WASSENAAR

PHILIPS

DATA HANDBOOK

PHILIPS ELECTRONIC COMPONENTS AND MATERIALS DIVISION

ELECTRON TUBES

PART 5 APRIL 1968

Cathode-Ray Tubes
Camera Tubes

Photo Tubes
Photoconductive Devices

Associated Accessories

ELECTRON TUBES

Part 5 **April 1968**

DATA HANDBOOK SYSTEM

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

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

Electron tubes	blue
Semiconductors and Integrated circuits	red
Components and Materials	green

The several volumes contain all pertinent data available at the time of publication, and each is revised and reissued annually.

We have made every effort to ensure that each series is as accurate, comprehensive and up-to-date as possible, and we hope you will find it to be a valuable source of reference. You will understand that we can not guarantee that all products listed in any edition of the handbook will remain available, or that their specifications will not be changed, before the next edition is published. If you need confirmation that the published data of any of our products are the latest available, therefore, may we ask that you contact our representative. He is at your service and will be glad to answer your inquiries.

This volume is a part of the (blue) series "Electron Tubes" issue 1967/68
The complete series will contain the following parts:

		Latest issue	Previous issue
PART 1	Transmitting tubes Tubes for R.F. heating High-voltage rectifiers Associated accessories	Dec. 1967	
PART 2	Tubes for microwave equipment	Jan. 1968	
PART 3	Special Quality tubes Miscellaneous devices	Febr. 1968	
PART 4	Receiving tubes T.V. picture tubes	March 1968	
PART 5	Cathode-ray tubes Photo tubes Camera tubes Photoconductive devices Associated accessories		May 1967
PART 6	Photomultiplier tubes	Part 5, May 1967	
	Radiation counter tubes	Part 6, Aug. 1967	
	Scintillators	Part 5, May 1967	
	Semiconductor detectors	–	
	Miscellaneous nuclear devices	Part 6, Aug. 1967	
PART 7	Voltage stabilizing and reference tubes Counter-, selector-, and indicator tubes Trigger tubes Switching diodes Thyratrons Ignitrons Industrial rectifying tubes	Part 6, Aug. 1967	
	High-voltage rectifying tubes	Part 1, Dec. 1967	

This handbook does not give information on delivery or terms.

Cathode-ray tubes

LIST OF SYMBOLS

Symbols denoting electrodes and electrode connections

Heater or filament	f
Cathode	k
Grid Grids are distinguished by means of an additional numeral; the electrode nearest to the cathode having the lowest number.	g
Deflection plates intended for deflection in horizontal direction.	x_1, x_2
Deflection plates intended for deflection in vertical direction. Sectioned deflection plates are indicated by an additional decimal e.g. $y_{1.1}$ $y_{1.2}$ and $y_{2.1}$ $y_{2.2}$	y_1, y_2
External conductive coating	m
Fluorescent screen	ℓ
Tube pin which must not be connected externally	i.c.
Tube pin which may be connected externally	n.c.

Symbols denoting voltages

Symbol for voltage, followed by an index denoting the relevant electrode.	V
Heater or filament voltage	V_f
Peak value of a voltage	V_p
Peak to peak value of a voltage	V_{pp}

7Z2 5887

Symbols denoting currents

Remark I	The positive electrical current is directed opposite to the direction of the electron current.	
Remark II	The symbols quoted represent the average values of the concerning currents unless otherwise stated.	
Symbol for current followed by an index denoting the relevant electrode.		I
Heater or filament current		I_f

Symbols denoting powers

Dissipation of the fluorescent screen	W_ℓ
Grid dissipation	W_g

Symbols denoting capacitances

See I.E.C. Publication 100.

Symbols denoting resistances

Symbol for resistance followed by an index for the relevant electrode pair. When only one index is given the second electrode is the cathode.	R

When R is replaced by Z the "resistance should read "impedance"

Symbols denoting various quantities

Brightness	B
Frequency	f
Magnetic field strength	H
Deflection factor	M

7Z2 5888

GENERAL OPERATIONAL RECOMMENDATIONS
CATHODE-RAY TUBES

GENERAL

Unless otherwise stated the data are given for a nominal tube.

LIMITING VALUES

Unless otherwise stated the tubes are rated according to the absolute maximum rating system.

HEATER

Parallel operation

The heater voltage must be within ±7 % of the nominal value when the supply voltage is at its nominal value, and when a tube having the published heater characteristics is employed.
This figure is permissible only if the voltage variation is dependent upon more than one factor. In these circumstances the total tolerance may be taken as the square root of the sum of the squares of the individual deviations arising from the effect of the tolerances of the separate factors, providing no one of these deviations exceeds ±5 %. Should the voltage variation depend on one factor only, the voltage variation must not exceed ±5 %.

Series operation

The heater current must be within ±5 % of the nominal value when the supply voltage is at its nominal value and a tube having the published heater characteristics is employed. This figure is permissible only if the current variation is dependent upon more than one factor. In these circumstances the total tolerance may be taken as the square root of the sum of the squares of the individual deviations arising from the effects of the tolerances of the separate factors, providing no one of these deviations exceeds ±3.5 %. Should the total current variation depend upon one factor only, the current variation must not exceed ±3.5 %.
When calculating the tolerances of associated components, the ratio of the change of heater voltage to the change of heater current in a typical series chain including a cathode ray tube is taken as 1.8, both deviations being expressed as percentages.

7Z2 5879

HEATER (continued)

With certain combinations of valves and tube, differences in the thermal inertia may result in particular heaters being run at exceedingly high temperature during the warming up period. During this period unless otherwise stated in the published data, it is permissible for the heater voltage of the tube to rise to a maximum value of 50 % in excess of the nominal rated value when using a tube with the published heater characteristics. A surge limiting device may be necessary in order to meet this requirement. When measuring the surge value of heater voltage, it is important to employ a peak reading device, such as an oscilloscope.

In addition to the quoted above, fluctuations in the mains supply voltage not exceeding ±10 % are permissible. These conditions are, however, the worst which are acceptable and it is better practise to maintain the heater as close to its published ratings as possible. Furthermore in all types of equipment closer adjustment of heater voltage or current will react favourably upon tube life and performance.

CATHODE

The potential difference between cathode and heater should be as low as possible and in any case must not exceed the limiting value given on the data sheets for individual tubes. Operation with the heater positive with respect to cathode is not recommended. In order to avoid excessive hum the A.C. component of the heater-to-cathode voltage should be as low as possible e.g. less than 20 V_{rms}. When the heater is in a series chain or earthed, the 50 c/s impedance between heater and cathode should not exceed 100 kΩ. If the heater is supplied from separate transformer windings the resistance between heater and cathode must not exceed 1 MΩ.

ELECTRODES

In no circumstances should the tube be operated without a D.C. connection between each electrode and the cathode. The total effective impedance between any electrode and the cathode should be as low as possible and must never be allowed to exceed the published maximum value.

ELECTRODE VOLTAGES

Reference point for electrode voltages is the cathode. For cathode drive service the reference point is grid No.1.

Grid cut-off voltages

Values are given for the limits of grid cut-off voltage per unit of the first accelerator voltage. The brightness control voltage should be arranged so that it can handle any tube within the limits shown, at the appropriate first accelerator voltage.

First accelerator voltage

The first accelerator electrode of a so called unipotential lens provides by applying a fixed voltage independent focus and brightness controls. Care should be taken not to exceed the maximum and minimum limits for reasons of reliability and performance.

Deflection blanking electrode voltage

The mean potential of the deflection blanking electrode should be equal to that of the first accelerator.
If applicable the voltage difference (ΔV_{g_3}) given in the data should be applied to the beam blanking electrode to obtain beam blanking of a stated beam current for all tubes of the relevant type.

Focusing voltage

The focusing electrode voltage limits are given in the data. The focus voltage supply should be arranged such that it can handle these limits, so that in any tube the cross-sectional area of the electron-beam on the screen can be optimally displayed. As the focus current is very limited a high resistance series chain may be used.

Astigmatism control electrode voltage

To achieve optimum performance under all conditions it is desirable to apply a voltage for control of astigmatism (a difference in potential of this electrode and the y plates). The required range to cover any tube is given in the relevant data.

Beam centring electrode voltage

The beam centring electrode facilitates the possibility to centre the scan in x-direction with respect to the geometric centre of the faceplate by applying a voltage, the limits of which are given in the relevant data, to this electrode. Optimum condition is obtained when the brightness at both left and right edges of the scan are equal.

Deflection plate shield voltage

It is essential that the deflection plate shield voltage equals the mean y plates voltage.

Geometry control electrode voltage

By varying the potential of this electrode the necessary range of which is given in the relevant data the possible occurrence of pin-cushion and barrel-pattern distortion can be controlled.

7Z2 5881

Deflection voltages

For optimum performance it is essential that true symmetrical voltages are applied. It should further be noted that the mean x and y plate potentials must be equal. Moreover the deflection plate shield voltage, the mean astigmatism control voltage, if applicable the mean beam centring electrode voltage and the geometry electrode voltage should also be equal to the mean x and y plate potentials. If use is made of the full deflection capabilities of the tube, the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Raster distortion and its determination

Limits of raster distortion are given for most tubes.
A graticule, consisting of concentric rectangles is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

Measuring procedure:

a) Shift the x-trace to the centre of the graticule.

b) Align horizontal centre line of graticule with the centre line of the x-trace.

c) Shift x-trace vertically between resp. upper and lower two horizontal lines of graticule.
The centre of the x-trace now will not fall outside the area bounded by the horizontal graticule lines.

d) Without moving the graticule, switch to a vertical trace and shift this trace horizontally (resp. left and right) between the pairs of vertical lines of the graticule, and also now the centre of the y-trace will not fall outside the area bounded by the vertical graticule lines.

e) Focus and astigmatism will be adjusted for optimum performance.

f) Pattern geometry correction will be adjusted for optimum performance in the sense of minimizing simultaneously the deviation of the centre of x- respectively y-trace.

Linearity

The linearity is defined as the sensitivity at a deflection of 75 % of the useful scan with respect to differ from the sensitivity at a deflection of 25 % of the useful scan. These sensitivities will not differ by more than the indicated value.

Post deflection shield voltage

In order to optimize contrast in mesh tubes a fixed negative voltage with respect to the geometry control electrode voltage should be applied. The range is given in the data.

7Z2 5882

Helix resistance

In order to calculate the high tension supply a minimum resistance is given in the data.

Final accelerator voltage

Tubes with PDA are designed for a given final accelerator voltage to astigmatism control electrode voltage ratio. Operation at higher ratio may result in changes in deflection uniformity and pattern distortion.

High tension supply

In order to avoid damage of the screen it is important that prior to the high tension a deflection voltage e.g. the time base voltage is applied.

LINE WIDTH

Shrinking raster method. Conditions as given in the relevant data.
Focus and astigmatism potentials should be adjusted for optimum performance. Optimum performance is that adjustment which will simultaneously minimize the horizontal and vertical trace widths at the centre of the useful scan.
The raster shall be compressed until the line structure first disappears or begins to overlap or show reverse line structure.
The line width is equal to the quotient of the width of the compressed pattern transverse to the line structure divided by the number of lines which are being scanned.
In older types the line width is measured on a circle with the aid of a microscope.

CAPACITANCES

Unless otherwise stated the values given are nominal values measured on a cold tube on the tube contacts. The contacts and measuring leads or sockets being screened.

MOUNTING

Unless otherwise stated the mounting position is any. However, the tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.
To avoid dangerous glass strain care should be taken when installing the tube.

Shielding

The tubes must be shielded against electrical and magnetic fields.
Special attention should be paid to the mounting of transformers, coils etc.

7Z2 5883

SCREEN

To prevent screen burn stationary or slow moving spots together with high screen currents should be avoided.
If measurements are to be made under high ambient light conditions it is advisable to use a contrast improving filter and or a light hood.

TRACKING ERROR

Tracking is the ability of a multigun tube to superimpose simultaneously information from each gun.
Tracking error is the maximum allowable distance between the displays of any two guns.

RATING SYSTEMS

(in accordance with I.E.C. publication 134)

Absolute maximum rating system

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

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

The equipment manufacturer should design so that, initially and throughout life, no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

Design-maximum rating system

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout life, no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

7Z2 5065

Design-centre rating system

Design-centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design-centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply-voltage.

7Z2 5066

NOMENCLATURE

Two type nomenclature systems are currently in existance for our C.R. tubes. All future tubes will have numbers in the "new system", earlier tubes will retain numbers in the "old system".

NEW CODE SYSTEM

The type number consists of a single letter followed by two sets of figures ending with one or two letters.

The first letter indicates the prime appplication of the tube.

A - Television display tube for domestic application

D - Oscilloscope tube - single trace

E - Oscilloscope tube - multiple trace

F - Radar display tube - direct view

L - Display storage tube

M - T.V. display tube for professional application - direct view

P - Display tube for professional application - projection

Q - Flying spot scanner

The first group of figures indicates the diameter or diagonal of the luminescent screen in cm.

The second group of figures is a two- or three figure serial number indicating a particular design or development.

The second group of letters indicates the properties if the phosphor screen. The first letter denotes the colour of the fluorescence or phosphorescence in the case of long or very long afterglow screens.

The second letter of this group is a serial letter to denote other specific differences in screen properties.

For the standard television tube phosphors, the letters 'W' and 'X' are used without a second letter.

A - Purple - reddish purple - bluish purple

B - Blue - purplish blue - greenish blue

D - Blue green

G - Green - bluish green - yellowish green

K - Yellow - green

L - Orange - Orange pink

R - Red - reddish orange - red purple - purplish red - pink - purplish pink

Y - Yellow - greenish yellow - yellowish orange

W - White screen for T.V. display tubes

X - Three-colour screen for T.V. display tubes

OLD SYSTEM

The type number consists of two letters followed by two sets of figures. The first letter indicates the method of focusing and deflection:

A - Electrostatic focusing and electromagnetic deflection

B - Electrostatic focusing and electrostatic deflection

M - Electromagnetic focusing and electromagnetic deflection

The second letter indicates the properties of the phosphor screen.

See also section "Screen Phosphors"

The first group of figures:

for round tubes: screen diameter in cm

for rectangular tubes: screen diagonal in cm

The second group of figures denotes the serial number.

SCREEN PHOSPHORS AND INDUSTRIAL CATHODE-RAY TUBES

CHOICE OF SCREEN

When a cathode ray tube is chosen for a particular application, the designer of the apparatus bases his choice on a number of factors; for example, screen shape and size, the operating potentials that will be available, and the screen characteristics. He may find that the required physical and electrical configuration is provided by a number of tube types which employ different screen phosphors, so that he will have to choose between one phosphor and another. In any event, the performance obtainable from the screen is of major importance, since the purpose of any cathode ray tube application is the provision of a suitable display.

Here the relationship between screen characteristics and the requirements of the main groups of applications will be discussed. The suitability of particular screen types is considered in terms of operating conditions that will be met and the performance that must be achieved.

The ultimate choice is determined by the detailed requirements of each specific application; therefore, in addition to general guidance, the methods of calculating the performance that will be obtained under given conditions are included. The calculations take into account the characteristics of the screen, the operational requirements, the nature of the viewing device, and the effect (where the screen is viewed by the eye) of the external viewing conditions.

GENERAL REQUIREMENTS

The three major screen properties - energy conversion efficiency, persistence, and spectral distribution - should be those most suitable for the application. Where there is any degree of conflict between one requirement and another, the best compromise must be achieved. The performance of the screen should be reasonably constant throughout the range of beam currents that is likely to be met.

These general requirements will be discussed in relation to the main groups of cathode ray tube applications. These are:

1. Raster type applications, in which the writing speed is generally constant but the beam current is modulated to produce variation of light and shade.
2. Oscilloscope applications, in which the beam current is usually constant during a trace but the writing speed may vary.

7Z2 5898

3. Radar applications

4. Flying-spot scanners

5. Storage applications

SCREENS FOR RASTER TYPE APPLICATIONS

A number of different screens are available for raster type displays. Those which are most suitable for the main sub-groups of this group of applications are indicated in the following notes.

Monitors and Viewfinders

Monitoring and viewfinding systems in television studios operate at the same field repetition frequency and timebase speed as the broadcast channel, and their screen requirements are substantially the same as those of domestic television tubes. The repetition frequencies are such that persistence of vision and the persistence of the screen obviate flicker. The persistence must not be sufficiently great to smear the images of moving objects.

In monochrome television systems, white fluorescence is used, for aesthetic reasons. The W type screen is widely established for domestic viewing tubes and studio monitors and viewfinders.

Closed Circuit Systems

Where closed circuit monochrome television systems make use of normal television field and line speeds, screens with W phosphor are suitable.

In some systems, however, other speeds are used. If the scanning speed is low, the screen must have a persistence which is long enough to minimise flicker, and a long-persistence screen such as type LA, LD or LC must be used in order to maintain a complete picture.

Data Transmission

Since the images to be transmitted are, in general, stationary, the information does not need to be modified at the same rate as television picture information. The field repetition frequency and the bandwidth can be reduced, and transmission over lines is relatively simple. At repetition frequencies down to five fields per second a tolerable freedom from flicker is achieved with the cadmium chloro-phosphate phosphors that are used, for example, in the LA screen. For even lower frequencies, the LD screen is recommended. This screen, it should be noted, has a relatively low power-loading limit, and care must be taken to avoid burning.

7Z2 5899

Telerecording

A major limitation to the quality of telerecording is the difficulty of both pulling the film through the camera gate and operating the shutter in the field flyback time. In early systems, the first field of the interlaced picture was used for these operations; therefore only half the information was recorded.

To overcome this limitation, the information from the first field is stored in the screen of the cathode ray tube during the time that the shutter is closed. The film is pulled through the gate and the shutter is opened. The second field is then imposed on the stored field on the screen. The stored information of the first field will, of course, have lost some of its initial luminance; therefore the second field is written on the screen at a correspondingly reduced luminance level. The full interlaced information is then photographed.

The application is obviously a critical one, and the screen must meet a number of special requirements. The persistence must be defined within narrow limits, and it must be substantially constant throughout the life of the tube, otherwise the timing of the system will be inaccurate. There must not be a sharp peak of light output ("flash") at the moment of excitation, otherwise the second field will appear brighter than the first. And the light output from the first field must not have decayed to an unusably low level by the time that the second field has to be written.

These special requirements are met by screen type LA.

SCREENS FOR RASTER TYPE APPLICATIONS

The range of frequencies for which oscilloscopes are designed is extremely wide, and even in a single instrument a wide range may have to be covered. The requirements of light output and persistence at high speeds conflict with the requirements at low speeds, therefore a compromise is usually necessary. If the screen that is used has a good luminous efficiency, a satisfactory compromise can be attained.

General Purpose Applications

The screens in the G group are widely used in general purpose oscilloscopy. They have a high efficiency and a reasonably fast build-up, so that they are suitable for use at fairly high writing speeds. The GH screen has two spectral distribution peaks, one in the green and one in the blue region. The blue peak provides a high actinic efficiency for use with panchromatic film or, in some instances, with orthochromatic film. However, the effective visual persistence is rather short, so that at slow scan speeds very little information is obtained from the trace.

7Z2 5900

The lack of visual persistence in the GH screen has led to the introduction of the GL and GP types. The high efficiency of the GH screen is largely retained, but the persistence is of the order of one to five seconds, depending on the operating conditions. Slow scan speeds can therefore be used.

The GM screen has a purplish-blue flash and a yellowish-green persistence. For normal oscilloscopic work, and especially at voltages between 1 kV and 10 kV, this is the recommended screen if a long persistence is the main requirement. The luminous efficiency is about one-fourth of that of the GH type, so that for this reason, as well as the long persistence, the GM screen is not suitable for high-speed applications.

Non-recurrent High-speed Applications

When a rapid non-recurrent phenomenon is to be observed, a long-persistence screen with a slow build-up is not suitable. The usual technique is to use a fast screen and photographic recording. A timebase, triggered by the incoming signal, is applied to the X deflectors, and the signal itself to the Y deflectors.

The choice of screen for the single-shot type of application is dictated by the recording material that is to be used. For panchromatic and some orthochromatic film, the GH screen provides the fastest writing speed. If the trace is visible on this screen, then, in general, it can also be photographed if good photographic materials and techniques are used. For blue-sensitive film or recording paper the BE screen is preferable. Its luminous efficiency is low, but its spectral characteristic matches that of the emulsion.

Moving Film Applications

When a moving film technique is employed for the recording of recurrent phenomena, the persistence of the screen must be short if smearing of the image is to be avoided. With orthochromatic film, the BE screen is recommended. Smearing is negligible in the majority of applications, and appears only under certain unusual and extreme conditions. Equally good results may be obtained with panchromatic film and the GH screen.

Slow-scan Applications

Visual observations of slowly-varying functions is often unsatisfactory with general purpose screens. The eye does not easily appreciate the path of a moving spot, since the spot tends to attract most of the observer's attention. This difficulty is overcome, to some extent, by the use of a long-persistence screen. The spot leaves a trace which persists long enough for the waveform to be examined.

The useful persistence of any screen is dependent on the ambient illumination. If the screen is provided with a hood, a dark-adapted eye can see the trace down to quite low levels of light output. Writing speed also affects the persistence, to a certain limit which depends on the screen type which is used. In single-shot applications an increase in spot velocity will reduce the persistence, and vice versa. The observation of information which recurs only a few times per second can be improved by the use of a long-persistence screen; but, in general, the length of the persistence obtained will not be great.

For most long-persistence applications the GM screen is recommended. The GL and GP screens are also useful.

For very long persistence the LC or LD screens are used. They have orange luminescence. Care should be taken to avoid overloading these screens, since they are prone to burning.

SCREENS FOR RADAR APPLICATIONS

A long persistence is usually of primary importance in radar applications, because the aerial sweep is slow and the picture must be retained for relatively long periods. The choice of a screen is complicated if the display is to be viewed where there is much ambient light. A long-persistence screen with a relatively low light output may be less suitable than a screen with shorter persistence but greater light output.

The build-up characteristic is of particular interest in radar applications. It can be exploited, under conditions of repeated excitation, to differentiate between the desired "permanent" echoes and noise such as sea clutter. The echo from a target is repeatedly displayed on successive scans, and full brightness is built up; whereas transitory echoes are not additive, and produce less than peak brightness. The published build-up curves for radar-type screens are presented in a way that simulates p.p.i. conditions. Points on the curve, as shown in "Screen data", represent the light output from the screen immediately before each excitation pulse.

Radar requirements, when examined in detail, are found to be exacting. For instance, in general purpose marine navigational systems the performance must be satisfactory throughout a wide variety of aerial sweep speeds, pulse repetition frequencies, and target ranges (say from 0.5 to 50 miles). In a single installation, a diversity of operating conditions must be catered for, therefore the choice of screen for the display tube is necessarily a compromise. A number of screen types are available.

The LD screen has found extensive use in medium-range marine navigational systems. It has a very long persistence which provides a good display over a large variety of aerial rotation speeds and pulse repetition frequencies.

In river radar systems with short ranges and fast-moving targets, a rather shorter persistence is required, since it is only necessary to maintain good brightness between sweeps. Also, if the range has to be changed when navigating at close quarters, the trace from the earlier scan must clear quickly if it is not to clutter the first traces of the later scan. The LB screen meets these requirements.

7Z2 5902

In long-range navigational radar, and particularly in marine true-motion installations, the LC very long-persistence screen is widely used. It is also suitable where successive traces of a moving target are required for comparison, so that paths and speeds can be seen directly. The LC screen is also used in meteorological work, in airfield control, and in military radar systems. In many instances it is used in conjunction with interscan and data-handling techniques.

The GM long-persistence screen is sometimes used in marine radar. Its persistence is considerably shorter than that of the LC and LD screens. It has a disadvantage in that it does not provide the resolution capabilities possessed by tubes which use LC or LD screens. The reason for the lower resolution is that the screen is of the double-layer type; and, in order to obtain the desired decay characteristic, it is thicker than the LC and LD screens. The first layer is excited by electrons. This layer re-emits energy in the ultraviolet region, which then excites the second layer from which the luminous output is obtained. Resolution is lost during this process because of the scattering of the ultraviolet through the thickness of the second layer.

The GB screen is, like the GM screen, of the double-layer variety. It is used successfully in weather warning systems in aircraft cockpits. The main requirement is the ability to withstand the high accelerating voltages used in tubes for this type of application. Its long persistence is similar to that of the GM screen. With the aerial scanning speeds that occur in this type of equipment it displays complete cloud formations during the aerial sweep.

One of the main uses of the GJ medium-persistence screen is in airborne radar systems, where the scan rate is high enough to overcome the limited persistence of the screen. Its spectral emission makes it suitable for visual observation at the high ambient light levels normally encountered in this type of application.

For large radar displays a projection system may be used. For this purpose the BC screen, which has a killed persistence, provides a purplish-blue and ultraviolet output which is projected, by optical means, on to a large secondary screen which has suitable long-persistence characteristics.

SCREENS FOR FLYING-SPOT SCANNERS

In flying-spot scanners the energy conversion efficiency of the screen, throughout the spectral range that corresponds to the colour response of the detecting device, must be as high as possible.

Very short persistence is essential where high-definition scans are used, but the requirement is less stringent for slow-speed facsimile reproduction. For example, if a 625-line raster of 5 Mc/s definition is required, then there must be no effective light output after 0.3 μs; but for a slow-speed system of comparable definition and a line speed of one second, the persistence can be as long as 2 ms.

7Z2 5903

The BA very short-persistence screen is widely used for monochrome raster-type applications. Its peak output is at 400 to 420 mμm, in the ultraviolet region. It is therefore particularly suitable for use with photomultipliers having conventional caesium-antimony photocathodes. The persistence enables a good overall signal-to-noise ratio to be achieved.

The GE short-persistence screen has been developed for flying-spot applications in colour television systems. Its persistence is sufficiently short. It has an adequate light output in the red region of the visible spectrum, with a peak at 510 mμm in the green region.

SCREENS FOR STORAGE APPLICATIONS

In some applications it is an advantage if a trace can be stored for future examination or for direct comparison with later traces. The GN screen provides storage for periods up to several hours.

A back layer emits energy in the blue and ultraviolet region when it is bombarded with electrons. The front layer, excited by the ultraviolet radiation, has blue fluorescence and green phosphorescence, with a persistence of the same order as that of the GM screen.

If the screen is subsequently exposed to infrared radiation, a second light output is obtained, with an intensity and a persistence which are functions of the original writing conditions and of the intensity of the infrared irradiation. The stored trace, or a succession of superimposed traces, can thus be made available. The stored traces, when they are made visible by irradiation, have a brightness related to that at which they were written, and they all decay at the same rate as one another. Erasure is effected by prolonged infrared irradiation.

Ambient ultraviolet radiation should be excluded, since it will activate the front layer and produce background light which reduces contrast. Stray infrared should also, of course, be excluded, since it will dissipate the stored trace. The GN screen has a rather low maximum writing speed.

7Z2 5904

INTERPRETATION OF PUBLISHED SCREEN CHARACTERISTICS

INTERPRETATION OF PUBLISHED SCREEN CHARACTERISTICS

The field of c.r.t. applications is very extensive. For this reason it is impossible to provide published data covering all conceivable requirements. The measurements for published data are taken under conditions as close as possible to those at which the given screen is expected to operate. In some applications, the nature of the display does not readily lend itself to measurement purposes, and a resort has to be made to a more suitable type of display.

Where a given application departs from the conditions specified in published data, some valuable information can be extracted by means of simple calculations. Inevitably, some errors will be introduced; but in view of the approximately logarithmic response of the eye, the answers obtained are reasonably valid.

Much of the information presented in published data is based on a raster type of display, using - for measurement purposes - a non-interlaced raster of 200 lines and 50 fields per second. Whenever possible, the raster is defocused so that the lines just begin to merge together. This produces reasonably uniform screen loading. The quoted values of screen loading apply to the loading while the screen is under electron bombardment, and the effect of flyback is taken into account. The values of screen luminance given in published data are in terms of photometric units. This implies that the results are intended to represent the appearance of the display as seen by the eye.

In the following discussions, small letters are used for general considerations and for quantities in published data, while capital letters represent quantities involved in a particular case under consideration.

SCREEN LUMINANCE

The user can control four factors which affect screen luminance as seen by the eye. They are the area of excitation, the beam current, the applied potential, and the duration of excitation. A brief review of the effect of these factors on luminance will be made. In the first instance it will be assumed that only one of the factors is varied at a time.

7Z2 5905

The relationship between the luminance b and the current i reaching the screen can be written as

$$b = k_1 i^\gamma \tag{1}$$

where k_1 is a constant and the index γ at small values of current is, for most screens, slightly less than unity. It decreases in value with increase in beam current.

The relationship between the potential v applied to the screen and the luminance is more complex, and is often written in the form

$$b = k_2 (v - v_0)^n \tag{2}$$

where

k_2 = a constant
v_0 = a threshold potential
n = an index, greater than unity.

Both v_0 and n are functions of the phosphor and of the manner in which it is deposited on the tube face. For this reason the relationship may vary from one tube type to another, although the same screen type may be used.

When a screen is operated at a current density well below the saturation level, it may be assumed that the luminance increases with increase of the duration of excitation. Thus,

$$b = k_3 t \tag{3}$$

This holds only within the maximum limit for t, which is set by the time resolution of the eye and is about 0.1 s.

Over reasonably small variations in size of the excited area, the luminance can be considered as inversely proportional to the area, or

$$b = k_4/a \tag{4}$$

Experimental results seem to indicate that the luminance of the screen produced by all the factors can be represented as:

$$b = \frac{k}{a} i^\gamma (v - v_0)^n t \tag{5}$$

Thus, to a first approximation, the luminance is a function of the energy applied to the screen. The range over which the beam current and the duration of excitation may vary is considerable. However, the amount of energy the screen can handle is limited; therefore the screen can deal with an increase in one of these quantities at the expense of the other. A large increase in both the beam current and the excitation time will lead to saturation and eventually to permanent screen damage in the form of burn.

7Z2 5906

The published data are normally given in the form of average luminance b as a function of average screen loading u, or

$$b = f(u) \tag{6}$$

for several values of potential applied to the screen.

The raster itself is formed by scanning a spot progressively over a specified area. Thus an elementary screen area can be considered as that covered by the area of the electron beam. For the purpose of calculation let us assume this elementary area to be w cm wide and w cm long. If the current in the beam is i μA, then as the beam is passing the elementary area, the real screen loading is given by

$$u_{(pk)} = \frac{i}{w^2} \tag{7}$$

The duration of the loading is t_w, that is the transit time of the spot over the elementary area.

The amplitude of the waveform of peak luminance is a function of the build-up and decay characteristics of the particular screen under consideration. For screens with extremely short characteristics, the luminance is in the form of a pulse of light of amplitude $b_{(pk)}$ and duration t_w. On the other hand, a screen having long characteristics will produce luminance which follows the build-up characteristic during the excitation time t_w, and afterwards the decay characteristic. Two screens operating under identical conditions and having the same conversion efficiency, but differing in build-up and decay characteristics, should have the same $b_{(pk)}\, t_w$ product. However, their instantaneous luminance will follow their build-up characteristics, and therefore may differ considerably.

Thus the $b_{(pk)}$ used in these calculations is largely a fictitious quantity. It is equal to the area embraced by the build-up and persistence characteristic of a given screen, divided by the time of excitation. As an absolute quantity it is of little value. However, since it is derived from the screen characteristics, it is useful in comparing screen operating conditions.

Let the raster repetition frequency be $f_r = \frac{1}{t_r}$. Then: the average screen loading is

$$u = \frac{i}{w^2} \frac{t_w}{t_r} \tag{8}$$

and the average screen luminance

$$b = b_{(pk)} \frac{t_w}{t_r} \tag{9}$$

7Z2 5907

Both equations contain the term t_w/t_r. Since the raster is scanned linearly,

$$t_w = t_l \frac{w}{l} \tag{10}$$

where l is the length of scanned line and t_l is the time required to scan the line, therefore

$$\frac{t_w}{t_r} = \frac{t_l}{t_r}\frac{w}{l} \tag{11}$$

Let us assume that the raster produced for preparation of published data is so defocused that the lines are touching each other. If the raster height is h, its width is l, and the number of lines is n, then

$$w = \frac{h}{n}$$

therefore

$$\frac{t_w}{t_r} = \frac{t_l}{t_r}\frac{h}{nl} \tag{12}$$

Furthermore,

$$t_l = \frac{t_r}{n}$$

therefore

$$\frac{t_w}{t_r} = \frac{h}{n^2 l} = \frac{w^2}{hl} \tag{13}$$

Substituting in Eqs (8) and (9) we obtain

$$u = \frac{i}{hl} \tag{14}$$

and

$$b = b_{(pk)} \frac{w^2}{hl} \tag{15a}$$

or

$$b = b_{(pk)} \frac{h}{n^2 l} \tag{15b}$$

when the lines just touch.

The published data provide the values of average screen luminance b as a function of average screen loading u. Thus, if one of the quantities is known, it is possible to determine the other. In many cases allowances have been made for flyback times, so i is the actual current and b the actual luminance during excitation.

7Z2 5908

In all cases the published data provide information at several values of potential applied to the screen. In this way all the factors in Eq (5) are taken into account.

The derived formulas enable investigation of the effect of various screen operating conditions on the screen luminance to be made. For instance, it has been shown in Eq (15) that the peak luminance is inversely proportional to the square of spot size. Thus, with the raster size and the number of lines maintained constant, halving of the spot diameter increases the screen loading by a factor of 4. If the efficiency characteristics were linear, no change in light output would be obtained. Any possible reduction in average light output can be found approximately from published data as a ratio of

$$\frac{\text{screen luminance at 4 x operating current}}{\text{4 x screen luminance at the operating current}}$$

But there would be an increase in peak luminance in accordance with Eq (15a). It should be noted that Eq (15b) will not apply in this case, as the lines would not be touching (that is, $nw \neq h$); this equation is relevant only for luminance changes of a raster in which the lines are just touching

In oscilloscope work, especially at high writing speeds, it is of importance to obtain as high a spot luminance as possible. Consequently, the value of beam current is pushed to the limit. Unfortunately, as the beam current is increased there is some increase in beam diameter. Since the spot luminance is proportional to i/w^2, the optimum conditions are occurring when the quotient is at a maximum.

In slow-scan applications, let us assume that the tube operating conditions and the number of lines used are the same as for the published data. For the same length of scanned line, let the scanning time be T_l (where $T_l > t_l$). The increase in screen loading is in the ratio T_l/t_l.

In consequence, one would expect only a slight drop in light output for a small value of the quotient; but for large values there would be not only a drop in average screen luminance but also some distortion of spot shape caused by screen saturation.

Let us now assume that the raster repetition frequency is constant and the number of lines is varied. On the whole, not much change will be expected when the lines are overlapping. When the lines are well separated, a reduction in the number of lines will produce higher screen loading and a reduction in light output. The converse will happen when the number of lines is increased.

In the following sections an attempt will be made to evaluate various applications in terms of published data information.

7Z2 5909

DATA INTERPRETATION FOR RASTER TYPE APPLICATIONS

From the preceding argument, the average screen loading in a practical case is

$$U = \frac{I}{W^2} \cdot \frac{T_W}{T_r} \tag{16}$$

where T_W is the time taken to traverse one spot width, and T_r is the time taken to scan one raster.

The average screen luminance is

$$B = B_{(pk)} \frac{T_W}{T_r} \tag{17}$$

Let us assume that the height of the scanned raster is H, the width is L, the active line scanning time is T_l, the raster repetition period is T_r, the number of lines is N, and the number of active lines is N_a. Then

$$T_W = T_l \frac{W}{L}$$

and

$$\frac{T_W}{T_r} = \frac{T_l}{T_r} \cdot \frac{W}{L} \,. \tag{18}$$

For any scan, if

τ_s = duration of scan
τ_f = duration of flyback
τ = duration of whole cycle

then

$$\tau = \tau_s + \tau_f \,.$$

If we write

$$\frac{\tau_f}{\tau_s + \tau_f} = p \text{ (the flyback fraction)}$$

then

$$\tau_s = \tau (1 - p) \tag{19}$$

In the case under consideration, T_l is the active scanning time, and T_m is the interval between lines, therefore

$$T_l = T_m (1 - P_l)$$

where P_l is the flyback fraction in the line direction. Similarly

$$N_a = N (1 - P_v)$$

where P_v is the vertical flyback factor.

