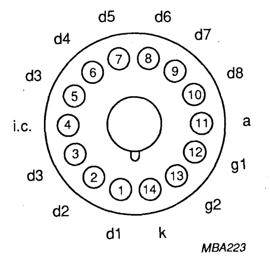


Fig.4 Mechanical outline.



i.c. = internally connected

Fig.5 Pin connections.

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

ACCESSORIES

Socket FE1014

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

XP3432B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.5 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 Pulse amplitude resolution for ^{137}Cs and ^{57}Co is measured with an NaI(Tl) cylindrical scintillator with a diameter of 50 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

9 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Measured with a pulse light source with a pulse duration (FWHM) below 1 ns with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

High pulse amplitude resolution, 8-stage, 60 mm (2.5″) diameter tube

XP3432B

12 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.2 times the voltage indicated on the test ticket of the tube.

13 A value less than 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 types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP3461B

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube

APPLICATIONS

For high-energy physics and other applications using CsI(Tl) scintillators and requiring good timing characteristics.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	lime glass		
profile	plano – concave		
refractive index at 400 nm	1.54		
Photocathode	semi-transparent, head-on		
material	extended green bialkaline		1
useful diameter	min. 68	mm	
spectral range	300 to 690	nm	2
wavelength for maximum radiant sensitivity	≈ **440**	nm	
luminous sensitivity	min. 100	μA/lm	3
	typ. 140	μA/lm	
blue sensitivity	≈ 14	μA/lmF	4
radiant sensitivity at **440 nm**	≈ 105	mA/W	5
Quantum efficiency at **440 nm**	≈ 29	%	
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	8		
slope: log(gain)/log(supply voltage)	≈ 5.5		
capacitance anode to all	≈ 5	pF	

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube — XP3461B

OUTPUT CHARACTERISTICS

gain = 10^6

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	1350	1600	V	
Anode dark current	–	10	40	nA	6,7
Background noise (x 10^3)	–	5	20	c/s	7,8
Single electron spectrum					
resolution	–	≈ 60	–	%	9
peak to valley ratio	–	≈ 3	–		10
Mean anode sensitivity deviation					11
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					12
perpendicular to axis "n'	–	≈ 0.1	–	mT	13
parallel to axis "n"	–	≈ 0.2	–	mT	13

see note 14

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	1350	1600	1450	V	
Gain x 10^6	≈ 1	≈ 1	≈ 1		
Anode current linear within 2% up to	≈ 50	≈ 200	≈ 120	mA	
Anode pulse rise time	≈ 3.5	≈ 3	≈ 3	ns	15
Anode pulse duration at half height	≈ 4.5	≈ 4	≈ 4	ns	15
Signal transit time	≈ 40	≈ 40	≈ 40	ns	15
Transit time difference between centre of photocathode and 30 mm from it		≈ 2.5		ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6	–	3		16
Supply voltage	–	2000	V	
Continuous anode current	–	0.2	mA	17
Voltage between g1 and photocathode	–	20	V	
Voltage between g2 and photocathode	–	700	V	
Voltage between first dynode and photocathode	300	700	V	18
Voltage between consecutive dynodes	–	400	V	
Voltage between anode and last dynode	80	600	V	19
Ambient temperatures				20
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube

XP3461B

RECOMMENDED CIRCUITS

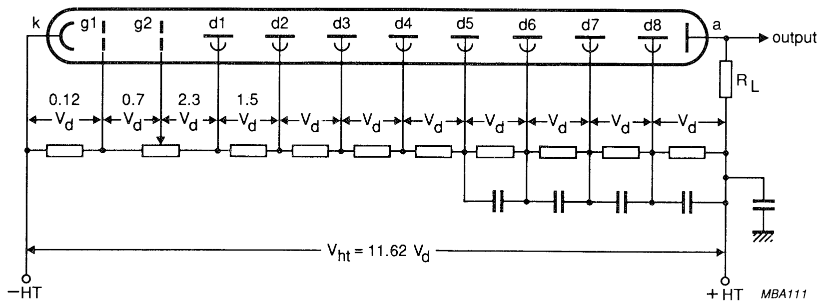


Fig.1 Voltage divider A.

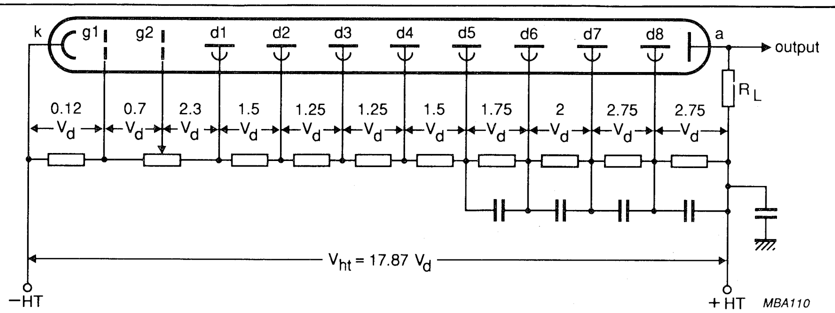


Fig.2 Voltage divider B.

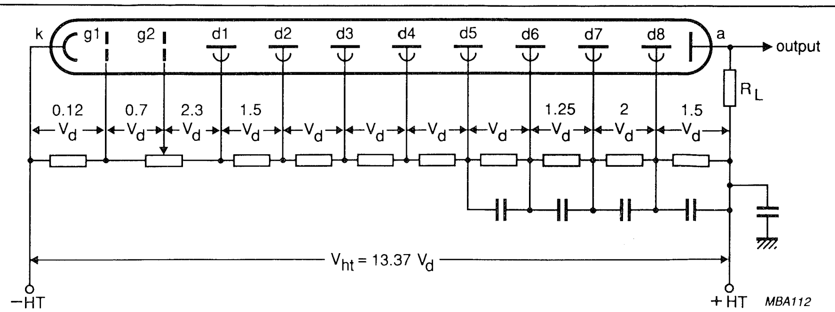


Fig.3 Voltage divider C.

a = anode
dn = dynode number
g = accelerating electrode
k = cathode

Typical values of capacitors 1 nF.

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube

XP3461B

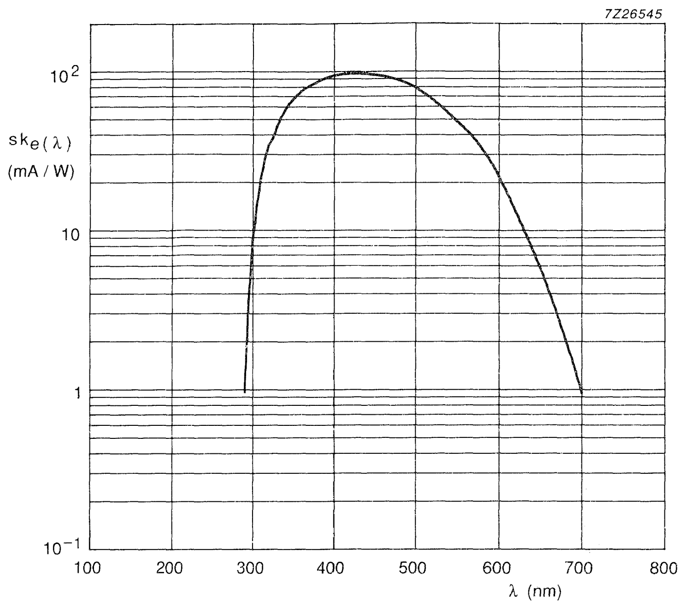


Fig.4 Cathode spectral characteristic.

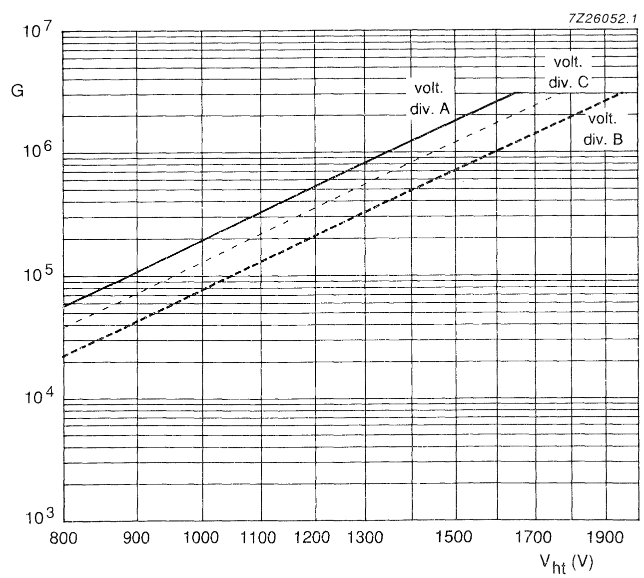


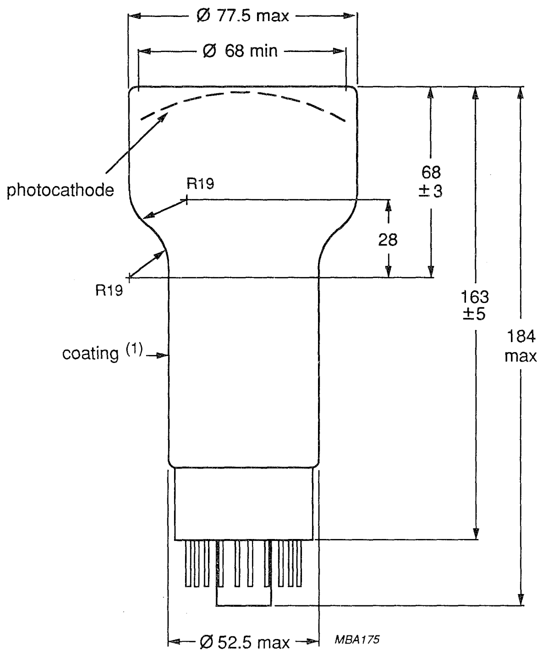
Fig.5 Gain as a function of supply voltage

Fast, green-sensitive, 8-stage, 76 mm (3") diameter tube

XP3461B

MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.

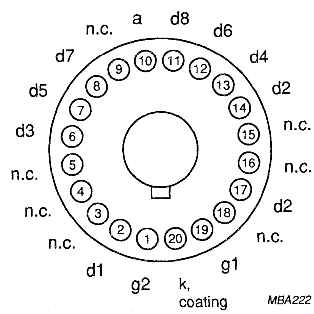


Fig.7 Pin connections.

Base 20-pin (IEC 67-1-42a JEDEC B20-102)
Net mass 245 g

ACCESSORIES

Socket	FE1120
Mu-metal shield	56639

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube

XP3461B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at –30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 7.5 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 After having been stored with its protection hood, the tube is placed in darkness with Vd set to a value to give a gain of 3 x 10^7. After a 30 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0.2 photoelectron) are recorded.

9 The single electron spectrum resolution will be optimized by adjusting the d2 voltage.

10 Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.

11 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

13 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 1 and 20.

Fast, green-sensitive, 8-stage, 76 mm (3″) diameter tube

XP3461B

14 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

15 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} aproximately as $V_{ht}^{-1/2}$.

16 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.2 times the voltage indicated on the test ticket of the tube.

17 A value less than 10 μA is recommended for applications requiring good stability.

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

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

20 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

8-STAGE PHOTOMULTIPLIER TUBE

- 68 mm useful diameter head-on type
- plano concave window
- semi-transparent bi-alkaline photocathode
- high cathode sensitivity
- good pulse linearity and time characteristics
- good compromise pulse amplitude resolution/time characteristics
- for scintillation detection applications, e.g. high energy physics experiments

QUICK REFERENCE DATA

Radiant sensitivity characteristic			bi-alkaline	
Useful diameter of the photocathode		>	68	mm
Quantum efficiency at 400 nm			27	%
Cathode blue sensitivity at 400 nm			12.2	μA/lmF
Supply voltage for a gain of 1 x 10^6			1350	V
Pulse amplitude resolution for ^{137}Cs		≈	7.2	%
Anode pulse rise time (with voltage divider B)		≈	3	ns
Linearity				
with voltage divider A	up to	≈	50	mA
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-concave	
Refractive index		
at 400 nm	1.54	
Photocathode		2
Semi-transparent, head-on		
Material	bi-alkaline	
Useful diameter	> 68 mm	
Radiant sensitvity characteristic	see Fig.4	
Maximum radiant sensitivity at	400 ± 30 nm	
Quantum efficiency at 400 nm	27%	
Luminous sensitivity	≈ 75 μA/lm	3
Blue sensitivity	typ. 12.2 μA/lmF	1
	> 9 μA/lmF	
Radiant sensitivity at 400 nm	≈ 95 mA/W	4

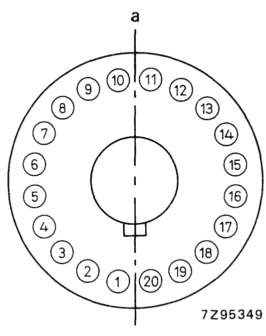
Multiplier system

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} = 1500 V)
– at a magnetic flux density of 0.1 mT perpendicular to the tube axis and to axis a;
– at a magnetic flux density of 0.2 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.



XP3462B

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

RECOMMENDED CIRCUITS

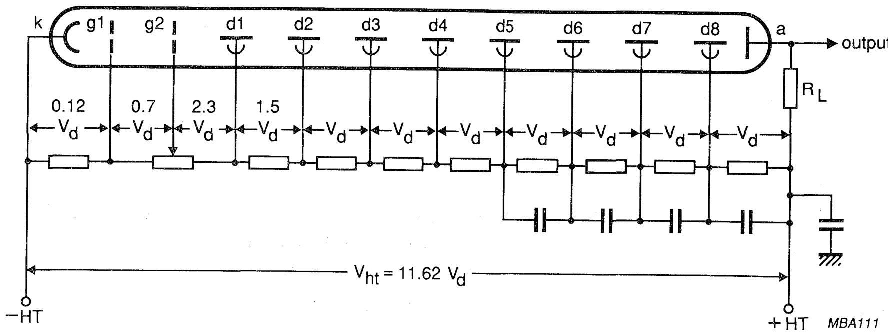


Fig. 2 Voltage divider A.

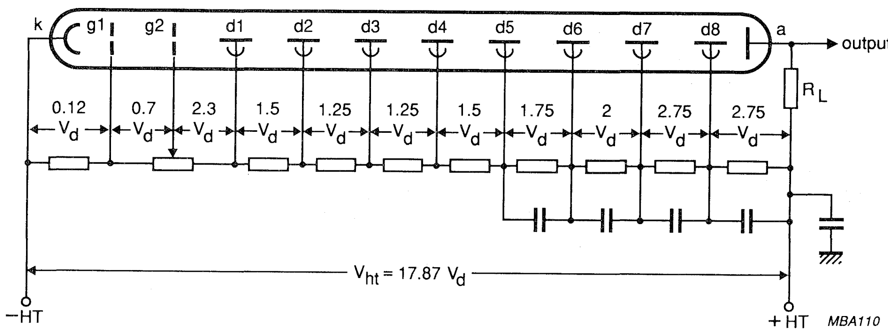


Fig. 3 Voltage divider B.