7Z2 5910

Substitution for T_l in Eq (18) gives

$$\frac{T_w}{T_r} = \frac{1 - P_l}{T_r} \cdot T_m \cdot \frac{W}{L} \tag{20}$$

But $T_r = NT_m$ and $N = N_a/(1 - P_v)$ therefore

$$T_m = \frac{T_r}{N_a}(1 - P_v) \tag{21}$$

If we assume that the lines are touching, then $N_a = H/W$, therefore

$$\frac{T_w}{T_r} = (1 - P_l)(1 - P_v)\frac{W^2}{HL} \tag{22}$$

Finally, substituting in Eqs (16) and (17) we have

$$U = \frac{I}{HL}(1 - P_l)(1 - P_v) \tag{23}$$

and

$$B = B_{(pk)}\frac{W^2}{HL}(1 - P_l)(1 - P_v) \tag{24}$$

Since $W = H/N_a$ and $N_a = N(1 - P_v)$, then

$$B = B_{(pk)}\frac{H\ (1 - P_l)}{N^2L\ (1 - P_v)}\,. \tag{25}$$

Now

$$I(1 - P_l)(1 - P_v) = I_{av} \tag{26}$$

where I_{av} represents an average current flowing through the cathode ray tube in presence of line and field blanking. For the 405-line and 625-line television systems, $P_l = 0.185$ and $P_v = 0.07$. Thus in these systems the current I present in the raster exceeds the average current by a factor of 1.31.

In the above calculations it has been assumed that the lines of the raster are touching each other. This is rather an exception than a rule. When considering this problem it is necessary to define more accurately the screen luminance. In most cases it is a mean value for the whole raster. For these considerations the calculations are acceptable in their present form.

Frequently, the published data for television tubes are given in terms of beam current for a quoted raster size. From these values the average screen loading $u = i/hl$ may be readily obtained. Alternatively, we have from Eqs (23) and (26)

$$\frac{i}{hl} = \frac{I}{HL}$$

or

$$i = I\,\frac{hl}{HL}\,. \tag{27}$$

7Z2 5911

Example

It is intended to operate a tube with a W screen as a television monitor at a screen potential of 14 kV and with a raster 20 cm by 15 cm. What luminance can be expected if the average beam current is 50 μA.

As the tube is intended for operation in a television system,

$$I_{av} = I\,(1 - P_l)\,(1 - P_v) = I \times 0.76$$

$$I = \frac{50}{0.76} = 66\ \mu A.$$

The current density is therefore

$$\frac{i}{hl} = \frac{66}{300} = 0.22\ \mu A/cm^2.$$

At this current density and at a screen potential of 14 kV, the luminance, as can be seen from the relevant curve, is 280 nt.

DATA INTERPRETATION FOR OSCILLOSCOPE APPLICATIONS

The requirements of repetitive and single-pulse applications must be considered.

Repetitive Excitation

An oscilloscope display is essentially a single trace display. In any particular situation, let us assume that the length of trace is L, the duration T_l, and the repetition frequency $F_r = 1/T_r$. For a line width W, let the transit time be T_w, then from Eq (8) the screen loading is

$$U = \frac{I}{W2}\frac{T_w}{T_r}\,.$$

Since

$$T_w = T_l\frac{W}{L}$$

then

$$U = \frac{I}{WL}\frac{T_l}{T_r}\,. \qquad (28)$$

The average screen loading obtained from the above formula may be used to find the corresponding average trace luminance from the published data.

Single-Pulse Excitation

It is possible to estimate, from the published data, the trace luminance under single-pulse excitation. Since the trace is not repetitive, let us take a repetition frequency at which the eye resolves light modulation, say about 10 c/s.

7Z2 5912

Let this repetitive time be T_r, then the average screen loading is

$$U = \frac{I}{W^2} \frac{T_w}{T_r} \tag{29}$$

and the corresponding average screen luminance B can be found from the published data.

From Eq (9) the peak luminance is

$$B(pk) = B \frac{T_r}{T_w} \tag{30}$$

and its duration is T_w.

The $B(pk)T_w$ product is equal to the area under the build-up and decay characteristic of a given screen. For fast- and medium-persistence screens, most of this area will be within time T_r (< 0.1 s). Hence the luminance perceived by the eye will be

$$\frac{B(pk)T_w}{T_r} = B \tag{31}$$

Example

In a particular application a scan of 4 cm and a duration of 10 μs are produced at a repetition frequency of 400 c/s. The tube has a GH type screen. It is operated at 10 kV, and the current reaching the screen during the trace is 10 μA. What trace luminance can be expected at a line width of 0.2 mm.

$$I = 10\ \mu A \qquad T_l = \frac{10}{10^6}\ s$$

$$W = \frac{2}{100}\ cm \qquad T_r = \frac{1}{400}\ s$$

$$L = 4\ cm$$

Substitution in Eq (28) gives

$$U = 10 \frac{100}{2 \times 4} \frac{10}{10^6} \frac{400}{1} = 0.5\ \mu A/cm^2$$

From the published data for the GH screen the trace luminance at 10 kV and this screen current density is seen to be 300 nt.

DATA INTERPRETATION FOR RADAR APPLICATIONS

For radar type applications, persistence is of primary importance. For this reason the published information on persistence characteristics of radar screens is more extensive than that provided for other types. The data are prepared from measurements made with a non-interlaced raster. Care is taken to defocus the raster uniformly, so that the individual lines of the raster touch each other. The whole raster is considered as a single pulse, since any given area is excited only once during any one field. 7Z2 5913

To cover a variety of situations, several sets of data are published. Single raster excitations simulate the case of moving targets, when the screen area is excited only once. For permanent echoes and marker pips, there are curves showing persistence with repeated raster excitation. The persistence is measured from the end of excitation. From this information can be derived the variation in trace luminance during normal operation and the screen persistence when changing from one range to another.

The build-up characteristic is important during range-changing. The required information is given by a separate build-up characteristic which shows the luminance of the trace just before the next pulse arrives.

Screen Loading

Consider a small portion of screen under published data conditions. As in previous considerations, the raster area is hl, but only one field of n lines is applied. The current reaching the screen is i, with suitable corrections for flyback times. The spot is defocused so that the lines are touching each other. The charge per unit area reaching the screen is

$$q = \frac{i}{w2} t_w \tag{32}$$

and this is proportional to screen luminance Eq (5).

Since

$$t_w = t_l \frac{w}{l}$$

$$q = \frac{i}{wl} t_l \tag{33}$$

also

$$w = \frac{h}{n} \text{ and } nt_l = t_r$$

therefore

$$q = \frac{i}{hl} t_r \tag{34}$$

Under p.p.i. conditions Eq (33) is also applicable. In order to express it in terms of p.p.i. constants, let

D = diameter of p.p.i. display
R = range corresponding to the radius of display.

Consider a portion of the display at a distance $\frac{1}{2}D'$ from the centre, so that

$$\frac{D'}{D} = x \text{ and } x < 1.$$

7Z2 5914

Then the length of considered scan is

$$L = \tfrac{1}{2}D'.$$

With a signal velocity of 12.3 μs per loop nautical mile,

$$T_x = 12.3 \times RK10^{-6}\ \text{s}.$$

It was necessary to include a constant K in the equation for T_x in order to take into account overlap of scanning lines of the p.p.i. display. The overlap can be calculated as the ratio of the number of scans per aerial rotation to the number of lines that can be placed on the circumference of the considered portion of display. In terms of p.p.i. data, at a point distant $\frac{1}{2}D'$ from the centre,

$$K_x = \frac{F_p T_a}{\pi x\ D} W$$

where

F_p = pulse repetition frequency
T_a = time of one aerial revolution.

Substitution of the above data in Eq (33) gives

$$Q_x = \frac{2\,I}{\pi x\ D^2}\, 12.3\ R\ F_p T_a 10^{-6}.$$

The screen luminance of the p.p.i. display is the same as that in published data if the above equation is equal to Eq (34). Equating and rearranging gives a screen loading of

$$u_x = \frac{i}{hl} = \frac{2\,I}{\pi x\ D^2} = 12.3\ R\ F_p \frac{T_a}{t_r} 10^{-6}.$$

For published data, $t_r = \frac{1}{50}$ s, therefore

$$u_x = \frac{i}{hl} = \frac{3.91}{x\ D^2} IRF_pT_a\ 10^{-4}\ \mu A/cm^2 \qquad (35)$$

Now i/hl is the screen loading used in the presentation of published data, therefore the value of screen persistence can be determined.

It should be noted that u_x varies over the screen. If a constant value of u is required, then a bright-up circuit must be incorporated, so that I/x will be constant.

Single-pulse Excitation: Moving Target Conditions

For fast-moving objects a situation can exist where within one aerial rotation the echo moves on the display a distance greater than the spot diameter of the tube. The persistence curve resulting from such an excitation is given in published data by graphs for single-pulse excitation. The screen loading can be calculated from Eq (35).

7Z2 5915

Repeated-pulse Excitation: Permanent Echoes

The luminance produced by a permanent echo is a result of excitation received from a succession of aerial sweeps. The persistence is given in the published data by graphs for repeated-pulse excitation. The repetition interval t_a of pulses in the published data is 1 s. In practical applications, the aerial rotation frequency may be different, and for that reason the equation for screen loading needs adjustment. Experimental evidence indicates that under the conditions shown in the published data, the screen luminance is a function u of the product of the current and the number of pulses. Thus the necessary adjustment can be effected by multiplying Eq (35) by t_a/T_a. With t_a = 1 s, the modified equation becomes

$$U_x = \frac{3.91}{x\ D^2} IRF_p\ 10^{-4}\ \mu A/cm^2 \qquad (36)$$

Build-up

The rate at which persistence luminance builds up for a permanent echo is shown in published data by means of build-up characteristics. Since these characteristics are given as a function of the number of pulses, the screen loading can be calculated from Eq (36).

Example

A tube with an LD screen is employed in a p.p.i. display. It is operated at 10 kV, and the peak current at the end of the trace is 150 μA. If the pulse repetition frequency is 3 kc/s and the aerial rotational frequency is 20 r.p.m., determine the luminance of the persistence trace at the edge of the display when the display is set to operate at a range of one nautical mile for the full useful screen radius of 10 cm.

(a) Moving targets

Screen loading is calculated from Eq (35):

$$U_x = \frac{3.91}{x\ D^2} IRF_pT_a\ 10^{-4}\ \mu A/cm^2$$

D = 20 cm	F_p = 3 kc/s
I = 150 μA	T_a = 3 s
R = 1 nautical mile	x = 1

so that

$$U_x = 1.32\ \mu A/cm^2.$$

7Z2 5916

The persistence characteristics of the LD screen (pages 68 and 69) gives persistence luminance for single-pulse excitation at an e.h.t. of 10 kV. The required persistence can be read off the graph for a screen loading of 1.32 μA/cm^2. This screen loading is higher than any shown on the graph, but the results can be deduced by extrapolation.

(b) Permanent echoes

Screen loading is calculated from Eq (36):

$$U_x = \frac{3.91}{x\,D^2}\,IRF_p\,10^{-4}\ \mu A/cm^2.$$

Substitution gives

$$U_x = 0.44\ \mu A/cm^2.$$

This lower value has no actual meaning in terms of current; but it indicates which curve in the graphs on pages 68 or 69 is to be used. The result will apply for a fully built-up condition - say after 60 or more pulses.

(c) Build-up

For any intermediate number of pulses down to about ten, the small variation in the starting point of the decay curves can be obtained from the build-up curve on page 70. The value of $U_x = 0.44\ \mu A/cm^2$, and the persistence curves for multiple pulse excitation on pages 68 and 69 can then be used.

AMBIENT ILLUMINATION

In the discussion of the requirements of different applications it has been assumed that the only light to be considered is that produced by the display. Background illumination has been altogether neglected. Under practical conditions the background illumination is of the greatest importance. In fact, it determines the luminance that the tube must produce if the display is to be usable.

There are three sources of stray illumination:

Light from the back of the screen is reflected by the tube walls. It returns to the screen in a diffuse form and reduces the contrast between the trace and the unexcited parts of the screen.

Light from the front of the screen is reflected back to the screen from surrounding surfaces. Again the effect is to illuminate the unexcited areas.

Ambient illumination, especially in lighted rooms and in daylight situations, is obviously a major factor in the reduction of contrast.

7Z2 5917

The minimum contrast perceptible by the eye is about 2 per cent. If the luminance of the trace in the absence of background illumination is B, and the luminance of the rest of the tube face is b, then the luminance of the trace in the presence of the background illumination is B + b. The change in luminance from trace to background is B. For limit perception,

$$\frac{B}{B+b}100 = 2$$

so that

$$B = \frac{b}{49}.$$

This is practically the absolute minimum that can be tolerated. For comfortable viewing the contrast should be about 80 per cent; that is, B = 4b. For an oscilloscope display a lower contrast is acceptable than for a raster display.

A laboratory during hours of daylight may have an illumination of about 250 lx. In this illumination a perfectly diffusing surface will have a luminance of $250/\pi \simeq 80$ nt. With transmission and reflection losses of 30 per cent, the tube surface will have a luminance of 56 nt.

For the examples calculated in this chapter we have

Television monitor tube	280 nt
Oscilloscope display	300 nt
P.P.I. display (permanent echo at 1 s)	1.3 nt

The contrast for the last case in the presence of a 250 lx background illumination is

$$\frac{1.3}{56}100 = 2.3\ \%,$$

which is just about perceptible.

At night an average laboratory will have a lower illumination. If this is, say, 50 lx, the luminance of the radar display quoted will improve, for the contrast will be

$$\frac{1.3}{11.2}100 = 11.6\ \%.$$

When the decay characteristic is taken into consideration, the effect of ambient illumination is even more serious. If the persistence of the p.p.i. display which has been discussed is plotted in the presence of laboratory illumination as above, the resulting curve will be entirely different from that given on pages 68 and 69 for a current density of 0.2 $\mu A/cm^2$. After about seven seconds the display will be lost in the background.

USE OF FILTERS

Contrast can be improved by placing a filter in front of the tube. Light from outside has to pass through the filter twice before reaching the eye, whereas the light from the trace passes through only once.

For maximum contrast the filter should be as dense as possible; but if the luminance of the trace is already low, it will be attenuated to an unusable level if the filter is too dense. However, a filter whose transmission characteristic is matched to the spectral distribution of the screen will provide differential filtering. The light output from the screen will be transmitted with minimum loss, while external light from other parts of the spectrum will be suppressed.

The GM double-layer screen has a purplish-blue fluorescence and a yellowish-green phosphorescence. As the blue component is subjectively brighter than the yellow, it is advantageous in some applications to filter it out with a suitable filter if maximum use is to be made of the yellow persistence period. The Chance C2 glass filter is suitable; or, for combination with a graticule, a sheet of amber Perspex may be used.

Exclusion of ambient ultraviolet radiation from the GN storage screen is provided by filters such as the Ilford 108. The infrared radiation for reading can be obtained from low-power tungsten lamps. They should be provided with filters to suppress the visible light which would reduce contrast. A combination of the Ilford filters 207 and 813 is suitable. A composite viewing hood can be used, containing the lamps, filters, and ultraviolet stop filter.

GENERAL DATA

The information given in this reference section is obtained from measurements of phosphors settled in typical cathode ray tubes. The tube used is, of course, of a type appropriate for the screen in question.

For each screen type there is a spectral response curve. The relative response is plotted against the wavelength of the light output, the peak light output being shown as 100 per cent. No absolute values of light output can be read off; and no comparisons of the luminance of different screen types can be made from these curves.

On each response curve is quoted the subjective colour sensation in terms of the x-y co-ordinates of the C.I.E. system. These points are also indicated on the diagram.

For two or three screen types, the diagram shows two points: one refers to the initial "flash" or fluorescence, while the other point refers to the persistence (phosphorescence) colour. Thus, the GM screen has a purplish-blue flash and a yellowish-green persistence, and it is classified as a screen of the G group. The two linked points shown for the GH screen are those pertaining to high-brilliance and low-brilliance operation.

For comparison of the spectral response of the screens available for each of the main groups of application, collective response curves, are given. Here again, the response curves are normalised, and they provide no information about the comparative light outputs of different screens.

The Kelly charts are marked - in accordance with general colorimetric practice - with the wavelengths in milli-micrometres (mμm) that correspond to the saturated spectral colours lying on the perimeter.

The persistence and efficiency curves, and the special curves relating to radar screens, should be read in conjunction with the relevant parts of the text.

PERSISTENCE NOMOGRAPHS FOR OSCILLOSCOPE SCREENS

Although the persistence curves give a good indication of the differences between screens under typical conditions, it is found in practice that the operation of the screen is often far removed from the published conditions. This is especially so for oscilloscope applications. With this as a prime consideration, the screens most used for oscilloscope work have been investigated in rather more detail than, say, the screens used in television monitors.

7Z2 5920

Radar screens, although subjected to some changes in operation conditions, are limited in their applicational range, and in most cases the published curves give adequate information. The flying spot screen BA has only a small dynamic characteristic change, and once again requires no elaboration.

Most oscilloscope screens have a persistence dependent on current density, electron energy, excitation time, and repetition frequency. The exception to this is the GJ screen which has a decay law of the form exp (-80 t) which is independent of the above characteristics and is therefore specified by the published decay curve. The dynamic range of the other oscilloscope screens has been evaluated empirically.

The BE and GH screens have a common decay law:

$$L_t \propto t_p^{-1}$$

where L_t is the light output at a time t_p during the decay.

Experiment has shown that modification to the form

$$\frac{L_t}{L_o} = \frac{k}{t_p + k}$$

where

L_o = initial light output at $t_p = 0$
k = a constant

produces a good approximation to the practical persistence curve.

Incorporation of some of the relevant screen characteristics gives

$$t_p = \left[\gamma(I_b/a)^{\beta}\, t_e^{\,\alpha(k - \tan^{-1} s \log \frac{I_b/a}{q})}\right]\left(\frac{L_o}{L_t} - 1\right)$$

where

t_e = excitation time
I_b/a = beam current density

and the constants α, β, γ, k, s, and q have been evaluated for each screen type.

Voltage and repetition frequency are not included in this formula. The voltage has little effect on persistence if it exceeds 3 kV. Below 3 kV the persistence increases. The repetition frequency has a pronounced effect; but, because of the complexity of interrelating occupance and build-up time limits, the formula in its present form applies only for single or low-occupance occurrences.

To simplify the use of the equation, nomographs have been constructed in which the variables are light output (as a percentage of flash), excitation time, and persistence. Current density is introduced as a parameter. Nomographs for the BE and GH screens are given.

7Z2 5921

Each nomograph consists of three main scales: t_e (excitation time), t_p (decay time), and L_t/L_o per cent (decay percentage). The t_e and t_p scales are split into three, for various current densities. As the current density has a second-order effect, the range over which the scales may be used is denoted at the foot of the scale.

To use the nomograph, a straight edge is placed across the sheet against the two known variables, and the third variable is read off. For example:

What is the persistence of the GH screen at 0.5 per cent of flash under the following conditions.

Excitation time = $10\ \mu s$
Current density = $0.8\ \mu A/mm^2$

A straight-edge placed against L_t/L_o = 0.5 per cent and $t_e = 10\ \mu s$ on the $> 0.8\ \mu A/mm^2$ scale will intersect the $> 0.8\ \mu A/mm^2$ t_p scale at 0.9 ms. Thus the persistence is 0.9 ms to 0.5 per cent under this condition.
Excitation time is determined, in practice, by dividing the spot diameter by the spot velocity. That is,

$$t_e = \frac{d}{v}$$

where

d = spot diameter (mm)
v = spot velocity (mm/s)

A maximum limit for t_e occurs when build-up is accomplished by steady excitation, or when the time occupance approaches unity. This maximum limit is indicated by the discontinuation of the t_e scale at its top end. Thus for excitation times greater than the limit value, the limit value should be used.

The reading accuracy of the nomographs has been reduced by including only the scale intervals of 5 and 10 on the logarithmic t_p and t_e scales. The reasons for this are that the nomograph includes several approximations, and, secondly, unavoidable spreads in screen production may cause significant deviations. This spread has less significance when the wide dynamic range covered by the logarithmic characteristics is being considered.
No nomograph is given for the GM screen, since the interdependent characteristics of the two phosphor layers are too complex for this kind of presentation.

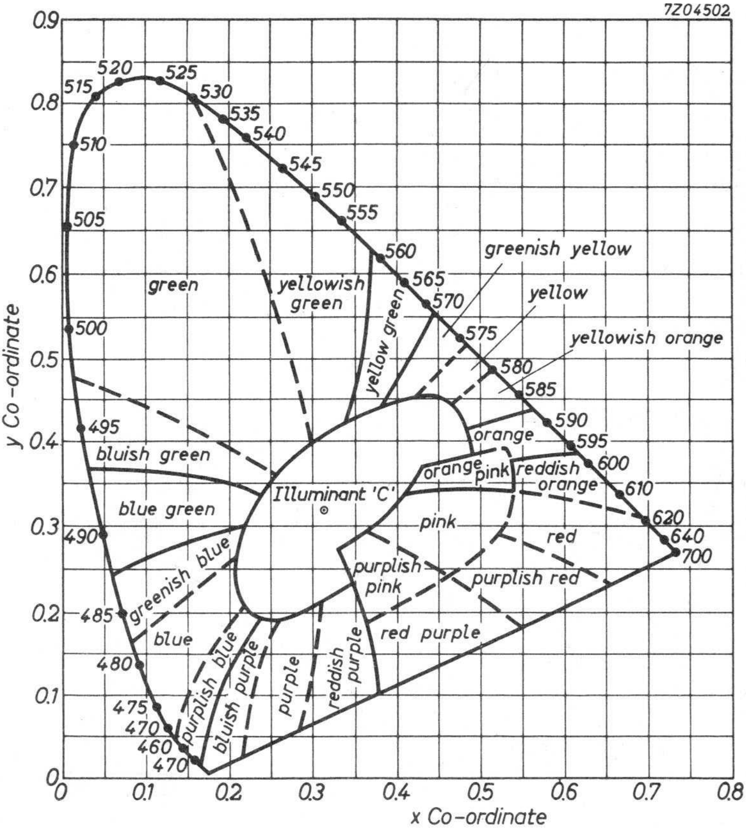
7Z2 5922

SCREEN TYPES

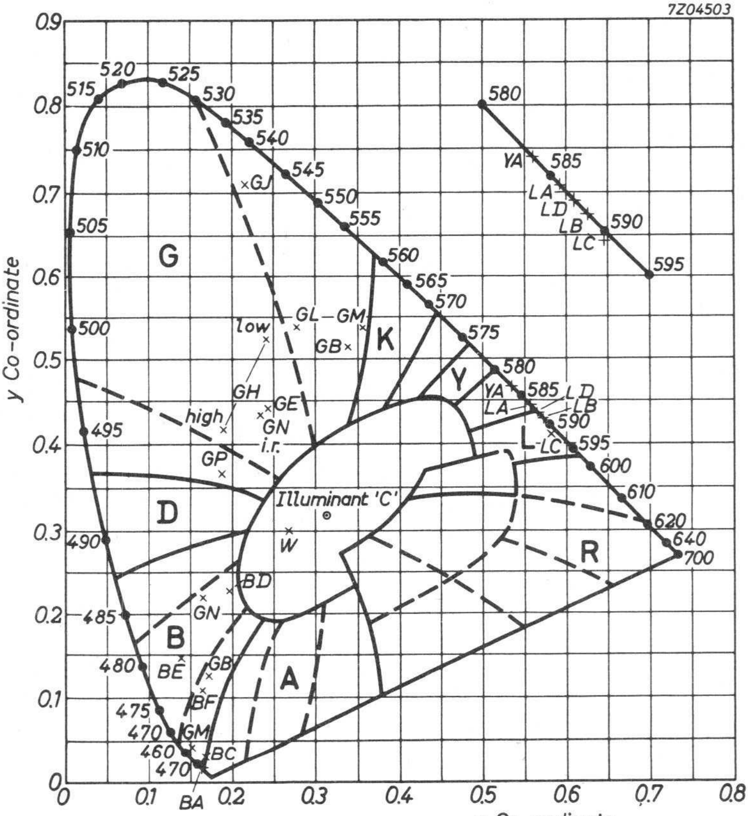
new system	old system	fluorescent colour	phosphorescent colour	persistence	equivalent Jedec designation
BA	C	purplish-blue	-	very short	-
BC	V	purplish-blue	-	killed	-
BD	A	blue	-	very short	-
BE	B	blue	blue	medium short	P11
BF	U	purplish-blue	-	medium short	-
GB	M	purplish-blue	yellowish-green	long	P32
GE	K	green	green	short	P24
GH	H	green	green	medium short	P31
GJ	G	yellowish-green	yellowish-green	medium	P1
GK	G [1]	yellowish-green	yellowish-green	medium	-
GL	N	yellowish-green	yellowish-green	medium short	P2
GM	P	purplish-blue	yellowish-green	long	P7
GN	J	blue	green (infrared excited)	medium short (fluorescence)	-
GP	-	bluish-green	green	medium short	P2
LA	D	orange	orange	medium	-
LB	E	orange	orange	long	-
LC	F	orange	orange	very long	-
LD	L	orange	orange	very long	P33
W	W	white	-	-	P4
X	X	tri-colour screen	-	-	P22
YA	Y	yellowish-orange	yellowish-orange	medium	-

[1]) used in projection tubes

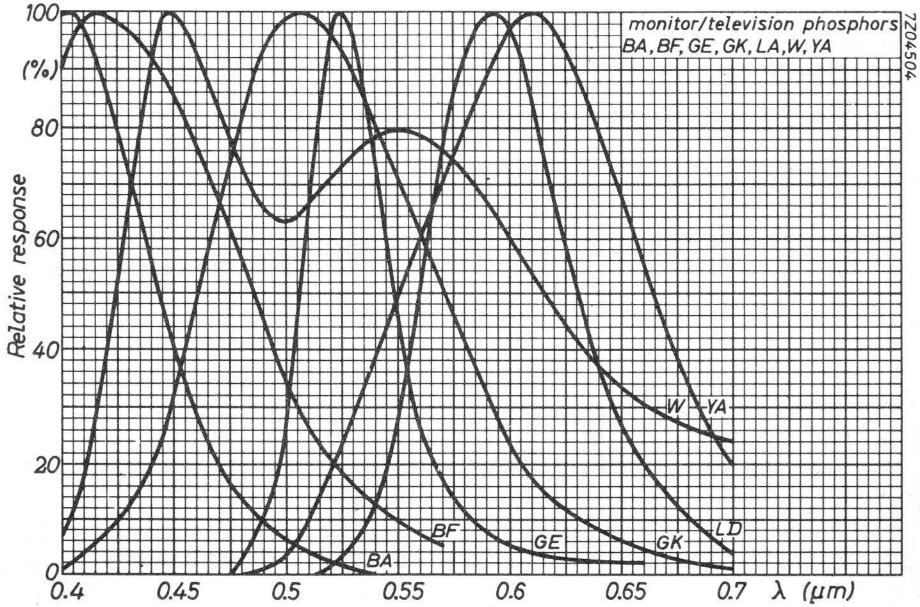
7Z2 5923

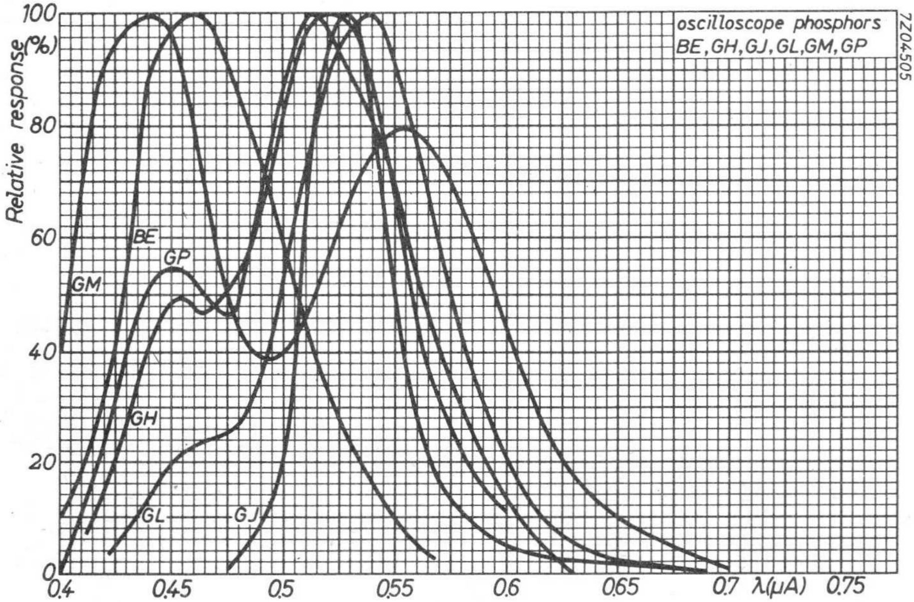

7Z04502
y Co-ordinate
x Co-ordinate
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
520
525
515
530
535
540
510
545
550
555
505
560
565
570
575
580
585
590
595
600
610
620
640
700
500
495
490
485
480
475
470
460
470
green
yellowish green
yellow green
greenish yellow
yellow
yellowish orange
orange
orange
pink
reddish orange
bluish green
blue green
Illuminant 'C'
pink
red
greenish blue
purplish pink
purplish red
blue
red purple
purplish blue
bluish purple
purple
reddish purple

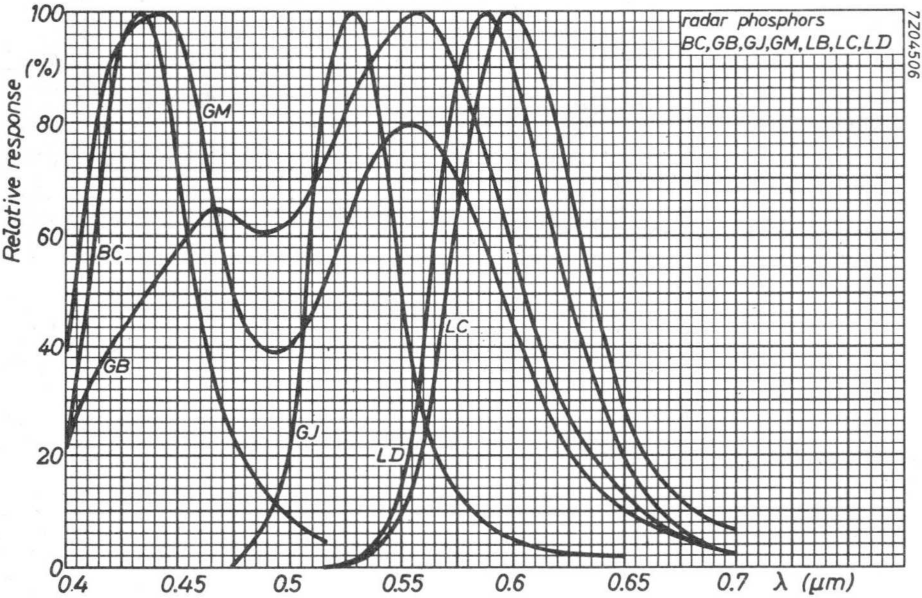
Kelly Chart

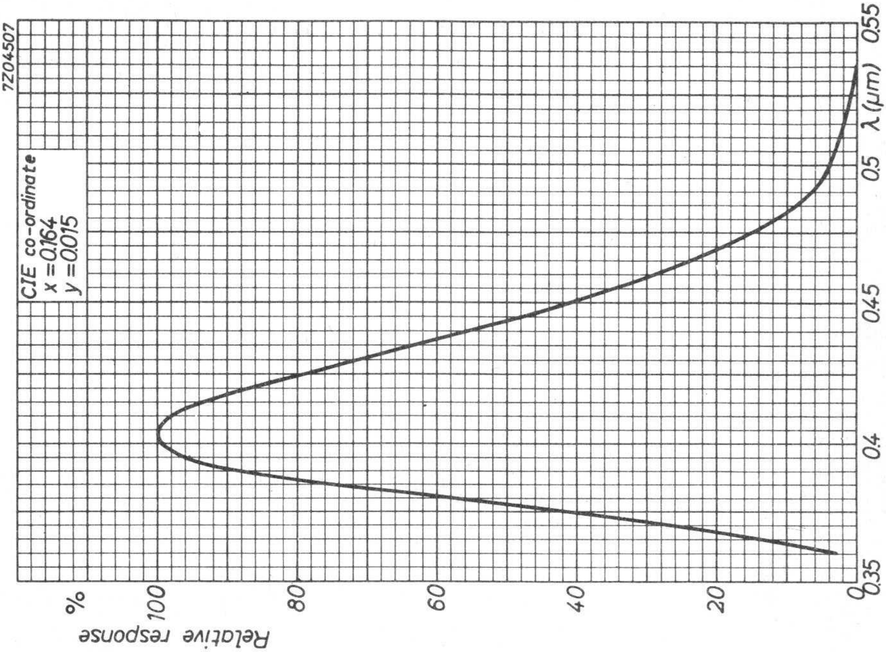


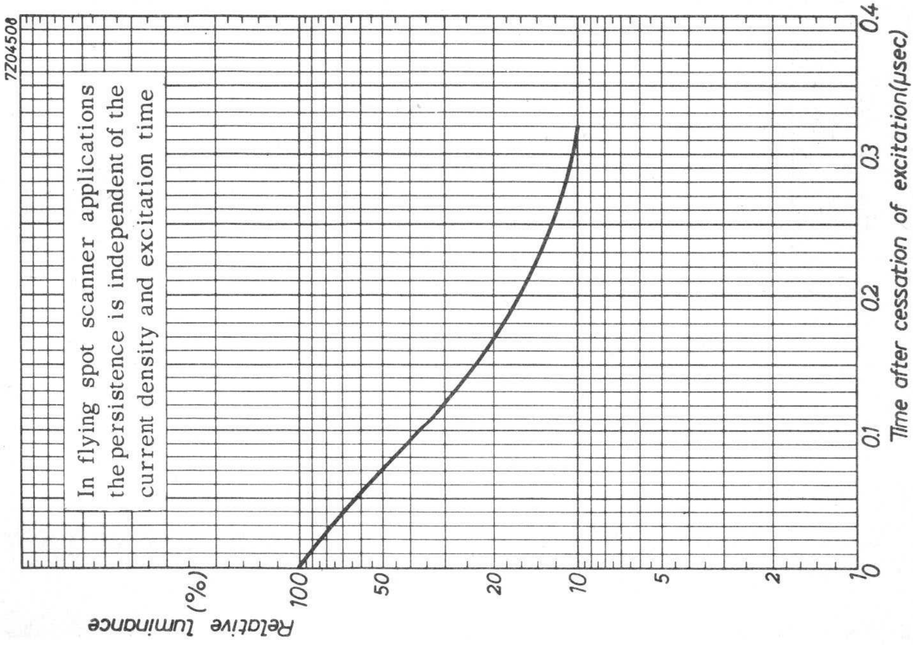
Co-ordinates of individual phosphors

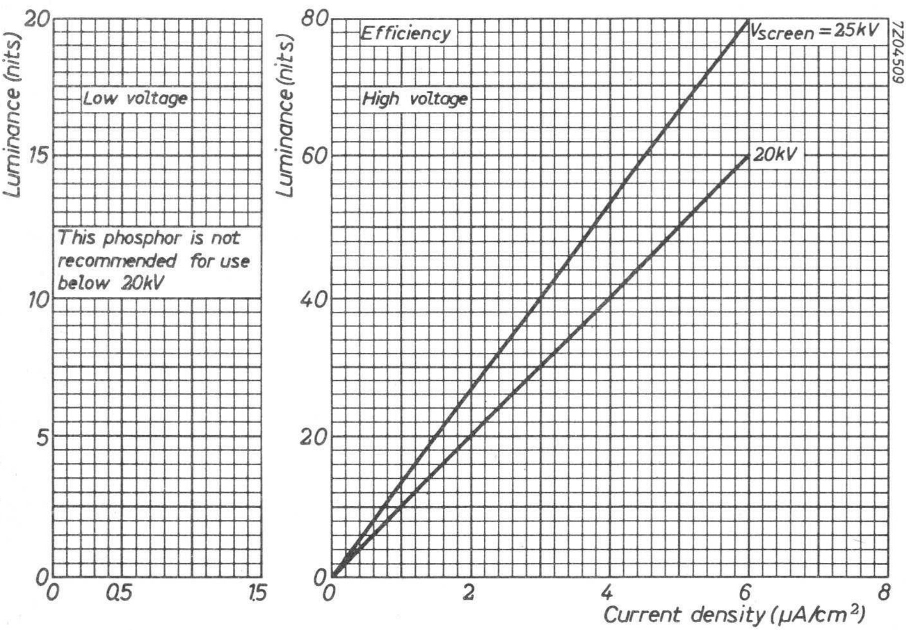

monitor/television phosphors
BA, BF, GE, GK, LA, W, YA
7Z04504
100
(%)
80
60
40
20
0
Relative response
0.4
0.45
0.5
0.55
0.6
0.65
0.7
λ (μm)
BA
BF
GE
GK
LD
W
YA