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 a gain of 1×10^6 (Fig.7)	typ.	1350	V	
	$<$	1600	V	
Anode dark current at a gain of 1×10^6 (Fig.7)	typ.	2	nA	6, 8
	$<$	20	nA	
Background noise at a gain of 1×10^6	≈	5000	c/s	7
Pulse amplitude resolution for ^{137}Cs at an anode blue sensitivity of 1.5 A/lmF	≈	7.2	%	10
Mean anode sensitivity deviation,				
long term (16 h)	≈	1	%	16
after change of count rate	≈	1	%	
versus temperature between 0 and 40 °C at 450 nm	≈	0.2	%	
Anode current linear within 2% at V_{ht} = 1350 V	up to	≈ 50	mA	
With voltage divider B (Fig. 3)				5
Gain at V_{ht} = 1650 V (Fig.7)	≈	1×10^6		
Anode pulse rise time at V_{ht} = 1600 V	≈	3	ns	9
Anode pulse duration at half height at V_{ht} = 1600 V	≈	4	ns	9
Signal transit time at V_{ht} = 1600 V	≈	40	ns	9
Signal transit time difference between the centre of the photocathode and 30 mm from the centre at V_{ht} = 1600 V	≈	2.5	ns	
Anode current linear within 2% at V_{ht} = 1600 V	up to	≈ 200	mA	

LIMITING VALUES (absolute maximum rating system)

Supply voltage	max.	2000	V	11
Continuous anode current	max.	0.2	mA	14
Voltage between first dynode and photocathode	max.	700	V	12
	min.	300	V	
Voltage between focusing electrode g_1 and photocathode	max.	20	V	
Voltage between accelerating electrode g_2 and photocathode	max.	700	V	
Voltage between consecutive dynodes	max.	400	V	
Voltage between anode and final dynode	max.	600	V	13
	min.	80	V	
Ambient temperature range				
operational (for short periods)	max.	+ 80	°C	15
	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.
3. Luminous sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K.
4. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm, expressed in A/W, can be estimated by multiplying the blue sensitivity, expressed in A/lmF, by 7.8×10^3 for this type of tube.
5. To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage 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 ratio between successive stages is less than a factor of 2.
6. The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to configure the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.
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 1×10^6. After a 5 min. stabilization period noise pulses with a threshold of 0.05 pC (corresponding to 0.3 photoelectron) are recorded. Lower values can be obtained after a longer stabilization period.
8. 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).
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. Pulse amplitude resolution for ^{137}Cs 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. The count rate used is $\approx 10^4$ c/s.
11. Or the voltage at which the tube has a gain of 3×10^6, 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.
14. A value of < 10 μA is recommended for applications requiring good stability.
15. 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.
16. The mean anode sensitivity deviation is measured by coupling an NaI(TI) 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 ≈ 10^4c/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 10^4c/s to 10^3c/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.

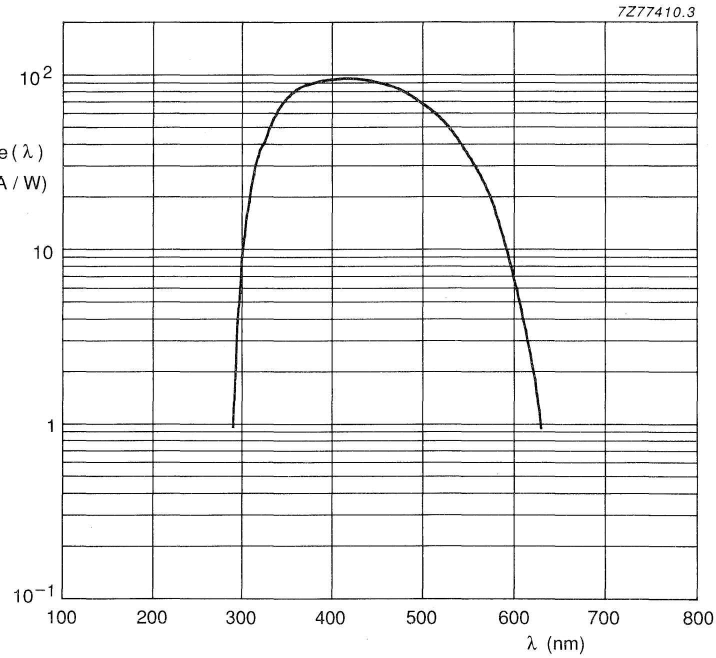
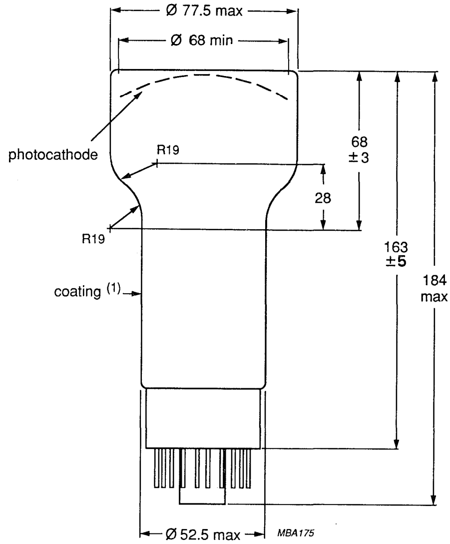


Fig.4 Radiant sensitivity characteristic.

MECHANICAL DATA



Base	20-pin IEC 67-1-42a, JEDEC B20-102
Net mass	245 g

PIN CONNECTIONS

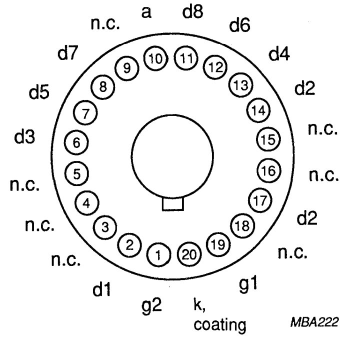


Fig.5.

(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.

ACCESSORIES

Socket	type FE1120
Mu-metal shield	type 56639

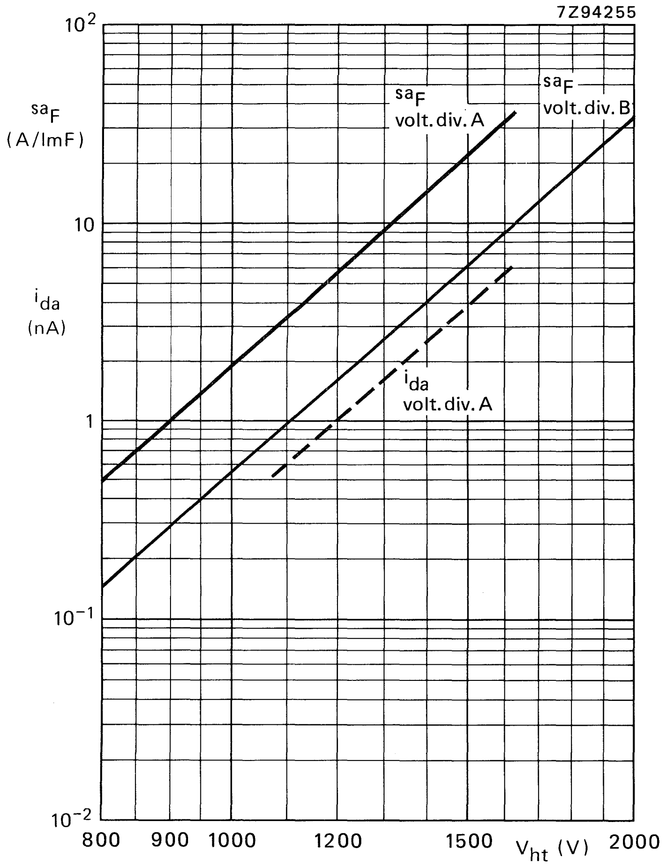


Fig. 6 Anode radiant sensitivity, $sa_{e(\lambda)}$, and anode dark current, i_{da} as a function fo supply voltage V_{ht}.

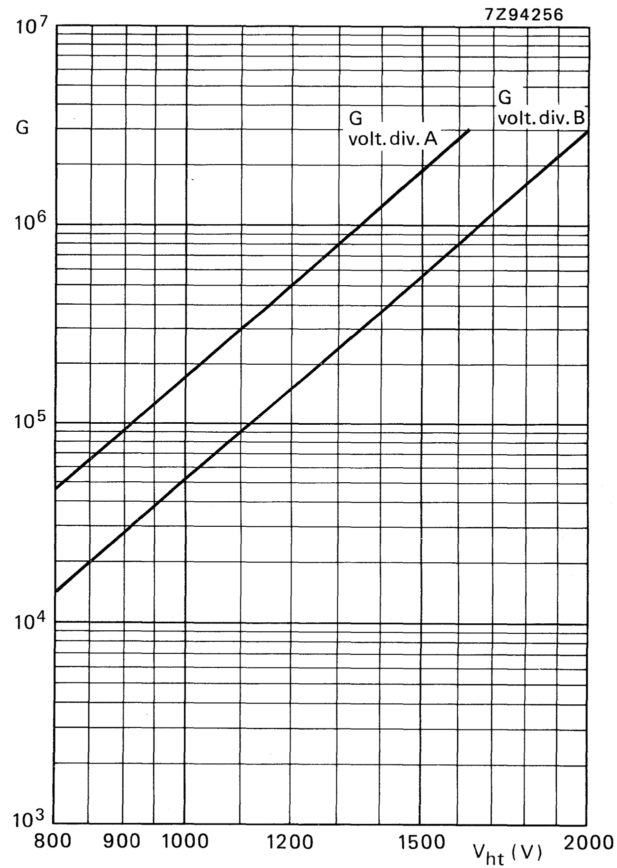


Fig. 7 Gain G as a function of supply voltage V_{ht}.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

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Very fast, high sensitivity 51 mm (2″) diameter tube

APPLICATIONS

All applications where high gain, top timing performances and high cathode sensitivity are required.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	borosilicate		
profile	plano – concave		
refractive index at 400 nm	1.48		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 44	mm	
spectral range	300 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 90	μA/lm	3
blue sensitivity	min. 10	μA/lmF	4
	typ. 11	μA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
quantum efficiency at 400 nm	≈ 28	%	
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	12		
slope: log(gain)/log(supply voltage)	≈ 9		
capacitance:			
anode to all	≈ 7	pF	
grid 1 to k + g2 + d1 + d5	≈ 20	pF	

OUTPUT CHARACTERISTICS

with voltage divider A, gain = 3 x 10^7

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	2000	2600	V	
Anode dark current	–	25	125	nA	6,7
Background noise (x 10^3)	–	5	25	c/s	7,8
Single electron spectrum					
resolution	–	≈ 70	–	%	9
peak to valley ratio	–	≈ 2.5	–		10
^{137}Cs pulse amplitude resolution	–	7	–	%	11
Mean anode sensitivity deviation					12
long term (16 hours)	–	≈ 2	–	%	
after change of count rate	–	≈ 2	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.4	–	%/K	
Anode current halved for magnetic field of					13
perpendicular to axis "n'	–	≈ 0.15	–	mT	14
parallel to axis "n"	–	≈ 0.12	–	mT	14

see note 15

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at	2000	2800	2500	V	
Gain x 10^6	≈ 30	≈ 4	≈ 40		
Anode current linear within 2% up to	≈ 25	≈ 280	≈ 70	mA	
Anode pulse rise time	≈ 1.6	≈ 1.7	≈ 1.5	ns	16
Anode pulse duration at half height	≈ 3.7	≈ 2.7	≈ 2.4	ns	17
Signal transit time	≈ 28	≈ 31	≈ 30	ns	15
Transit time standard deviation σ	–	–	0.25	ns	16
Transit time difference between centre of photocathode and 18 mm from it	–	≈ 0.25	0.25	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6	–	200		18
Supply voltage	–	3000	V	
Continuous anode current	–	0.2	mA	19
Voltage between g1 and photocathode	–	300	V	
Voltage between first dynode and photocathode	210	800	V	20
Voltage between consecutive dynodes (except d11 and d12)	–	400	V	
Voltage between dynodes d11 and d12	–	600	V	
Voltage between anode and last dynode	80	700	V	21
Ambient temperatures				22
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Very fast high sensitivity, 51 mm (2″) diameter tube XP4222B

RECOMMENDED CIRCUITS

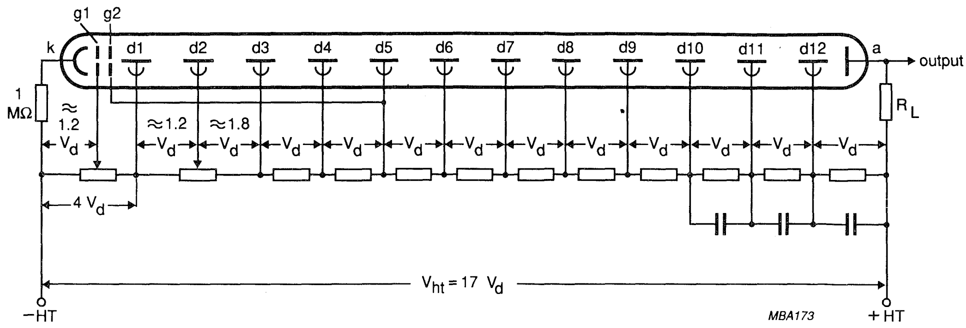

Fig.1 Voltage divider A.

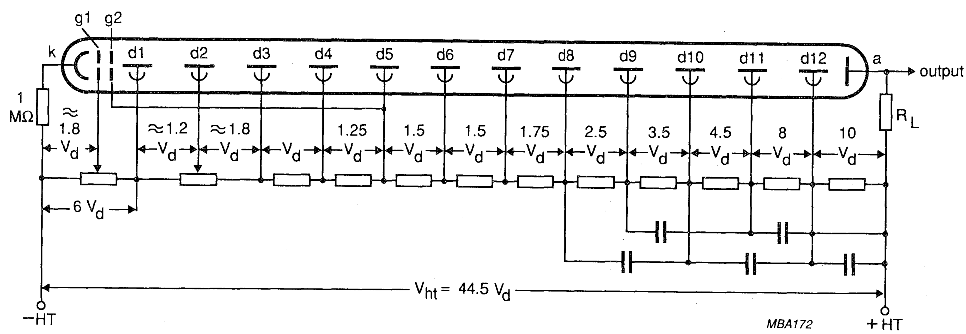

Fig.2 Voltage divider B.

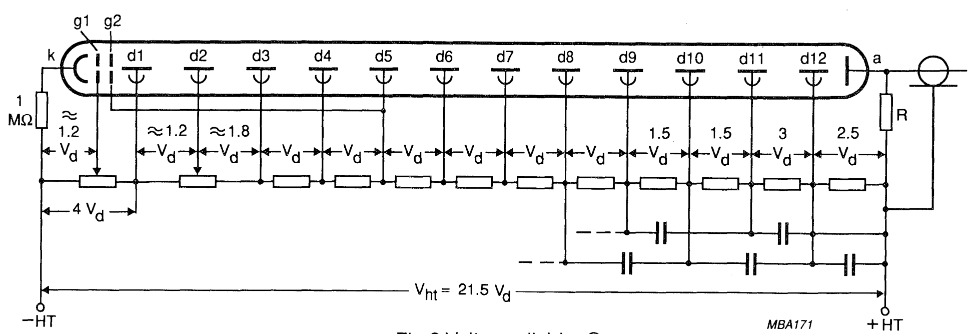

Fig.3 Voltage divider C.

a = anode
dn = dynode number
g1, g2 = focusing and accelerating electrodes
k = cathode

Typical values of capacitors 1 nF.

Very fast high sensitivity, 51 mm (2″) diameter tube

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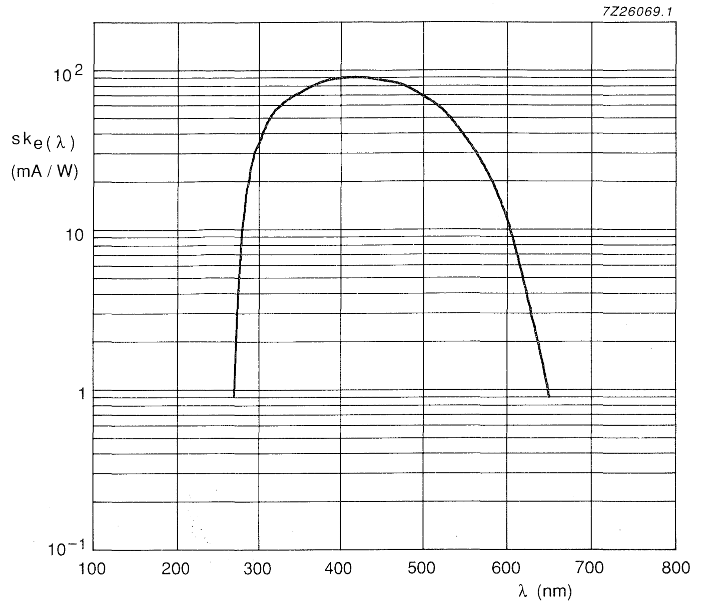

Fig.4 Cathode spectral characteristic.

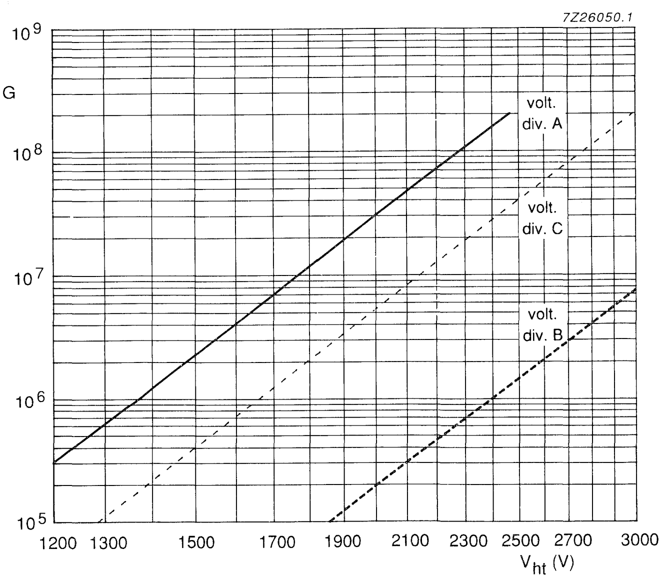

Fig.5 Gain as a function of supply voltage

Very fast high sensitivity, 51 mm (2″) diameter tube

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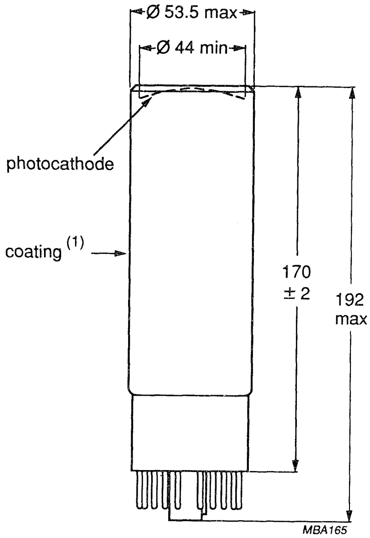
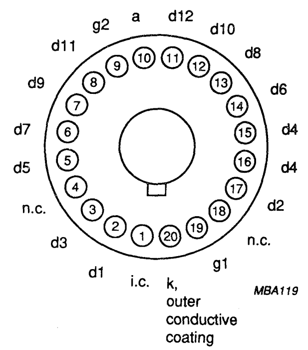
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.7 Pin connections.

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

ACCESSORIES

Socket	FE1120
Mu-metal shield	56619

Very fast high sensitivity, 51 mm (2″) diameter tube

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Notes

1 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 to 1 nA at room temperature and to 0.1 nA at −30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in μA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8.2×10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 After having been stored with its protection hood, the tube is placed in darkness with Vd 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 pC (corresponding to 0.2 photoelectron) are recorded.

9 The single electron spectrum resolution will be optimized by adjusting the d2 voltage.

10 Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.

11 Pulse amplitude for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 44 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

12 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

Very fast high sensitivity, 51 mm (2″) diameter tube

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

14 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 7 and 8.

15 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

16 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.

17 Transit times of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation.

18 The voltage corresponding to this maximum gain is equal to 1.2 times the voltage indicated on the test ticket of the tube.

19 A value less than 10 μA is recommended for applications requiring good stability.

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

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

22 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP4227B

Very fast, extended-red sensitive, 51 mm (2″) diameter tube

APPLICATIONS

All applications where high gain, top timing performances and sensitivity to the far – red part of the spectrum are required.

GENERAL CHARACTERISTICS

			NOTES
Window			
material	borosilicate		
profile	plano – concave		
refractive index at 550 nm	1.48		
Photocathode	semi-transparent, head-on		
material	extended red multialkaline		
useful diameter	min. 44	mm	
spectral range	250 to 930	nm	1
wavelength for maximum radiant sensitivity	≈ 550	nm	
luminous sensitivity	≈ 160	µA/lm	2
radiant sensitivity at 800 nm	≈ 15	mA/W	
radiant sensitivity at 850 nm	min. 3	mA/W	3
	typ. 8	mA/W	
Quantum efficiency at 850 nm	≈ 1	%	
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	12		
slope: log(gain)/log(supply voltage)	≈ 9		
capacitance			
anode to all	≈ 7	pF	
grid 1 to k + g2 + d1 + d5	≈ 20	pF	

Very fast, extended-red sensitive, 51 mm (2″) diameter tube

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OUTPUT CHARACTERISTICS

with voltage divider A, gain = 3 x 10^7

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	2200	2600	V	
Anode dark current	–	500	5000	nA	4,5
Background noise (x 10^3)	–	100	1000	c/s	5,6
Single electron spectrum					
resolution	–	≈ 70	–	%	7
peak to valley ratio	–	≈ 2.5	–		8
Mean anode sensitivity deviation					9
long term (16 hours)	–	≈ 1	–	%	
after change of count rate	–	≈ 1	–	%	
at a temperature between 0 and 40 °C at 450 nm	–	≈ 0.2	–	%/K	
Anode current halved for magnetic field of					10
perpendicular to axis "n"	–	≈ 0.15	–	mT	11
parallel to axis "n"	–	≈ 0.12	–	mT	11

see note 12

PARAMETER	VOLTAGE DIVIDER			UNIT	NOTES
	A	B	C		
Supply voltage set at	2200	2800	2500	V	
Gain x 10^6	≈ 30	≈ 2	≈ 20		
Anode current linear within 2% up to	≈ 25	≈ 280	≈ 70	mA	
Anode pulse rise time	≈ 1.6	≈ 1.7	≈ 1.5	ns	13
Anode pulse duration at half height	≈ 3.7	≈ 2.7	≈ 2.4	ns	13
Signal transit time	≈ 28	≈ 31	≈ 30	ns	13
Transit time standard deviation σ	–		≈ 0.25	ns	14
Transit time difference between centre of photocathode and 18 mm from it	–	≈ 0.25	≈ 0.25	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6	–	200		15
Supply voltage	–	3000	V	
Continuous anode current	–	0.2	mA	16
Voltage between g1 and photocathode	–	300	V	
Voltage between first dynode and photocathode	210	800	V	17
Voltage between consecutive dynodes (except d11 and d12)	–	400	V	
Voltage between dynodes d11 and d12	–	600	V	
Voltage between anode and last dynode	80	700	V	18
Ambient temperatures				19
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Very fast, extended-red sensitive, 51 mm (2″) diameter tube XP4227B

RECOMMENDED CIRCUITS

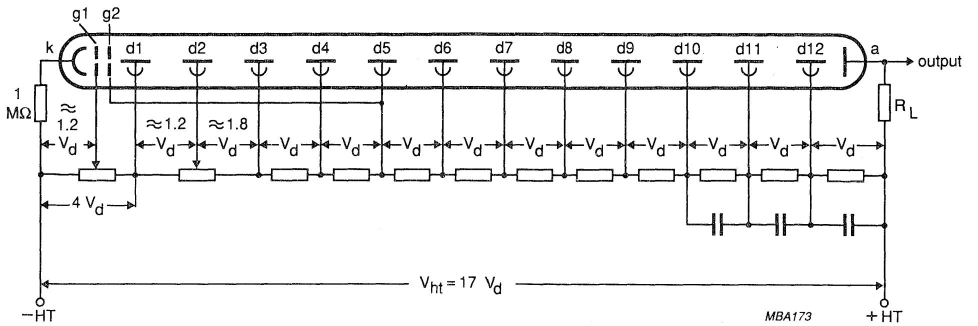


Fig.1 Voltage divider A.

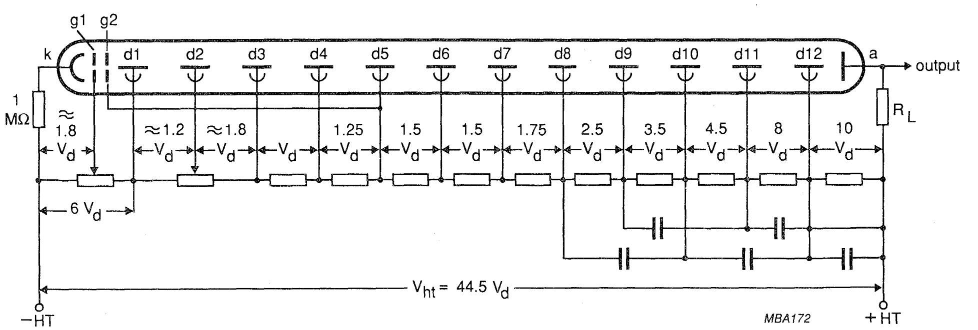


Fig.2 Voltage divider B.

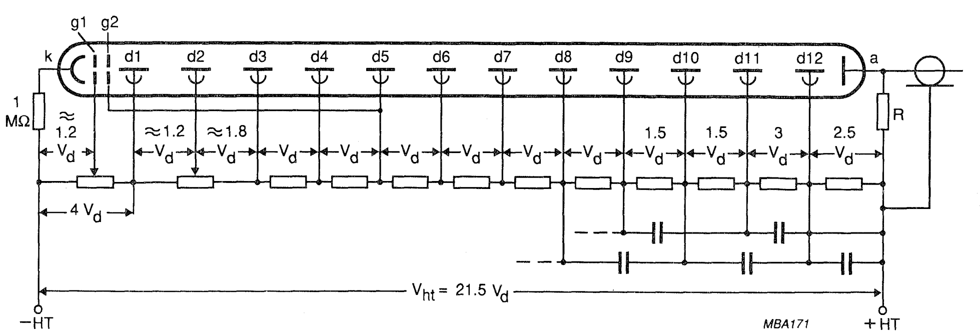


Fig.3 Voltage divider C.

a = anode
dn = dynode number
g1, g2 = focusing and accelerating electrodes
k = cathode

Typical values of capacitors 1 nF.

Very fast, extended-red sensitive, 51 mm (2″) diameter tube XP4227B

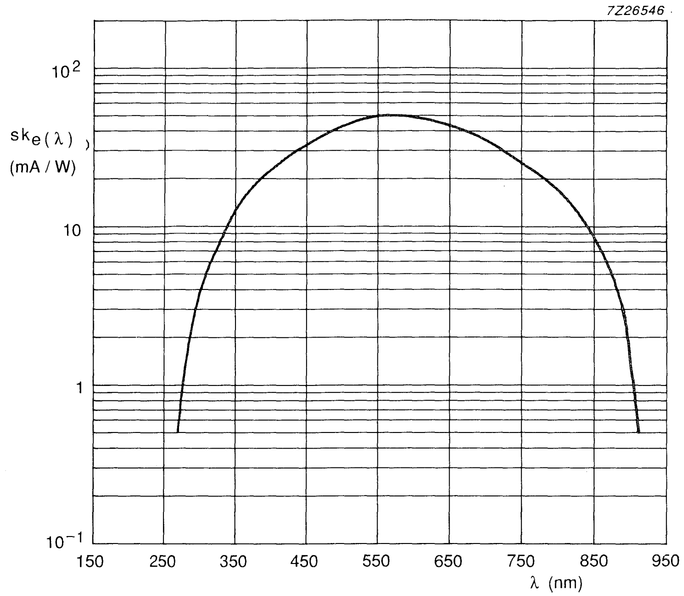


Fig.4 Cathode spectral characteristic.

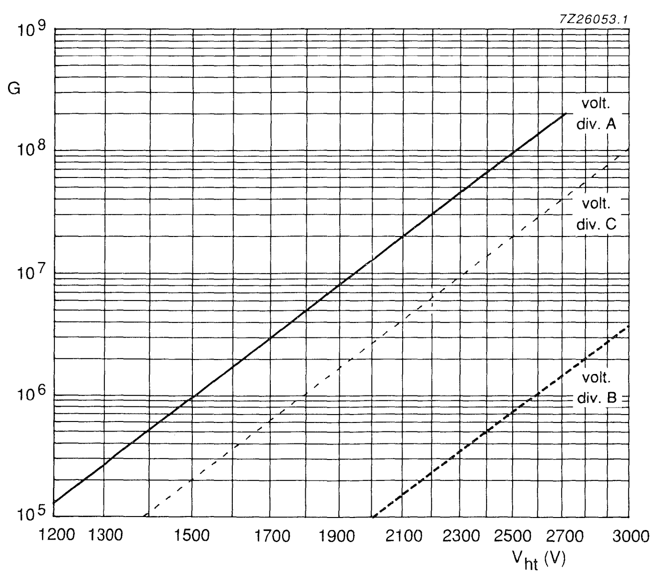


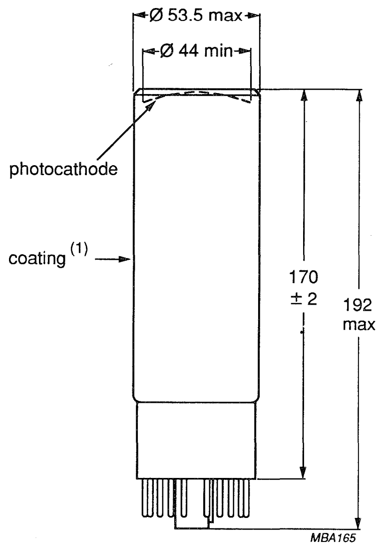
Fig.5 Gain as a function of supply voltage

Very fast, extended-red sensitive, 51 mm (2″) diameter tube

XP4227B

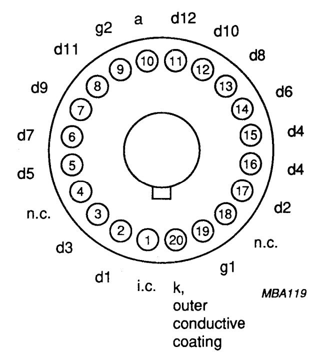
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.7 Pin connections.