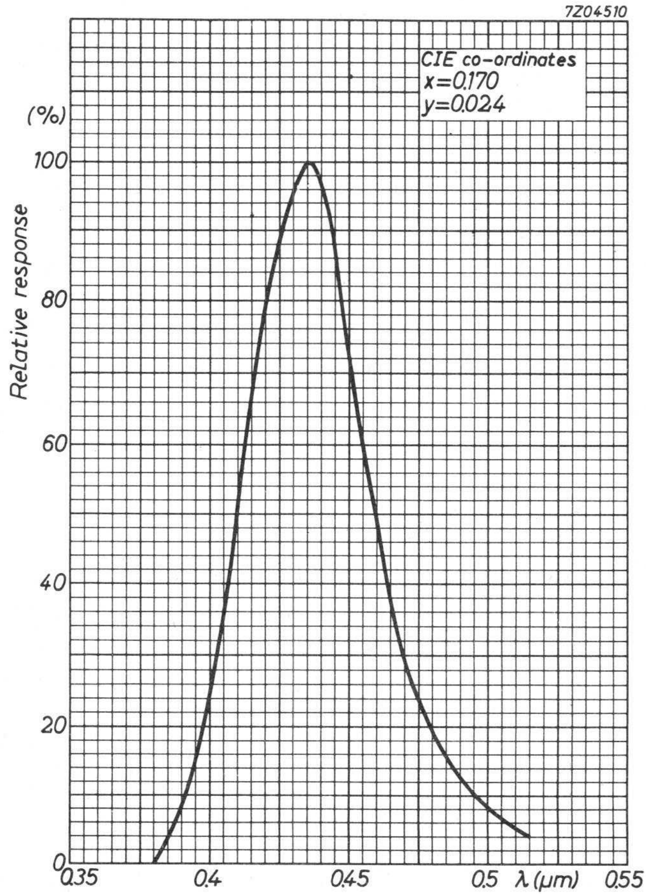

oscilloscope phosphors
BE, GH, GJ, GL, GM, GP
7Z04505
Relative response (%)
100
80
60
40
20
0
0.4
0.45
0.5
0.55
0.6
0.65
0.7
λ(μA)
0.75
BE
GP
GM
GH
GL
GJ

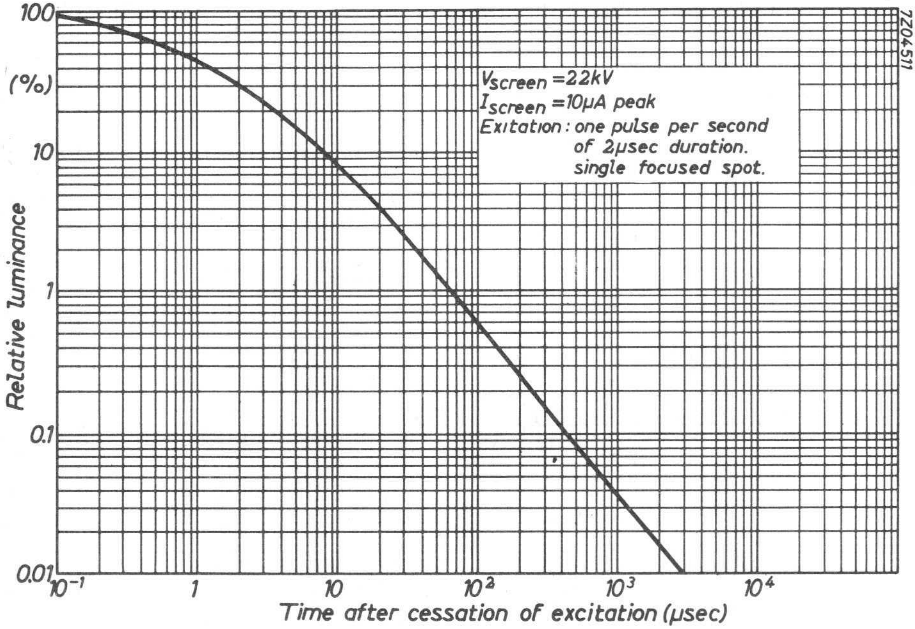

radar phosphors
BC, GB, GJ, GM, LB, LC, LD
7Z04506
Relative response (%)
100
80
60
40
20
0
0.4
0.45
0.5
0.55
0.6
0.65
0.7
λ (μm)
GM
BC
GB
GJ
LD
LC

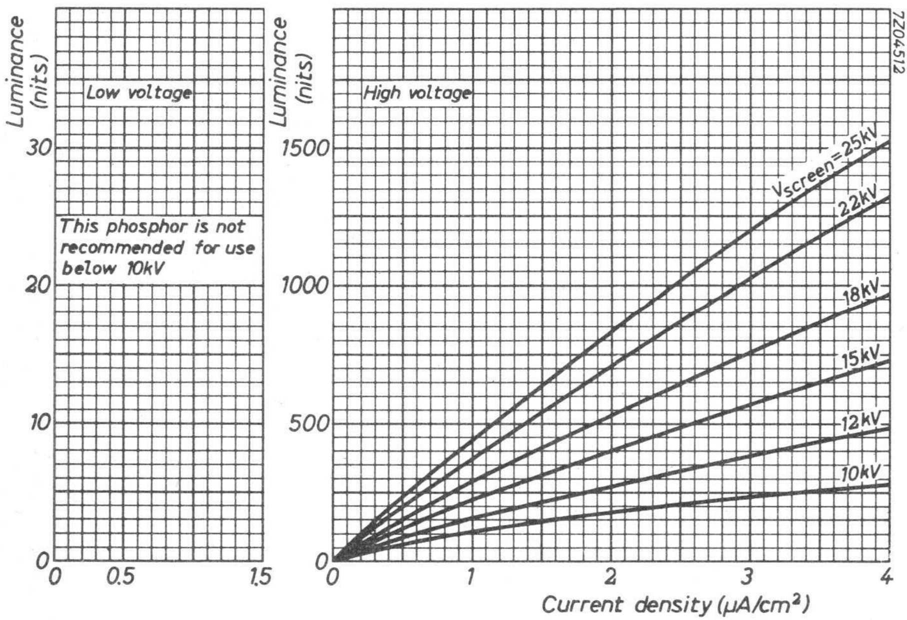

7Z04507
CIE co-ordinate
x = 0.164
y = 0.015
Relative response
%
100
80
60
40
20
0
0.35
0.4
0.45
0.5
0.55
λ (μm)

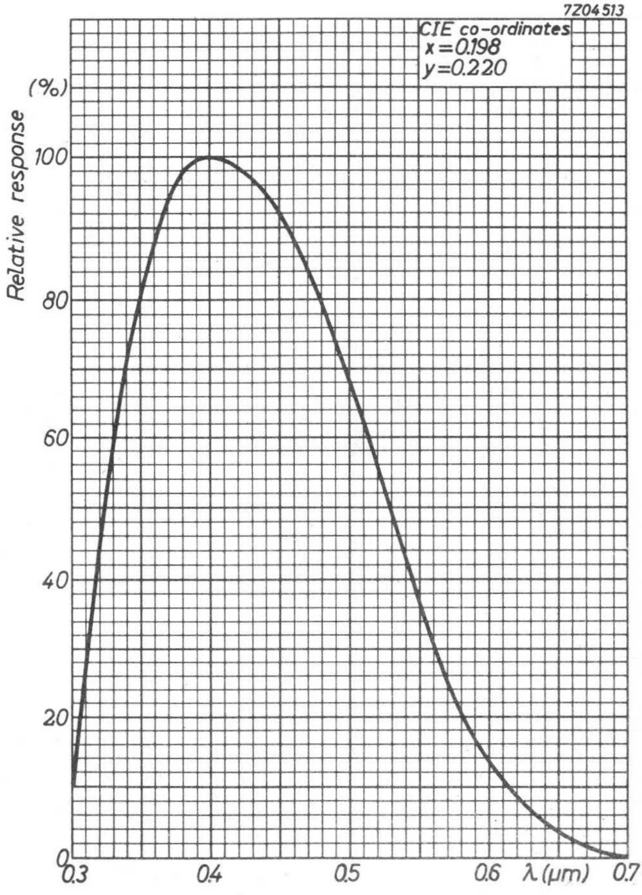

7Z04508
In flying spot scanner applications the persistence is independent of the current density and excitation time
Relative luminance (%)
100
50
20
10
5
2
1
0
0.1
0.2
0.3
0.4
Time after cessation of excitation (μsec)

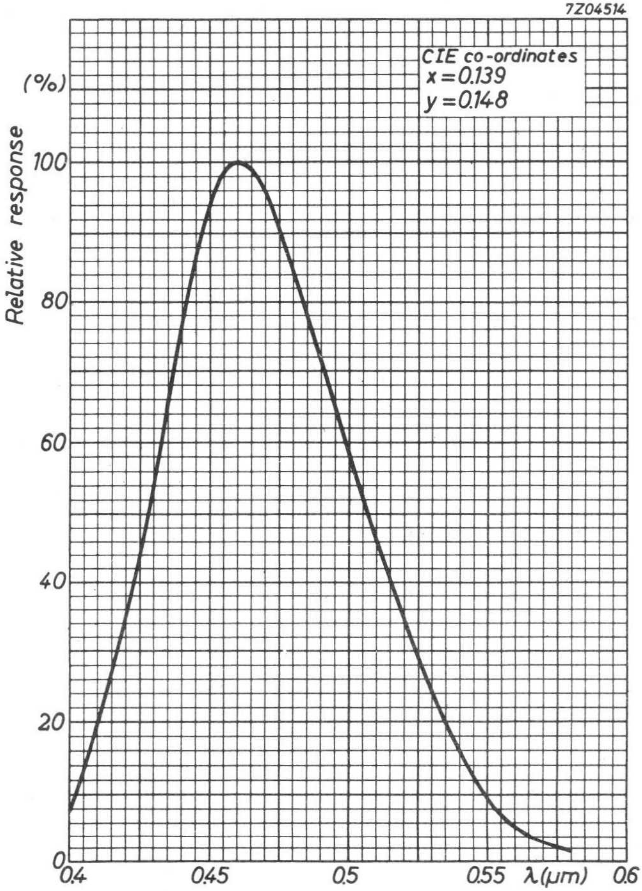

Luminance (nits)
Low voltage
This phosphor is not recommended for use below 20kV
Luminance (nits)
Efficiency
High voltage
V_{screen} = 25kV
20kV
Current density (μA/cm^2)
7Z04509

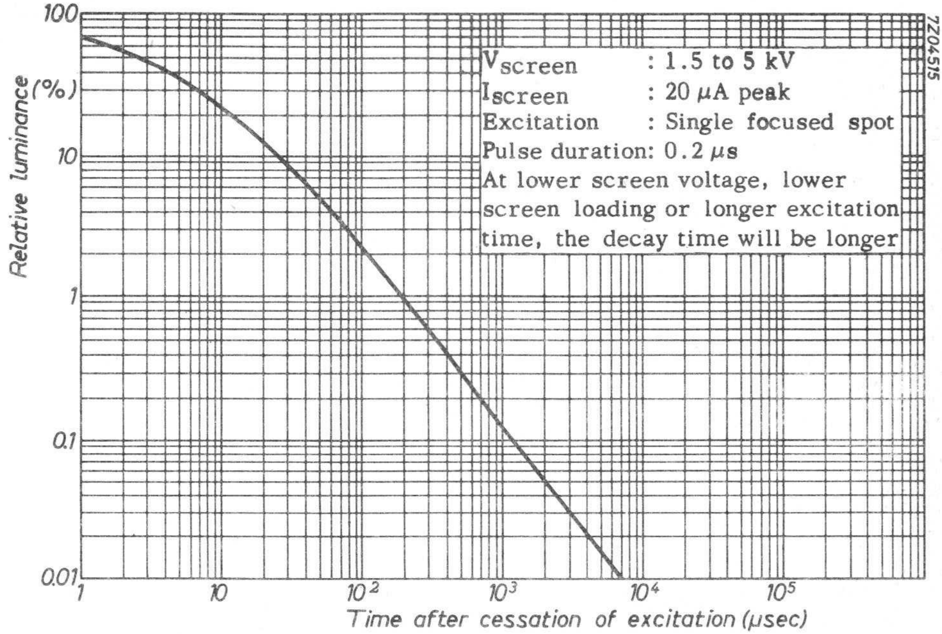

7Z04510
CIE co-ordinates
x=0.170
y=0.024
(%)
Relative response
100
80
60
40
20
0
0.35
0.4
0.45
0.5
λ (μm)
0.55

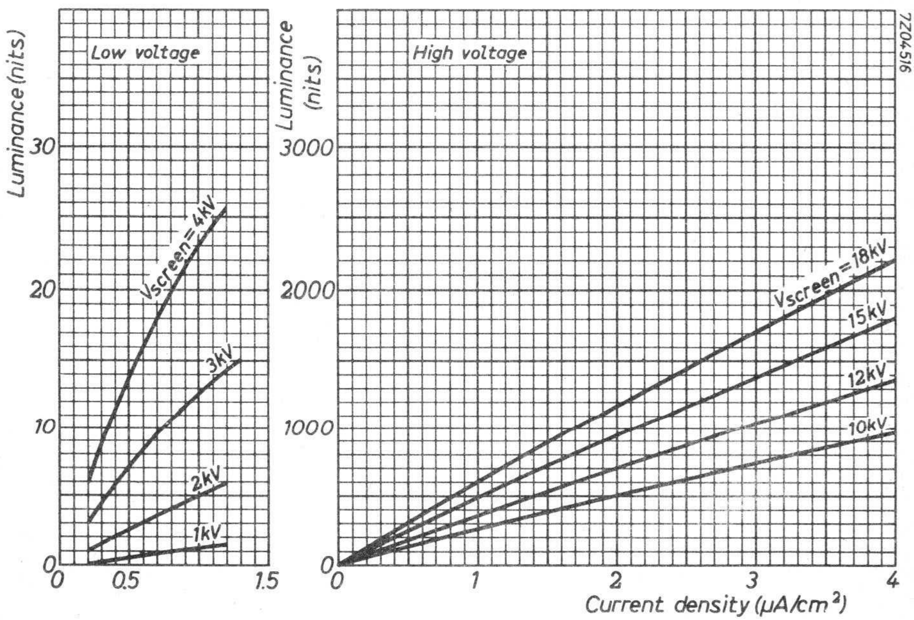

7Z04511
100
(%)
10
1
0.1
0.01
Relative luminance
V_{screen} =22kV
I_{screen} =10µA peak
Exitation: one pulse per second
of 2µsec duration.
single focused spot.
10^{-1}
1
10
10^2
10^3
10^4
Time after cessation of excitation (µsec)

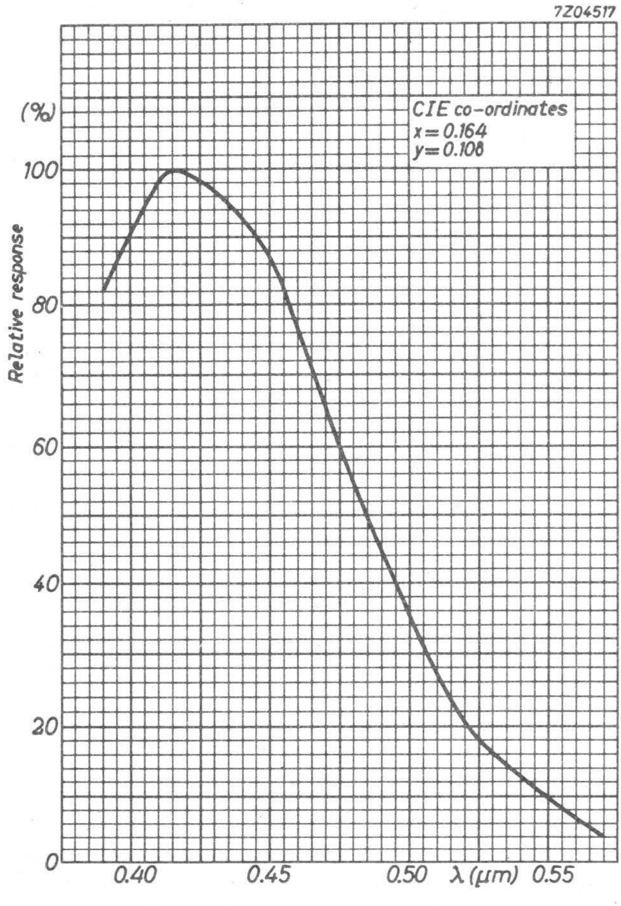

7Z04512
Luminance (nits)
Low voltage
This phosphor is not recommended for use below 10kV
30
20
10
0
0
0.5
1.5
Luminance (nits)
High voltage
1500
1000
500
0
V_{screen}=25kV
22kV
18kV
15kV
12kV
10kV
0
1
2
3
4
Current density (µA/cm²)

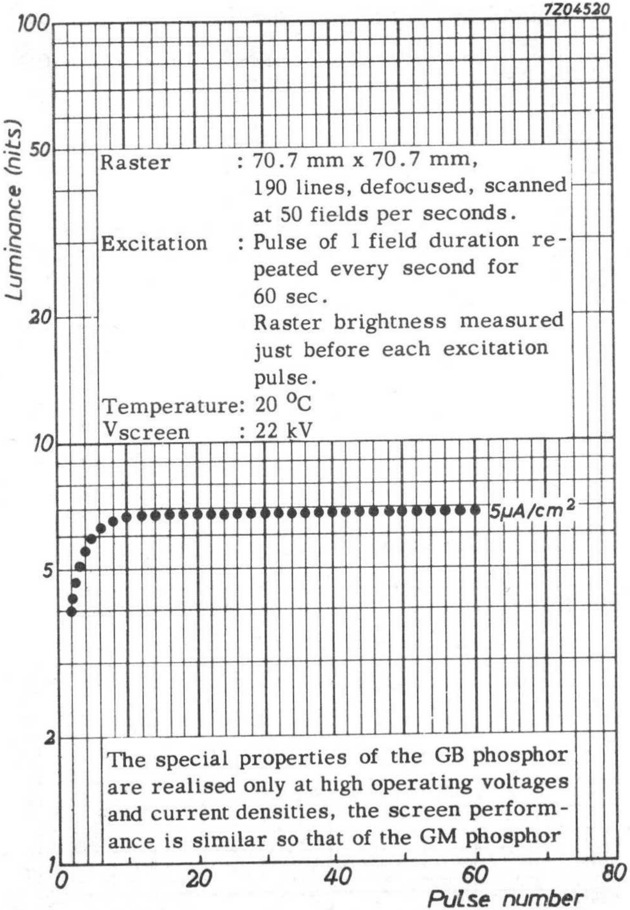

7Z04513
CIE co-ordinates
x = 0.198
y = 0.220
(%)
Relative response
100
80
60
40
20
0
0.3
0.4
0.5
0.6
λ (μm)
0.7

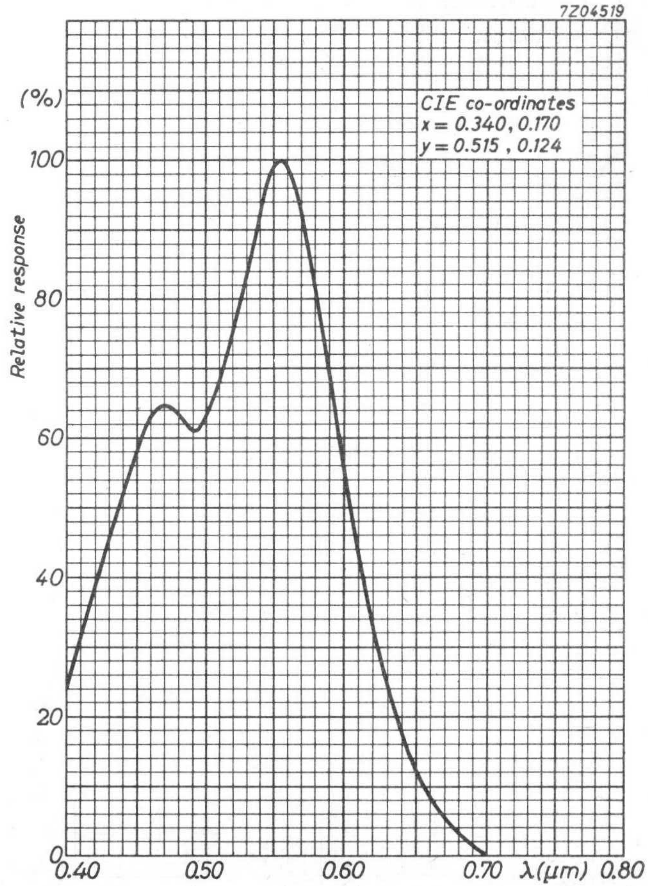

7Z04514
CIE co-ordinates
x = 0.139
y = 0.148
(%)
Relative response
100
80
60
40
20
0
0.4
0.45
0.5
0.55
λ (μm)
0.6

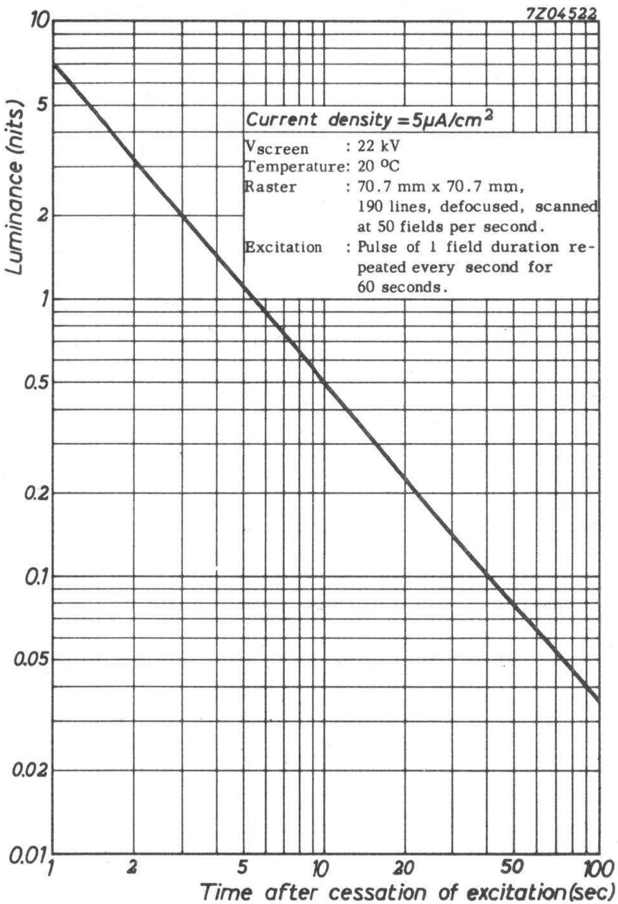

7Z04515
Vscreen : 1.5 to 5 kV
Iscreen : 20 μA peak
Excitation : Single focused spot
Pulse duration: 0.2 μs
At lower screen voltage, lower screen loading or longer excitation time, the decay time will be longer
Relative luminance (%)
100
10
1
0.1
0.01
1
10
10²
10³
10⁴
10⁵
Time after cessation of excitation (μsec)

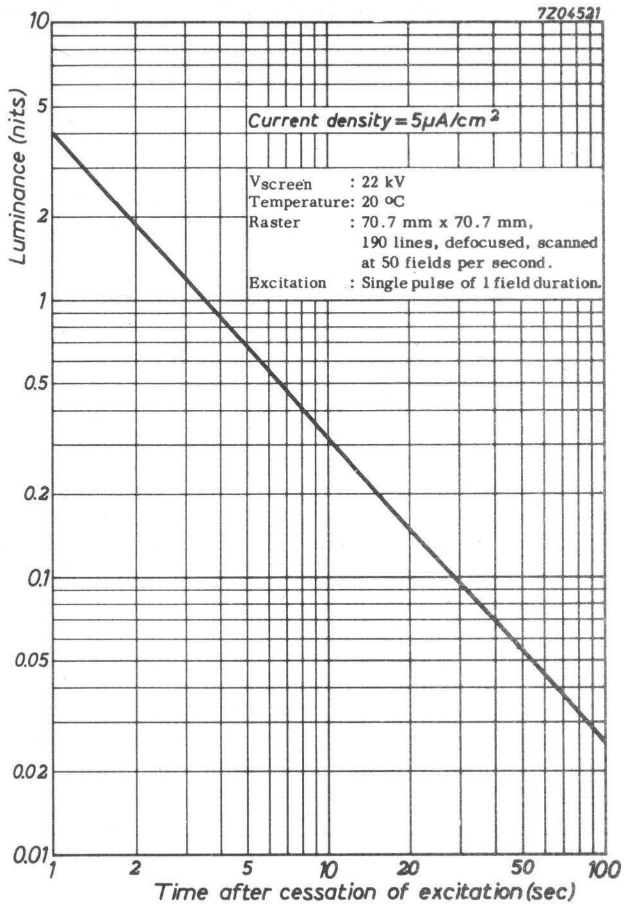

7Z04516
Low voltage
Luminance (nits)
Vscreen=4kV
3kV
2kV
1kV
High voltage
Luminance (nits)
Vscreen=18kV
15kV
12kV
10kV
Current density (μA/cm²)

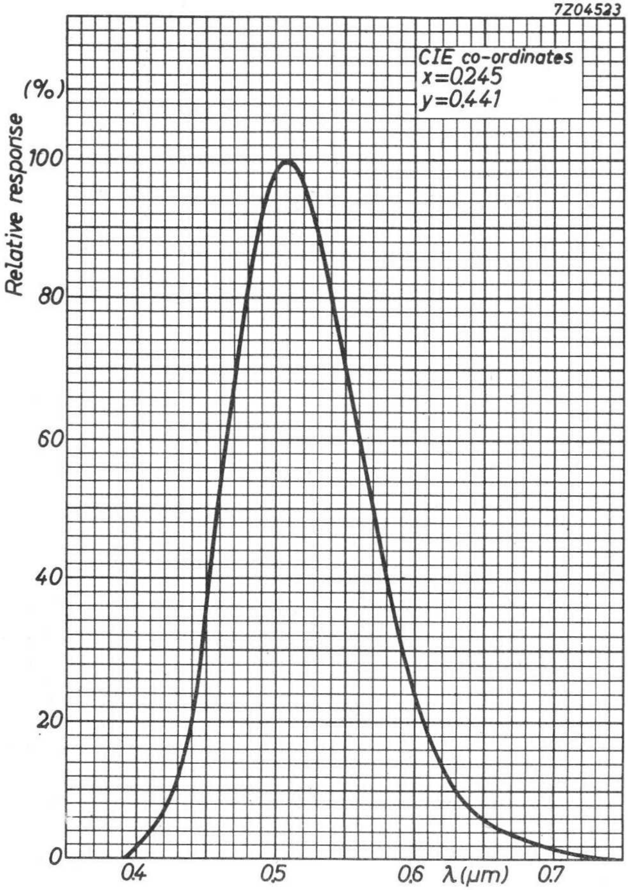

7Z04517
CIE co-ordinates
x = 0.164
y = 0.108
(%)
100
80
60
40
20
0
Relative response
0.40
0.45
0.50
λ (μm)
0.55

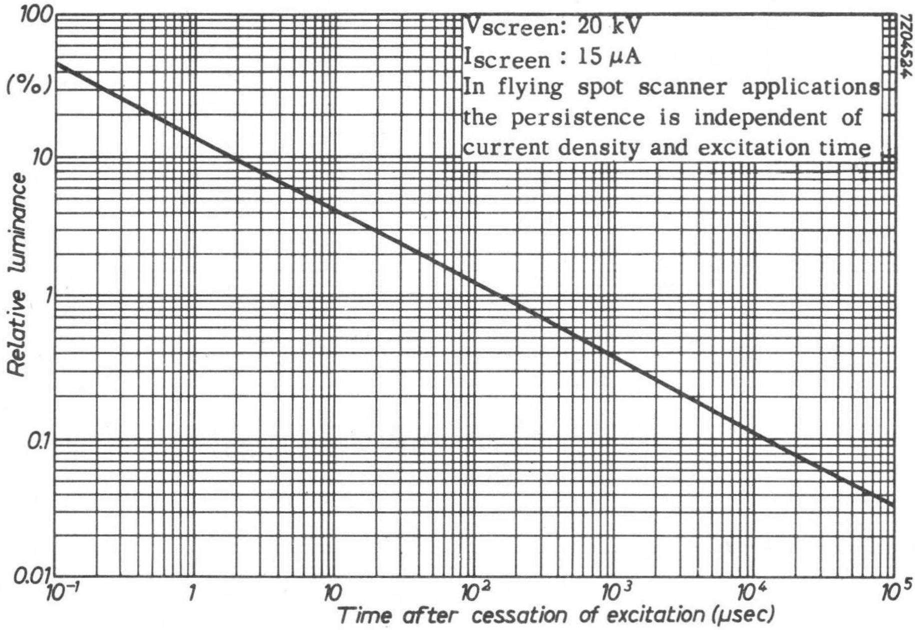

7Z04520
Luminance (nits)
100
50
20
10
5
2
1
Raster : 70.7 mm x 70.7 mm, 190 lines, defocused, scanned at 50 fields per seconds.
Excitation : Pulse of 1 field duration repeated every second for 60 sec. Raster brightness measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 22 kV
5µA/cm²
The special properties of the GB phosphor are realised only at high operating voltages and current densities, the screen performance is similar so that of the GM phosphor
0
20
40
60
80
Pulse number

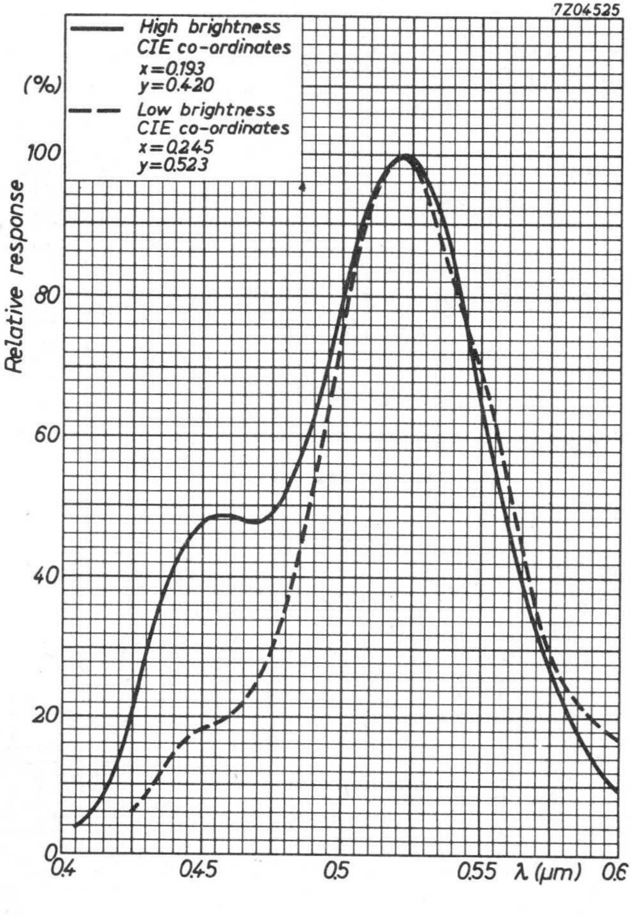

7Z04519
(%)
Relative response
100
80
60
40
20
0
CIE co-ordinates
x = 0.340, 0.170
y = 0.515 , 0.124
0.40
0.50
0.60
0.70
λ(µm)
0.80

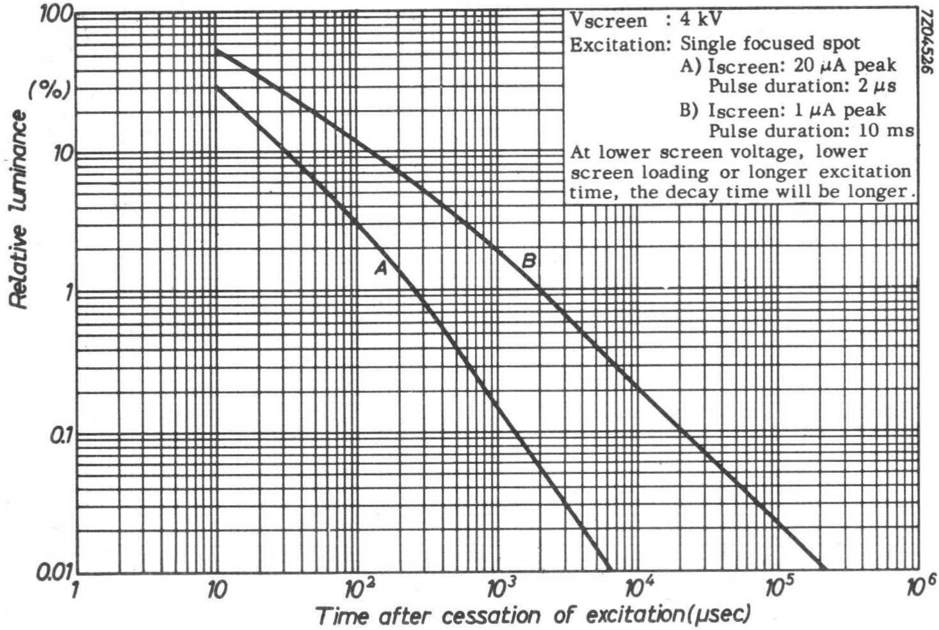

7Z04522
Current density = 5μA/cm²
Vscreen : 22 kV
Temperature: 20 °C
Raster : 70.7 mm x 70.7 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds.
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

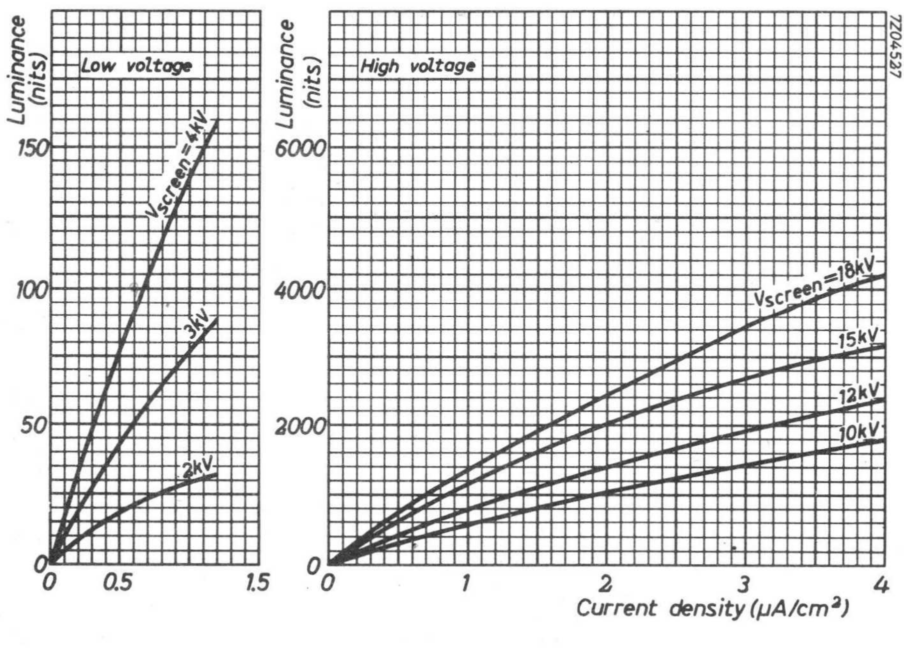

7Z04521
Current density = 5μA/cm²
Vscreen : 22 kV
Temperature: 20 °C
Raster : 70.7 mm x 70.7 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Single pulse of 1 field duration.
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

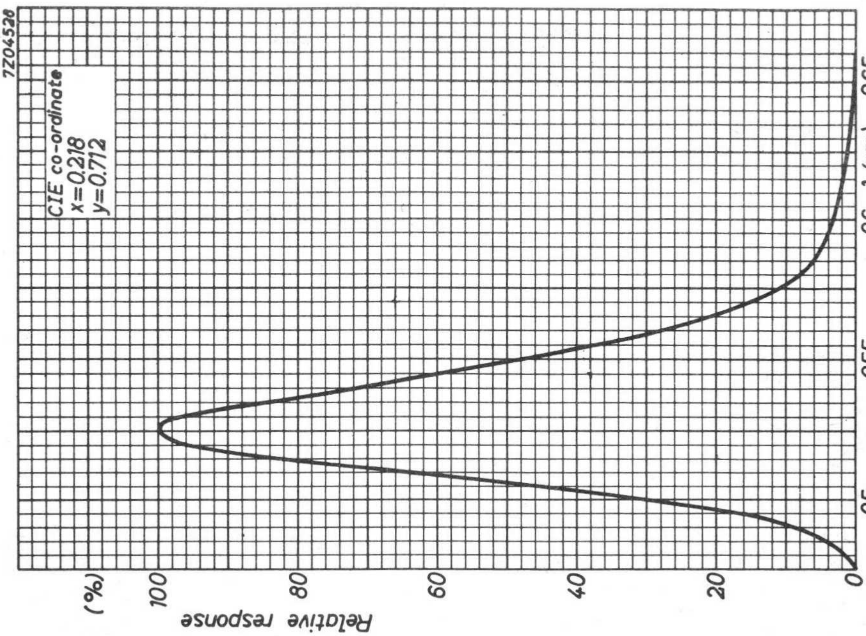

7Z04523
CIE co-ordinates
x=0.245
y=0.441
(%)
Relative response
100
80
60
40
20
0
0.4
0.5
0.6
λ(μm)
0.7

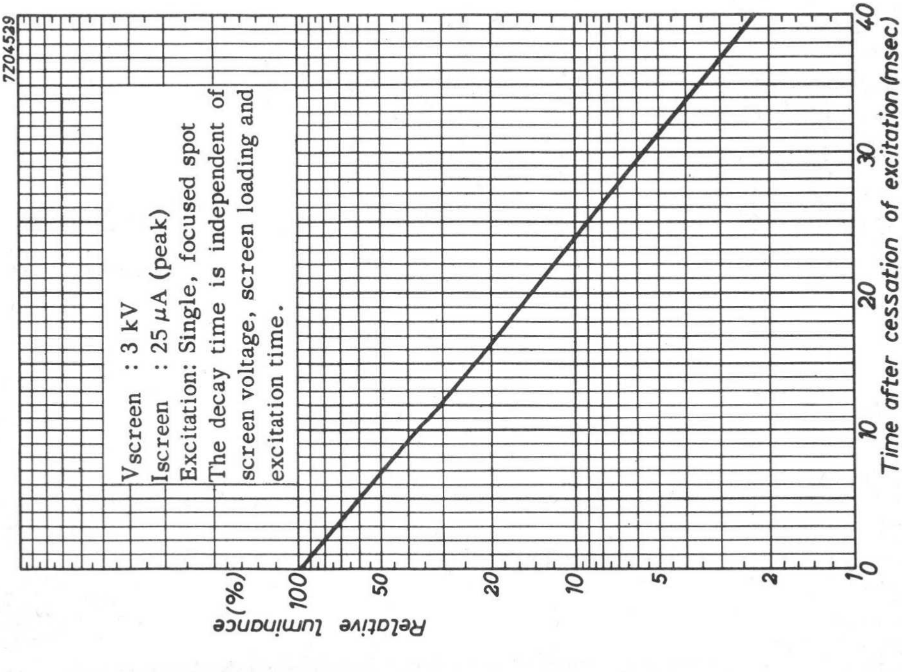

100
(%)
10
1
0.1
0.01
Relative luminance
10^{-1}
1
10
10^2
10^3
10^4
10^5
Time after cessation of excitation (μsec)
Vscreen: 20 kV
Iscreen : 15 μA
In flying spot scanner applications the persistence is independent of current density and excitation time
7Z04524

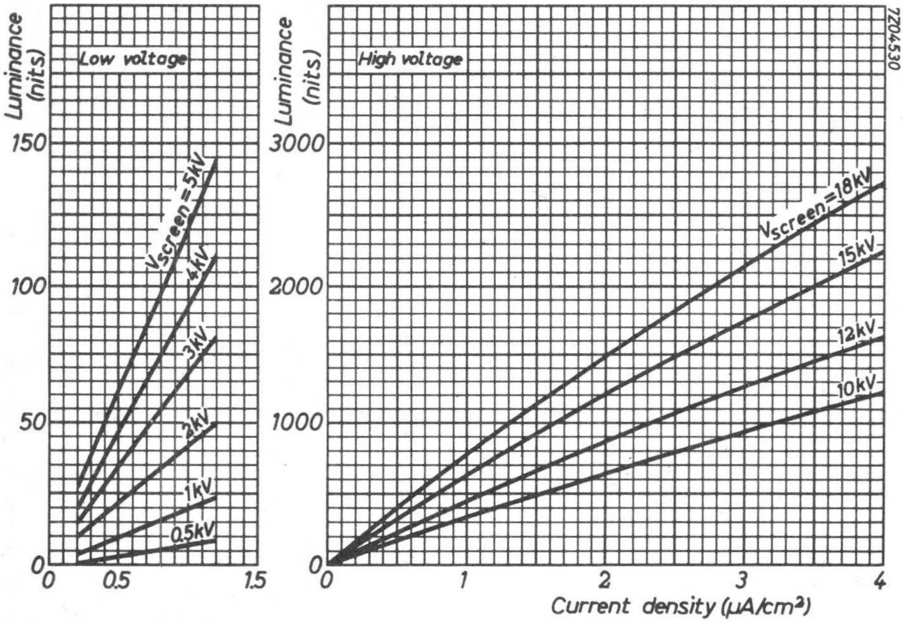

7Z04525
High brightness
CIE co-ordinates
x=0.193
y=0.420
Low brightness
CIE co-ordinates
x=0.245
y=0.523
(%)
Relative response
100
80
60
40
20
0
0.4
0.45
0.5
0.55
λ (μm)
0.6

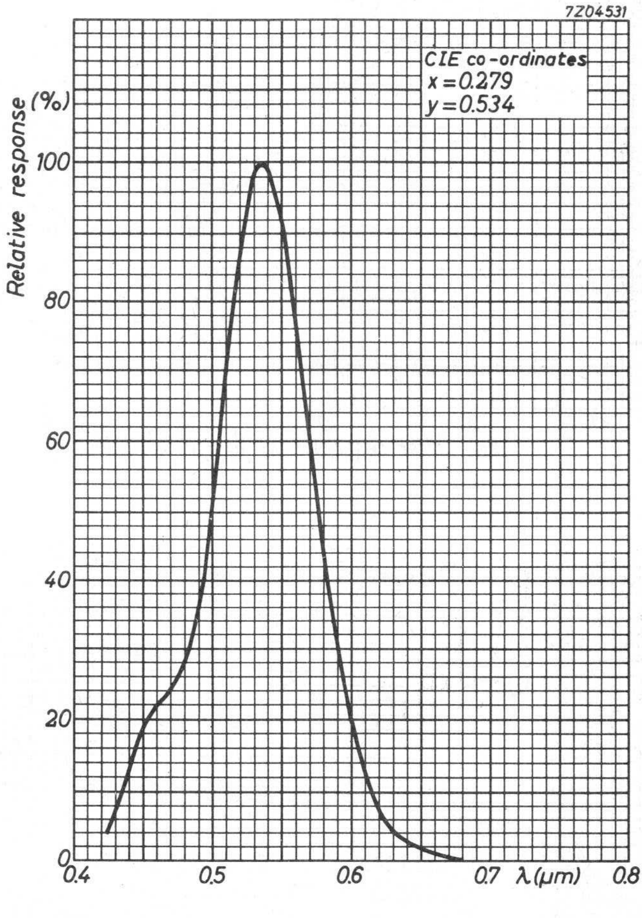

Vscreen : 4 kV
Excitation: Single focused spot
A) Iscreen: 20 μA peak
Pulse duration: 2 μs
B) Iscreen: 1 μA peak
Pulse duration: 10 ms
At lower screen voltage, lower screen loading or longer excitation time, the decay time will be longer.
7Z04526
Relative luminance (%)
100
10
1
0.1
0.01
A
B
1
10
10²
10³
10⁴
10⁵
10⁶
Time after cessation of excitation (μsec)

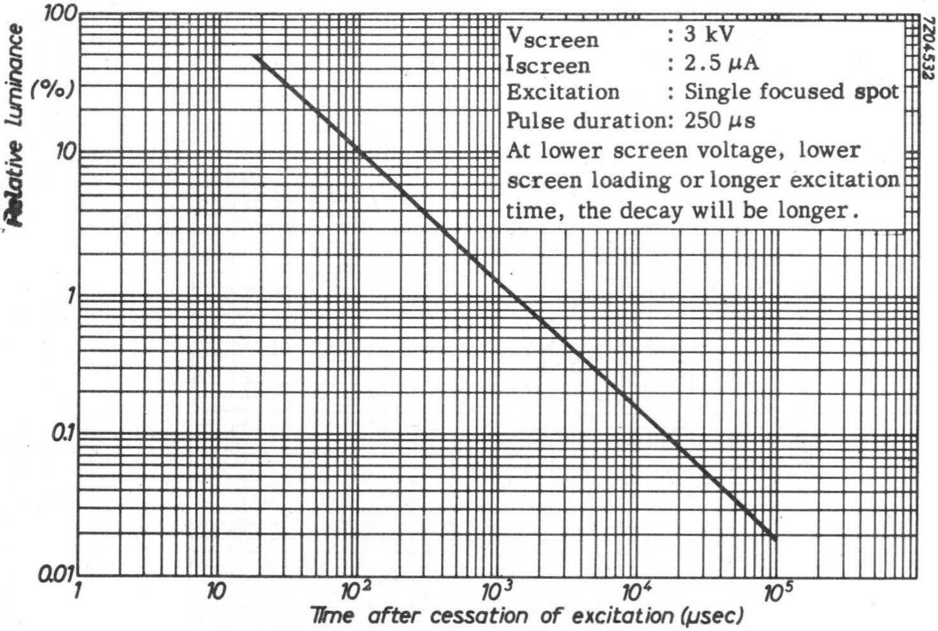

Luminance (nits)
Low voltage
Vscreen=4kV
3kV
2kV
150
100
50
0
0
0.5
1.5
Luminance (nits)
High voltage
7Z04527
Vscreen=18kV
15kV
12kV
10kV
6000
4000
2000
0
0
1
2
3
4
Current density (μA/cm²)

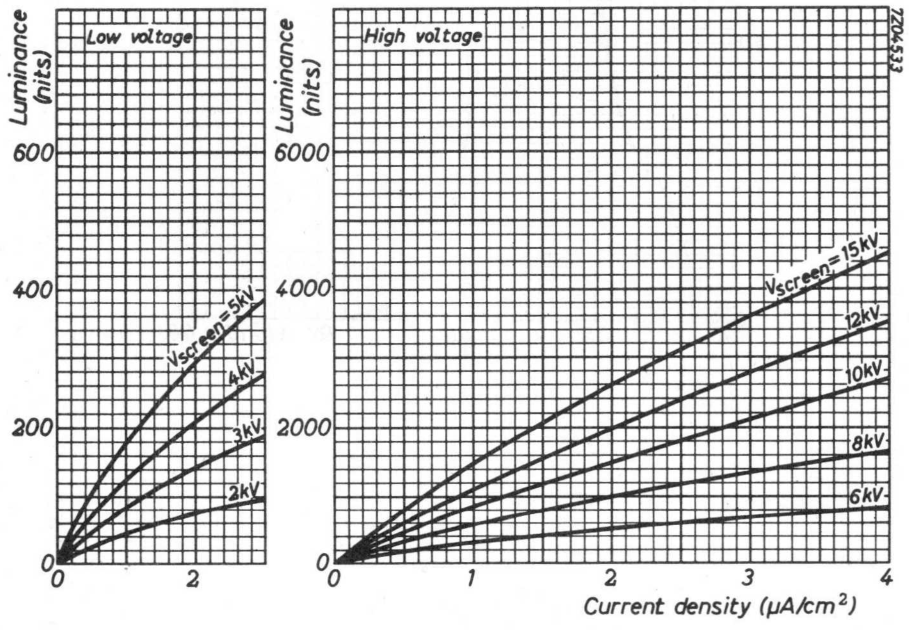

7204528
CIE co-ordinate
x=0.218
y=0.712
Relative response
(%)
100
80
60
40
20
0
0.5
0.55
0.6
0.65
λ (μm)

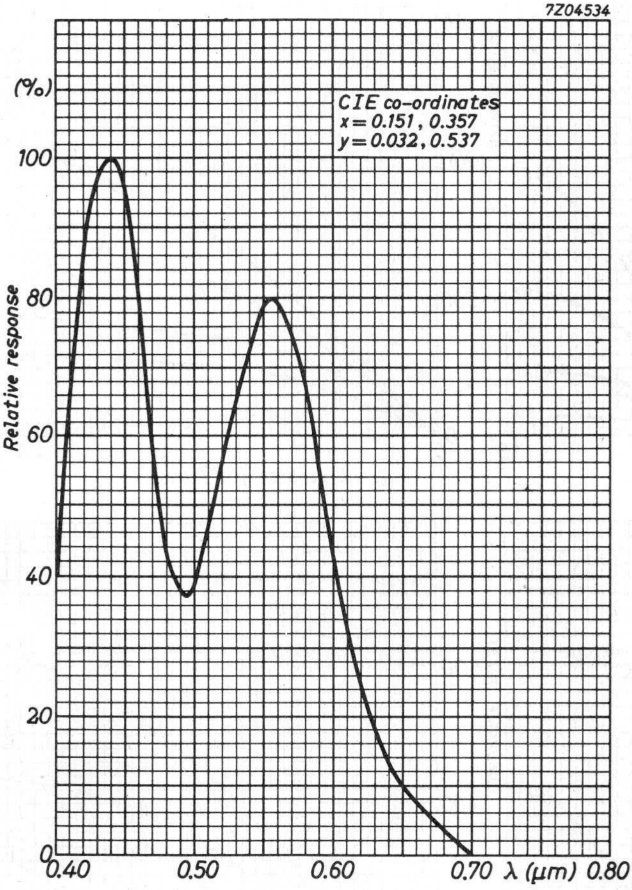

7204529
Vscreen : 3 kV
Iscreen : 25 μA (peak)
Excitation: Single, focused spot
The decay time is independent of screen voltage, screen loading and excitation time.
Relative luminance
(%)
100
50
20
10
5
2
1
0
10
20
30
40
Time after cessation of excitation (msec)

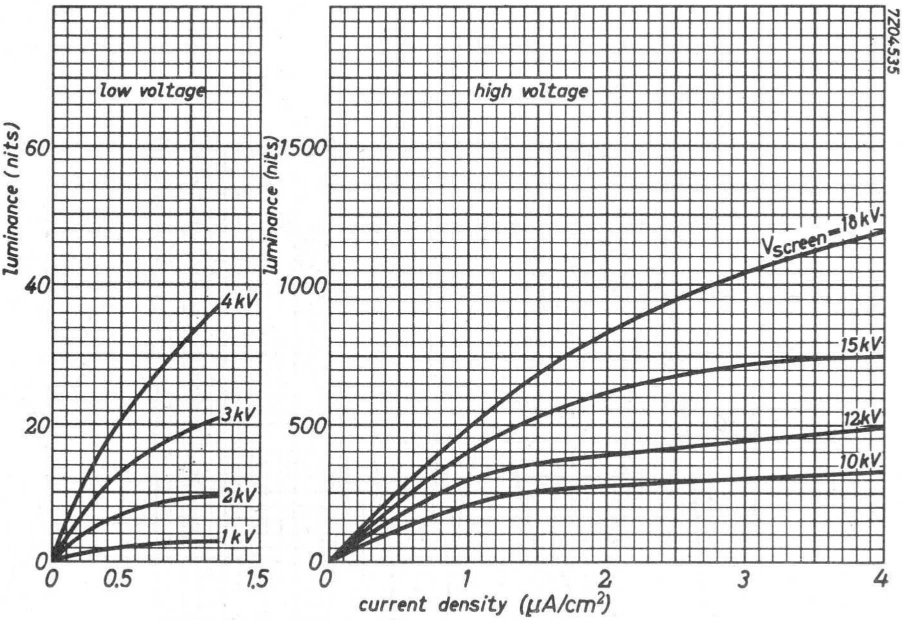

Luminance (nits)
Low voltage
150
100
50
0
0
0.5
1.5
Vscreen=5kV
4kV
3kV
2kV
1kV
0.5kV
Luminance (nits)
High voltage
3000
2000
1000
0
0
1
2
3
4
Vscreen=18kV
15kV
12kV
10kV
Current density (μA/cm²)
7Z04530

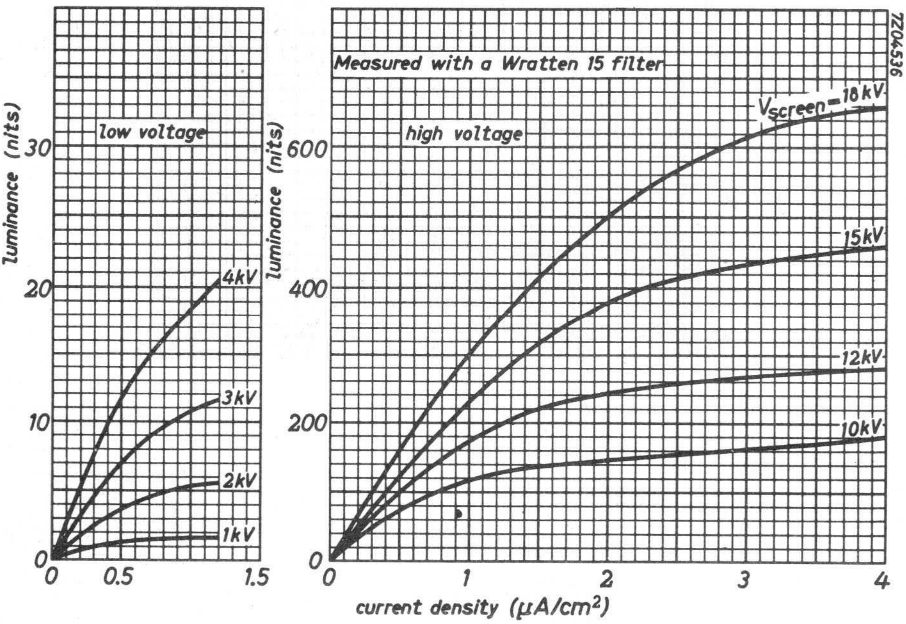

7Z04531
CIE co-ordinates
x = 0.279
y = 0.534
Relative response (%)
100
80
60
40
20
0
0.4
0.5
0.6
0.7
λ (μm)
0.8

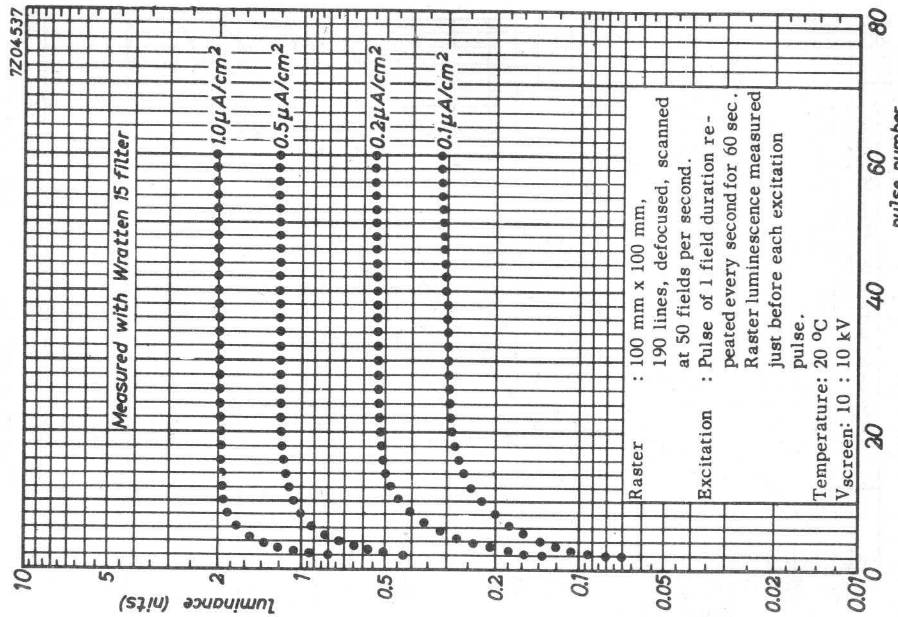

Vscreen : 3 kV
Iscreen : 2.5 μA
Excitation : Single focused spot
Pulse duration: 250 μs
At lower screen voltage, lower screen loading or longer excitation time, the decay will be longer.
Relative luminance (%)
100
10
1
0.1
0.01
1
10
10^2
10^3
10^4
10^5
Time after cessation of excitation (μsec)
7Z04532

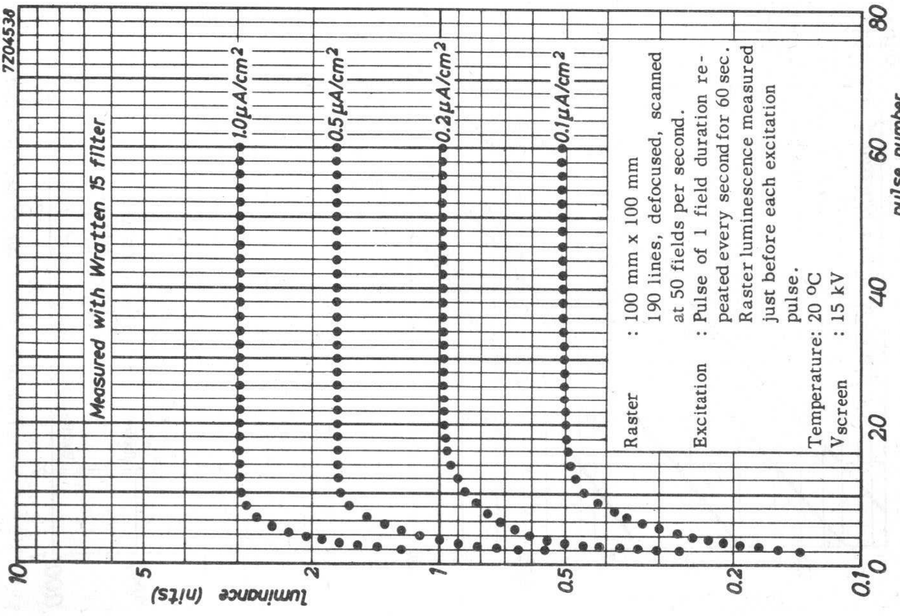

Low voltage
Luminance (nits)
600
400
200
0
Vscreen=5kV
4kV
3kV
2kV
0
2
High voltage
Luminance (nits)
6000
4000
2000
0
Vscreen=15kV
12kV
10kV
8kV
6kV
0
1
2
3
4
Current density (μA/cm²)
7Z04533

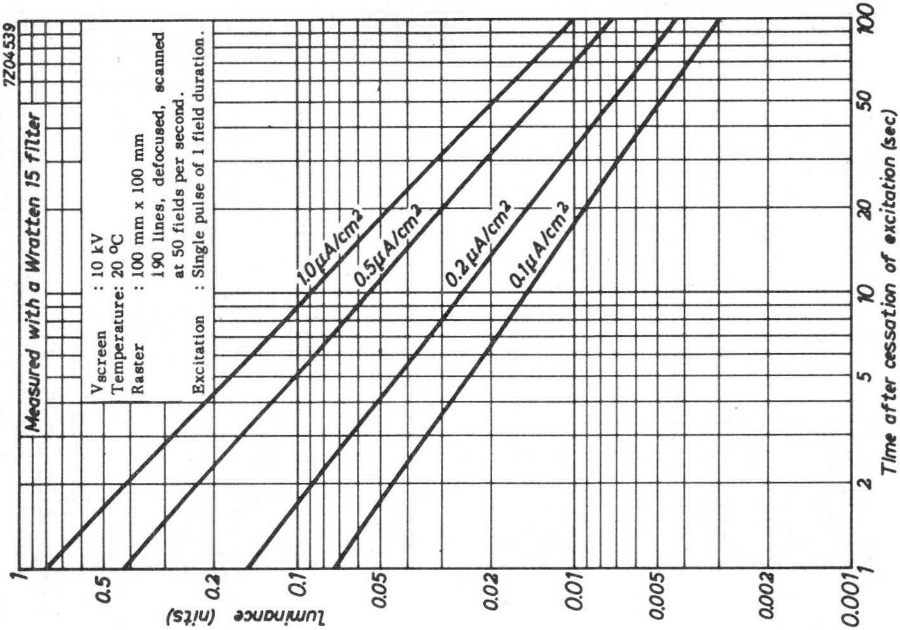

7Z04534
(%)
CIE co-ordinates
x = 0.151 , 0.357
y = 0.032 , 0.537
100
80
60
40
20
0
Relative response
0.40
0.50
0.60
0.70
λ (μm)
0.80

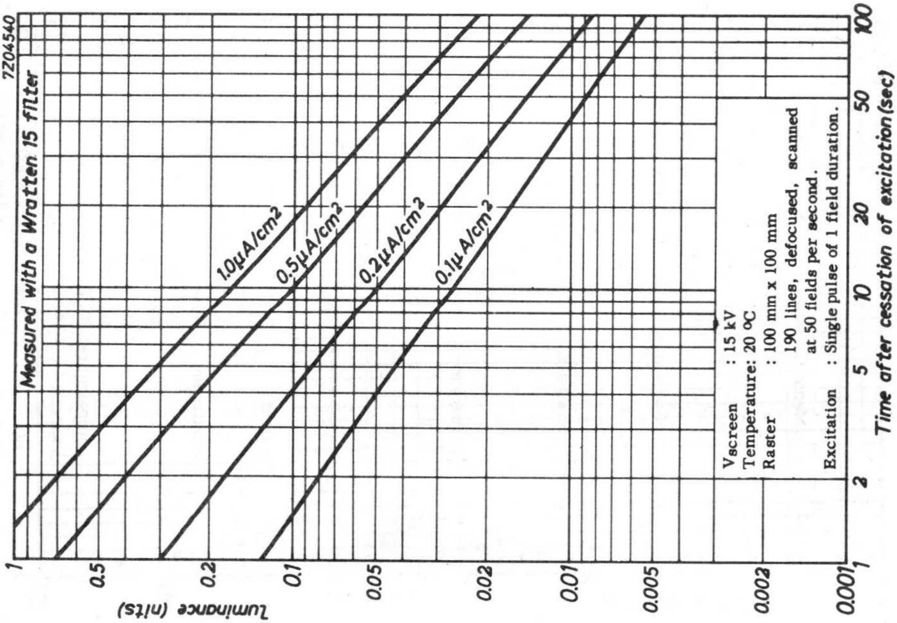

7Z04535
low voltage
luminance (nits)
0
20
40
60
0
0.5
1.5
4kV
3kV
2kV
1kV
high voltage
luminance (nits)
0
500
1000
1500
0
1
2
3
4
V_{screen}=18kV
15kV
12kV
10kV
current density (µA/cm²)

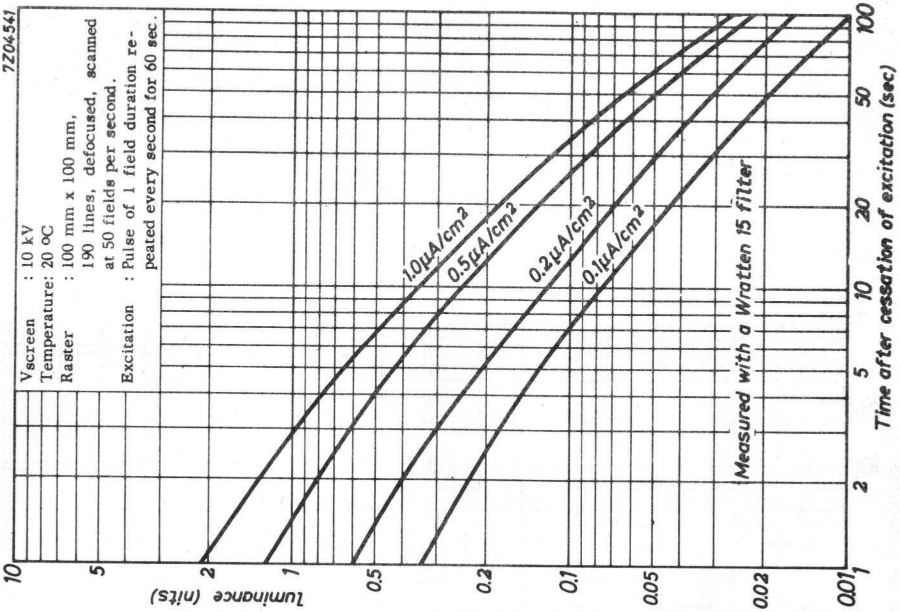

7Z04536
low voltage
luminance (nits)
0
10
20
30
0
0.5
1.5
4kV
3kV
2kV
1kV
Measured with a Wratten 15 filter
high voltage
luminance (nits)
0
200
400
600
0
1
2
3
4
V_{screen}=18kV
15kV
12kV
10kV
current density (µA/cm²)

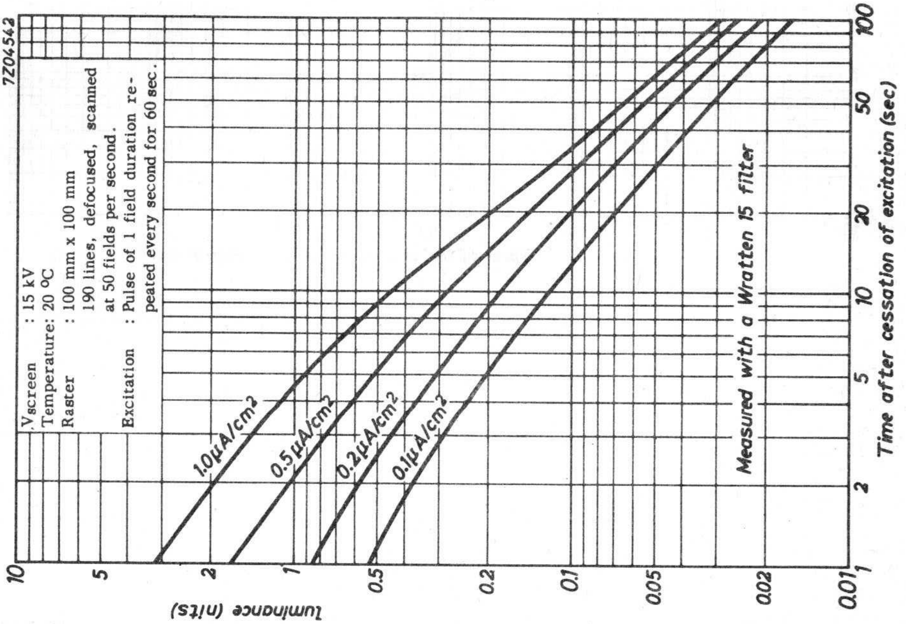

7Z04537
Measured with Wratten 15 filter
1.0 μA/cm²
0.5 μA/cm²
0.2 μA/cm²
0.1 μA/cm²
Raster : 100 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec. Raster luminescence measured just before each excitation pulse.
Temperature: 20 °C
Vscreen: 10 : 10 kV
luminance (nits)
pulse number
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0
20
40
60
80

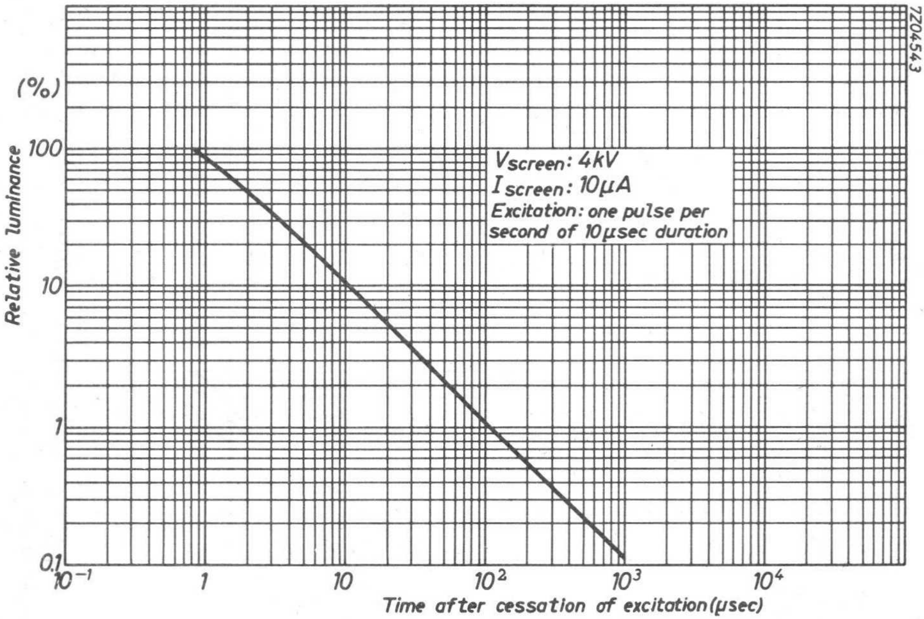

7Z04538
Measured with Wratten 15 filter
1.0 μA/cm²
0.5 μA/cm²
0.2 μA/cm²
0.1 μA/cm²
Raster : 100 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec. Raster luminescence measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 15 kV
luminance (nits)
pulse number
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80

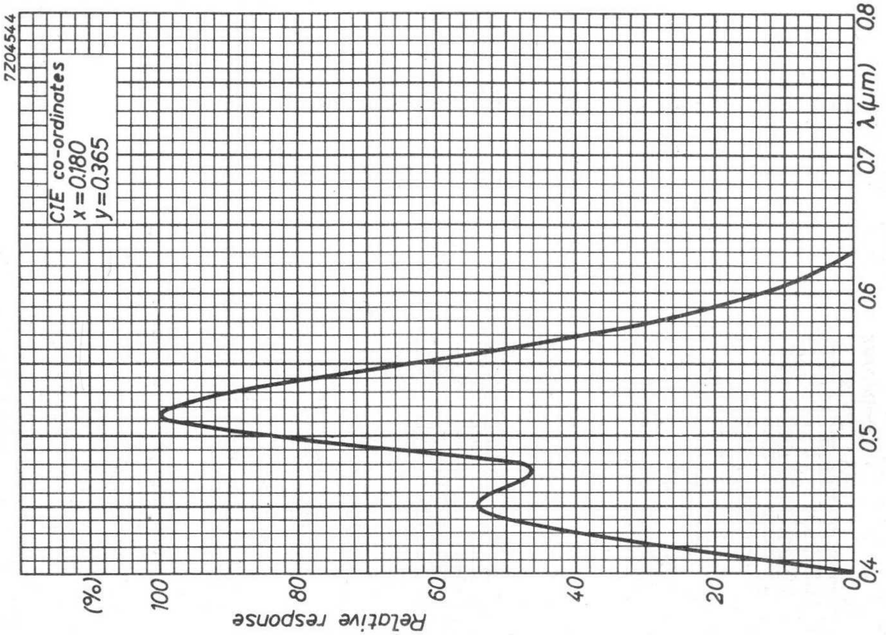

7Z04539
Measured with a Wratten 15 filter
Vscreen : 10 kV
Temperature: 20 °C
Raster : 100 mm x 100 mm
190 lines, defocused, scanned
at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1.0μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
Time after cessation of excitation (sec)
1
2
5
10
20
50
100

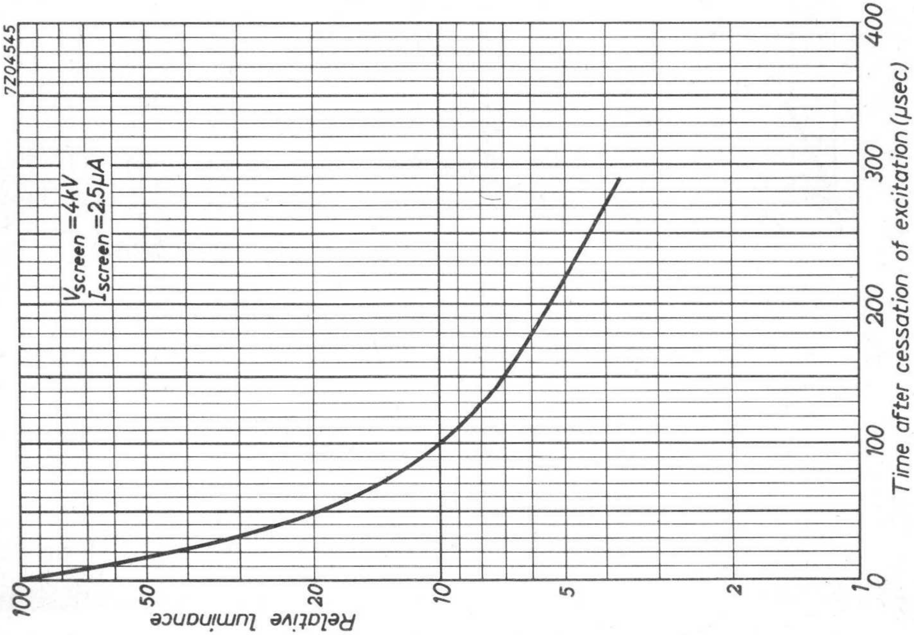

7Z04540
Measured with a Wratten 15 filter
Vscreen : 15 kV
Temperature: 20 °C
Raster : 100 mm x 100 mm
190 lines, defocused, scanned
at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1.0μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
Time after cessation of excitation (sec)
1
2
5
10
20
50
100