Base	20-pin (IEC 67-1-42a, JEDEC B20-102)
Net mass	240 g

ACCESSORIES

Socket	FE1120
Mu-metal shield	56619

Notes

1 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

2 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

3 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter.

4 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

5 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at −HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with an insulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

6 After having been stored with its protection hood, the tube is placed in darkness with Vd set to a value to give a gain of 3 x 10^7. After a 30 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0.2 photoelectron) are recorded.

7 The single electron spectrum resolution will be optimized by adjusting the d2 voltage.

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 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 μA and 0.1 μA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

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

11 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 7 and 8.

12 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

13 Measured with a pulse light source with a pulse duration (FWHM) below 1 μs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.

Very fast, extended-red sensitive, 51 mm (2″) diameter tube

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14 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.

15 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.2 times the voltage indicated on the test ticket of the tube.

16 A value less than 10 µA is recommended for applications requiring good stability.

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

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

19 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

Philips Components

Data sheet	
status	Preliminary specification
date of issue	October 1989

XP4228B

Very fast, high UV sensitivity, 51 mm (2″) diameter tube

APPLICATIONS

High and medium-energy physics experiments where top timing performances and high sensitivity in the ultra-violet region are required (e.g. with BaF_2 scintillators).

GENERAL CHARACTERISTICS

			NOTES
Window			
material	fused silica		
profile	plano – concave		
refractive index at 250 nm	1.50		
refractive index at 400 nm	1.47		
Photocathode	semi-transparent, head-on		
material	bialkaline		1
useful diameter	min. 44	mm	
spectral range	150 to 650	nm	2
wavelength for maximum radiant sensitivity	≈ 400	nm	
luminous sensitivity	≈ 90	µA/lm	3
blue sensitivity	min. 10	µA/lmF	4
	typ. 11	µA/lmF	4
radiant sensitivity at 400 nm	≈ 90	mA/W	5
Quantum efficiency at 400 nm	≈ 28	%	
Multiplier			
first dynode	high – gain		
structure	linear focused		
number of stages	12		
slope: log(gain)/log(supply voltage)	≈ 9		
capacitance			
anode to all	≈ 7	pF	
grid 1 to k + g2 + d1 + d5	≈ 20	pF	

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

OUTPUT CHARACTERISTICS

with voltage divider A, gain = 3 x 10^7

PARAMETER	MIN.	TYP. or approx.	MAX.	UNIT	NOTES
Supply voltage	–	2000	2600	V	
Anode dark current	–	25	125	nA	6,7
Background noise (x 10^3)	–	5	25	c/s	7,8
Single electron spectrum					
resolution	–	≈ 70	–	%	9
peak to valley ratio	–	≈ 2.5	–		10
^{137}Cs pulse amplitude resolution	–	≈ 7	–	%	11
Mean anode sensitivity deviation					12
long term (16 hours)	–	≈ 2	–	%	
after change of count rate	–	≈ 2	–	%	
at a temperature between 0 and 40 °C at 400 nm	–	≈ 0.4	–	%/K	
Anode current halved for magnetic field of					13
perpendicular to axis "n"	–	≈ 0.15	–	mT	14
parallel to axis "n"	–	≈ 0.12	–	mT	14

see note 15

PARAMETER	VOLTAGE DIVIDER A	VOLTAGE DIVIDER B	VOLTAGE DIVIDER C	UNIT	NOTES
Supply voltage set at	2000	2800	2500	V	
Gain x 10^6	≈ 30	≈ 4	≈ 40		
Anode current linear within 2% up to	≈ 25	≈ 280	≈ 70	mA	
Anode pulse rise time	≈ 1.6	≈ 1.7	≈ 1.5	ns	16
Anode pulse duration at half height	≈ 3.7	≈ 2.7	≈ 2.4	ns	16
Signal transit time	≈ 28	≈ 31	≈ 30	ns	16
Transit time standard deviation σ	–		≈ 0.25	ns	17
Transit time difference between centre of photocathode and 18 mm from it	–	≈ 0.25	≈ 0.25	ns	

LIMITING VALUES

Limiting values in accordance with Absolute Maximum System (IEC 134)

PARAMETER	MIN.	MAX.	UNIT	NOTES
Gain x 10^6	–	200		18
Supply voltage	–	3000	V	
Continuous anode current	–	0.2	mA	19
Voltage between g1 and photocathode	–	300	V	
Voltage between first dynode and photocathode	210	800	V	20
Voltage between consecutive dynodes (except d11 and d12)	–	400	V	
Voltage between dynodes d11 and d12	–	600	V	
Voltage between anode and last dynode	80	700	V	21
Ambient temperatures				22
short operation (30 min. maximum)	–30	80	°C	
continuous operation and storage	–30	50	°C	

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

RECOMMENDED CIRCUITS

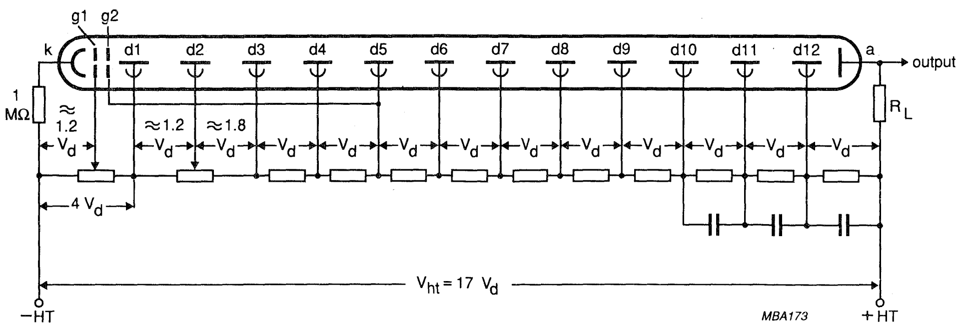


Fig.1 Voltage divider A.

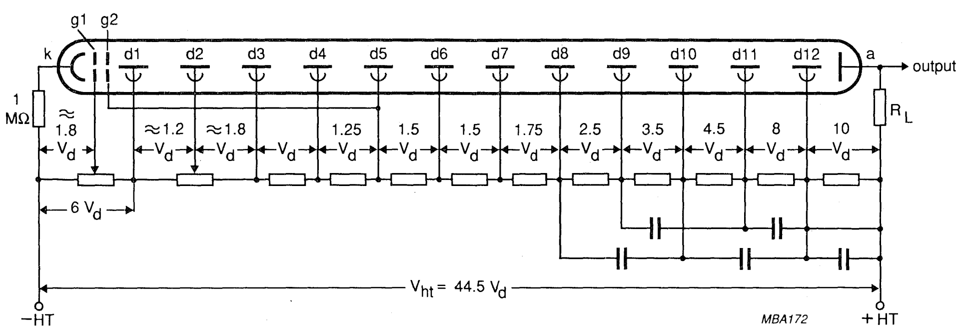


Fig.2 Voltage divider B.

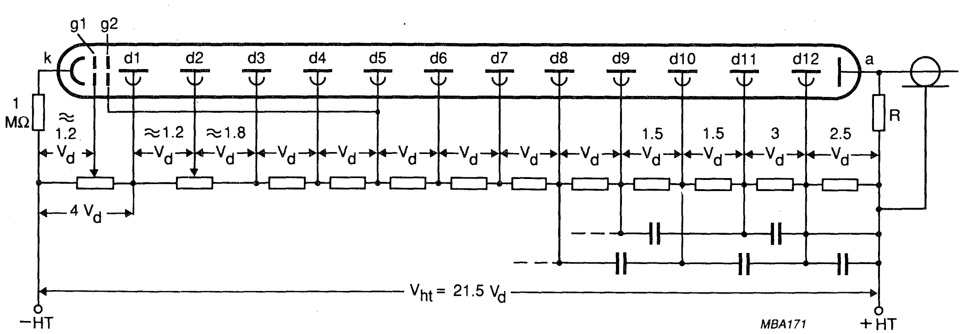


Fig.3 Voltage divider C.

a = anode
dn = dynode number
g1, g2 = focusing and accelerating electrodes
k = cathode

Typical values of capacitors 1 nF.

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

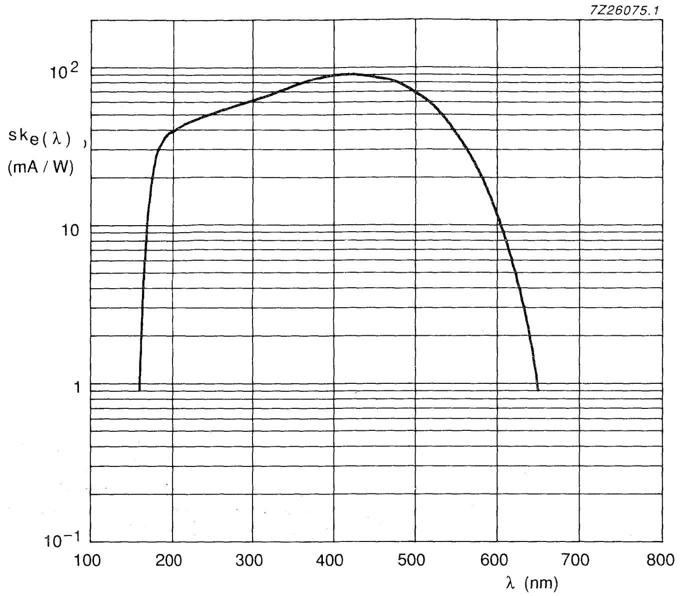


Fig.4 Cathode spectral characteristic.

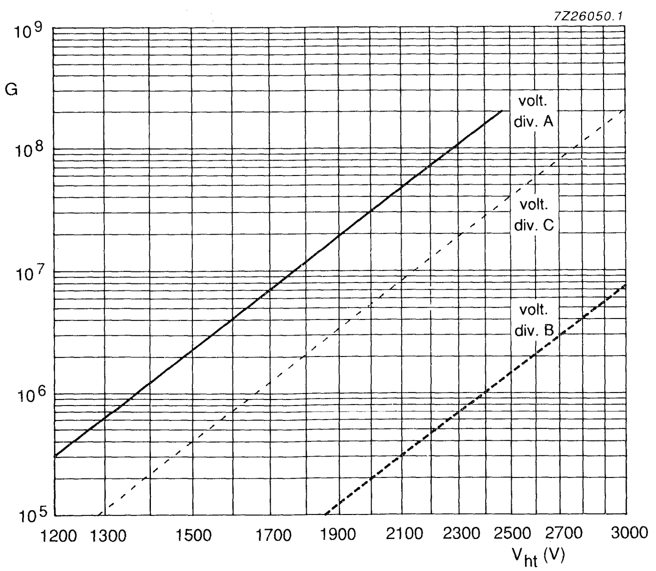
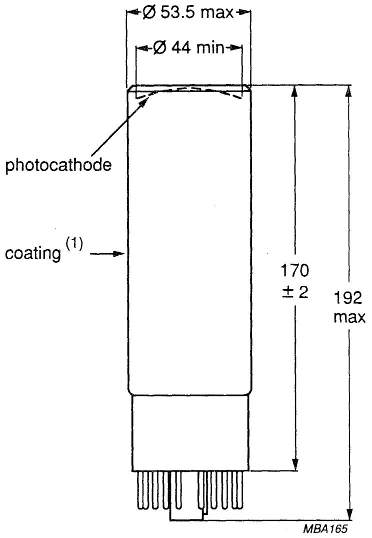


Fig.5 Gain as a function of supply voltage

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

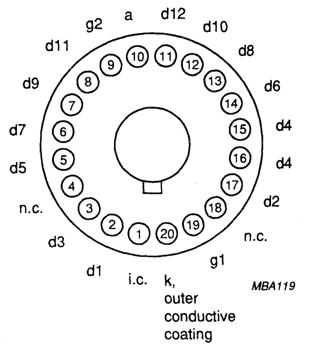
MECHANICAL DATA

Dimensions in mm



(1)
The glass envelope 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.6 Mechanical outline.



i.c. = internally connected
n.c. = not connected

Fig.7 Pin connections.

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

ACCESSORIES

Socket	FE1120
Mu-metal shield	56619

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

Notes

1 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 to 1 nA at room temperature and to 0.1 nA at –30 °C. If the photocurrent is too high, the cathode can no longer be considered an equipotential surface and the focusing of electrons onto the first dynode will be affected resulting in non-linearity. In applications with short pulse times, the photocathode is able to deliver pulses containing 10^6 to 10^7 photo electrons without disturbance.

2 The spectral range is defined between the minimum and maximum wavelengths for which the radiant sensitivity is 1/100 of its peak value.

3 Luminous sensitivity is measured with a tungsten lamp with a colour temperature of 2856 ± 5 K.

4 Blue sensitivity is expressed in µA/lmF and is measured using a tungsten filament light source with a colour temperature of 2856 ± 5 K. The light is transmitted through a blue filter (Corning CS No. 5-58) polished to half stock thickness.

5 Radiant sensitivity is measured using a tungsten filament light source with a colour temperature of 2586 ± 5 K. Light is transmitted through an interference filter. Radiant sensitivity at 400 nm is expressed in A/W and can be estimated by multiplying the blue sensitivity (expressed in A/lmF) by 8.2 x 10^3 for this type of tube.

6 Dark current is measured at ambient temperature after the tube has been in darkness for approximately 1 minute. A lower value can be obtained after a longer stabilization period in darkness (e.g. 30 minutes).

7 The power supply should be arranged such that the cathode is at earth potential and the anode is at +HT. However, it is sometimes necessary to connect the device with the anode earthed and the cathode at –HT, but under these conditions the noise and dark current will generally increase and become erratic, particularly after application of voltage. The glass envelope of the tube should be supported only on insulators with aninsulating resistance greater than 10^{15} Ω. If a metal shield is used, it should be kept at the cathode potential.

8 After having been stored with its protection hood, the tube is placed in darkness with Vd set to a value to give a gain of 3 x 10^7. After a 30 min. stabilization period noise pulses with a threshold of 1 pC (corresponding to 0.2 photoelectron) are recorded.

9 The single electron spectrum resolution will be optimized by adjusting the d2 voltage.

10 Peak to valley ratio is defined as the single electron peak value divided by the minimum value to the left of the peak.

11 Pulse amplitude for ^{137}Cs is measured with an NaI(Tl) scintillator with a diameter of 44 mm and a height of 50 mm. The count rate used is ≈ 10^4 counts per second.

12 The mean pulse amplitude deviation is measured by coupling an NaI(Tl) scintillator to the window of the tube. Long term (16 hours) deviation is measured by placing a ^{137}Cs source at a distance from the scintillator such that the count rate is ≈ 10^4 counts per second corresponding to an anode current of ≈ 300 nA. The mean pulse amplitude deviation after change of count rate is measured with a ^{137}Cs source at a distance such that the count rate can be changed from 10^4 to 10^3 counts per second corresponding to anode currents of ≈ 1 µA and 0.1 µA respectively. Both tests are carried out to ANSI-N42-9-1972 of IEEE recommendations.

Very fast, high UV sensitivity, 51 mm (2″) diameter tube XP4228B

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

14 Axis "n" belongs to the plane of symmetry of the tube (perpendicular to the dynodes) and is perpendicular to the tube axis. The plane of symmetry cuts the base between pins 7 and 8.

15 To obtain a peak pulse current greater than that obtainable with divider "A", it will be necessary to increase the inter-dynode voltage progressively. Divider circuits "B" and "C" are examples of a 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 voltage ratio between successive stages is less than 2.