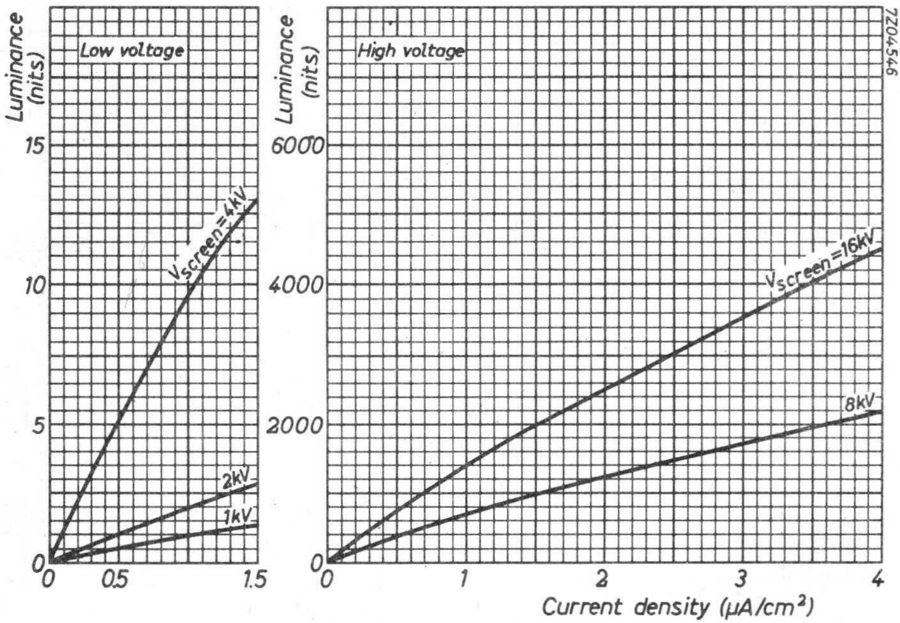

7Z04541
Vscreen : 10 kV
Temperature: 20 °C
Raster : 100 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec.
1.0μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Measured with a Wratten 15 filter
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

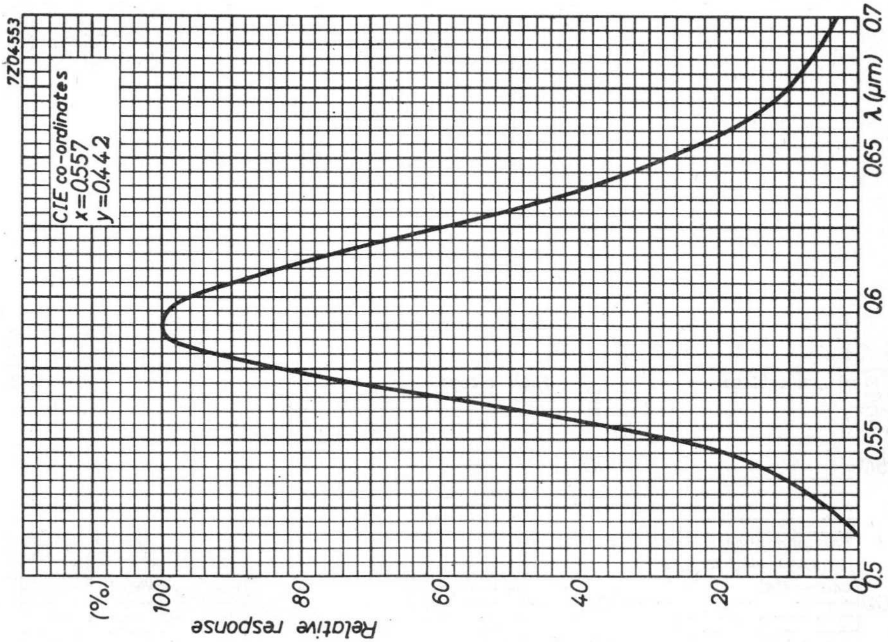

7Z04542
Vscreen : 15 kV
Temperature: 20 °C
Raster : 100 mm x 100 mm 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec.
1.0μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Measured with a Wratten 15 filter
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

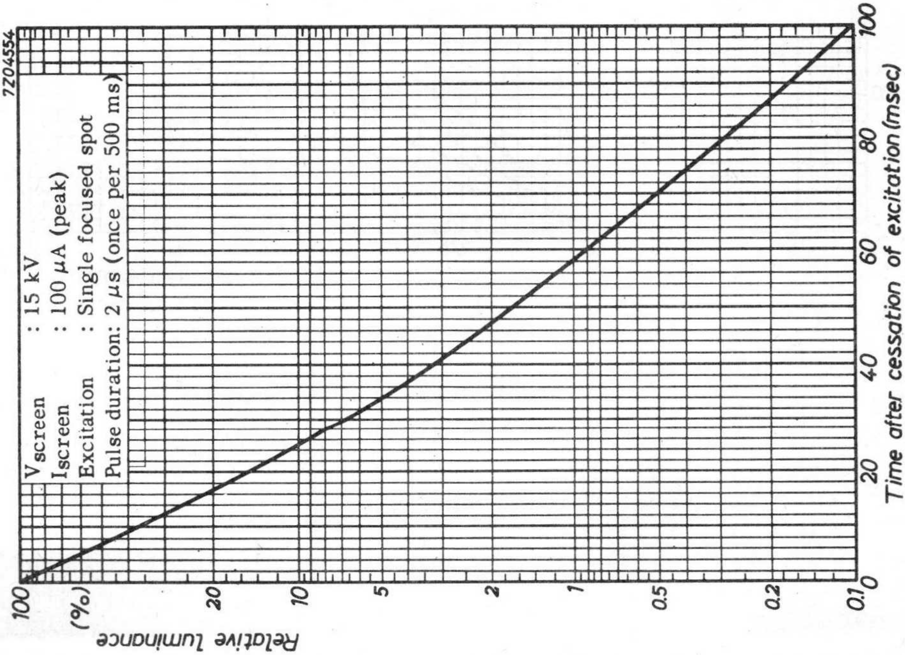

7Z04543
(%)
100
10
1
0.1
Relative luminance
10^{-1}
1
10
10^2
10^3
10^4
Time after cessation of excitation (μsec)
V_{screen}: 4kV
I_{screen}: 10μA
Excitation: one pulse per second of 10μsec duration

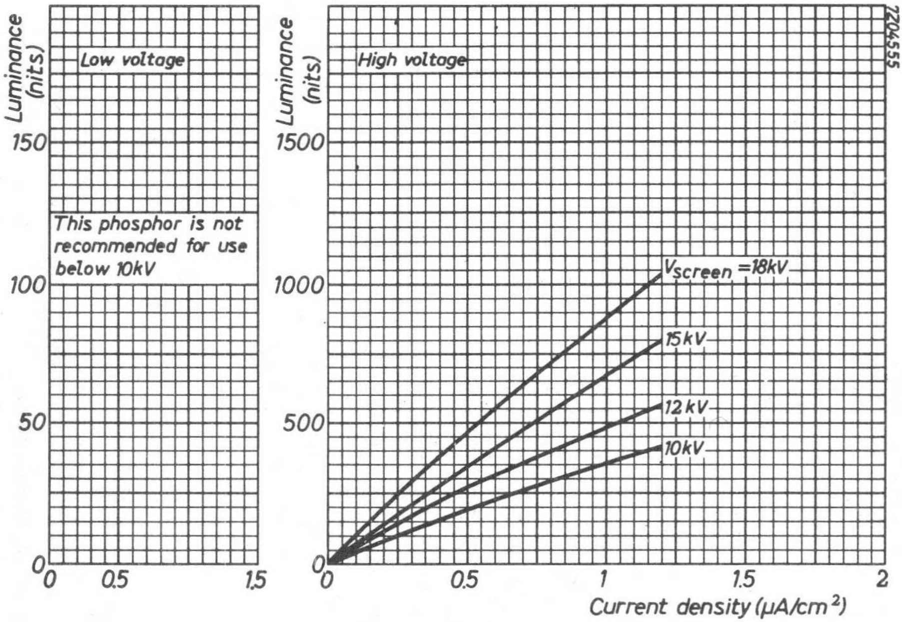

7Z04544
CIE co-ordinates
x = 0.180
y = 0.365
Relative response
(%)
100
80
60
40
20
0
0.4
0.5
0.6
0.7
λ (μm)
0.8

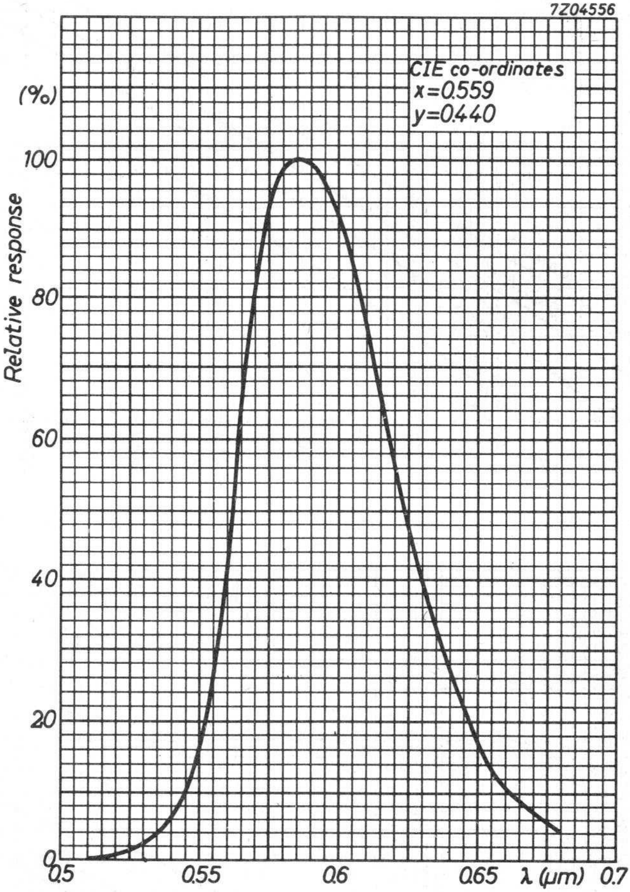

7Z04545
Vscreen = 4kV
Iscreen = 2.5μA
Relative luminance
100
50
20
10
5
2
1
0
100
200
300
400
Time after cessation of excitation (μsec)

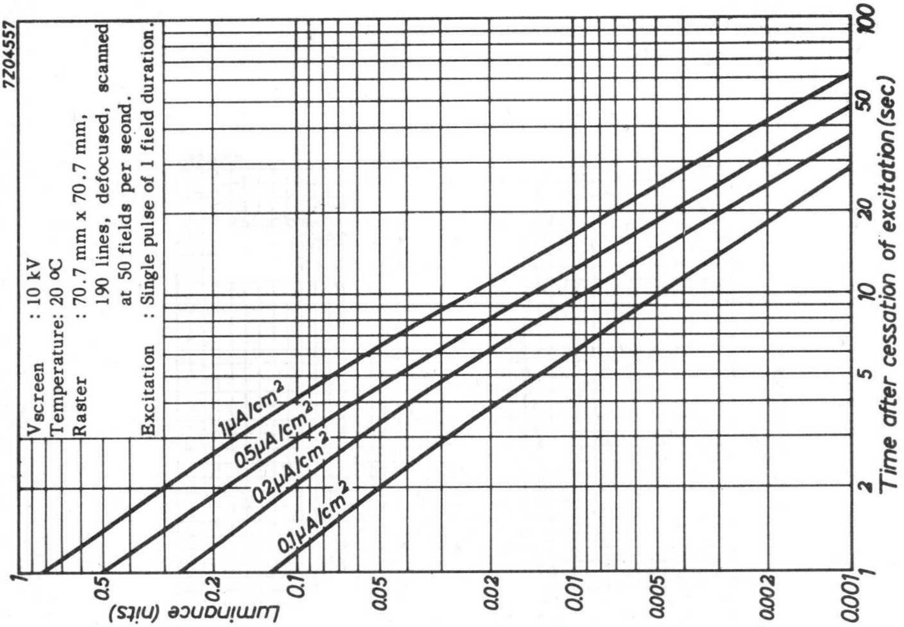

Luminance (nits)
Low voltage
15
10
5
0
0
0.5
1.5
V_{screen}=4kV
2kV
1kV
Luminance (nits)
High voltage
6000
4000
2000
0
0
1
2
3
4
V_{screen}=16kV
8kV
Current density (μA/cm²)
7Z04546

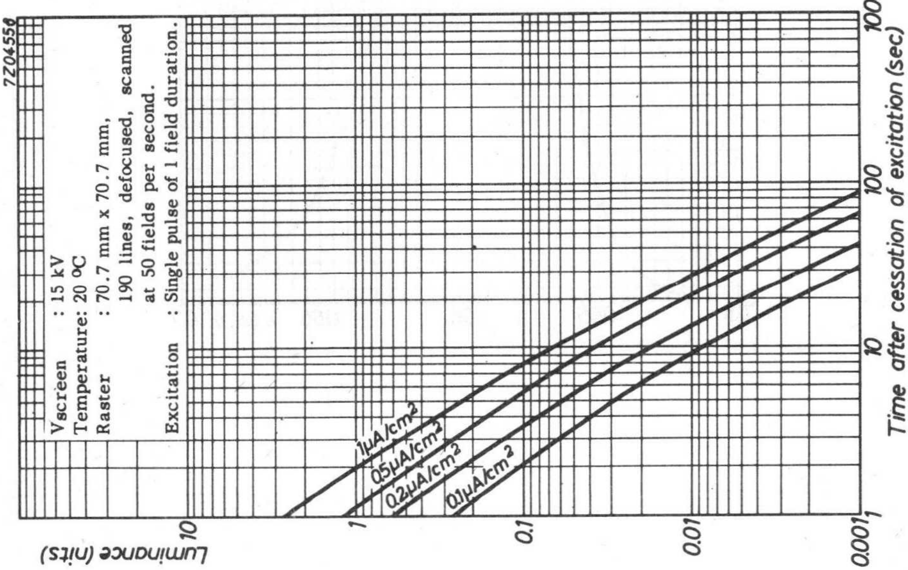

7Z04553
CIE co-ordinates
x=0.557
y=0.442
Relative response
(%)
100
80
60
40
20
0
0.5
0.55
0.6
0.65
0.7
λ (μm)

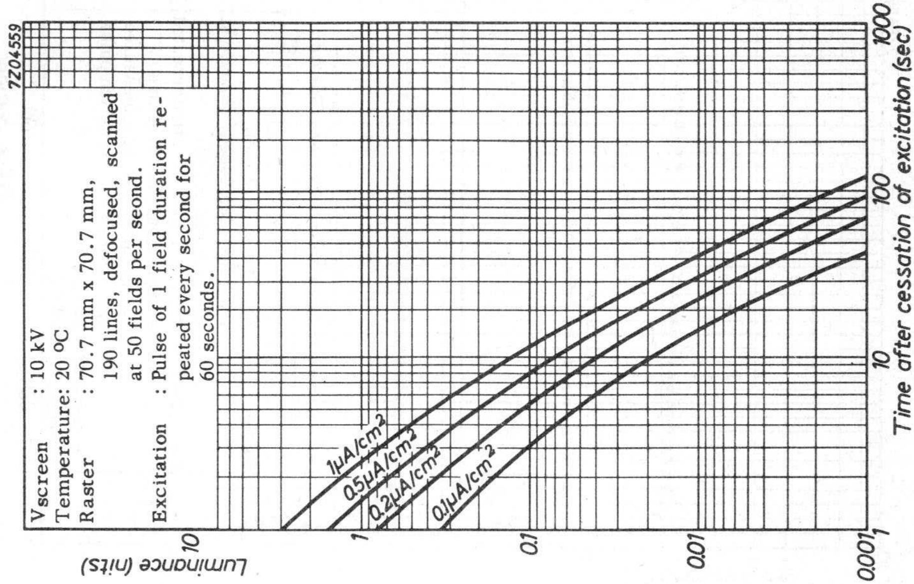

7Z04554
Vscreen : 15 kV
Iscreen : 100 μA (peak)
Excitation : Single focused spot
Pulse duration: 2 μs (once per 500 ms)
Relative luminance
(%)
100
20
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80
100
Time after cessation of excitation (msec)

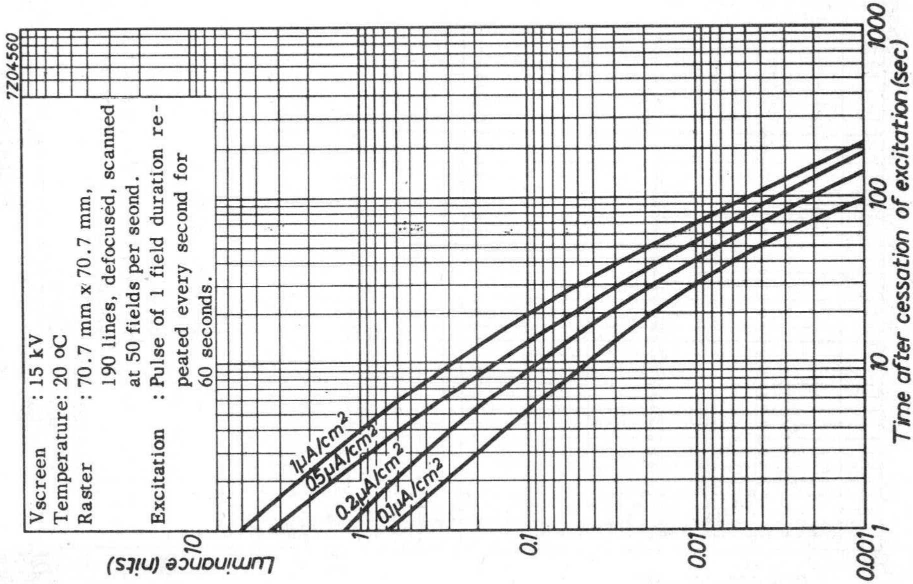

Luminance (nits)
Low voltage
This phosphor is not recommended for use below 10kV
150
100
50
0
0
0.5
1.5
Luminance (nits)
High voltage
1500
1000
500
0
0
0.5
1
1.5
2
Current density (μA/cm²)
Vscreen =18kV
15kV
12kV
10kV
7Z04555

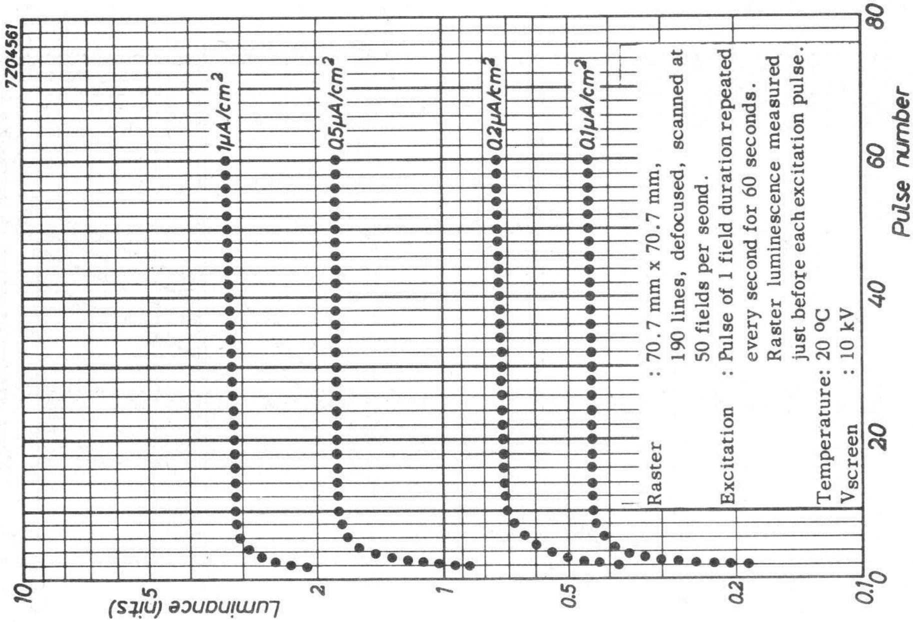

7Z04556
CIE co-ordinates
x=0.559
y=0.440
(%)
Relative response
100
80
60
40
20
0
0.5
0.55
0.6
0.65
λ (μm)
0.7


7204557
Vscreen : 10 kV
Temperature: 20 °C
Raster : 70.7 mm x 70.7 mm,
190 lines, defocused, scanned
at 50 fields per seond.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

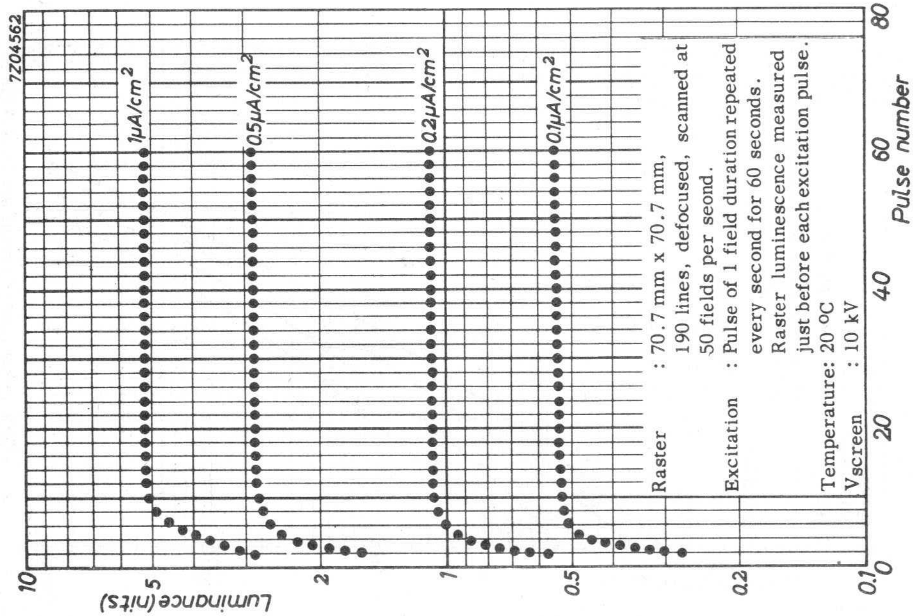

7204556
Vscreen : 15 kV
Temperature: 20 °C
Raster : 70.7 mm x 70.7 mm,
190 lines, defocused, scanned
at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
10
1
0.1
0.01
0.001
1
10
100
1000
Time after cessation of excitation (sec)


7Z04559
Vscreen : 10 kV
Temperature: 20 oC
Raster : 70.7 mm x 70.7 mm,
190 lines, defocused, scanned
at 50 fields per seond.
Excitation : Pulse of 1 field duration re-
peated every second for
60 seconds.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
10
1
0.1
0.01
0.001
1
10
100
1000
Time after cessation of excitation (sec)

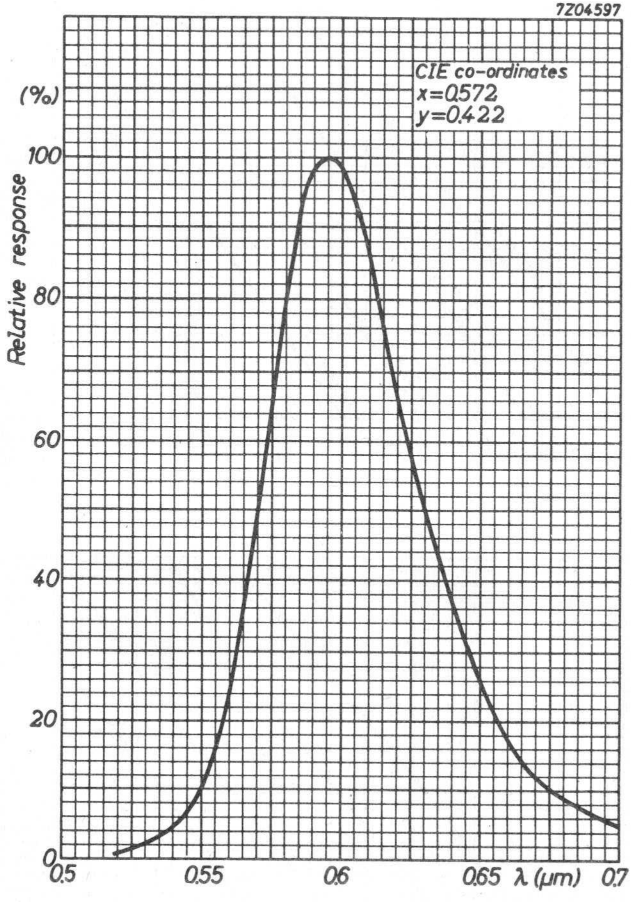

7Z04560
Vscreen : 15 kV
Temperature: 20 oC
Raster : 70.7 mm x 70.7 mm,
190 lines, defocused, scanned
at 50 fields per seond.
Excitation : Pulse of 1 field duration re-
peated every second for
60 seconds.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
10
1
0.1
0.01
0.001
1
10
100
1000
Time after cessation of excitation (sec)

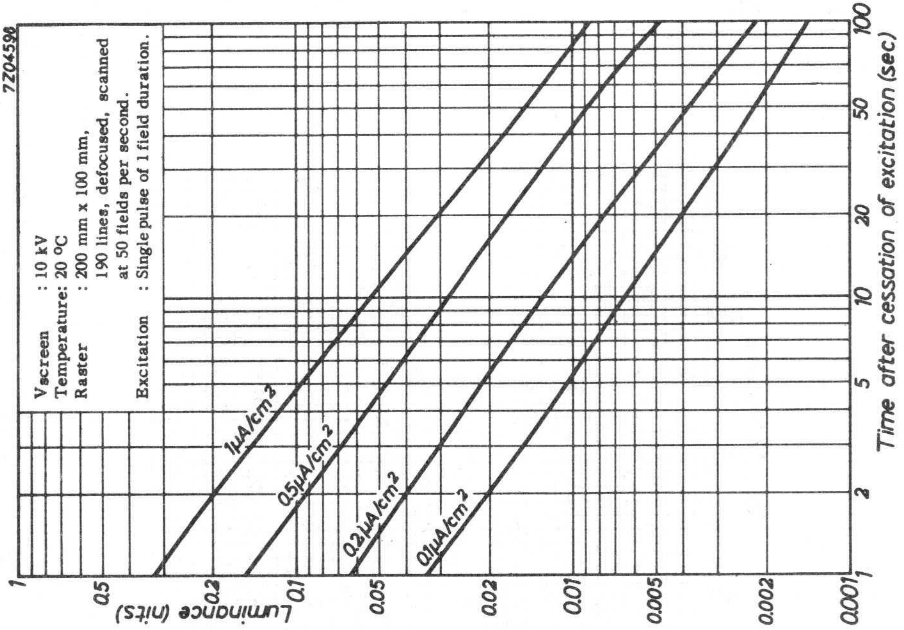


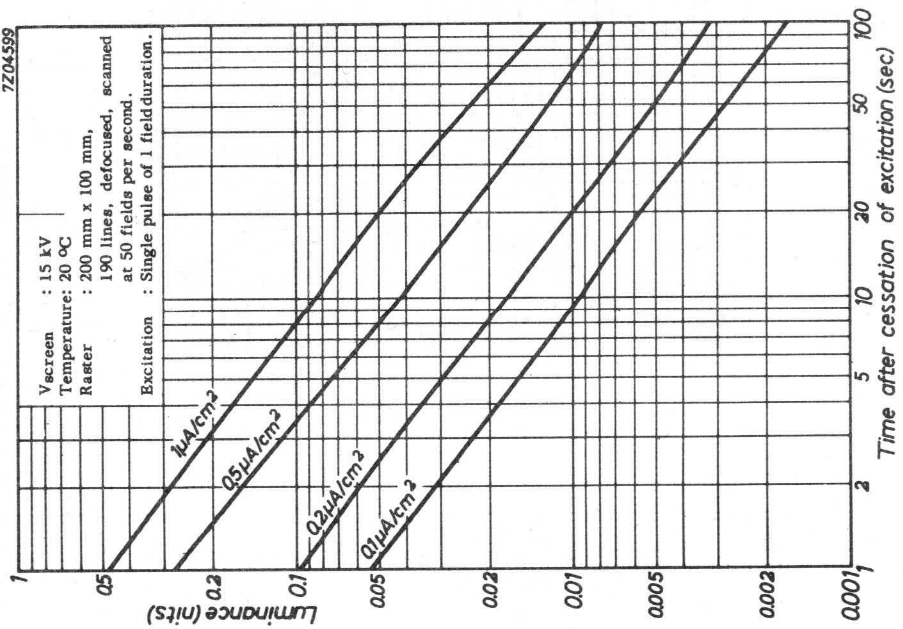
7Z04561
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 70.7 mm x 70.7 mm, 190 lines, defocused, scanned at 50 fields per seond.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminescence measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 10 kV

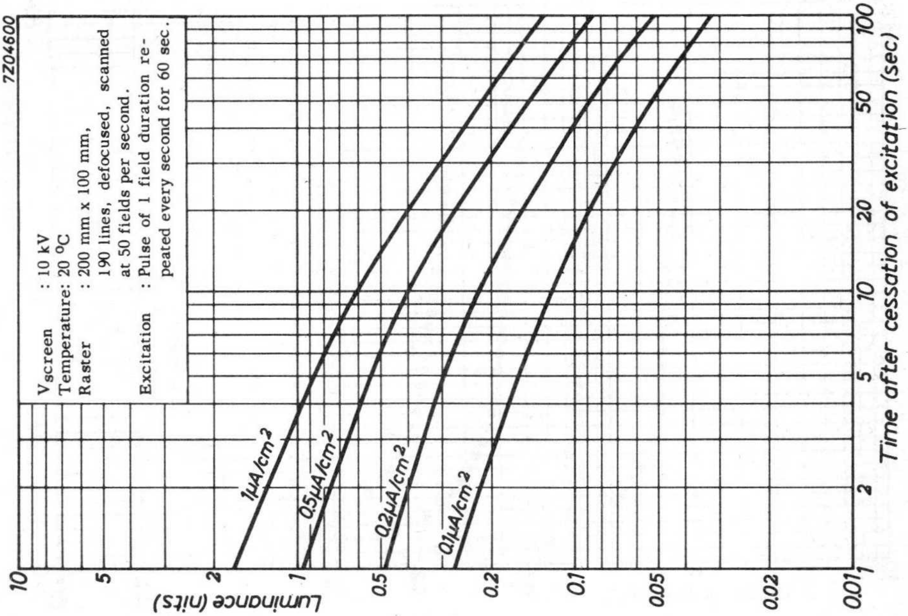


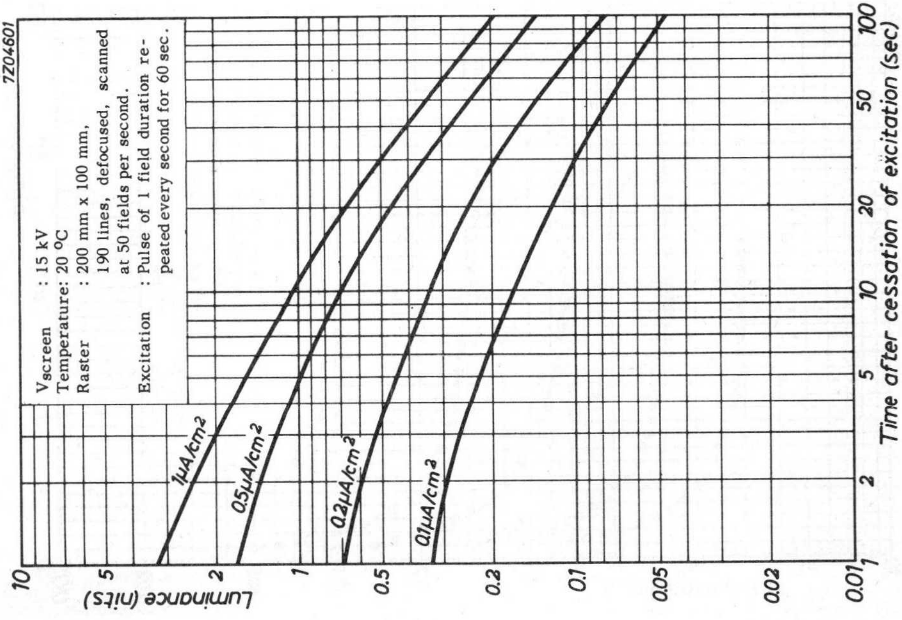
7Z04562
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 70.7 mm x 70.7 mm, 190 lines, defocused, scanned at 50 fields per seond.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminescence measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 10 kV

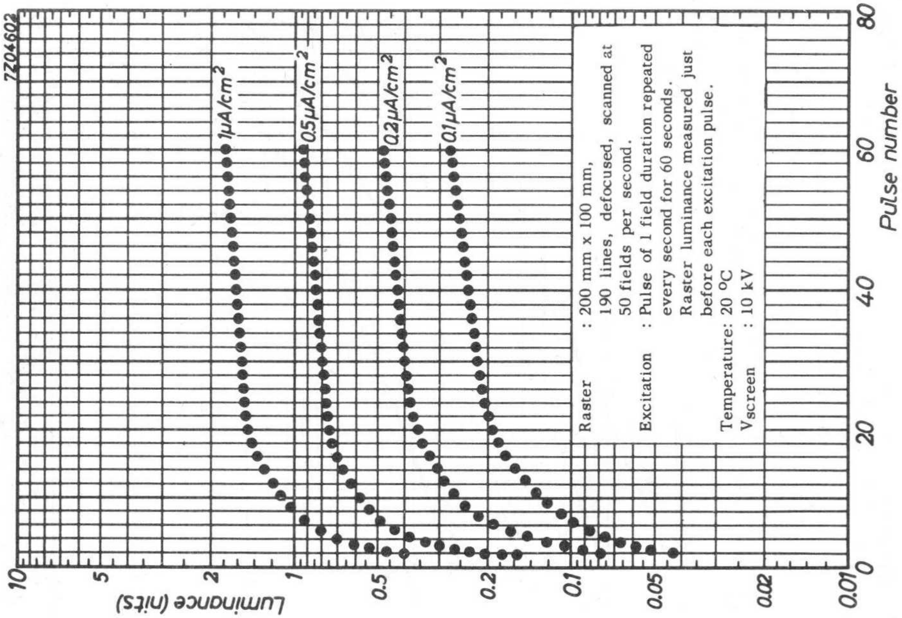

7Z04597
CIE co-ordinates
x=0.572
y=0.422
(%)
Relative response
100
80
60
40
20
0
0.5
0.55
0.6
0.65
λ (μm)
0.7

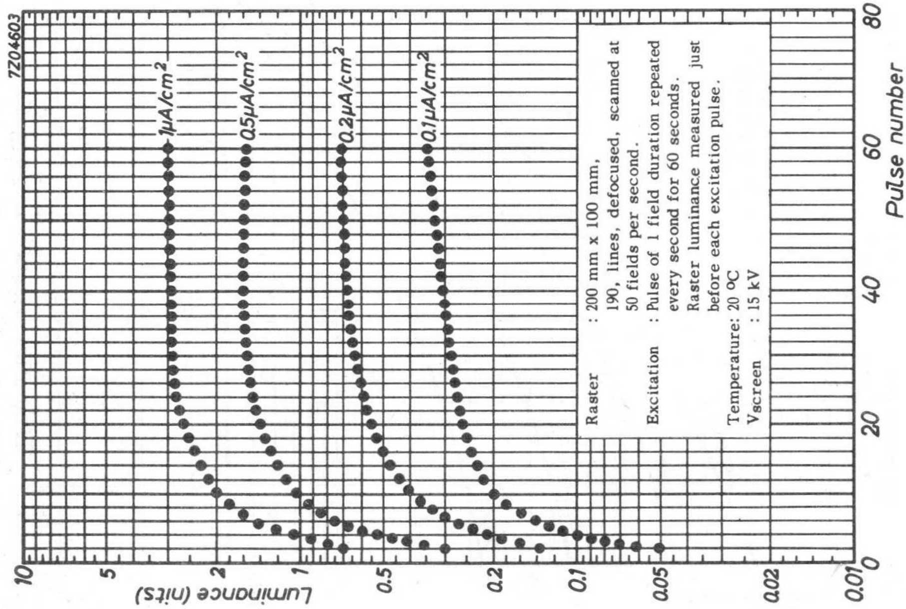

7Z04598
Vscreen : 10 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

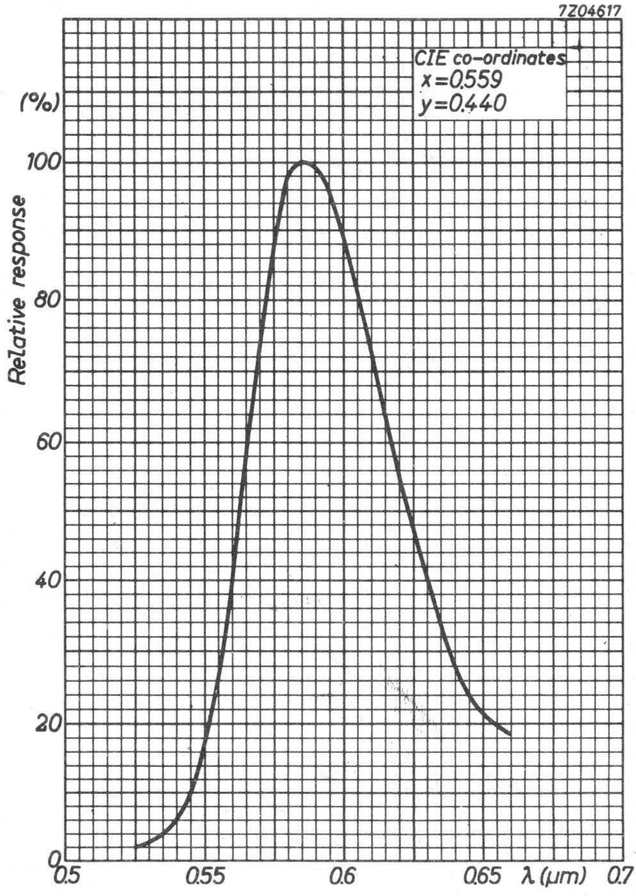

7Z04599
Vscreen : 15 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

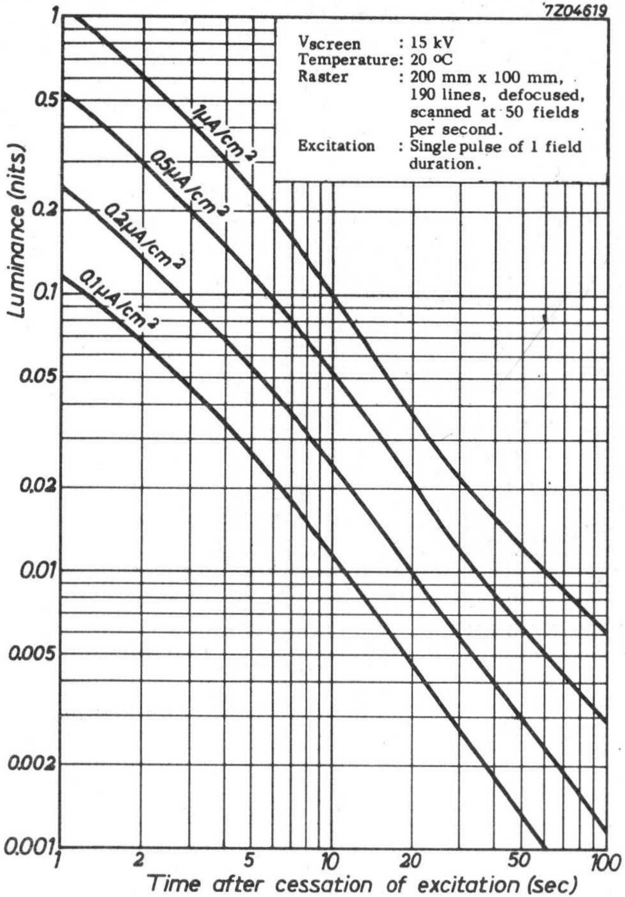

7Z04600
Vscreen : 10 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec.
1μA/cm2
0.5μA/cm2
0.2μA/cm2
0.1μA/cm2
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

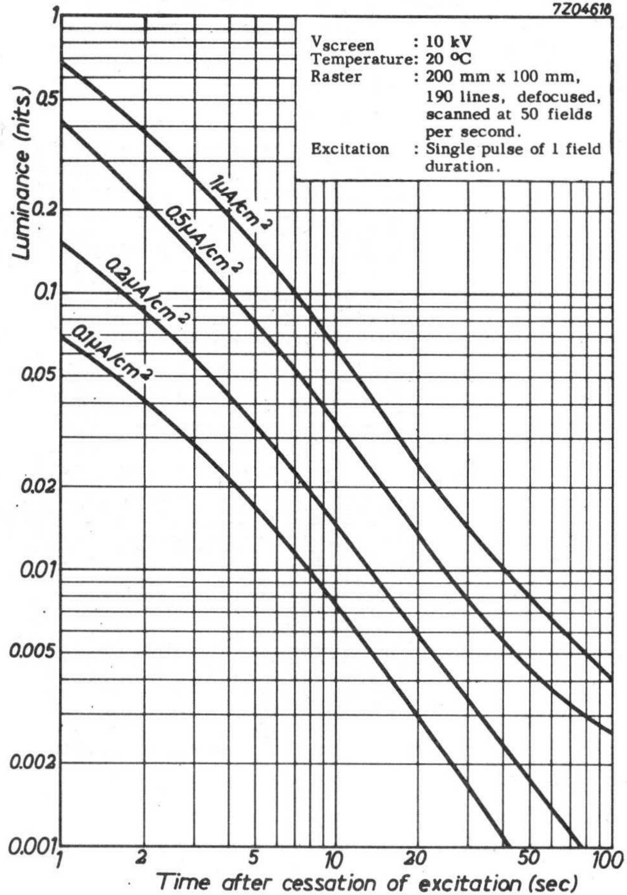

7Z04601
Vscreen : 15 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 sec.
1μA/cm2
0.5μA/cm2
0.2μA/cm2
0.1μA/cm2
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

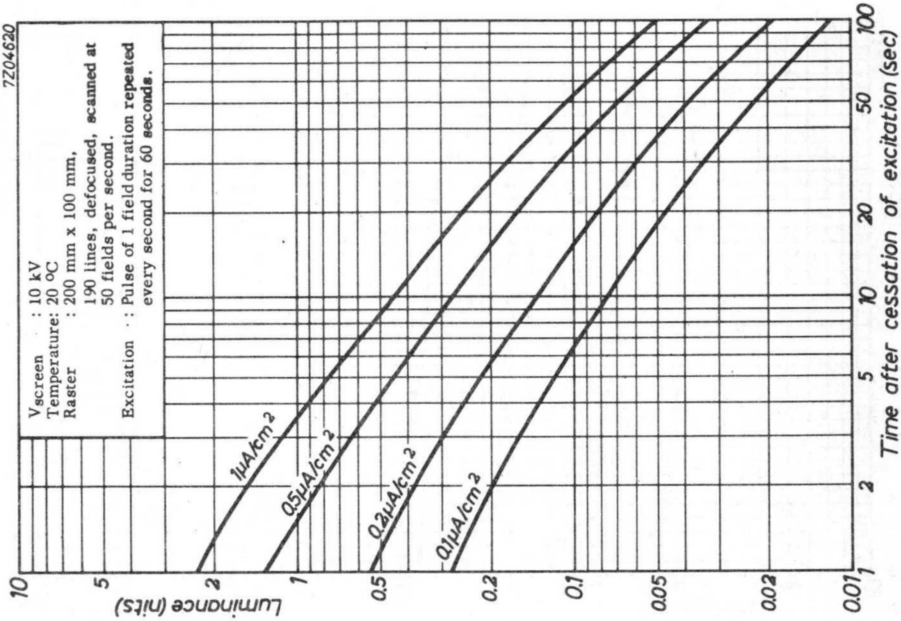

7Z04602
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminance measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 10 kV

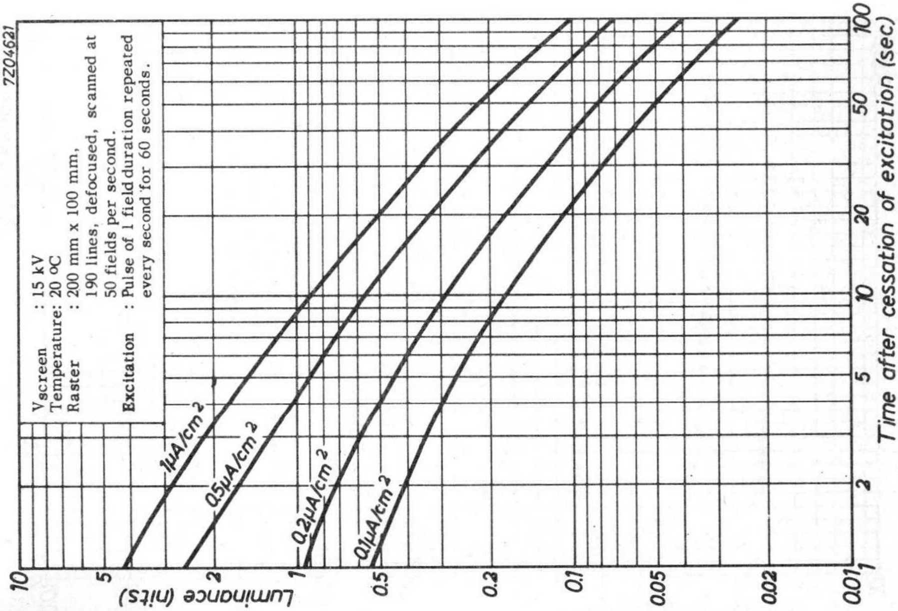

7Z04603
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 200 mm x 100 mm, 190, lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminance measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 15 kV

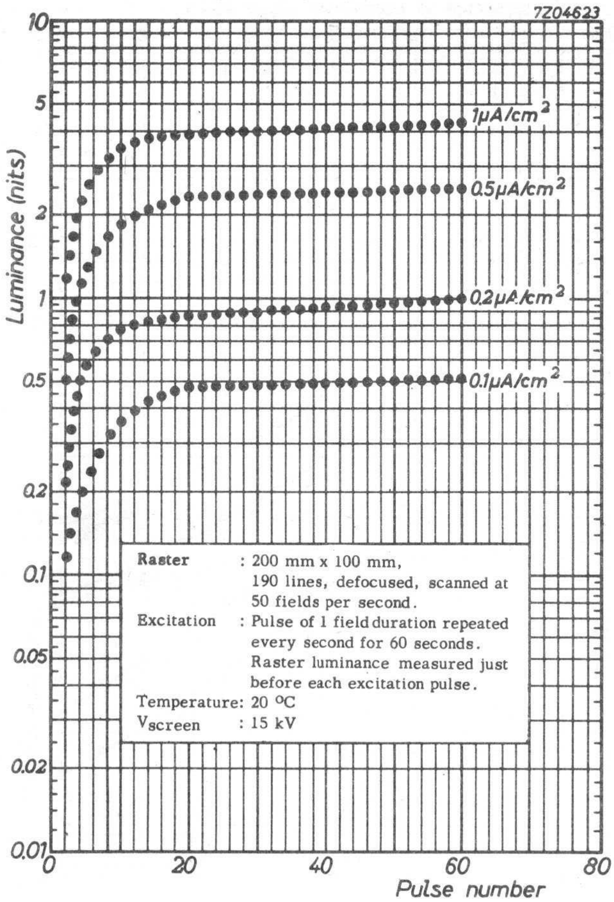

7Z04617
CIE co-ordinates
x = 0.559
y = 0.440
(%)
Relative response
100
80
60
40
20
0
0.5
0.55
0.6
0.65
λ (μm)
0.7

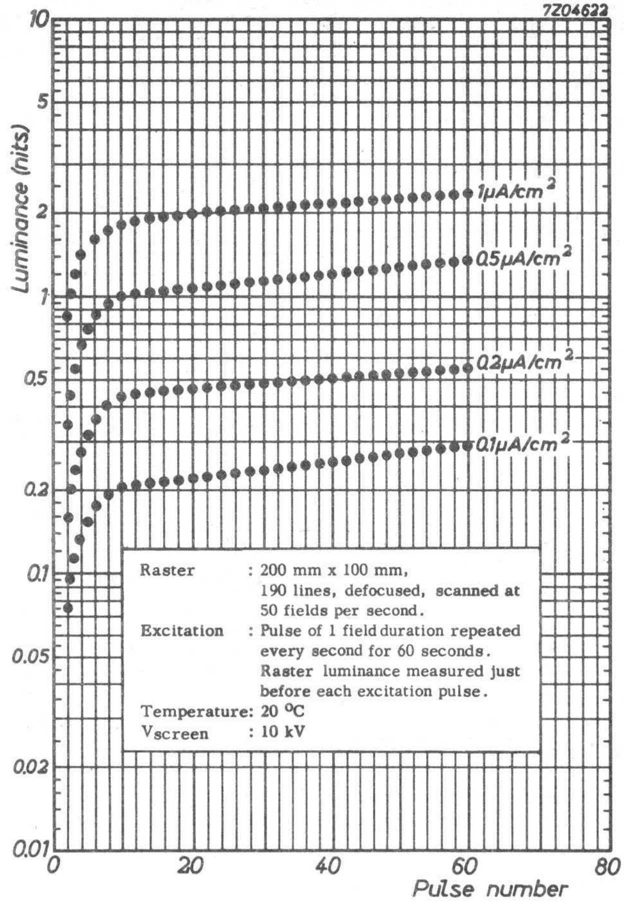

7Z04619
Vscreen : 15 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

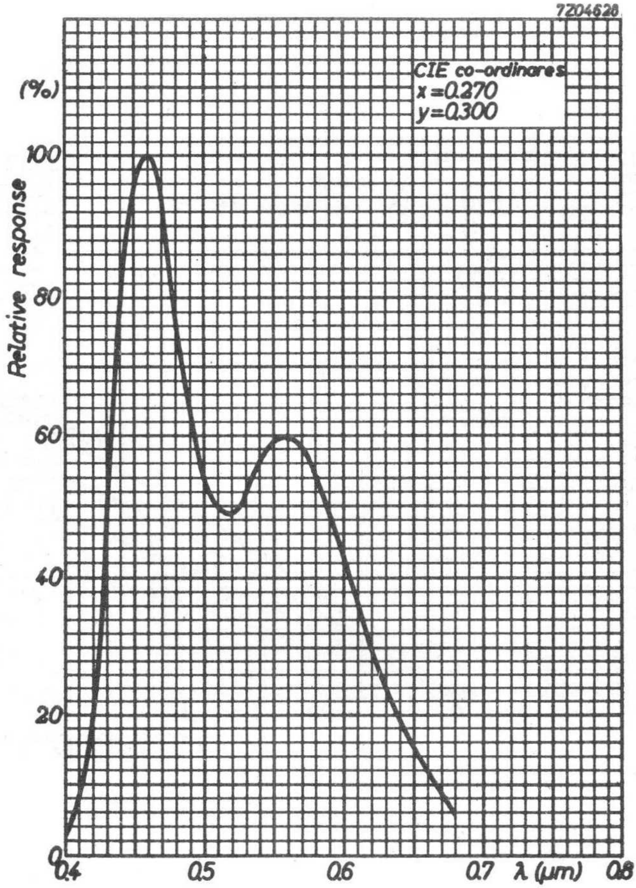

7Z04618
Vscreen : 10 kV
Temperature: 20 °C
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Single pulse of 1 field duration.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
1
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
1
2
5
10
20
50
100
Time after cessation of excitation (sec)

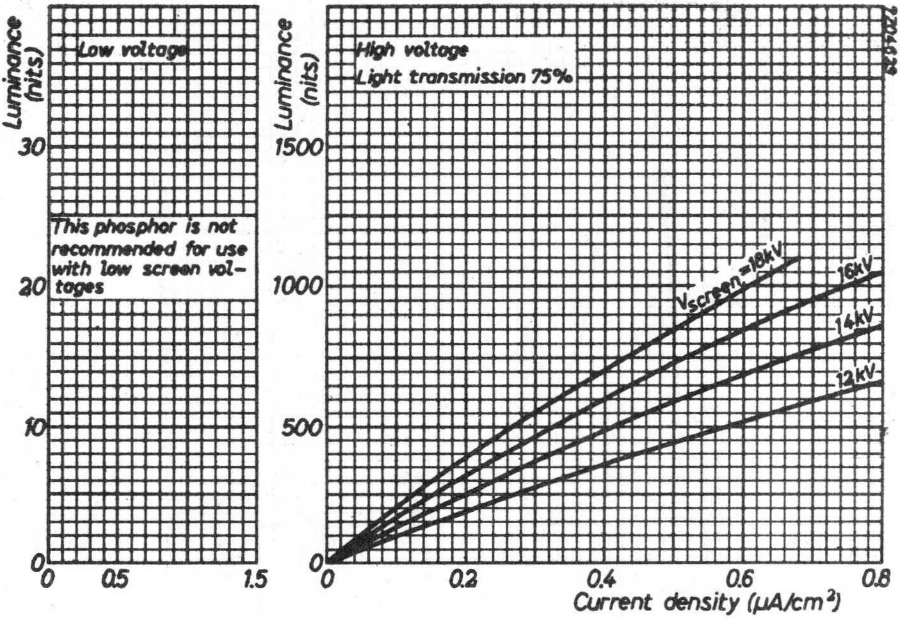

7Z04620
Vscreen : 10 kV
Temperature: 20 ºC
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
Time after cessation of excitation (sec)
1
2
5
10
20
50
100

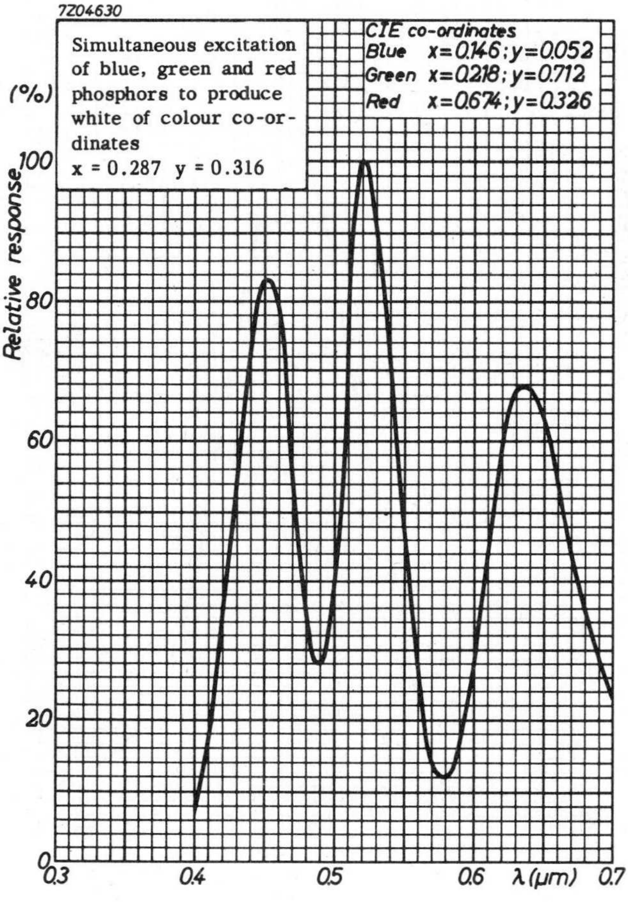

7Z04621
Vscreen : 15 kV
Temperature: 20 ºC
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds.
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
Time after cessation of excitation (sec)
1
2
5
10
20
50
100

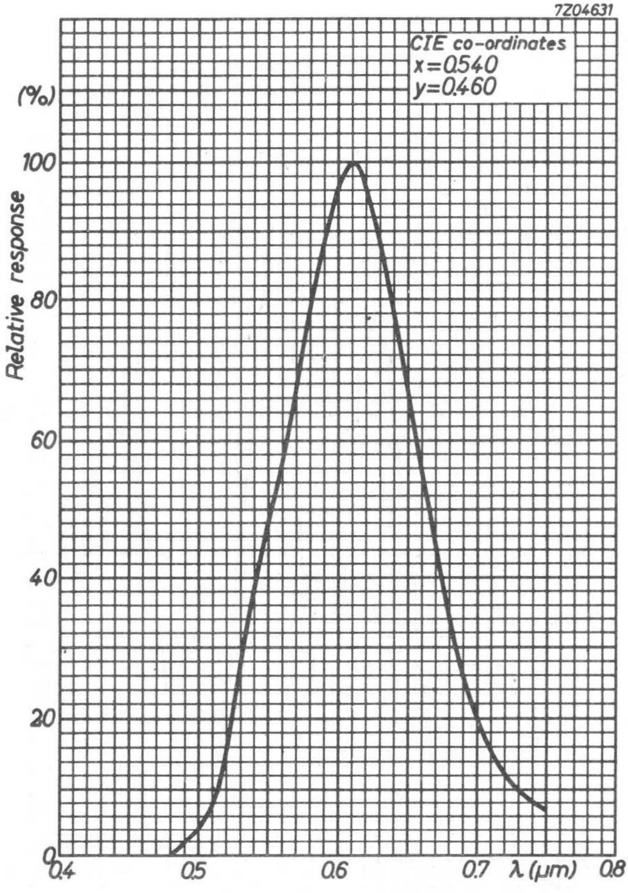

7Z04623
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminance measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 15 kV

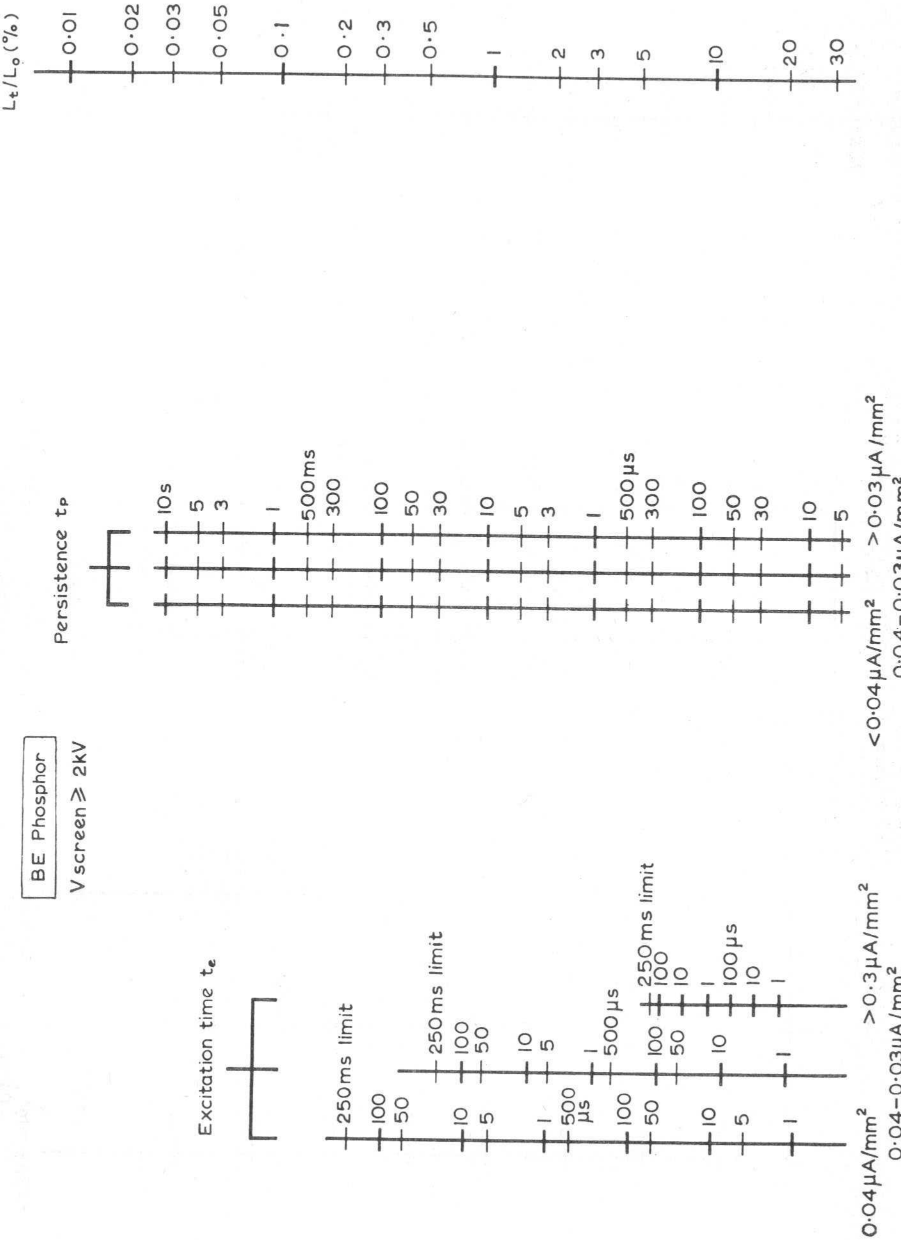

7Z04622
Luminance (nits)
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
0
20
40
60
80
Pulse number
1μA/cm²
0.5μA/cm²
0.2μA/cm²
0.1μA/cm²
Raster : 200 mm x 100 mm, 190 lines, defocused, scanned at 50 fields per second.
Excitation : Pulse of 1 field duration repeated every second for 60 seconds. Raster luminance measured just before each excitation pulse.
Temperature: 20 °C
Vscreen : 10 kV

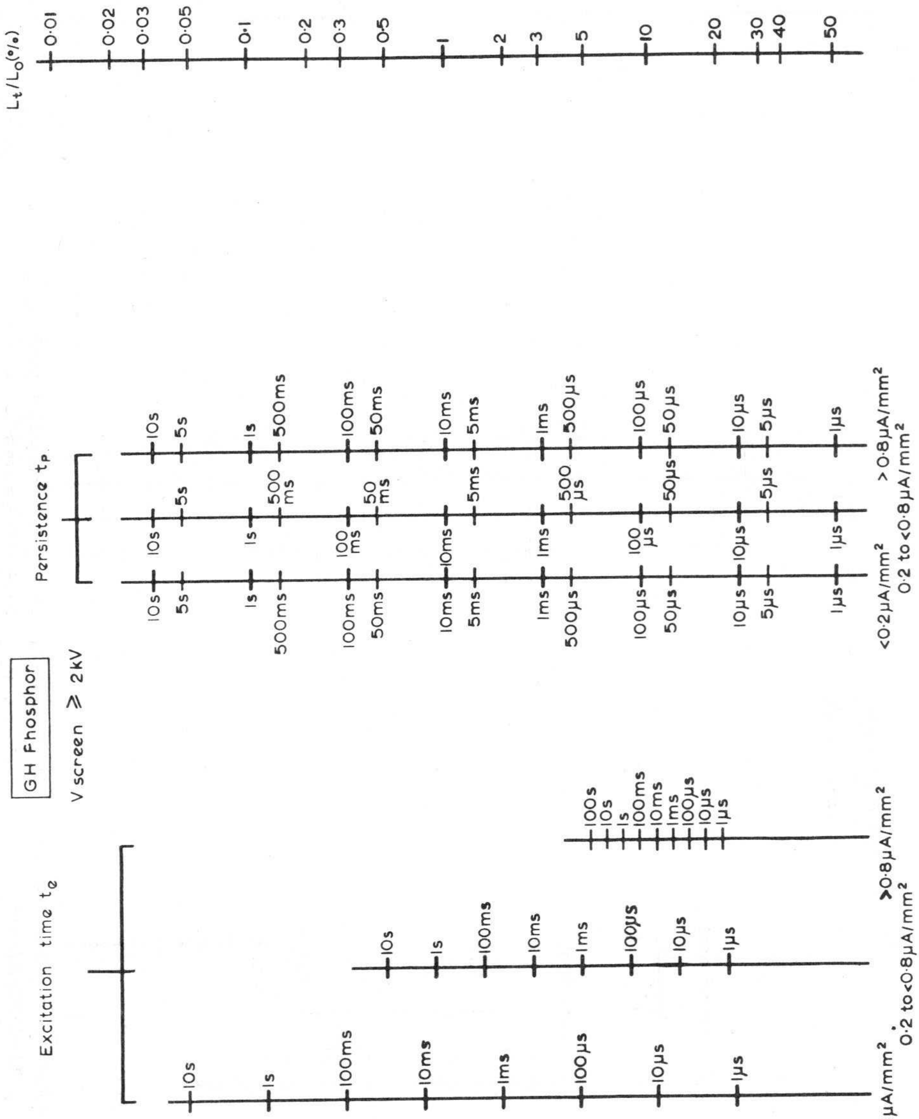

7204628
CIE co-ordinares
x =0.270
y=0.300
(%)
Relative response
100
80
60
40
20
0
0.4
0.5
0.6
0.7
λ (μm)
0.8


Luminance (nits)
Low voltage
This phosphor is not recommended for use with low screen voltages
30
20
10
0
0
0.5
1.5
Luminance (nits)
High voltage
Light transmission 75%
1500
1000
500
0
0
0.2
0.4
0.6
0.8
Current density (μA/cm²)
Vscreen =18kV
16kV
14kV
12kV
7Z04624


7Z04630
Simultaneous excitation of blue, green and red phosphors to produce white of colour co-ordinates
x = 0.287 y = 0.316
CIE co-ordinates
Blue x=0.146; y=0.052
Green x=0.218; y=0.712
Red x=0.674; y=0.326
Relative response (%)
100
80
60
40
20
0
0.3
0.4
0.5
0.6
λ (μm)
0.7


7Z04631
CIE co-ordinates
x=0.540
y=0.460
(%)
Relative response
100
80
60
40
20
0
0.4
0.5
0.6
0.7
λ (μm)
0.8


Lt/Lo (%)
0·01 0·02 0·03 0·05 0·1 0·2 0·3 0·5 1 2 3 5 10 20 30
BE Phosphor
V screen ≥ 2kV
Persistence tP
10s 5 3 1 500ms 300 100 50 30 10 5 3 1 500μs 300 100 50 30 10 5
<0·04μA/mm²
0·04–0·03μA/mm²
>0·03μA/mm²
Excitation time te
250ms limit 100 50 10 5 1 500 μs 100 50 10 5 1
250ms limit 100 50 10 5 1 500μs 100 50 10 1
250ms limit 100 10 1 100μs 10 1
0·04μA/mm²
0·04–0·03μA/mm²
>0·3μA/mm²


GH Phosphor
V screen ≥ 2kV
Excitation time t_e
<0·2μA/mm²
0·2 to <0·8μA/mm²
>0·8μA/mm²
10s
1s
100ms
10ms
1ms
100μs
10μs
1μs
100s
Persistence t_p
5s
500ms
50ms
5ms
500μs
50μs
5μs
L_t/L_o(%)
0·01
0·02
0·03
0·05
0·1
0·2
0·3
0·5
1
2
3
5
10
20
30
40
50

INSTRUMENT CATHODE-RAY TUBE

7 cm diameter flat faced monoaccelerator oscilloscope tube primarily intended for use in inexpensive oscilloscopes and monitoring devices.

QUICK REFERENCE DATA			
Accelerator voltage	$V_{g2,g4,g5,\ell}$	1000	V
Display area		60 x 50	mm^2
Deflection factor, horizontal	M_x	29	V/cm
vertical	M_y	12	V/cm

SCREEN

	colour	persistence
D7-190GH	green	medium short

Useful screen diameter	min.	64	mm
Useful scan			
horizontal	min.	60	mm
vertical	min.	50	mm

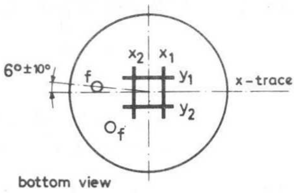
The useful scan may be shifted vertically to a maximum of 4mm with respect to the geometric centre of the faceplate.

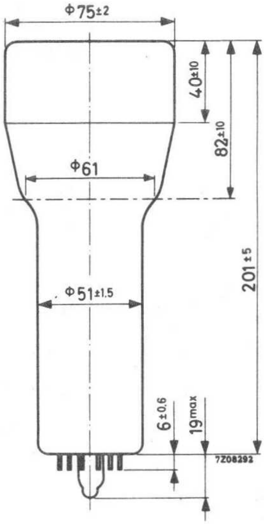
HEATING: Indirect by A.C. or D.C.; parallel supply

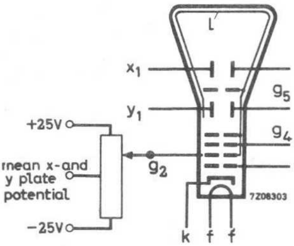
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

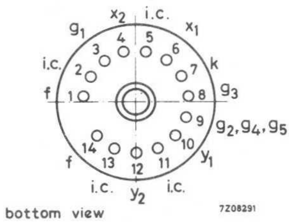
Data based on pre-production tubes

MECHANICAL DATA (Dimensions in mm)









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length	max.	225	mm
Face diameter	max.	77	mm

Base 14 pin all glass

Net weight	approx.	260	g

Accessories

Socket (supplied with tube)	type	55566
Mu-metal shield	type	55534

CAPACITANCES

x_1 to all other elements except x_2	$C_{x1(x2)}$	4	pF
x_2 to all other elements except x_1	$C_{x2(x1)}$	4	pF
y_1 to all other elements except y_2	$C_{y1(y2)}$	3.5	pF
y_2 to all other elements except y_1	$C_{y2(y1)}$	3.5	pF
x_1 to x_2	C_{x1x2}	2.5	pF
y_1 to y_2	C_{y1y2}	1.5	pF
Control grid to all other elements	C_{g1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION 3) double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam, hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90 \pm 1^{\circ}$

LINE WIDTH 3)

Measured with the shrinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current $I_{\ell} = 10\ \mu A$. 1)

Line width l.w. 0.30 mm

---

1) As the construction of this tube does not permit a direct measurement of the beam current, this current should be determined as follows:
a) under typical operating conditions, apply a small raster display (no overscan), adjust V_{g1} for a beam current of approx. $10\ \mu A$ and adjust V_{g3} and $V_{g2,g4,g5,\ell}$ for optimum spot quality at the centre of the screen.
b) under these conditions, but no raster, the deflection plate voltages should be changed to
$V_{y1} = V_{y2} = 1000$ V; $V_{x1} = 300$ V; $V_{x2} = 700$ V, thus directing the total beam current to x2.
Measure the current on x_2 and adjust V_{g1} for $I_{x2} = 10\ \mu A$ (being the beam current I_{ℓ})
c) set again for the conditions under a), without touching the V_{g1} control. Now a raster display with a true $10\ \mu A$ screen current is achieved.
d) focus optimally in the centre of the screen (do not adjust the astigmatism control) and measure the line width.

3) See page 4

TYPICAL OPERATING CONDITIONS [3]

Accelerator voltage	$V_{g2,g4,g5,\ell}$	1000	V	
Astigmatism control voltage	$\Delta V_{g2,g4,g5,\ell}$	$\pm$ 25	V	1)
Focusing electrode voltage	V_{g3} approx.	150	V	
Control grid voltage for visual extinction of focused spot	V_{g1} approx.max.	-30	V	
Deflection factor, horizontal	M_x	29	V/cm	
vertical	M_y	12	V/cm	
Deviation of linearity of deflection	max.	2	%	2)
Useful scan, horizontal	min.	60	mm	
vertical	min.	50	mm	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g2,g4,g5,\ell}$	max.	2200	V
		min.	900	V
Focusing electrode voltage	V_{g3}	max.	2200	V
Control grid voltage, negative	$-V_{g1}$	max.	200	V
		min.	0	V
Cathode to heater voltage	V_{kf}	max.	125	V
	$-V_{kf}$	max.	125	V
Grid drive, average		max.	20	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2

---

1) The astigmatism control electrode voltage should once be adjusted for optimum spot shape in the centre of the screen. For any necessary adjustment the control voltage will be within the stated range, if the mean x and certainly the mean y plate potential are equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

2) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

3) The mean x and certainly the mean y plate potential should be equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with 10 cm diameter flat face-plate and post deflection acceleration by means of a helical electrode. The low heater consumption together with the high sensitivity and short overall length render this tube suitable for transistorised equipment.

QUICK REFERENCE DATA					
Final accelerator voltage		$V_{g6(\ell)}$	=	4	kV
Display area	horizontal			full scan	
	vertical		=	6	cm
Deflection factor,	horizontal	M_x	=	27.5	V/cm
	vertical	M_y	=	9.8	V/cm

SCREEN

	Colour	Persistence
D10-11BE	blue	medium short
D10-11GH	green	medium short
D10-11GM	yellowish green	long
D10-11GP	bluish green	medium short

Useful screen diameter		min.	85	mm
Useful scan at $V_{g6(\ell)}/V_{g4} = 4$				
	horizontal	full scan		
	vertical	min.	60	mm

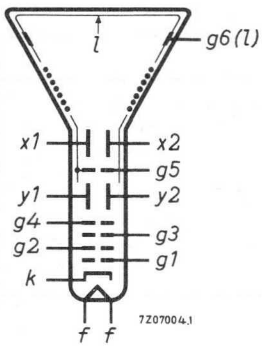
The useful scan may be shifted vertically to a max. of 4 mm with respect to the geometric centre of the faceplate.