16 Measured with a pulse light source with a pulse duration (FWHM) below 1 µs with the cathode completely illuminated. The rise time is determined between 10% and 90% of the anode pulse amplitude. The signal transit time is measured between the instant at which the illuminating pulse of the cathode becomes maximum and the instant at which the anode pulse reaches its maximum. The rise time, pulse duration and transit time will vary with respect to the high tension supply voltage V_{ht} approximately as $V_{ht}^{-1/2}$.

17 Transit times of single electrons leaving the photocathode result in a transit time distribution at the anode. This distribution is characterized by its standard deviation.

18 The voltage corresponding to this maximum anode blue sensitivity is equal to 1.2 times the voltage indicated on the test ticket of the tube.

19 A value less than 10 µA is recommended for applications requiring good stability.

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

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

22 For types with a plastic base, this range of temperature is limited principally by stresses in the sealing layer of the base to the glass bulb.

10-STAGE 64-CHANNEL PHOTOMULTIPLIER TUBE

- 64 independent outputs
- 8 x 8 matrix
- semi-transparent bi-alkaline photocathode
- good life time
- for fibre read-out, Cerenkov imaging, spectrophotometry

QUICK REFERENCE DATA

Spectral response		bialkaline
Useful area of the photocathode		20 mm x 20 mm
Cathode radiant sensitivity at 400 nm	min.	40 mA/W
Supply voltage for a gain of 1×10^6	typ.	1250 V
Anode pulse rise time at 1250 V		4.8 ns

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

GENERAL CHARACTERISTICS

Window

Material	Borosilicate glass
Shape	plano-plano
Refractive index at 400 nm	1.50

Photocathode

Type	semi-transparent, head-on
Material	bialkaline
Useful area	20 mm x 20 mm
Maximum radiant sensitivity	400 ± 30 nm
Cut-off at	280/620 nm

Multiplier system

Number of stages	10

Output

Segmented output electrode	last dynode
Number of elements	64
Arrangement	matrix 8 x 8
Pitch	2.54 mm
Useful area of elements	2.54 mm x 2.54 mm
Output pulse polarity	positive

RECOMMENDED CIRCUIT

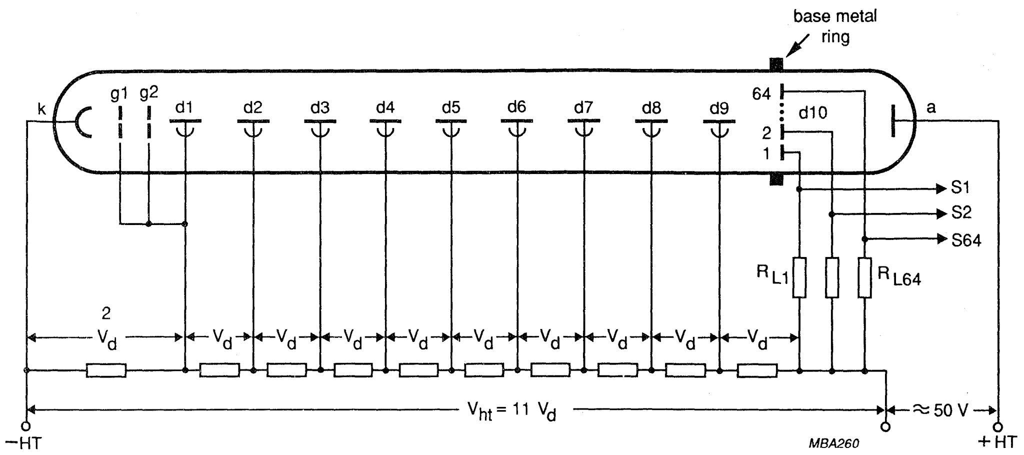


Fig. 1 Voltage divider.

k = cathode
gn = grid no.
dn = dynode no
a = anode
R_{Ln} = load resistor no.

Remarks

- With the voltage divider of Fig.1, the multi-output collector (d10) operates as a dynode and the output signals are positive.
- By connecting the anode electrode (a) to a potential between that of d9 and that of the multi-output collector (d10), the latter operates as an electron collector and the output signals are negative. In this event the electron gain is considerably reduced (by about a factor of 6) due to the suppression of the last amplification stage.
- The grid g1 is internally connected to 4 pins on the base (see Fig.4), so each one can be used indifferently.

TYPICAL CHARACTERISTICS

(with voltage divider as shown in Fig.1)

				notes
Photocathode sensitivity at 400 nm	min.	40	mA/W	1, 2
Gain at 1250 V, Fig.3	min.	3×10^5		2
	typ.	1.0×10^6		
Anode sensitivity uniformity over the 64 channels				
for 60 channels	max.	5:1		
for 4 channels	max.	8:1		
Output pulse rise time at 1250 V	approx.	4.8	ns	
Output dark current per output element at 1250 V	approx.	1	nA	
Cross talk between adjacent elements	max.	5	%	3
Life expectation (50% gain drop)	min.	100	C	4

LIMITING VALUES (Absolute maximum rating system)

Supply voltage between		
last dynode (multi-output element) and cathode	1500	V
anode and last dynode	100	V
Total average output current (sum of the 64 outputs)	50	μA
Average output current per output element	5	μA

RECOMMENDATIONS

* The base metalic ring should preferably be at ground potential. However, in order to minimize the noise level, it may be necessary to adjust its potential to a value between the potentials of the anode and cathode.
* Do not solder on the pins or the metallic rings.
* Do not deform the pins by e.g. bending or filing.
* Grids g1 and g2 can be used for gating operation.

CONNECTIONS

* Voltage divider
  Extension pins are supplied with the tube for the connection to all electrodes (except d10).
* Multi-output (d10) connection kit FE4064
  This kit can be supplied on order. It includes:
  – 8 pieces of 8-pin extension strips
  – a 10 x 10 grid zip socket.

Notes

1. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Radiant sensitivity at 400 nm is expressed in A/W.
2. Average value over the 64 pixels.
3. The tube is exposed to a 2 mm x 2 mm parallel light beam centered on the pixel to be tested. The currents of this pixel and one of the adjacent ones are recorded. The crosstalk is given by the percentage of those two values.
4. Information on life time: no significant change of anode sensitivity has been noted after charge delivery at the anode of about 40 C, the photocathode being uniformly illuminated.

SIGNAL PROCESSING

(1) Parallel processing

Due to the negligible crosstalk between the photocathode pixels and the multi-output element, this device may be considered equivalent to 64 PMTs. Up to 64 discrete light channels can be processed simultaneously (1 processing channel per pixel). In addition to position information, amplitude and timing can be obtained for each channel.
The common collector (anode, carrying the sum of the signals) may also be used for amplitude analysis or triggering purposes.

The 64 outputs may be externally connected in parallel to achieve different PMT configurations.
e.g. PMT with a 4 x 4 matrix (16 pixels measuring 5 mm x 5 mm).
quadrant PMT (4 pixels measuring 10 mm x 10 mm).
segmented tube with 8 strip outputs, etc.

(2) Semi-parallel processing

Localisation of 64 discrete events can be achieved with a smaller number of processing channels. By connecting the pins of each eight pin row to a distributed transmission line (resistive, RC or LC) it is possible to get the position of the signal on the row (see ref. 1, 2, 5) by one of the following three methods.

Charge division method (resistive line) see Fig.2

The ratio $\frac{QA}{QA + QB}$ of the charges QA and QB collected at the ends of the line will give the position (i) of the pixel that has been excited at the input:

$$\frac{QA}{QA + QB} = \frac{n(i)}{N = 8} \quad \text{where } i = 1 \text{ to } 8$$

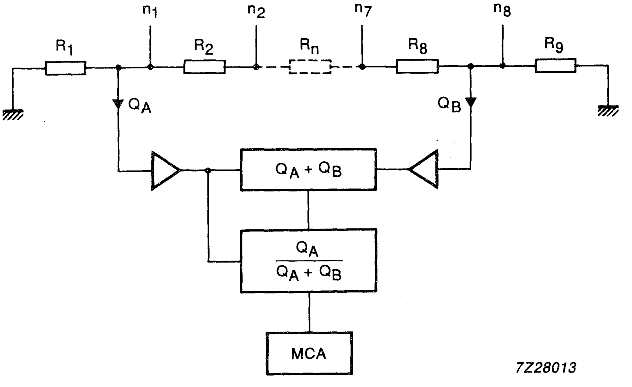


Fig.2 Circuit for charge division method.

Rise time method (RC line)

The position information is derived from the rise time measurement of the pulse at one end of the line (the pulse shape of the signal depending upon the position of the signal current impulse).

Delay line method (LC line)

The position information is directly derived from the transit time difference on the delay line of the two signals collected at the two ends.

(3) X-Y localisation

Localisation of light events with a better spatial resolution can be obtained by allowing the light to fall on adjacent pixels (i.e. multi-photon light events) and processing the signals by the **centroid method** of calculating the centroid of electron distribution.

references:
1. E. Mathieson – Nucl. Instr. Meth. pp. 171 – 176, 1971
2. G. Comby et al., Nucl. Instr. Meth 217, pp. 345 – 350, 1983
3. J.P. Boutot et al., IEEE Trans. Nucl. Sci., NS-34, pp. 449 – 452, 1987
4. L. Ericsson et al., IEEE Trans. Nucl. Sci., NS-34, pp. 344 – 348, 1987
5. G. Comby and R. Meunier, Nucl. Instr. Meth. A269, pp. 246 – 260, 1988.

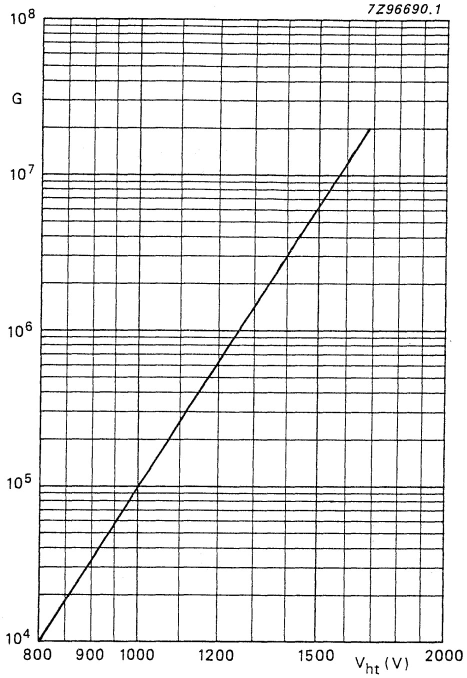


Fig.3 Gain as a function of high voltage.
(average gain over all 64 pixels)

MECHANICAL DATA

Dimensions in mm

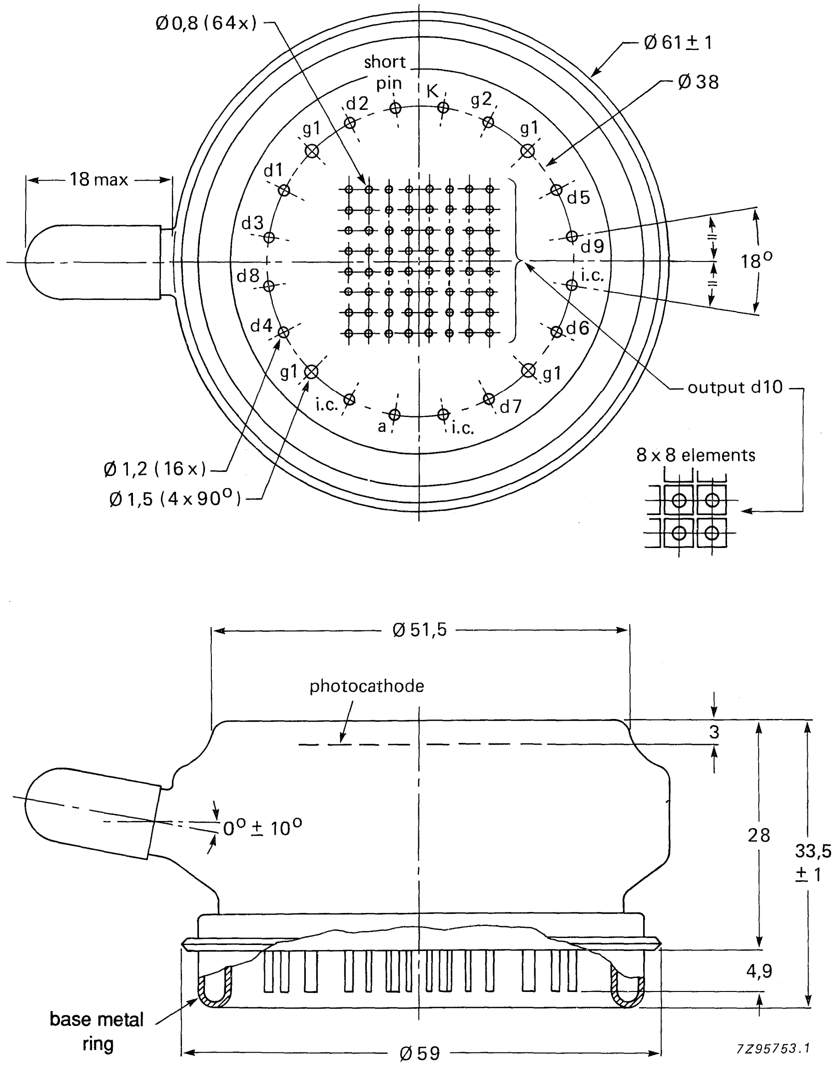


Fig.4 Mechanical outline.

10-STAGE 64-CHANNEL PHOTOMULTIPLIER TUBE

- Fibre optic input window
- 64 independent outputs
- 8 x 8 matrix
- semi-transparent bi-alkaline photocathode
- good life time
- for fibre read-out, Cerenkov imaging, spectrophotometry

QUICK REFERENCE DATA

Spectral response		bialkaline
Useful area of the photocathode		20 mm x 20 mm
Cathode radiant sensitivity at 430 nm	min.	30 mA/W
Supply voltage for a gain of 1 x 10^6	typ.	1300 V
Anode pulse rise time at 1300 V		4.8 ns

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

GENERAL CHARACTERISTICS

Window

Material	fibre optic plate*
Shape	plano-plano

Photocathode

Type	semi-transparent, head-on
Material	bialkaline
Useful area	20 mm x 20 mm
Maximum radiant sensitivity	430 ± 30 nm
Cut-off at	350/620 nm

Multiplier system

Number of stages	10

Output

Segmented output electrode	last dynode
Number of elements	64
Arrangement	matrix 8 x 8
Pitch	2.54 mm
Useful area of elements	2.54 mm x 2.54 mm
Output pulse polarity	positive

* Fibre pitch = 6 μm, NA (numerical aperture) = 1.