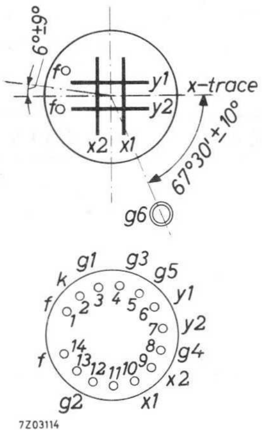
HEATING

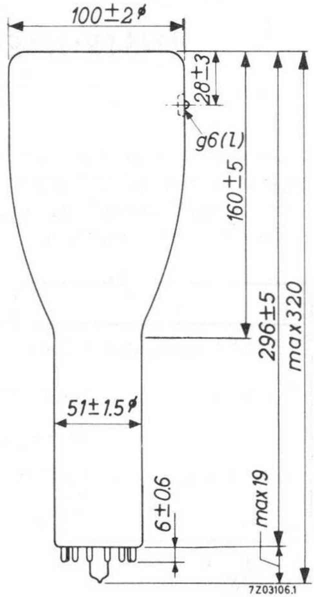
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	95	mA

→ **MECHANICAL DATA** Dimensions in mm







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base 14 pin all glass

Dimensions and connections

Overall length (also inclusive socket type 55566)	max.	320	mm
Face diameter	max.	102	mm

Net weight	approx.	480	g

Accessories

Socket (supplied with the tube)	type	55566
Final accelerator contact connector	type	55560
Mu-metal shield	type	55541

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	= 3.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	= 3.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	= 2.5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	= 3.0	pF
x_1 to x_2	$C_{x_1x_2}$	= 2.0	pF
y_1 to y_2	$C_{y_1y_2}$	= 1.7	pF
Control grid to all other elements	C_{g_1}	= 4.5	pF
Cathode to all other elements	C_k	= 3.0	pF

FOCUSING
electrostatic

DEFLECTION
double electrostatic

x plates	symmetrical
y plates	symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^\circ \pm 1^\circ$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen

Final accelerator voltage	$V_{g_6(\ell)}$	= 4000	V
Astigmatism control electrode voltage	V_{g_4}	= 1000	V [2)]
First accelerator voltage	V_{g_2}	= 1000	V
Beam current	$I_{(\ell)}$	= 10	μA
Line width	l.w.	= 0.35	mm

HELIX

Post deflection accelerator helix resistance = min. 50 MΩ

2) See page 5

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g6(\ell)}$	=	4000	V
Geometry control electrode voltage	V_{g5}	=	1000 ± 100	V [1]
Astigmatism control electrode voltage	V_{g4}	=	1000 ± 50	V [2]
Focusing electrode voltage	V_{g3}	=	50 to 200	V
First accelerator voltage	V_{g2}	=	1000	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	25 to 67	V
Deflection factor				
horizontal	M_x	=	24 to 31	V/cm
vertical	M_y	=	8.6 to 11	V/cm
Deviation of linearity of deflection		=	max. 2	% [3]
Geometry distortion			See note 4	
Useful scan				
horizontal			full scan	
vertical		=	min. 60	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	=	50 to 200	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	25 to 67	V per kV of V_{g2}
Deflection factor at $V_{g6(\ell)}/V_{g4} = 4$				
horizontal	M_x	=	24 to 31	V/cm per kV of V_{g4}
vertical	M_y	=	8.6 to 11	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	=	max. 1.5	MΩ
Focusing electrode current	I_{g3}	=	−30 to +30	μA [5]

[1][2][3][4][5] See page 5

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g6(\ell)}$	= max.	5000	V
		= min.	1500	V
Geometry control electrode voltage	V_{g5}	= max.	2200	V
Astigmatism control electrode voltage	V_{g4}	= max.	2200	V
		= min.	900	V
Focusing electrode voltage	V_{g3}	= max.	1500	V
First accelerator voltage	V_{g2}	= max.	2200	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	100	V
cathode negative	$V_{-k/f+}$	= max.	15	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	= max.	500	V
	$V_{g4/y}$	= max.	500	V
Cathode current, average	I_k	= max.	300	μA
Screen dissipation	W_{ℓ}	= max.	3	mW/cm^2
Ratio $V_{g6(\ell)}/V_{g4}$	$V_{g6(\ell)}/V_{g4}$	= max.	4	
Ratio V_{g2}/V_{g4}	V_{g2}/V_{g4}	= max.	1	
		= min.	1	

[1]) This tube is designed for optimum performance when operating at the ratio $V_{g6(\ell)}/V_{g4} = 4$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

[2]) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

[3]) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

[4]) A graticule, consisting of concentric rectangles of 50 mm x 60 mm and 48.4 mm x 58.4 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[4]) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with 10 cm diameter flat faceplate and post deflection acceleration by means of a helical electrode. The tube is intended for small compact oscilloscopes.

QUICK REFERENCE DATA					
Final accelerator voltage		$V_{g6(\ell)}$	=	4000	V
Display area	horizontal		=	full scan	
	vertical		=	6	cm
Deflection factor,	horizontal	M_x	=	27.5	V/cm
	vertical	M_y	=	9.8	V/cm

SCREEN

	Colour	Persistence
D10-12BE	blue	medium short
D10-12GH	green	medium short
D10-12GP	bluish green	medium short
D10-12GM	yellowish green	long

Useful screen diameter	min. 85 mm
Useful scan at $V_{g6(\ell)}/V_{g4} = 4$	
horizontal	full scan
vertical	min. 60 mm

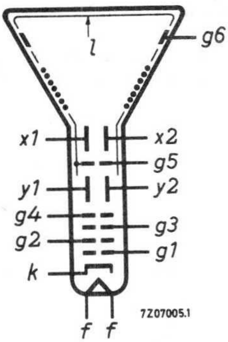
The useful scan may be shifted vertically to a max. of 4 mm with respect to the geometric centre of the faceplate.

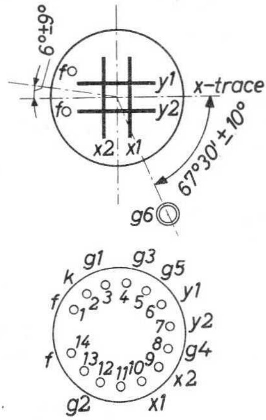
HEATING

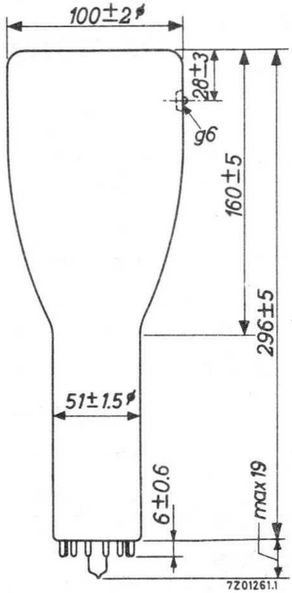
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3 V
Heater current	I_f	=	300 mA

→ **MECHANICAL DATA** (Dimensions in mm)







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base 14 pin all glass

Dimensions and connections

Overall length (inclusive socket 55566)	max.	320	mm
Face diameter	max.	102	mm

Net weight approx. 480 g

Accessories

Socket (supplied with the tube)	type	55566
Final accelerator contact connector	type	55560
Mu-metal shield	type	55541

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4.0	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4.0	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.0	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.0	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.0	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.7	pF
Control grid to all other elements	C_{g_1}	=	5.0	pF
Cathode to all other elements	C_k	=	3.0	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^\circ \pm 1^\circ$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen

Final accelerator voltage	$V_{g_6(\ell)}$	=	4000	V
Astigmatism control electrode voltage	V_{g_4}	=	1000	V [2]
First accelerator voltage	V_{g_2}	=	1000	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.35	mm

HELIX

Post deflection accelerator helix resistance min. 50 MΩ

[2]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_6(\ell)}$	= 4000	V
Geometry control electrode voltage	V_{g_5}	= 1000 ± 100	V [1]
Astigmatism control electrode voltage	V_{g_4}	= 1000 ± 50	V [2]
Focusing electrode voltage	V_{g_3}	= 50 to 200	V
First accelerator voltage	V_{g_2}	= 1000	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 25 to 67	V
Deflection factor			
horizontal	M_x	= 24 to 31	V/cm
vertical	M_y	= 8.6 to 11	V/cm
Deviation of linearity of deflection		= max. 2	% [3]
Geometry distortion		See note 4	
Useful scan			
horizontal		= full scan	
vertical		= min. 60	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g_3}	= 50 to 200	V per kV of V_{g_4}
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 25 to 67	V per kV of V_{g_2}
Deflection factor at $V_{g_6(\ell)}/V_{g_4} = 4$			
horizontal	M_x	= 24 to 31	V/cm per kV of V_{g_4}
vertical	M_y	= 8.6 to 11	V/cm per kV of V_{g_4}
Control grid circuit resistance	R_{g_1}	= max. 1.5	MΩ
Focusing electrode current	I_{g_3}	= -30 to +30	μA [5]

[1][2][3][4][5]) See page 6

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_6(\ell)}$	= max.	5000	V
		= min.	1500	V
Geometry control electrode voltage	V_{g_5}	= max.	2200	V
Astigmatism control electrode voltage	V_{g_4}	= max.	2200	V
		= min.	900	V
Focusing electrode voltage	V_{g_3}	= max.	1500	V
First accelerator voltage	V_{g_2}	= max.	2200	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g_4/x}$	= max.	500	V
	$V_{g_4/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Ratio $V_{g_6(\ell)}/V_{g_4}$	$V_{g_6(\ell)}/V_{g_4}$	= max.	4	
Ratio V_{g_2}/V_{g_4}	V_{g_2}/V_{g_4}	= max.	1	
		= min.	1	

1) This tube is designed for optimum performance when operating at the ratio $V_{g6}(\ell)/V_{g4} = 4$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

3) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

4) A graticule, consisting of concentric rectangles of 50 mm x 60 mm and 48.4 mm x 58.4 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

5) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

10 cm diameter flat faced monoaccelerator oscilloscope tube primarily intended for use in inexpensive oscilloscopes and read-out devices.

QUICK REFERENCE DATA			
Accelerator voltage	$V_{g_2,g_4,g_5(\ell)}$	1500	V
Display area		80 x 60	mm^2
Deflection factor, horizontal	M_x	33	V/cm
vertical	M_y	14.5	V/cm

SCREEN

	colour	persistence
D10-160GH	green	medium short

Useful screen diameter	min.	85	mm
Useful scan			
horizontal	min.	80	mm
vertical	min.	60	mm

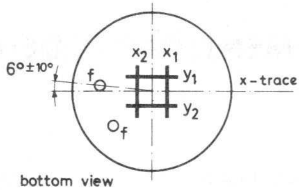
The useful scan may be shifted vertically to a max. of 5 mm with respect to the geometric centre of the faceplate.

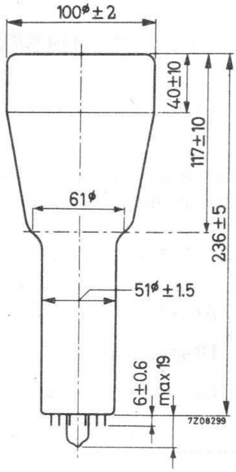
HEATING: Indirect by A.C. or D.C.; parallel supply

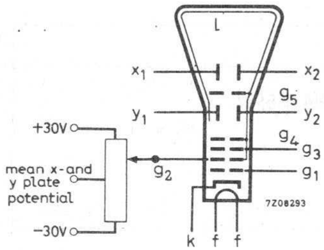
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

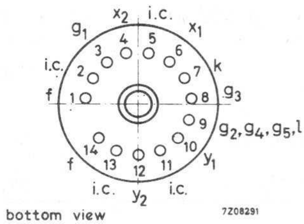
Data based on pre-production tubes

MECHANICAL DATA (Dimensions in mm)









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length	max.	260	mm
Face diameter	max.	102	mm

Base 14 pin all glass

Net weight	approx.	400	g

Accessories

Socket (supplied with tube)	type	55566
Mu metal shield	type	55547

CAPACITANCES

x_1 to all other elements except x_2	$C_{x1(x2)}$	4	pF
x_2 to all other elements except x_1	$C_{x2(x1)}$	4	pF
y_1 to all other elements except y_2	$C_{y1(y2)}$	3.5	pF
y_2 to all other elements except y_1	$C_{y2(y1)}$	3.5	pF
x_1 to x_2	C_{x1x2}	2.5	pF
y_1 to y_2	C_{y1y2}	1.5	pF
Control grid to all other elements	C_{g1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION 3) double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam, hence a low impedance deflection plate drive is desirable.

Angle between x and y traces 90 ± 1^o

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current $I_\ell = 10\ \mu A$. 1)

Line width l.w. 0.30 mm

1) As the construction of this tube does not permit a direct measurement of the beam current, this current should be determined as follows:
a) under typical operating conditions, apply a small raster display (no overscan), adjust V_{g1} for a beam current of approx. 10 μA and adjust V_{g3} and $V_{g2,g4,g5,\ell}$ for optimum spot quality at the centre of the screen.
b) under these conditions, but no raster, the deflection plate voltages should be changed to
$V_{y1} = V_{y2} = 1500$ V; $V_{x1} = 800$ V; $V_{x2} = 1200$ V, thus directing the total beam current to x2.
Measure the current on x_2 and adjust V_{g1} for $I_{x2} = 10\ \mu A$ (being the beam current I_ℓ)
c) set again for the conditions under a), without touching the V_{g1} control. Now a raster display with a true 10 μA screen current is achieved.
d) focus optimally in the centre of the screen (do not adjust the astigmatism control) and measure the line width.

3) See page 4

TYPICAL OPERATING CONDITIONS [3)]

Accelerator voltage	$V_{g2,g4,g5,\ell}$	1500 V	
Astigmatism control voltage	$\Delta V_{g2,g4,g5,\ell}$	± 30 V	1)
Focusing electrode voltage	V_{g3} approx.	225 V	
Control grid voltage for visual extinction of focused spot	V_{g1} approx.max.	- 50 V	
Deflection factor, horizontal	M_x	33 V/cm	
vertical	M_y	14.5 V/cm	
Deviation of linearity of deflection	max.	2 %	2)
Useful scan, horizontal	min.	80 mm	
vertical	min.	60 mm	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g2,g4,g5,\ell}$	max.	2200 V
		min.	1350 V
Focusing electrode voltage	V_{g3}	max.	2200 V
Control grid voltage, negative	$-V_{g1}$	max.	200 V
		min.	0 V
Cathode to heater voltage	V_{kf}	max.	125 V
	$-V_{kf}$	max.	125 V
Grid drive, average		max.	20 V
Screen dissipation	W_ℓ	max.	3 mW/cm^2

---

1) The astigmatism control electrode voltage should once be adjusted for optimum spot shape in the centre of the screen. For any necessary adjustment the control voltage will be within the stated range, if the mean x and certainly the mean y plate potentials are equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

2) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25 % of the useful scan by more than the indicated value.

3) The mean x and certainly the mean y plate potentials should be equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

INSTRUMENT CATHODE-RAY TUBE

10 cm diameter flat faced oscilloscope tube with mesh.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g_7(\ell)}$	6	kV
Display area		80 x 60	mm^2
Deflection factor, horizontal	M_x	13	V/cm
vertical	M_y	3.5	V/cm

SCREEN

	colour	persistence
D10-170GH	green	medium short

Useful screen diameter min. 85 mm

Useful scan at $V_{g_7(\ell)}/V_{g_2,g_4} = 6$

horizontal	min.	80	mm
vertical	min.	60	mm

The useful scan may be shifted vertically to a max. of 5 mm with respect to the geometric centre of the faceplate.

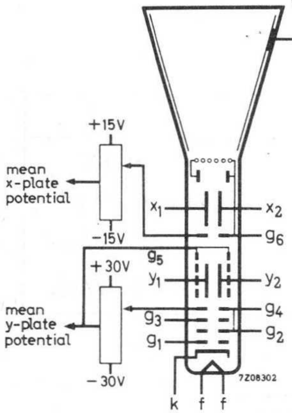
HEATING: Indirect by A.C. or D.C.; parallel supply

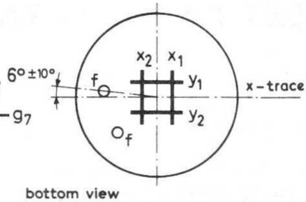
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

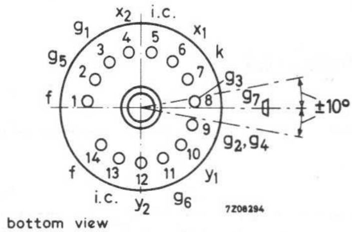
Data based on pre-production tubes.

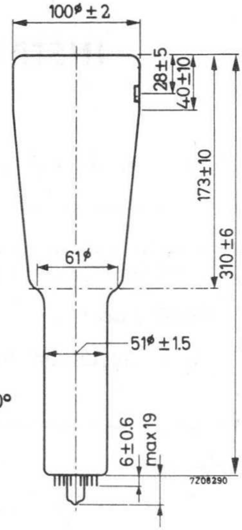
MECHANICAL DATA

Dimensions in mm









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length (socket included)	max.	335	mm
Face diameter	max.	102	mm
Net weight	approx.	500	g

Base 14 pin all glass

Accessories

Socket (supplied with tube)	type	55566
Final accelerator contact connector	type	55563
Mu-metal shield	type	55548

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	7	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	7	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	5	pF
x_1 to x_2	$C_{x_1x_2}$	2.5	pF
y_1 to y_2	$C_{y_1y_2}$	1.5	pF
Control grid to all other elements	C_{g_1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces 90 ± 1^o

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current $I_\ell = 10\ \mu A$.

Line width l.w. ~~0.45~~ 0.52 mm

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g7}(\ell)$		6000	V	
Interplate shield voltage	V_{g6}		1000	V	
Geometric control voltage	ΔV_{g6}		± 15	V	1)
Deflection plate shield voltage	V_{g5}		1000	V	2)
Focusing electrode voltage	V_{g3}	~~approx.~~	170 - 230 ~~200~~	V	
First accelerator voltage	$V_{g2,g4}$		1000	V	
Astigmatism control voltage	$\Delta V_{g2,g4}$		± 30	V	3)
Control grid voltage for visual extinction of focused spot	V_{g1}	~~approx.~~	16 — 40 ~~[illegible]~~	V	
Deflection factor, horizontal	M_x	12 - 14 V/cm approx.	13	V/cm	max 14
vertical	M_y	mean ~~approx.~~	3.5	V/cm	max 3.0
		3.2 - 3.0 V/cm.			
Useful scan, horizontal		min.	80	mm	
vertical		min.	60	mm	

LIMITING VALUES (Absolute maximum rating system)

Final accelerator voltage	$V_{g7}(\ell)$	max.	6600	V
		min.	4000	V
Interplate shield voltage and geometry control electrode voltage	V_{g6}	max.	2200	V
Deflection plate shield voltage	V_{g5}	max.	2200	V
Focusing electrode voltage	V_{g3}	max.	2200	V
First accelerator and astigmatism control electrode voltage	$V_{g2,g4}$	max.	2200	V
		min.	900	V
Control grid voltage, negative	$-V_{g1}$	max.	200	V
		min.	0	V
Cathode to heater voltage	V_{kf}	max.	125	V
	$-V_{kf}$	max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	max.	500	V
	$V_{g4/y}$	max.	500	V
Grid drive, average		max.	20	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2
Ratio $V_{g7}(\ell)/V_{g2,g4}$	$V_{g7}(\ell)/V_{g2,g4}$	max.	6	

For notes see page 5

Notes

1) This tube is designed for optimum focus when operating at a ratio $V_{g7}/V_{g2,g4}$ not higher than 6.
The geometry electrode voltage should be adjusted within the indicated range (values with respect to the mean x-plate potential). A negative control voltage will cause some pincushion distortion and less background light, a positive control voltage will give some barrel distortion and a slight increase of background light.

2) The deflection plate shield voltage should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

3) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

Rasterveld. 60 x 60 - 58.6 x 58.6. mm

ei. ; 60 x 60 - 59 x 59 mm?.

punt 16 - 40 V.
cirkel 14 - 30 V.
II 15 37
F 16 36.

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter flat faced oscilloscope tube with thin metal backing and post deflection acceleration by means of a helical electrode.

QUICK REFERENCE DATA					
Final accelerator voltage		$V_{g7(\ell)}$	=	4000	V
Display area			=	6x10	cm
Deflection factor,	horizontal	M_x	=	22.9	V/cm
	vertical	M_y	=	5.9	V/cm

SCREEN

	Colour	Persistence
D13-15BE	blue	medium short
D13-15GH	green	medium short
D13-15GM	bluish green	medium short
D13-15GP	yellowish green	long

Useful screen diameter	min.	114	mm
Useful scan at $V_{g7(\ell)}/V_{g4} = 2$			
horizontal	min.	100	mm
vertical	min.	60	mm

The useful scan may be shifted vertically to a max. of 4 mm with respect to the geometric centre of the faceplate.

HEATING

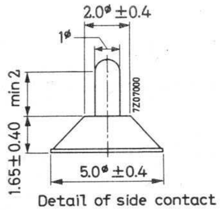
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

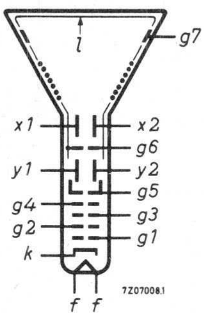
MECHANICAL DATA (Dimensions in mm)

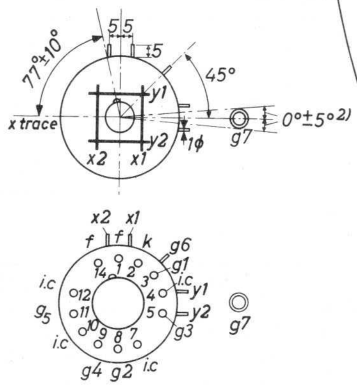
1) Straight part of the bulb.

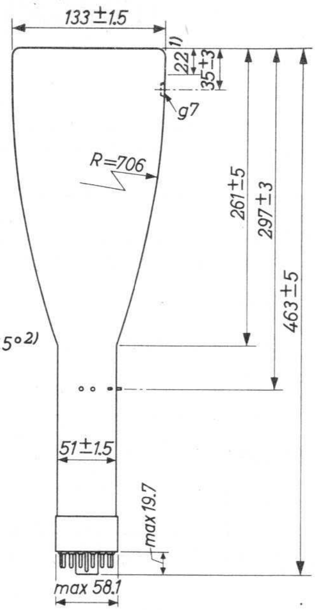
2) Location of the recessed cavity button contact with respect to the x-trace.



Detail of side contact







Mounting position : any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Diheptal medium shell

Dimensions and connections

Overall length	max.	486	mm
Face diameter	max.	134.5	mm
Net weight	approx.	910	g

Accessories

→ Socket	type	2422 517 00001
Final accelerator contact connector	type	55560
Side contact connector	type	55561
Mu-metal shield	type	55551

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	2.8	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	2.8	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	2.8	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.9	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.5	pF
Control grid to all other elements	C_{g_1}	=	5.5	pF
Cathode to all other elements	C_k	=	3.5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^o \pm 1^o$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen

Final accelerator voltage	$V_{g7(\ell)}$	=	4000	V
Astigmatism control electrode voltage	V_{g4}	=	2000	V[3]
First accelerator voltage	V_{g_2}	=	2000	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.5	mm

HELIX

Post deflection accelerator helix resistance min. 300 MΩ

[3]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g7(\ell)}$	=	4000	V
Geometry control electrode voltage	V_{g6}	=	2000 ± 200	V [1]
Deflection plate shield voltage	V_{g5}	=	2000	V [2]
Astigmatism control electrode voltage	V_{g4}	=	2000 ± 100	V [3]
Focusing electrode voltage	V_{g3}	=	220 to 710	V
First accelerator voltage	V_{g2}	=	2000	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	60 to 96	V
Deflection factor				
horizontal	M_x	=	19.8 to 26.5	V/cm
vertical	M_y	=	5.1 to 6.7	V/cm
Deviation of linearity of deflection		=	max. 2	% [4]
Geometry distortion			See note 5	
Useful scan				
horizontal		=	min. 100	mm
vertical		=	min. 60	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	=	110 to 355	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	30 to 48	V per kV of V_{g2}
Deflection factor at $V_{g7(\ell)}/V_{g4} = 2$				
horizontal	M_x	=	11.9 to 15.6	V/cm per kV of V_{g4}
vertical	M_y	=	3.3 to 4.0	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 5	MΩ
Focusing electrode current	I_{g3}	=	−15 to +10	μA [6]

---

[1][2][3][4][5][6] See page 6

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_7(\ell)}$	= max.	8800	V
		= min.	2500	V
Geometry control electrode voltage	V_{g_6}	= max.	2200	V
Deflection plate shield voltage	V_{g_5}	= max.	2200	V
Astigmatism control electrode voltage	V_{g_4}	= max.	2200	V
		= min.	1000	V
Focusing electrode voltage	V_{g_3}	= max.	1500	V
First accelerator voltage	V_{g_2}	= max.	2200	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
positive peak	$V_{g_{1p}}$	= max.	2	V
Cathode to heater voltage				
cathode positive	V+k/f-	= max.	200	V
cathode negative	V-k/f+	= max.	125	V
Voltage between astigmatism control electrode and any deflection plate	V_g /x	= max.	500	V
	V_g /y	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Ratio $V_{g_7(\ell)}/V_{g_4}$	$V_{g_7(\ell)}/V_{g_4}$	= max.	4	
Ratio V_{g_2}/V_{g_4}	V_{g_2}/V_{g_4}	= max.	1	

---

1) This tube is designed for optimum performance when operating at the ratio $V_{g7(\ell)}/V_{g2}$ = 2. Operation at higher ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

4) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

5) A graticule, consisting of concentric rectangles of 60 mm x 100 mm and 58.5 mm x 98 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these ractangles with optimum correction potentials applied.

6) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with flat 13 cm diameter face, post deflection acceleration by means of a helical electrode, metal backed screen, deflection blanking and sectioned y deflector plates. The tube is designed to display high frequencies combined with a high writing speed.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g_9(\ell)}$	=	10	kV
Display area		=	6x10	cm
Deflection factor, horizontal	M_x	max.	18	V/cm
vertical	M_y	=	6	V/cm

SCREEN

	Colour	Persistence
D13-16BE	blue	medium short
D13-16GH	green	medium short
D13-16GP	bluish green	medium short

Useful screen diameter	min.	114	mm
Useful scan at $V_{g_9(\ell)}/V_{g_5} = 6$			
horizontal	min.	100	mm
vertical	min.	60	mm

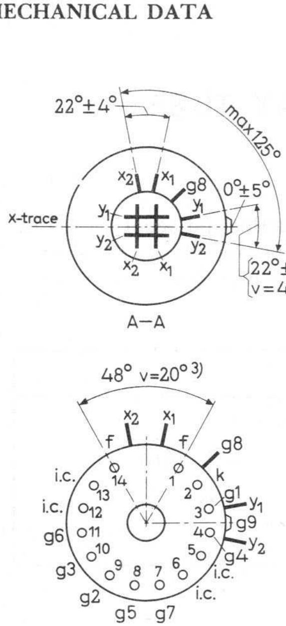
HEATING

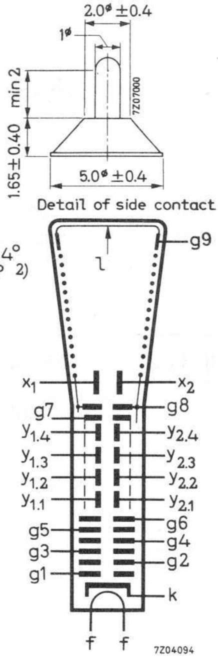
Indirect by A.C. or D.C.; parallel supply

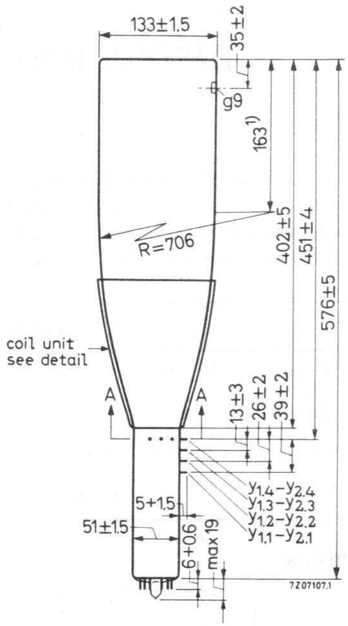
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm







Mounting position: any

The socket should under no circumstances be used to support the tube.

Base	14 pin all glass		
Dimensions and connections			
Overall length (inclusive socket 55566)	max.	600	mm
Face diameter	max.	134.5	mm
Net weight:	approx.	1300	g
Accessories			
Socket (supplied with tube)	type	55566	
Final accelerator contact connector	type	55563	
Side contact connector	type	55561	
Mu-metal shield	type	55554 [4]	

[1]) Straight part

[2]) The tolerance of the position of the neck pins with respect to the x-trace is $\pm 2^{o}$.

[3]) The tolerance of the position of the base pins with respect to the x-trace is $\pm 10^{o}$.

[4]) See page 6.

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	2.8	pF
$y_{1.1}$ to all other elements except $y_2, y_{1.2}, y_{1.3}, y_{1.4}$	$C_{y_{1.1}(y_2, y_{1.2}, y_{1.3}, y_{1.4})}$	=	1.6	pF
$y_{2.1}$ to all other elements except $y_1, y_{2.2}, y_{2.3}, y_{2.4}$	$C_{y_{2.1}(y_1, y_{2.2}, y_{2.3}, y_{2.4})}$	=	1.6	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.3	pF
$y_{1.1}$ to $y_{2.1}$	$C_{y_{1.1}, y_{2.1}}$	=	0.7	pF
Control grid to all other elements	C_{g_1}	=	5.0	pF
Cathode to all other elements	C_k	=	3.0	pF
g_3 to all other elements	C_{g_3}	=	9	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan, hence a low impedance deflection plate drive is desirable.

Angle between x and y traces 90° See "Correction Coils"

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen

Final accelerator voltage	$V_{g_9(\ell)}$	=	10 000	V
Astigmatism control electrode voltage	V_{g_5}	=	1670	V [5]
First accelerator voltage	V_{g_2}	=	1670	V
Beam current	$I_{g_9(\ell)}$	=	10	μA
Line width	l.w.	=	0.35	mm

HELIX

Post deflection acc. helix resistance min. 300 MΩ

The helix is connected between $g_9(\ell)$ and g_8

[5]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_9(\ell)}$	=	10 000	V
Geometry control electrode voltage	V_{g_8}	=	1670 ± 100	V [1]
Deflection plate shield voltage	V_{g_7}	=	1670	V [2]
Beam centring electrode voltage	V_{g_6}	=	1670 ± 20	V [3]
Astigmatism control electrode voltage	V_{g_5}	=	1670 ± 100	V [5]
Focusing electrode voltage	V_{g_4}	=	230 to 500	V
Deflection blanking electrode voltage	V_{g_3}	=	1670	V
Deflection blanking control voltage	ΔV_{g_3}	=	max. 60	V [6]
First accelerator voltage	V_{g_2}	=	1670	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	50 to 120	V
Deflection factor				
horizontal	M_x	=	max. 18	V/cm
vertical	M_y	=	5.6 to 6.6	V/cm
Deviation of linearity of deflection		=	max. 2	% [7]
Geometry distortion	See note 8			
Useful scan				
horizontal		=	100	mm
vertical		=	60	mm

[1] [2] [3] [5] [6] [7] [8] See page 6

LIMITING VALUES (Absolute limits)

Final accelerator voltage	$V_{g9(\ell)}$	= max.	16000	V
		= min.	9000	V
Geometry control electrode voltage	V_{g8}	= max.	2500	V
Deflection plate shield voltage	V_{g7}	= max.	2500	V
Beam centring electrode voltage	V_{g6}	= max.	2500	V
Astigmatism control electrode voltage	V_{g5}	= max.	2500	V
Focusing electrode voltage	V_{g4}	= max.	2500	V
Deflection blanking electrode voltage	V_{g3}	= max.	2500	V
First accelerator voltage	V_{g2}	= max.	2500	V
		= min.	1250	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Voltage between cathode and heater				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Ratio $V_{g9(\ell)}/V_{g5}$	$V_{g9(\ell)}/V_{g5}$	= max.	10	
Ratio V_{g2}/V_{g5}	V_{g2}/V_{g5}	= max.	1	
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Average cathode current	I_k	= max.	300	μA

CIRCUIT DESIGN VALUES

Focusing electrode voltage	V_{g4}	= 138 to 300	V per kV of V_{g2}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	= 24 to 72	V per kV of V_{g2}
Deflection factor at $V_{g9(\ell)}/V_{g5} = 6$			
horizontal	M_x	= max. 10.8	V/cm per kV of V_{g5}
vertical	M_y	= 3.4 to 4.0	V/cm per kV of V_{g5}
Focusing electrode current	I_{g4}	= −10 to +15	μA
Control grid circuit resistance	R_{g1}	= max. 1.5	MΩ

1) This tube is designed for optimum performance when operating at the ratio $V_{g_9}(\ell)/V_{g_5} = 6$.
Operation at other ratio may result in changes in deflection uniformity and geometry distortion.
The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x and y plates potential.

3) The beam centring electrode voltage should be adjusted for equal brightness in the x direction with respect to the electrical centre of the tube.

4) To avoid damaging the side contacts the narrower end of the mu-metal shield should have an internal diameter of not less than 70 mm.

5) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

6) For beam blanking of a beam current $I_{g_9}(\ell)$ of 10 μA.

7) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

8) A graticule, consisting of concentric rectangles of 100 mm x 60 mm and 98 mm x 58.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

CORRECTION COILS

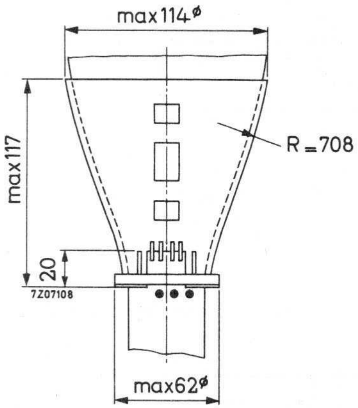
The D13-16.. is provided with a coil unit consisting of a pair of coils for:

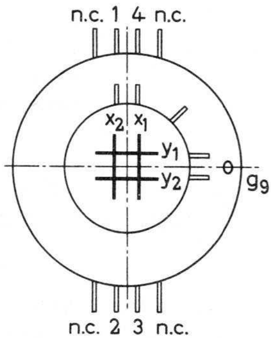
a. Correction of the orthogonality of the x and y traces (which means that at the centre of the screen the angle between the x and y traces can be made exactly 90°).

b. Vertical shift of the scanned area.

DETAIL DRAWING OF COIL UNIT

Dimensions in mm

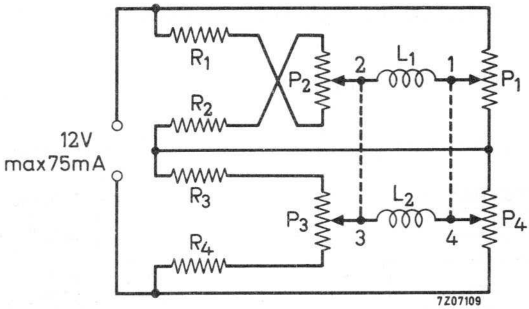




The currents required under typical operating conditions, the tube being screened by a mu-metal shield closely surrounding the coils (e.g. 55554), are max. 2.5 mA per degree of angle correction and max. 2 mA per mm of shift. If not such shield is used these values have to be multiplied by a factor k ($1 < k < 2$), the value of which depends on the diameter of the shield and approaches 2 for the case no shield is present.
The D.C. resistance is approx. 180 Ω per coil.
When designing the supply circuit for these coils it should be considered that the maximum current required in either coil can be 15 mA.

Circuit diagrams

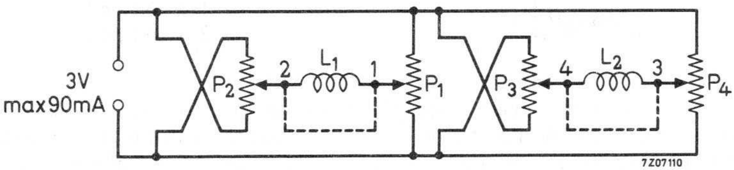
A suitable circuit permitting independent controls of orthogonality correction and vertical shift is given in fig. 1.