RECOMMENDED CIRCUIT

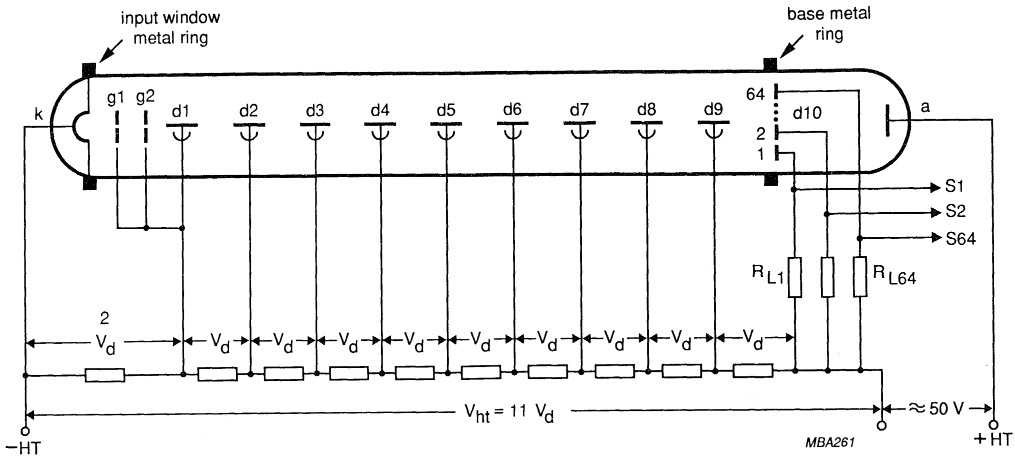


Fig. 1 Voltage divider.

k = cathode
gn = grid no.
dn = dynode no
a = anode
R_{Ln} = load resistor no.

WARNING

The input metal ring is connected to the cathode. Care should be taken to avoid electrical shocks.

Remarks

- With the voltage divider of Fig.1, the multi-output collector (d10) operates as a dynode and the output signals are positive.
- By connecting the anode electrode (a) to a potential between that of d9 and that of the multi-output collector (d10), the latter operates as an electron collector and the output signals are negative. In this event the electron gain is considerably reduced (by about a factor of 6) due to the suppression of the last amplification stage.
- The grid g1 is internally connected to 4 pins on the base (see Fig.4), so each one can be used indifferently.

TYPICAL CHARACTERISTICS

(with voltage divider as shown in Fig.1)				notes
Photocathode sensitivity at 430 nm	min.	30	mA/W	1, 2
Gain at 1300 V, Fig.3	min.	4.0×10^5		2
	typ.	1.0×10^6		
Anode sensitivity uniformity over the 64 channels				
for 60 channels	max.	5:1		
for 4 channels	max.	8:1		
Output pulse rise time at 1300 V	approx.	4.8	ns	
Output dark current per output element at 1300 V	approx.	1	nA	
Cross talk between adjacent elements	max.	5	%	3
Life expectation (50% gain drop)	min.	100	C	4

LIMITING VALUES (Absolute maximum rating system)

Supply voltage between		
last dynode (multi-output element) and cathode	1500	V
anode and last dynode	100	V
Total average output current (sum of the 64 outputs)	50	μA
Average output current per output element	5	μA

RECOMMENDATIONS

* The base metalic ring should preferably be at ground potential. However, in order to minimize the noise level, it may be necessary to adjust its potential to a value between the potentials of the anode and cathode.
* Do not solder on the pins or the metallic rings.
* Do not deform the pins by e.g. bending or filing.
* Grids g1 and g2 can be used for gating operation.

CONNECTIONS

* Voltage divider
  Extension pins are supplied with the tube for the connection to all electrodes (except d10).
* Multi-output (d10) connection kit FE4064
  This kit can be supplied on order. It includes:
  – 8 pieces of 8-pin extension strips
  – a 10 x 10 grid zip socket.

Notes

1. Radiant sensitivity is measured with a tungsten filament lamp with a colour temperature of 2856 ± 5 K. Light is transmitted through an interferential filter. Radiant sensitivity at 430 nm is expressed in A/W.
2. Average value over the 64 pixels.
3. The tube is exposed to a 2 mm x 2 mm parallel light beam centered on the pixel to be tested. The currents of this pixel and one of the adjacent ones are recorded. The crosstalk is given by the percentage of those two values.
4. Information on life time: no significant change of anode sensitivity has been noted after charge delivery at the anode of about 40 C, the photocathode being uniformly illuminated.

SIGNAL PROCESSING

(1) **Parallel processing**

Due to the negligible crosstalk between the photocathode pixels and the multi-output element, this device may be considered equivalent to 64 PMTs. Up to 64 discrete light channels can be processed simultaneously (1 processing channel per pixel). In addition to position information, amplitude and timing can be obtained for each channel.
The common collector (anode, carrying the sum of the signals) may also be used for amplitude analysis or triggering purposes.

The 64 outputs may be externally connected in parallel to achieve different PMT configurations.
e.g. PMT with a 4 x 4 matrix (16 pixels measuring 5 mm x 5 mm).
quadrant PMT (4 pixels measuring 10 mm x 10 mm).
segmented tube with 8 strip outputs, etc.

(2) **Semi-parallel processing**

Localisation of 64 discrete events can be achieved with a smaller number of processing channels.
By connecting the pins of each eight pin row to a distributed transmission line (resistive, RC or LC) it is possible to get the position of the signal on the row (see ref. 1, 2, 5) by one of the following three methods.

Charge division method (resistive line) see Fig.2

The ratio $\frac{QA}{QA + QB}$ of the charges QA and QB collected at the ends of the line will give the position (i) of the pixel that has been excited at the input:

$$\frac{QA}{QA+QB} = \frac{n(i)}{N=8} \quad \text{where } i = 1 \text{ to } 8$$

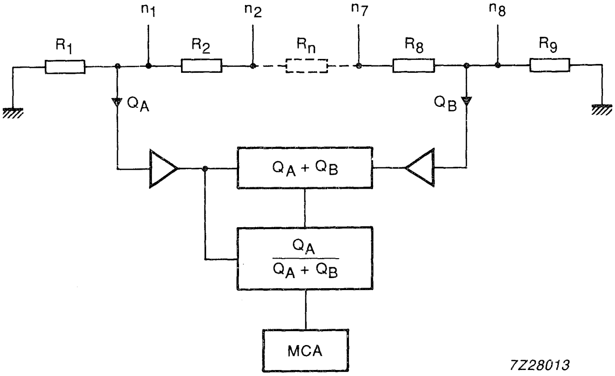


Fig.2 Circuit for charge division method.

Rise time method (RC line)

The position information is derived from the rise time measurement of the pulse at one end of the line (the pulse shape of the signal depending upon the position of the signal current impulse).

Delay line method (LC line)

The position information is directly derived from the transit time difference on the delay line of the two signals collected at the two ends.

(3) **X-Y localisation**

Localisation of light events with a better spatial resolution can be obtained by allowing the light to fall on adjacent pixels (i.e. multi-photon light events) and processing the signals by the **centroid method** of calculating the centroid of electron distribution.

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2. G. Comby et al., Nucl. Instr. Meth 217, pp. 345 – 350, 1983
3. J.P. Boutot et al., IEEE Trans. Nucl. Sci., NS-34, pp. 449 – 452, 1987
4. L. Ericsson et al., IEEE Trans. Nucl. Sci., NS-34, pp. 344 – 348, 1987
5. G. Comby and R. Meunier, Nucl. Instr. Meth. A269, pp. 246 – 260, 1988.

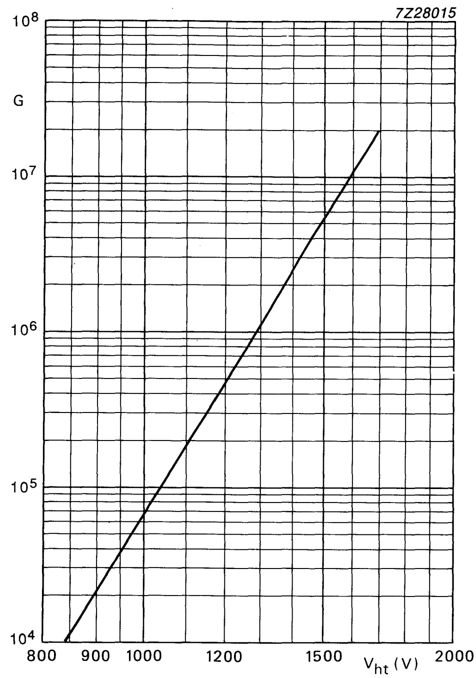


Fig.3 Gain as a function of high voltage.
(average gain over all 64 pixels)

DEVELOPMENT DATA

MECHANICAL DATA

Dimensions in mm

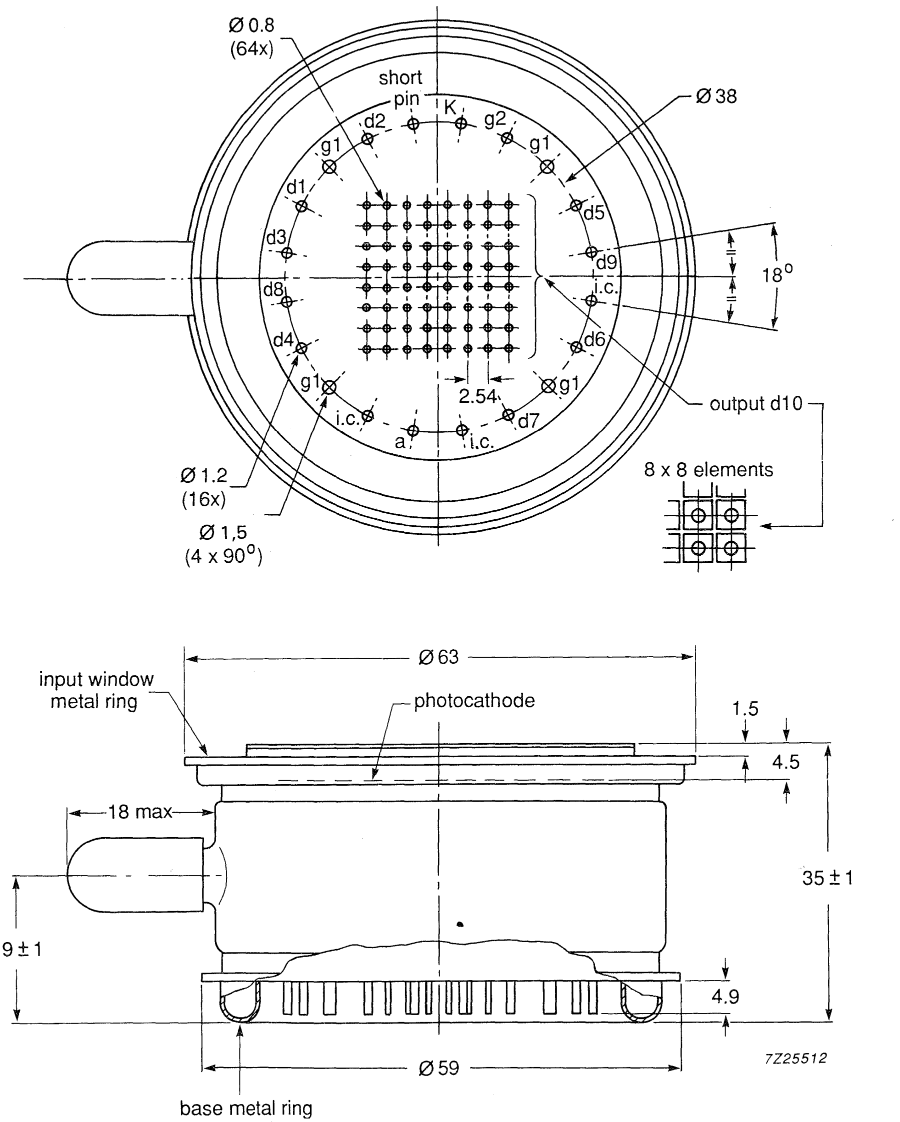


Fig.4 Mechanical outlines.

VACUUM PHOTODIODE

PHOTODIODE

- 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

Radiant sensitivity characteristic	bi-alkaline
Useful diameter of the photocathode	> 20 mm
Blue sensitivity of the photocathode	10,5 μA/lmF
Spectral sensitivity of the photocathode at 440 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	bi-alkaline	
Useful diameter	> 20 mm	
Radiant sensitivity characteristic	see Fig. 2	
Wavelength for maximum radiant sensitivity	420 ± 30 nm	
Radiant sensitivity at 440 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.

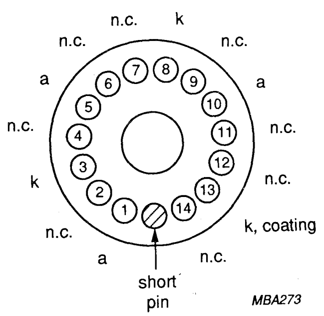
Warnings

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



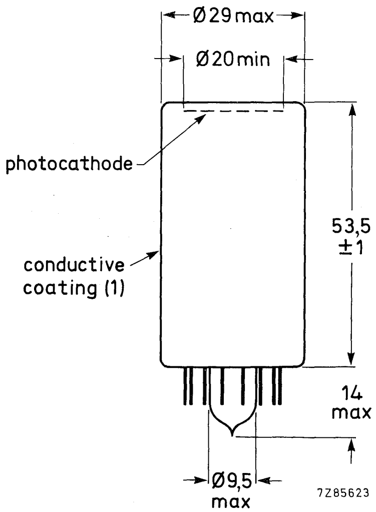


Fig. 1.

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.

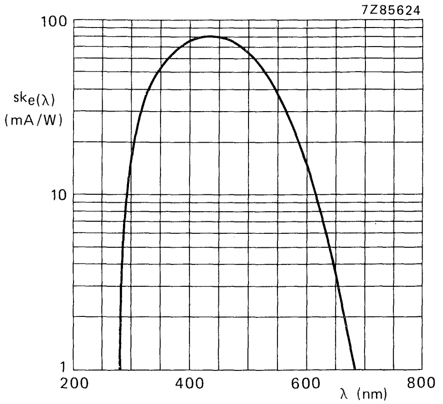


Fig. 2 Spectral sensitivity characteristic.

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

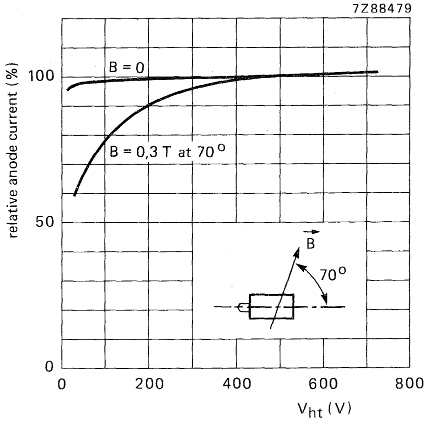


Fig. 3 Relative anode current as a function of supply voltage; typical curves. Tube is in a magnetic field with flux densities B = 0 or 0,3 T; angle between flux density and tube axis is 70°. (Curves by courtesy of CERN, Geneva.)

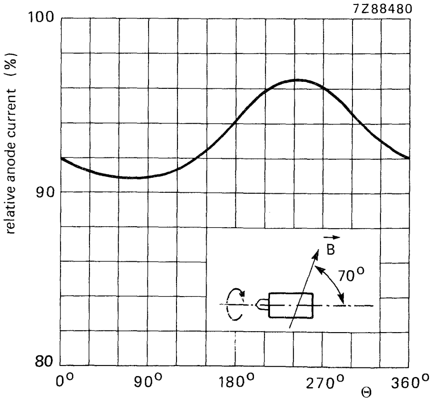


Fig. 4 Relative anode current as a function of tube rotation angle; typical curve. Tube is in a magnetic field with flux density B = 0,3 T; angle between flux density and tube axis is 70°; V_{ht} = 300 V. (Curve by courtesy of CERN, Geneva.)

ASSOCIATED ACCESSORIES

SURVEY OF TYPES

socket type number	for tubes with:			page
	nominal diameter (mm)	base		
		all-glass	plastic	
FE1004	19	12-pin		443
FE1114	29	14-pin		451
FE1112	38	14-pin		449
FE1012			JEDEC B12-43	445
FE2019	⩾ 51	19-pin		455
FE2021		21-pin		457
FE1014			JEDEC B14-38	447
FE1120			JEDEC B20-102	453

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.

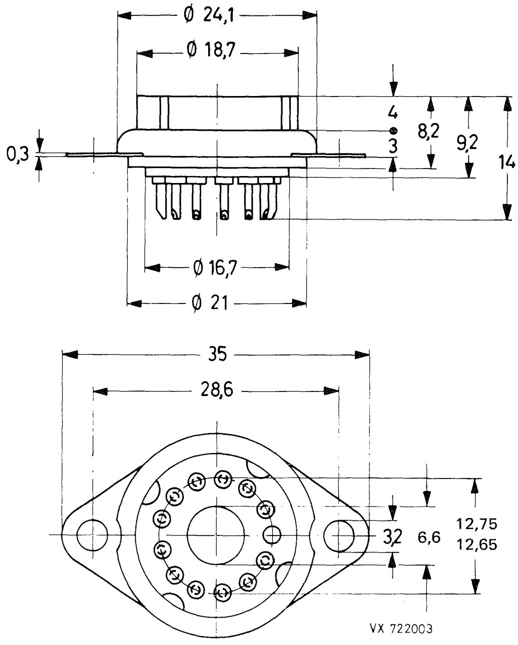
ELECTRICAL DATA

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.

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 M3 screws.

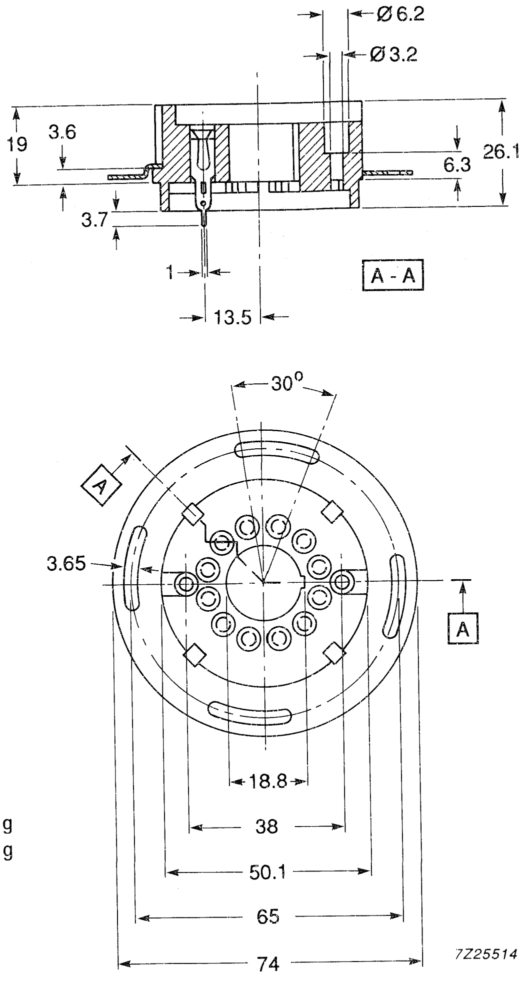
ELECTRICAL DATA

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

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 M3 screws

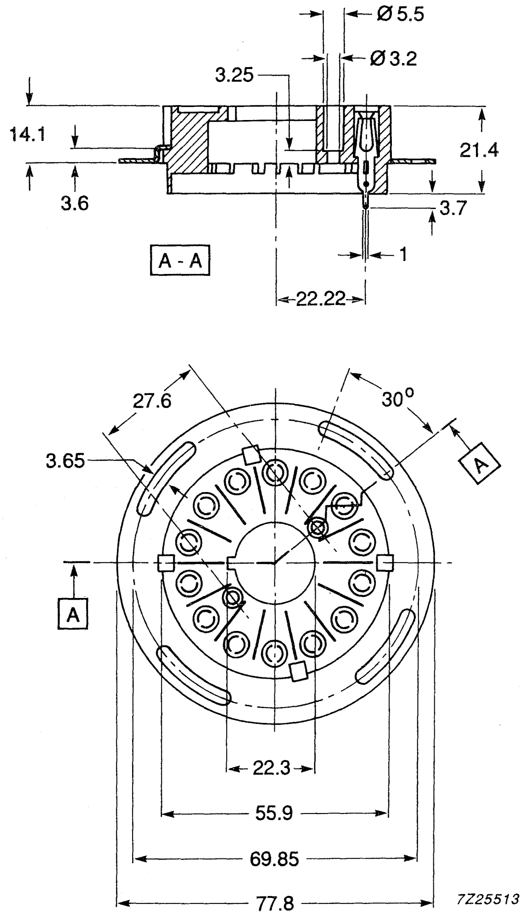
ELECTRICAL DATA

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

SOCKET

DESCRIPTION

This socket has a plastic moulding with 12 tin-plated printed-wiring contacts.

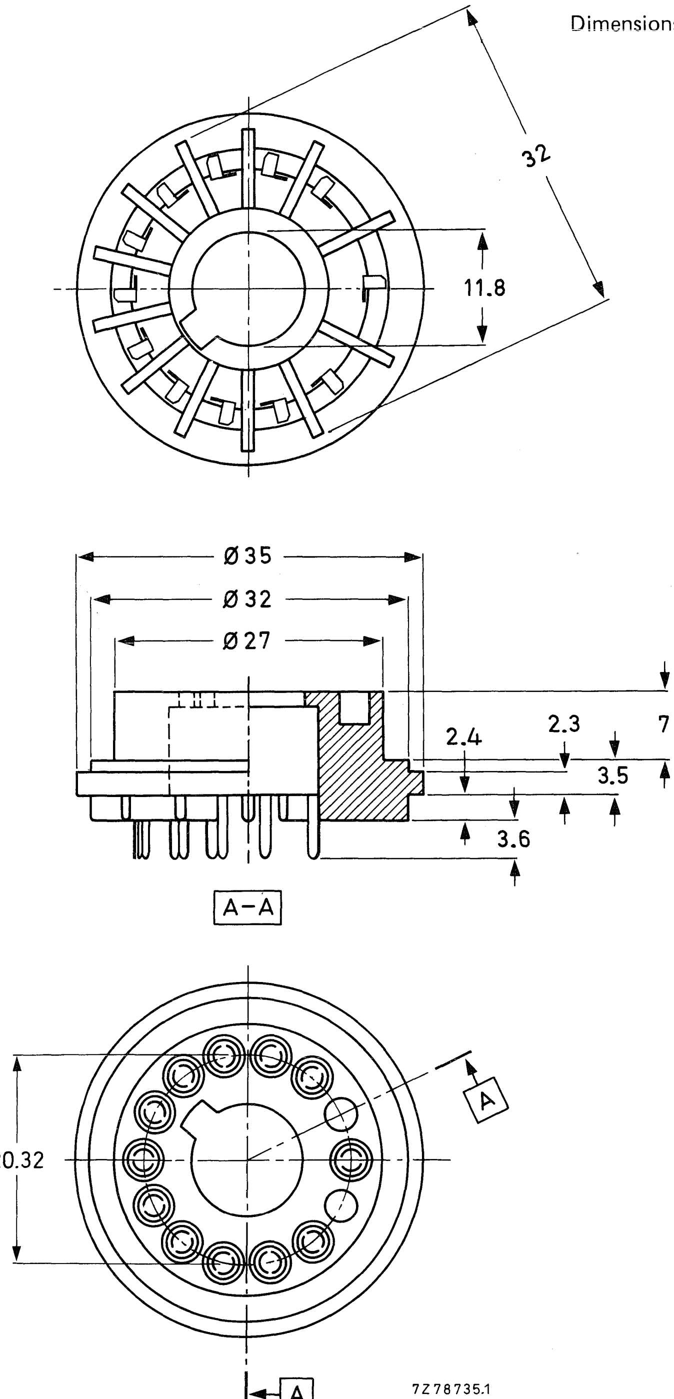
ELECTRICAL DATA

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

Outlines

Dimensions in mm



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.

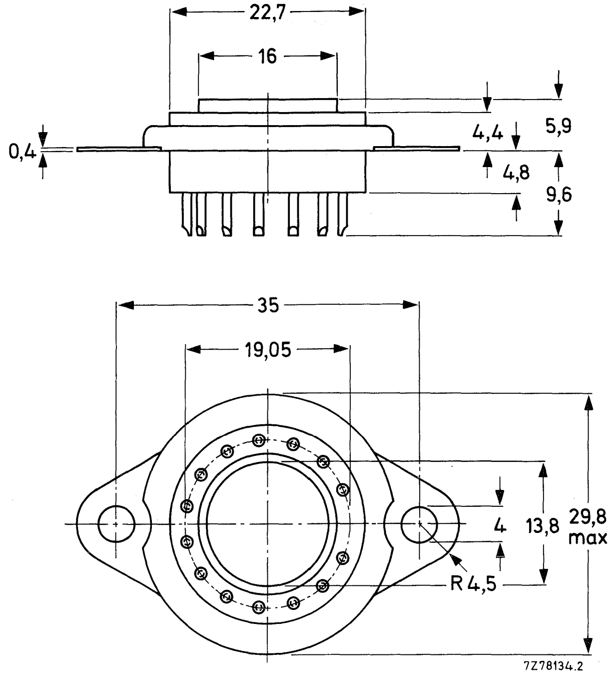
ELECTRICAL DATA

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 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.

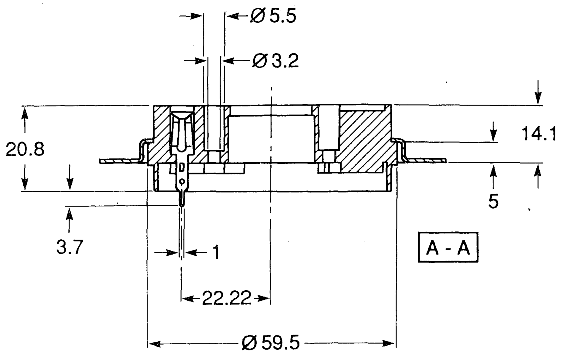
ELECTRICAL DATA

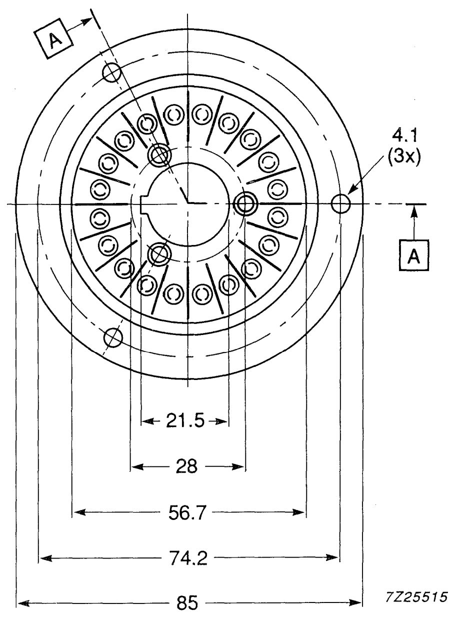
Maximum working voltage between two adjacent contacts		2000	V
Maximum working voltage between any contact and saddle		4000	V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13}	Ω
Contact resistance	<	50	mΩ
Temperature	max.	80	°C

MECHANICAL DATA

Dimensions in mm

Outlines





Mass

socket	64 g
mounting ring	44 g

SOCKET

DESCRIPTION

This socket 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 M3 screws.

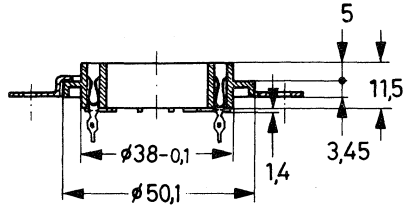
ELECTRICAL DATA

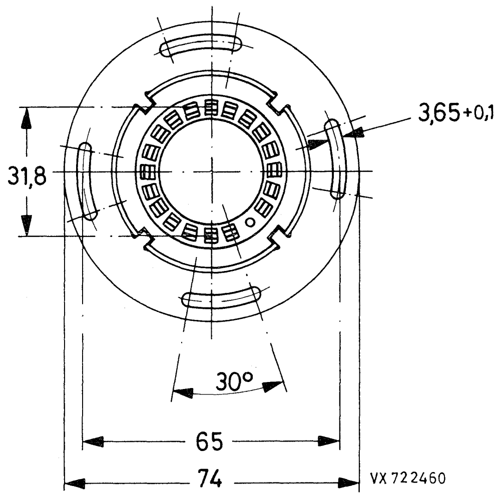
Maximum working voltage between two adjacent contacts		2000 V
Maximum working voltage between any contact and saddle		3000 V
Insulation resistance between two adjacent contacts (at 500 V)	>	10^{13} Ω
Contact resistance	<	50 mΩ
Temperature	max.	80 °C

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 M3 screws.

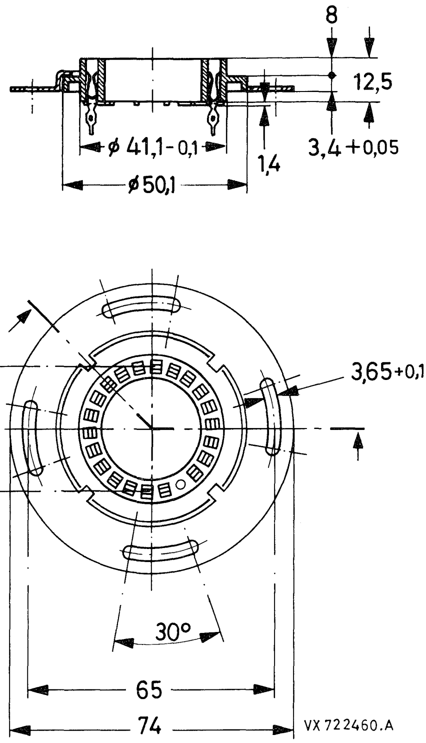
ELECTRICAL DATA

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

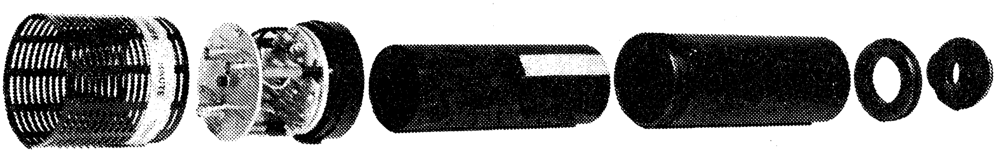
socket	35 g
mounting ring	15 g

BASE ASSEMBLY AND HOUSING FOR FAST TUBES

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 front shield assembly for fast photomultiplier tubes with a nominal diameter of 51 mm;

S563 voltage divider base assembly for most fast photomultiplier tubes with a nominal diameter of 51 mm, 76 mm or 130 mm, and a 20-pin plastic base.

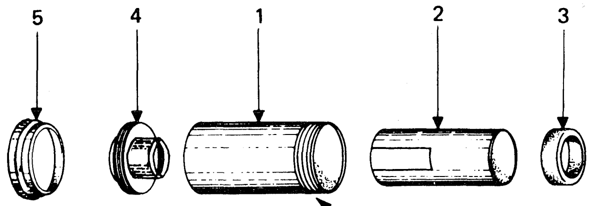
The parts can also be used separately; see table below.

photomultiplier tube		front + base assembly	front shield assembly	base assembly
useful diameter of photocathode	type			
51 mm	XP2020(Q) XP2233B XP2237B XP2254B XP2262B XP4222B XP4227B XP4228B	S5632	S5632/AV	S563
76 mm	XP2312B	not available		S563
130 mm	XP2041(Q)			

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

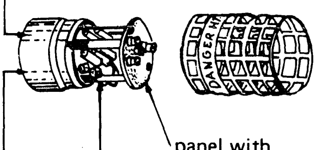


Fig. 1 S5632 = S5632/AV + S563.

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

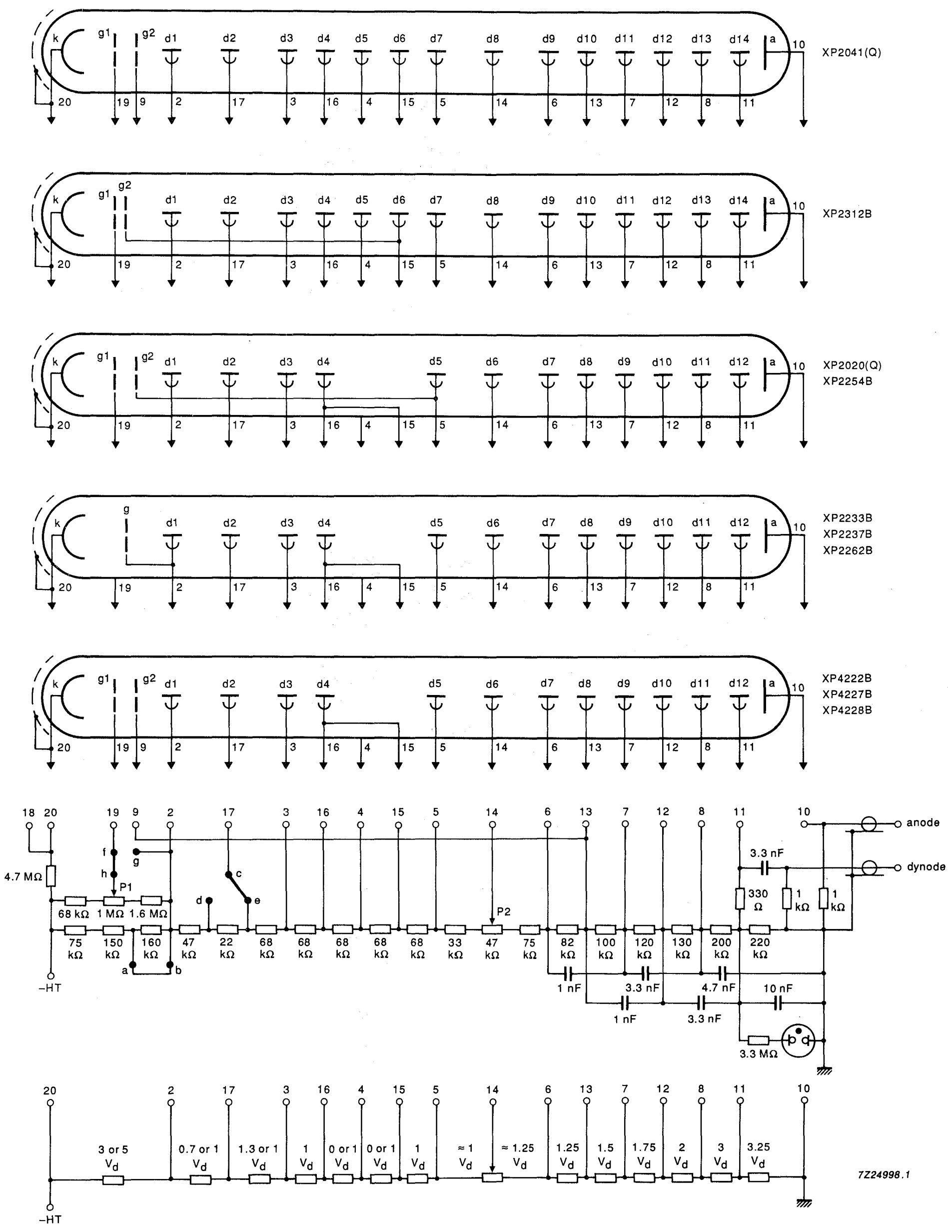


Fig.2.

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 with any of the listed 51 mm and 76 mm tubes. However, for XP2233B tubes with serial numbers between 1606 and 11576, remove jumper f-h and insert new jumper f-g.

For use with 130 mm tubes XP2041 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.

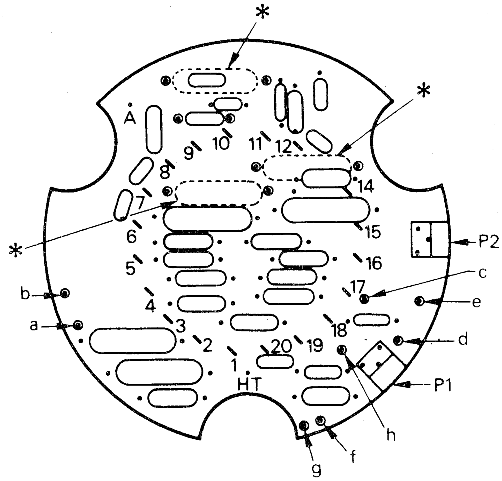


Fig. 3.

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

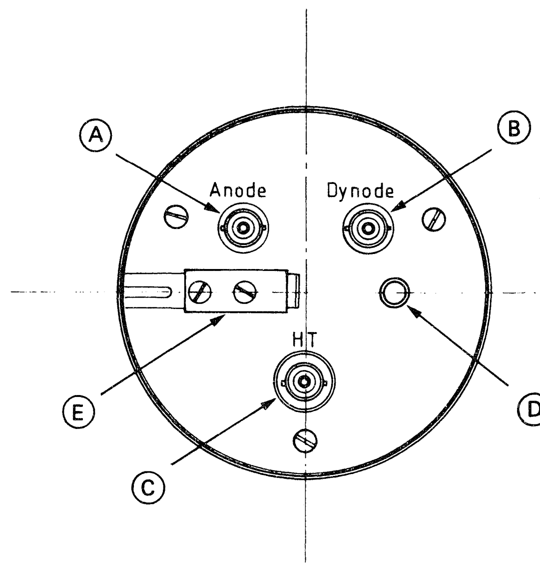


Fig. 4.

** Not supplied with 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 C for tubes XP2020(Q), XP2041(Q), XP2254B, XP4222B, XP4227B and XP4228B and type B for tubes XP2233B, XP2237B, XP2262B and XP2312B. 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.

Tube	Gain	Pulse response		
	supply voltage for G = 10^7 (V)	t_r (ns)	t_W (ns)	for a supply voltage of (V)
XP2020(Q) XP2254B XP4222B XP4227B XP4228B	2000 2200 2000 2200 2000	1.6	2.5	2500
XP2233B XP2237B XP2262B	2200 2200 1900	2.1	3.1	2100
XP2312B	1900	2.6	3.7	2100
XP2041(Q)	2150	2.4	3.3	2200

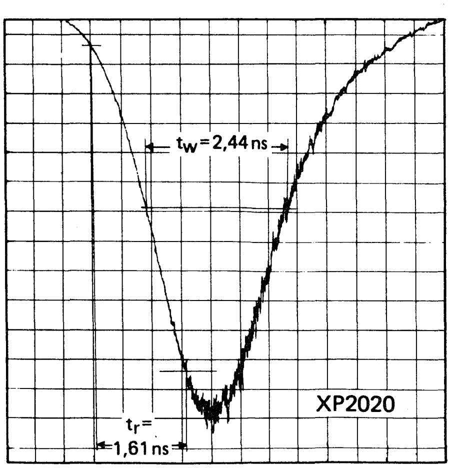
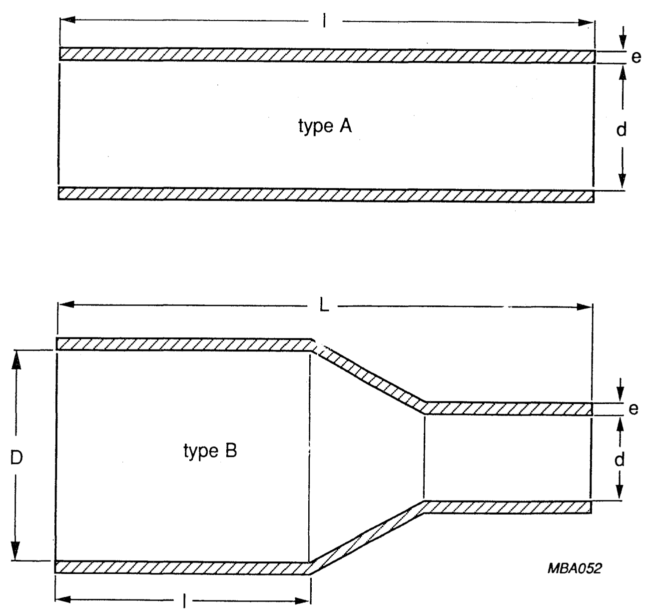


Fig. 5.

MU-METAL SHIELD

Type number	Type A end B			Type B		For tube diameter	notes
	e	l	d	L	D		
56689	0.8	80	20.5			19 mm (¾")	
56699	0.8	130	30			29 mm (1⅛")	
56609	0.8	125	42			38 mm (1½")	
56619	0.8	170	57.5			51 mm (2")	very fast tubes
56629	0.8	85	54			51 mm (2")	other tubes
56639	0.8	55	57.5	135	82	76 mm (3")	
56658	0.8	180	57.5	225	138	130 mm (5")	XP2041
56659	0.8	85	85	220	138	130 mm (5")	XP2050



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DATA HANDBOOK SYSTEM

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 six series of handbooks:

INTEGRATED CIRCUITS

DISCRETE SEMICONDUCTORS

DISPLAY COMPONENTS

PASSIVE COMPONENTS*

PROFESSIONAL COMPONENTS**

MATERIALS*

The contents of each series are listed on pages iii 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 is given it is advisory and does not form part of the product specification.

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

Information on current Data Handbooks and 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.

* Will replace the Components and materials (green) series of handbooks.
** Will replace the Electron tubes (blue) series of handbooks.

INTEGRATED CIRCUITS

This series of handbooks comprises:

code	handbook title
IC01	**Radio, audio and associated systems** Bipolar, MOS
IC02a/b	**Video and associated systems** Bipolar, MOS
IC03	**ICs for Telecom** Bipolar, MOS Subscriber sets, Cordless Telephones
IC04	**HE4000B logic family** CMOS
IC05	**Advanced Low-power Schottky (ALS) Logic Series**
IC06	**High-speed CMOS; PC74HC/HCT/HCU** Logic family
IC07	**Advanced CMOS logic (ACL)**
IC08	**ECL 10K and 100K logic families**
IC09N	**TTL logic series**
IC10	**Memories** MOS, TTL, ECL
IC11	**Linear Products**
IC12	**I^2C-bus compatible ICs**
IC13	**Semi-custom** Programmable Logic Devices (PLD)
IC14	**Microcontrollers** NMOS, CMOS
IC15	**FAST TTL logic series**
IC16	**CMOS integrated circuits for clocks and watches**
IC17	**ICs for Telecom** Bipolar, MOS Radio pagers Mobile telephones ISDN
IC18	**Microprocessors and peripherals**
IC19	**Data communication products**

DISCRETE SEMICONDUCTORS

This series of data handbooks comprises:

current code	new code	handbook title
S1	**SC01**	**Diodes** High-voltage tripler units
S2a	**SC02**	**Power diodes**
S2b	**SC03***	**Thyristors and triacs**
S3	**SC04**	**Small-signal transistors**
S4a	**SC05**	**Low-frequency power transistors and hybrid IC power modules**
S4b	**SC06**	**High-voltage and switching power transistors**
S5	**SC07**	**Small-signal field-effect transistors**
S6	**SC08** **SC09**	**RF power transistors** **RF power modules**
S7	**SC10**	**Surface mounted semiconductors**
S8a	**SC11***	**Light emitting diodes**
S8b	**SC12**	**Optocouplers**
S9	**SC13***	**PowerMOS transistors**
S10	**SC14**	**Wideband transistors and wideband hybrid IC modules**
S11	**SC15**	**Microwave transistors**
S15**	**SC16**	**Laser diodes**
S13	**SC17**	**Semiconductor sensors**
S14	**SC18***	**Liquid crystal displays and driver ICs for LCDs**

* Not yet issued with the new code in this series of handbooks.
** New handbook in this series; will be issued shortly.

DISPLAY COMPONENTS

This series of data handbooks comprises:

current code	new code	handbook title
T8	**DC01**	**Colour display components**
T16	**DC02**	**Monochrome monitor tubes and deflection units**
C2	**DC03**	**Television tuners, coaxial aerial input assemblies**
C3	**DC04***	**Loudspeakers**
C20	**DC05**	**Flyback transformers, mains transformers and general-purpose FXC assemblies**

* These handbooks are currently issued in another series; they are not yet issued in the Display Components series of handbooks.

PASSIVE COMPONENTS

This series of data handbooks comprises:

current code	new code	handbook title
C14	PA01	**Electrolytic capacitors; solid and non-solid**
C11	PA02	**Varistors, thermistors and sensors**
C12	PA03	**Potentiometers and switches**
C7	PA04	**Variable capacitors**
C22	PA05*	**Film capacitors**
C15	PA06*	**Ceramic capacitors**
C9	PA07*	**Piezoelectric quartz devices**
C13	PA08	**Fixed resistors**

* Not yet issued with the new code in this series of handbooks.

PROFESSIONAL COMPONENTS

This series of data handbooks comprises:

current code	new code	handbook title
T1	*	**Power tubes for RF heating and communications**
T2a	*	**Transmitting tubes for communications, glass types**
T2b	*	**Transmitting tubes for communications, ceramic types**
T3	**PC01**	**High-power klystrons**
T4	*	**Magnetrons for microwave heating**
T5	**PC02****	**Cathode-ray tubes**
T6	**PC03****	**Geiger-Müller tubes**
T9	**PC04**	**Photomultipliers**
T10	**PC05**	**Plumbicon camera tubes and accessories**
T11	**PC06**	**Circulators and Isolators**
T12	**PC07**	**Vidicon and Newvicon camera tubes and deflection units**
T13	**PC08**	**Image intensifiers**
T15	**PC09**	**Dry reed switches**
C8	**PC10**	**Variable mains transformers; annular fixed transformers**
	PC11	**Solid state image sensors and peripheral integrated circuits**
T9	**PC12****	**Electronmultipliers**

* These handbooks will not be reissued.
** Not yet issued with the new code in this series of handbooks.

MATERIALS

This series of data handbooks comprises:

current code	new code	handbook title
C4 **C5**	**MA01***	**Soft Ferrites**
C16	**MA02****	**Permanent magnet materials**
C19	**MA03****	**Piezoelectric ceramics**

* Handbooks C4 and C5 will be reissued as one handbook having the new code MA01.

** Not yet issued with the new code in this series of handbooks.

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