P_1, P_4 : Potentiometers 220 Ω, 1 Watt, ganged
P_2, P_3 : Potentiometers 100 Ω, 0,5 Watt, ganged
R_1, R_2, R_3, R_4 : Resistors 56 Ω, 0,5 Watt

Fig. 1

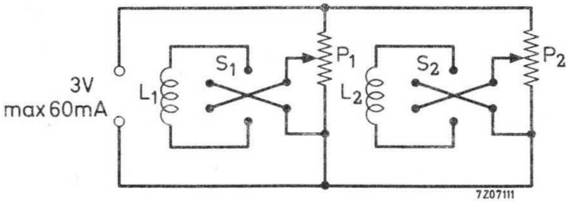
The dissipation in the potentiometers can be reduced considerably if the requirement of independent controls is dropped (see fig. 2).



P_1, P_2 : Potentiometers, 220 Ω, 0,5 Watt, ganged
P_3, P_4 : Potentiometers, 220 Ω, 0,5 Watt, ganged

Fig. 2

A further reduction of the dissipation can be obtained by inserting a commutator for each coil (see fig.3).
The procedure of adjustment will then become more complicated, but it should be kept in mind that a readjustment is necessary only when the tube has to be replaced.



P_1, P_2 : Potentiometers, 500 Ω, 0,5 Watt.
S_1, S_2 : Commutators

Fig.3

For the adjustment of the currents the following procedure is recommended:

a. With the tube fully scanned in the vertical direction the scanned area must be shifted so that the useful vertical scan on either side of the geometric centre of the screen meets the published value of 30 mm min.
With the circuit according to fig.1 this is done by means of the ganged potentiometers P_1 and P_4.

b. Adjustment of orthogonality by means of the ganged potentiometers P_2 and P_3 in fig.1. A slight readjustment of P_1 and P_4 may be necessary afterwards.

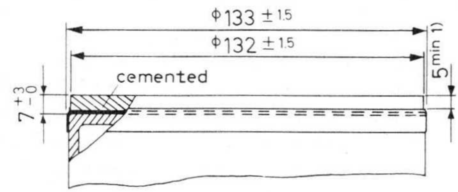
With a circuit according to fig.2 or 3 these corrections have to be performed by means of successive adjustments of the currents in the coils.
The most convenient deflection signal is a square waveform permitting an easy and fairly accurate check of orthogonality.

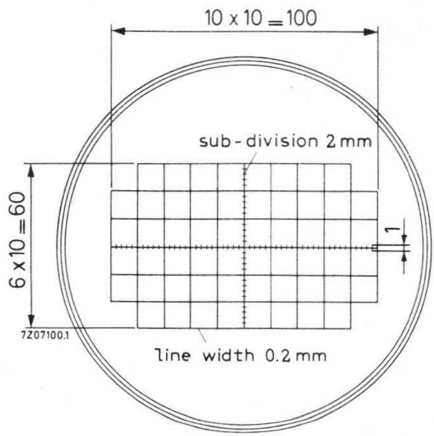
INSTRUMENT CATHODE-RAY TUBE

The D13-16../01 is equivalent to the D13-16.. but features an internal graticule. This graticule can be illuminated.

MECHANICAL DATA

Dimensions in mm





Maximum angle between x-trace and x-axis of the graticule $\pm 5^{\circ}$

1) Clear area for light conductor.

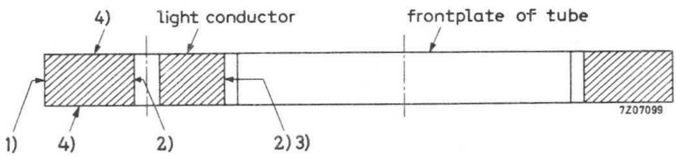
ALIGNMENT

In order to align the x-trace and the x-axis of the graticule an image rotating coil may be used. This coil should be positioned at one third of the cone length, seen from the face end, and can be attached to the inner surface of the mu-metal shield.
Under typical operating conditions maximum 50 ampere-turns are required for alignment.

ILLUMINATION

To illuminate the internal graticule the use of a light conductor (e.g. of Perspex) is obligatory. The following design considerations should be observed:

In order to achieve the most efficient light conductance the holes for the light bulb as well as the contact area with the front plate should be polished. The contact with the edges of the front plate should be as close as possible and the edges of the front plate and the corresponding hole in the light conductor should be parallel to achieve light beams perpendicular to the edges. It is advised to apply reflective material to the outer circumference of the conductor and if possible also to both planes (see drawing).



---

1) Reflective material.

2) Polished.

3) Close and constant distance to front plate of tube.
It is essential that the light conductor and the front plate of the tube are in plane.

4) If possible reflective material.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with flat face post deflection acceleration by means of a helical electrode, side contacts, metal backed screen, 6 cm scan for high frequency and high writing speed applications.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g_7(\ell)}$	=	10	kV
Display area		=	6 x 10	cm
Deflection factor, horizontal	M_x	=	30	V/cm
vertical	M_y	=	10.9	V/cm

SCREEN

	colour	persistence
D13-19BE	blue	medium short
D13-19GH	green	medium short
D13-19GM	bluish green	medium short
D13-19GP	yellowish green	long

Useful screen diameter	min.	114	mm
Useful scan at $V_{g_7(\ell)}/V_{g_4} = 6$			
horizontal	min.	100	mm
vertical	min.	60	mm

The useful scan may be shifted vertically to a max. of 3 mm with respect to the geometric centre of the faceplate.

HEATING

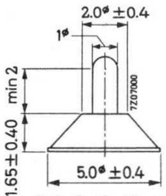
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

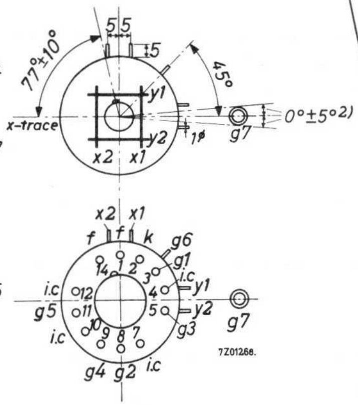
MECHANICAL DATA

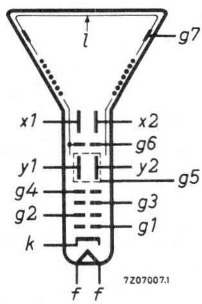
Dimensions in mm

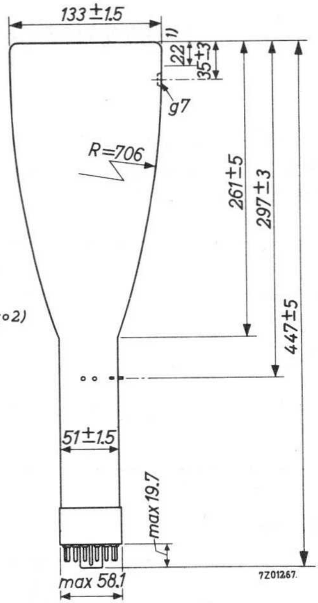
1) Straight part of the bulb
2) Location of the recessed cavity button contact with respect to the x-trace.



Detail of side contact







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Diheptal

Dimensions and connections

See also outline drawing

Overall length	max.	452	mm
Face diameter	max.	134.5	mm

Net weight: approx. 910 g

Accessories

Socket	type	2422 517 00001
Final accelerator contact connector	type	55563
Side contact connector	type	55561
Mu-metal shield	type	55551

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	3.0	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	3.0	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.0	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.0	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.9	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.0	pF
Control grid to all other elements	C_{g_1}	=	6.0	pF
Cathode to all other elements	C_k	=	3.5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces. $90^{\circ} \pm 1^{\circ}$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_7(\ell)}$	=	10	kV
Astigmatism control electrode voltage	V_{g_4}	=	1670	V[3]
First accelerator voltage	V_{g_2}	=	1670	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.4	mm

HELIX

Post deflection accelerator-helix resistance = min. 200 MΩ

[3]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g7(\ell)}$	= 10	kV
Geometry control electrode voltage	V_{g6}	= 1670 ± 170	V [1]
Deflection plate shield voltage	V_{g5}	= 1670 ± 85	V [2]
Astigmatism control electrode voltage	V_{g4}	= 1670 ± 85	V [3]
Focusing electrode voltage	V_{g3}	= 320 to 500	V
First accelerator voltage	V_{g2}	= 1670	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	= 53 to 82	V
Deflection factor, horizontal	M_x	= 27 to 33	V/cm
vertical	M_y	= 9.5 to 12.4	V/cm
Deviation of linearity of deflection		= max. 2	% [4]
Geometry distortion		See note [5]	
Useful scan, horizontal		= min. 100	mm
vertical		= min. 60	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	= 190 to 300	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	= 32 to 49	V per kV of V_{g2}
Deflection factor at $V_{g7(\ell)}/V_{g4} = 6$			
horizontal	M_x	= 16 to 20	V/cm per kV of V_{g4}
vertical	M_y	= 5.7 to 7.4	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	= max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max. 1	MΩ
Focusing electrode current	I_{g3}	= −15 to +10	μA [6]

[1][2][3][4][5][6] See page 6

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g7(\ell)}$	= max.	12	kV
		= min.	6	kV
Geometry control electrode voltage	V_{g6}	= max.	2200	V
Deflection plate shield voltage	V_{g5}	= max.	2100	V
Astigmatism control electrode voltage	V_{g4}	= max.	2100	V
		= min.	1000	V
Focusing electrode voltage	V_{g3}	= max.	1500	V
First accelerator voltage	V_{g2}	= max.	2100	V
		= min.	1000	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	= max.	500	V
	$V_{g4/y}$	= max.	500	V
Screen dissipation	W_{ℓ}	= max.	3	mW/cm^2
Ratio $V_{g7(\ell)}/V_{g4}$	$V_{g7(\ell)}/V_{g4}$	= max.	6	

---

1) This tube is designed for optimum performance when operating at the ratio $V_{g7(\ell)}/V_{g4} = 6$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

4) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25 % of the useful scan by more than the indicated value.

5) A graticule, consisting of concentric rectangles of 100 mm x 60 mm and 98 mm x 58.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these ractangles with optimum correction potentials applied.

6) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with flat face post deflection acceleration by means of a helical electrode, side contacts, metal backed screen, 4 cm scan for high frequency and high writing speed applications.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g}(\ell)$	=	10	kV
Display area		=	4 x 10	cm
Deflection factor, horizontal	M_x	=	30	V/cm
vertical	M_y	=	6.4	V/cm

SCREEN

	colour	persistence
D13-21BE	blue	medium short
D13-21GH	green	medium short
D13-21GP	bluish green	medium short
D13-21GM	yellowish green	long

Useful screen diameter min. 114 mm

Useful scan at $V_{g_7(\ell)}/V_{g_4} = 6$

horizontal	min.	100	mm
vertical	min.	40	mm

The useful scan may be shifted vertically to a max. of 3 mm with respect to the geometric centre of the faceplate.

HEATING

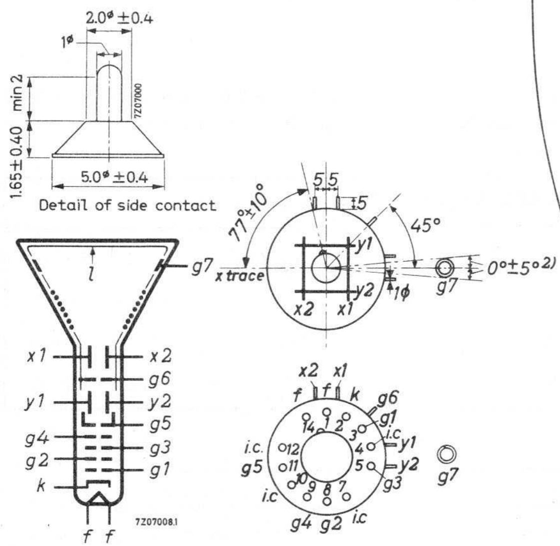
Indirect by A.C. or D.C.; parallel supply

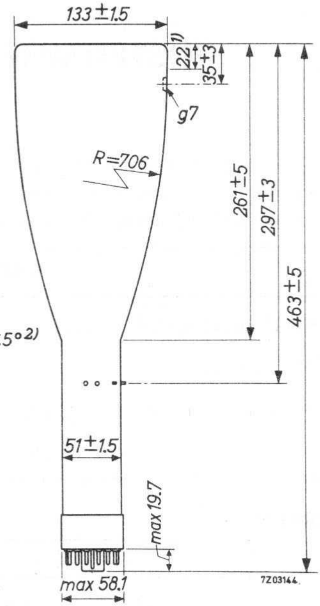
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA Dimensions in mm

1) Straight part of the bulb.

2) Location of the recessed cavity button contact with respect to the x-trace.





Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Diheptal 12 pins

Dimensions and connections

See also outline drawing

Overall length	max.	468	mm
Face diameter	max.	134.5	mm

Net weight:	approx.	910	g

Accessories

Socket	type	2422 517 00001
Final accelerator contact connector	type	55563
Side contact connector	type	55561
Mu-metal shield	type	55551

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1 (x_2)}$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2 (x_1)}$	=	2.8	pF
y_1 to all other elements except y_2	$C_{y_1 (y_2)}$	=	2.8	pF
y_2 to all other elements except y_1	$C_{y_2 (y_1)}$	=	2.8	pF
x_1 to x_2	$C_{x_1 x_2}$	=	1.9	pF
y_1 to y_2	$C_{y_1 y_2}$	=	1.5	pF
Control grid to all other elements	C_{g_1}	=	6.0	pF
Cathode to all other elements	C_k	=	3.5	pF

FOCUSING

electrostatic

DEFLECTION

double electrostatic

x plates	symmetrical
y plates	symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^o \pm 1^o$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_7 (\ell)}$	=	10	kV
Astigmatism control electrode voltage	V_{g_4}	=	1670	V[3]
First accelerator voltage	V_{g_2}	=	1670	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.4	mm

HELIX

Post deflection accelerator helix resistance = min. 200 MΩ

[3]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g7(\ell)}$	=	10	kV
Geometry control electrode voltage	V_{g6}	=	1670 ± 170	V [1]
Deflection plate shield voltage	V_{g5}	=	1670 ± 85	V [2]
Astigmatism control electrode voltage	V_{g4}	=	1670 ± 85	V [3]
Focusing electrode voltage	V_{g3}	=	320 to 500	V
First accelerator voltage	V_{g2}	=	1670	V
Control grid voltage for visual extinction of focused spot	V_{g1}	=	−50 to −80	V
Deflection factor, horizontal	M_x	=	27 to 33	V/cm
vertical	M_y	=	5.7 to 7.1	V/cm
Deviation of linearity deflection				
horizontal		=	max. 1.5	% [4]
vertical		=	max. 1.0	% [4]
Geometry distortion			See note 5	
Useful scan, horizontal		=	min. 100	mm
vertical		=	min. 40	mm

CIRCUIT DESIGN VALUES

Focusing electrode	V_g	=	190 to 300	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	30 to 48	V per kV of V_{g2}
Deflection factor at $V_{g7(\ell)}/V_{g4} = 6$				
horizontal	M_x	=	16.2 to 19.8	V/cm per kV of V_{g4}
vertical	M_y	=	3.4 to 4.25	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 1.0	MΩ
Focusing electrode current	I_g	=	−15 to +10	μA [6]

---

[1][2][3][4][5][6] See page 6

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g7(\ell)}$	= max.	12	kV
		= min.	6	kV
Geometry control electrode voltage	V_{g6}	= max.	2200	V
Deflection plate shield voltage	V_{g5}	= max.	2100	V
Astigmatism control electrode voltage	V_{g4}	= max.	2100	V
		= min.	1000	V
Focusing electrode voltage	V_{g3}	= max.	1500	V
First accelerator voltage	V_{g2}	= max.	2100	V
		= min.	1000	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	= max.	500	V
	$V_{g4/y}$	= max.	500	V
Screen dissipation	W_{ℓ}	= max.	3	mW/cm^2
Ratio $V_{g7(\ell)}/V_{g4}$	$V_{g7(\ell)}/V_{g4}$	= max.	6	

1) This tube is designed for optimum performance when operating at the ratio $V_{g7(\ell)}/V_{g4} = 6$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

4) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25 % of the useful scan by more than the indicated value.

5) A graticule, consisting of concentric rectangles of 100 mm x 40 mm and 98.8 mm x 39 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

6) Values to be taken into account for the calculation of the V_{g3}-potentiometer.

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter flat faced oscilloscope tube, with metal-backed screen, helical PDA and side connections to the x and y plates. The y plates are intended to be included in a resonant circuit tunable to frequencies from 300 MHz to 900 MHz by means of adapter units outside the tube. This tube incorporates deflection blanking and is intended for high frequency, narrow bandwidth displays.

QUICK REFERENCE DATA					
Final accelerator voltage	$V_{g9(\ell)}$	=		6	kV
Display area		=		5x10	cm
Deflection factor, horizontal	M_x	=	max.	14	V/cm
vertical	M_y		See note 1		

SCREEN

	colour	persistence
D13-23GH	green	medium short

Useful screen diameter	min.	114	mm
Useful scan at $V_{g9(\ell)}/V_{g5}$ = 5			
horizontal	min.	100	mm
vertical	min.	50	mm

The useful scan may be shifted vertically to a max. of 5 mm with respect to the geometric centre of the faceplate.

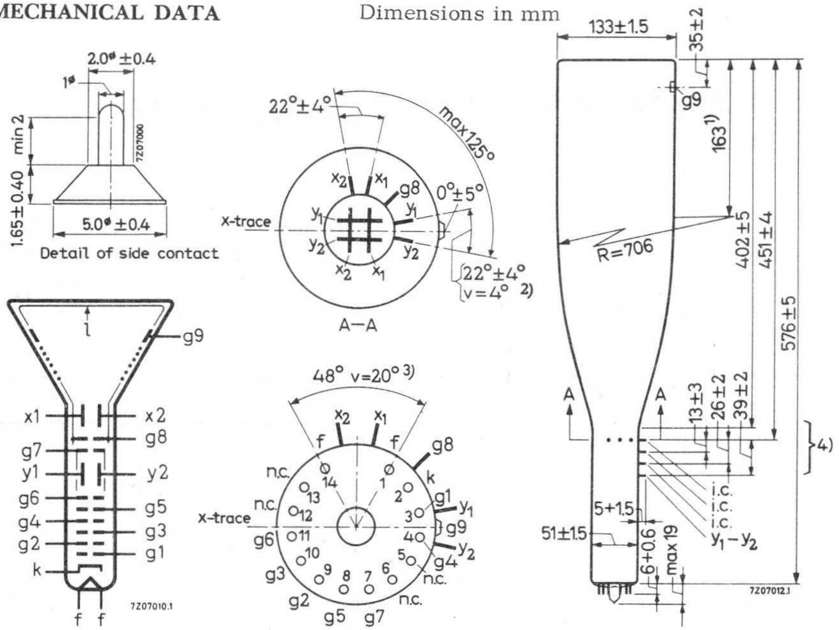
HEATING

Indirect by A C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pins all glass		
Dimensions and connections			
Overall length (inclusive socket 55566)	max.	596	mm
Face diameter	max.	134.5	mm
Net weight:	approx.	1300	g
Accessories:			
Socket (supplied with the tube)	type	55566	
Final accelerator contact connector	type	55563	
Side contact connector	type	55561	
Mu-metal shield	type	55554	

1) Straight part

2) The tolerance of the position of the neck pins with respect to the x-trace is $\pm 2^{\circ}$.

3) The tolerance of the position of the base pins with respect to the x-trace is $+10^{\circ}$.

4) To avoid damaging the side contacts the narrower end of the mu-metal shield should have an internal diameter of not less than 70 mm.

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	2.8	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.3	pF
Control grid to all other elements	C_{g_1}	=	5.0	pF
Cathode to all other elements	C_k	=	3.5	pF
Deflection blanking electrode to all other elements	C_{g_3}	=	9	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y plates $90^o \pm 1^o$

HELIX

Post deflection accelerator helix resistance min. 300 MΩ

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g_4}	=	138 to 300	V per kV of V_{g_2}
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	24 to 72	V per kV of V_{g_2}
Deflection factor at $V_{g_9(\ell)}/V_{g_5} = 5$				
horizontal	M_x	=	max. 10.8	V/cm per kV of V_{g_5}
vertical	M_y		See note 1	
Control grid circuit resistance	R_{g_1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 50	kΩ
Focusing electrode current	I_{g_4}	=	+15 to −10	μA 2)

1) Depends on the frequency and the adaptors being used.

2) Values to be taken into account for the calculation of the focus potentiometer.

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_9(\ell)}$	=		6000	V	
Geometry control electrode voltage	V_{g_8}	=	1300 ±	100	V	1)
Deflection plate shield voltage	V_{g_7}	=		1300	V	2)
Beam centring electrode voltage	V_{g_6}	=	1300 ±	20	V	3)
Astigmatism control electrode voltage	V_{g_5}	=	1300 ±	100	V	4)
Focusing electrode voltage	V_{g_4}	=	180 to	390	V	
Deflection blanking electrode voltage	V_{g_3}	=		1300	V	
Deflection blanking control voltage	ΔV_{g_3}	=	max.	60	V	5)
First accelerator voltage	V_{g_2}	=		1300	V	
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	31 to	93	V	
Deflection factor						
horizontal	M_x	=	max.	14	V/cm	
vertical		See note 7				
Geometry distortion		See note 6				
Useful scan						
horizontal		=	min.	100	mm	
vertical		=	min.	50	mm	

1) This tube is designed for optimum performance when operating at the ratio $V_{g_9(\ell)}/V_{g_5} = 5$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The beam centring electrode voltage should be adjusted for equal brightness in the x direction with respect to the electrical centre of the tube.

4) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

5) For beam blanking of a beam current of 10 μA.

6) A graticule, consisting of concentric rectangles of 100 mm x 50 mm and 98 mm x 48.2 mm is aligned with the electrical x aixs of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

7) Depends on the frequency and the adaptors being used.

7Z2 5540

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g9(\ell)}$	=	max.	10000	V
		=	min.	5000	V
Geometry control electrode voltage	V_{g8}	=	max.	2000	V
Deflection plate shield voltage	V_{g7}	=	max.	2000	V
Beam centring electrode voltage	V_{g6}	=	max.	2000	V
Astigmatism control electrode voltage	V_{g5}	=	max.	2000	V
Focusing electrode voltage	V_{g4}	=	max.	2000	V
Deflection blanking electrode voltage	V_{g3}	=	max.	2000	V
First accelerator voltage	V_{g2}	=	max.	2000	V
		=	min.	1200	V
Control grid voltage					
negative	$-V_{g1}$	=	max.	200	V
positive	V_{g1}	=	max.	0	V
positive peak	V_{g1p}	=	max.	2	V
Cathode to heater voltage					
cathode positive	$V_{+k/f-}$	=	max.	200	V
cathode negative	$V_{-k/f+}$	=	max.	125	V
Voltage between astigmatism electrode	V_{g5}/x	=	max.	500	V
and any deflection plate	V_{g5}/y	=	max.	500	V
Cathode current (average)	I_k	=	max.	300	mA
Screen dissipation	W_ℓ	=	max.	3	mW/cm^2
Ratio $V_{g9(\ell)}/V_{g5}$	$V_{g9(\ell)}/V_{g5}$	=	max.	10	
Ratio V_{g9}/V_{g5}	V_{g2}/V_{g5}	=	max.	1	

APPLICATION DATA

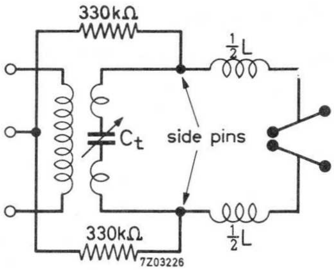
The D13-23GH is intended for use at ultra high frequencies as a monitor of transmitter output.
To achieve the necessary sensitivity the y-deflection plates are designed to form part of a tuned circuit, resonant at the carrier frequency of the transmitter. Details of the coupling units and tuning arrangements are given below.

Mechanical construction of the coupling units

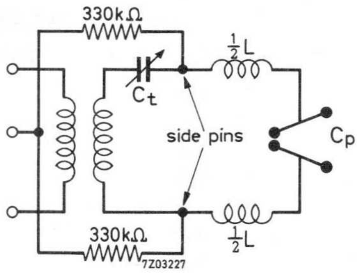
	Unit 1 (475 to 575 MHz)	Unit 2 (500 to 775 MHz)	Unit 3 (675 to 900 MHz)	
Coil former				
Length	20	20	18	mm
Diameter	9	9	3	mm
Primary				
No. of turns	4	1.5	1.5	
Wire diameter	0.9	0.9	0.9	mm
Approx. coil length	14	10	7	mm
Secondary				
No. of turns	4	2	2	
Wire diameter	0.5	1.5	0.9	mm
Approx. coil length	14	10	7	mm
Trimming capacitance	0.6 to 12	0.5 to 6	0.5 to 6	pF

Copper wire is used for all primary windings and enamelled copper wire is used for the secondaries.
The secondary turns are wound between the primary turns.
The trimmer capacitors of units 1 and 2 are connected between the secondary transformer windings in order to obtain good symmetry.
For unit 3 the trimmer is connected between secondary transformer windings and one connecting pin of the deflection system in order not to reduce the coupling factor.

APPLICATION DATA (continued)



Unit 1 and 2
fig.1



Unit 3
fig.2

Ct = trimmer capacitance
Cp = plate capacitance
L = inductivity of the strips between deflection system and pins in the neck of the tube

Measurement of vertical sensitivity as a function of frequency

1. Adjust the trimmer so that the trimming capacitance is a minimum, to enable resonance at the highest frequency to be obtained.

2. Change the frequency of the signal generator and adjust the trimming capacitance successively until a maximum deflection is obtained on the tube face. Some care must be taken with these adjustments because several spurious resonances will be observed.

3. When the resonance frequency has been found, the input impedance of the tube must be transformed to exactly 50Ω to obtain a well defined signal voltage. For this purpose a transforming circuit is needed as shown in fig.3, and any reflectometer would be suitable. The impedance is matched when no reflection is measured and zero reflection can be obtained by the successive adjustment of the stubs, 1 and 2 shown in fig.3.

4. The tube should now be connected to the generator and the output power regulated for a scan of 5 cm.

5. Replace the tube by a Watt-meter to measure the output power, see fig.4.

The signal voltage can be calculated from:

$$V_{RMS} = WxR = 7.07 \quad W$$

The above procedure must be repeated for matching, each time the operating frequency of the tube is altered.

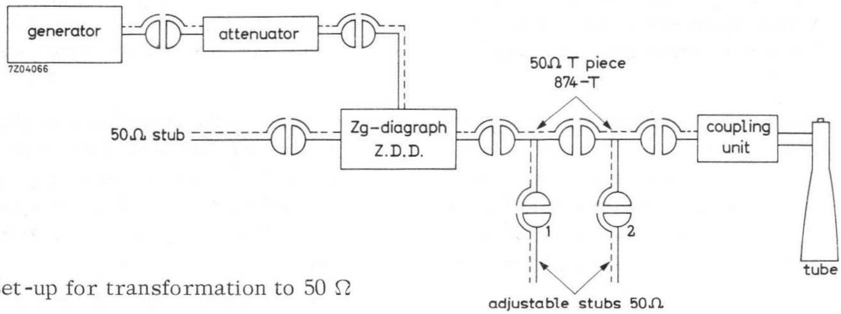
APPLICATION DATA (continued)

Typical power and sensitivity values

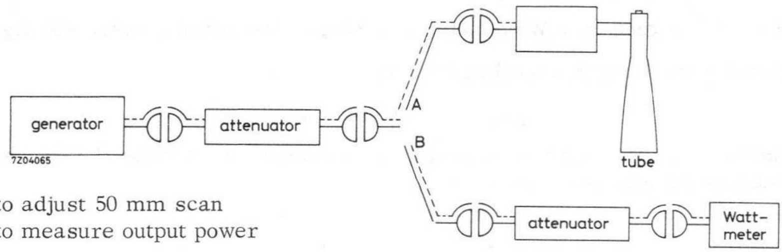
Unit	Frequency (MHz)	Power (mW)	Sensitivity (V_{RMS}/5 cm)
1	445	37	1.36
1	480	39	1.40
1	540	55	1.66
2	565	46	1.52
2	680	69	1.86
3	680	91	2.14
3	750	110	2.35
3	800	195	3.12
3	850	240	3.47
3	900	390	4.43

All measurements: $\left.\begin{array}{l} V_{g_{2+5}} = 1300 \text{ V} \\ V_{g_9} = 6000 \text{ V} \end{array}\right\}$ with respect to cathode

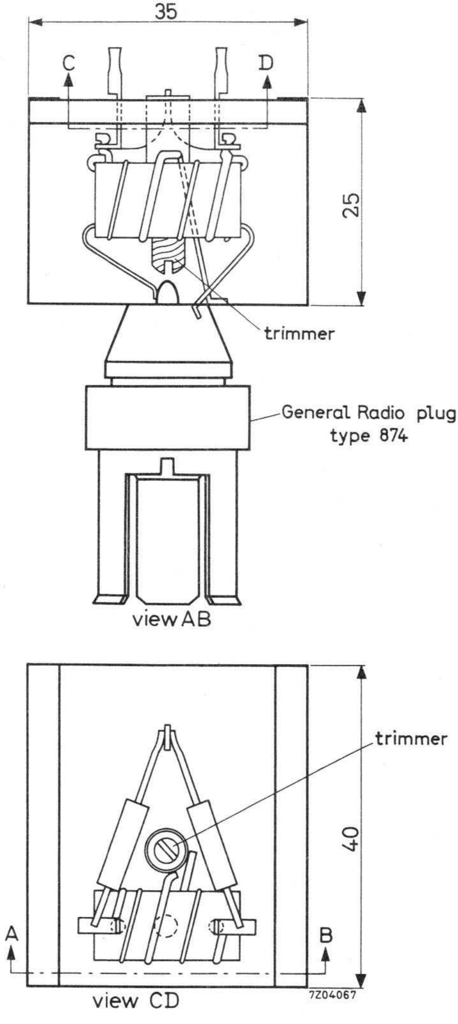
It should be noted that an increase in acceleration voltage will cause a loss of sensitivity at the lowest frequencies. At the higher frequencies this loss will partly be compensated by the decrease of the transit-time so that at 900 MHz the acceleration voltage can be increased to 2000 V, without changing the sensitivity.



Set-up for transformation to 50 Ω



A: to adjust 50 mm scan
B: to measure output power



35
C
D
25
trimmer
General Radio plug
type 874
view AB
trimmer
40
A
B
view CD
7Z04067

INSTRUMENT CATHODE-RAY TUBE

The D13-24BE is a wide-band oscilloscope tube especially designed for observation and measurement of high frequency (1000 MHz) phenomena.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g_9(\ell)}$		24	kV
Display area			2 x 6	cm
Deflection factor, horizontal	M_x	max.	32	V/cm
vertical	M_y	max.	8	V/cm

SCREEN

	colour	persistence
D13-24BE	blue	medium short

Useful screen diameter min. 114 mm

Useful scan at $V_{g_9}(\ell)/V_{g_5} = 8$

horizontal	min.	60	mm
vertical	min.	20	mm

The useful scan may be shifted vertically to a max. of 10 mm with respect to the geometric centre of the faceplate. The vertical useful scan will be at least 8 mm in either direction from the position of the undeflected spot, with a total of at least 20 mm. A positive voltage on the vertical deflection system will deflect the beam towards pin no.7.

DESCRIPTION

The D13-24BE is a wide-band oscilloscope tube especially designed for observation and measurement of high frequency (1000 MHz) phenomena.
The high-frequency performance of conventional oscilloscope tubes is limited by transit-time effects and by resonance phenomena occurring in the circuit consisting of the deflection plates and their connection leads.

In order to overcome these limitations a travelling-wave deflection system is used in the D13-24BE. This deflection system consists of a metal tape wound in the shape of a flattened helix and the electron beam is deflected in the region between the flat part of the helix and a metal plate inserted into the helix. This metal plate is interconnected to the shield surrounding the system.
The mechanical dimensions of the helix have so been chosen that the signal delay per turn is equal to the electron transit-time per turn. This means that the transit-time effects are determined by the width of one turn only, whereas the defelction sensitivity is determined by the sum of the deviations of the beam due to the field of all the turns.
As for the transmissions of wide band signals containing ultra-high frequencies coaxial lines are most suitable. The deflection system has been designed for asymmetrical deflection (helix and plate are connected to inner and outer conductor respectively).
For the connection between the deflection system and coaxial plugs a three strip transmission-line is used which is brought out through the tube neck by means of pins sealed into the glass. The transition to coaxial plugs is made outside the tube. The characteristic impedance of the tube is 100 Ohms, and a modified version of the well-known General Radio type 874 coaxial connector is used (The diameter of the inner conductor has been reduced so as to obtain 100 Ohm impedance). Both input and output of the deflection system have been brought out through the tube neck so that it is possible to pick up the signal which is being observed at the output and to use it for other purposes, if desired.
The performance of the deflection system may be expressed in terms of bandwidth (min. 1000 MHz for 3 dB down with respect to D.C.) or in terms of rise time of the display of a step-function signal (max. 0.35 nanoseconds for 10% to 90% of the final value).
Great care has been taken in the design to avoid phase distortion which would introduce overshoot in the display of such a signal. The extent to which a constant input impedance has been realized is indicated by the voltage standing-wave ratio (maximum 1.25 up to 1000 MHz). In order to be able to shift the display in vertical direction the deflection system shield is not directly connected but capacitively coupled to the outer connector of the coaxial plugs.
A D.C. shift voltage can be applied to the shield.
The useful vertical scan has been limited to 2 cm in order to obtain the highest possible sensitivity. This is important as in most cases the signal to be observed will be applied directly to the deflection system without any amplification.
The horizontal deflection plates giving 6 cm useful scan, are of conventional design and, of course, also brought out through the neck.

The typical acceleration voltage is 3 kV. Deviations from this value will cause deterioration of band-width and rise time, since the electron velocity will then not be equal to the velocity of signal propagation of the vertical deflection system. However this adjustment is not very critical. The electron gun features apart from astigmatism and geometry control electrodes auxiliary electrodes such as deflection blanking electrodes and a beam centring electrode. The latter can be used to center the beam with respect to the x plates.
Post deflection acceleration is achieved by a helical resistive coating in the innerside of the envelope which allows a P.D.A. to acceleration electrode voltage ratio of 10. The maximum P.D.A. voltage is 24 kV. This high voltage, the metal-backed screen and the small linewidth (0.12 mm) assure a high writingspeed.
In order to make use of the full capabilities of this tube some precautions have to be taken in the way the signal is applied to the tube. First, a good termination at the output of the deflection system is essential when pulse signals are to be observed, otherwise reflections from a mismatch at the output may distort the displayed wave-form.
A coaxial resistor is the most suitable termination.
For signal delays in oscilloscopes a high-quality delay-line should be used in order to avoid deterioration of performance due to band-width limitations of the delay-line.

HEATING

Indirect by A.C. or D.C.; parallel supply

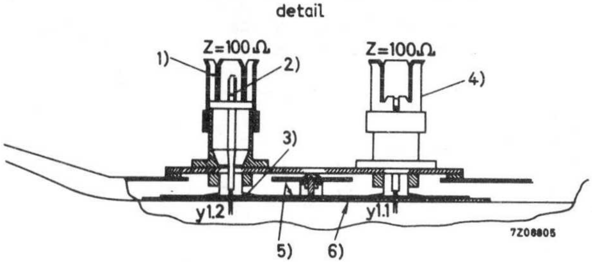
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

CAPACITANCES

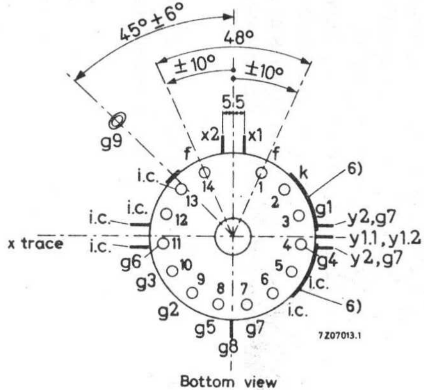
x_1 to all other elements except x_2	$C_{x_1(x_2)}$	3.0	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	3.0	pF
x_1 to x_2	$C_{x_1x_2}$	2.7	pF
Control grid to all other elements	C_{g_1}	5.0	pF
Cathode to all other elements	C_k	3.5	pF
Deflection blanking electrode to all other elements	C_{g_3}	9.0	pF

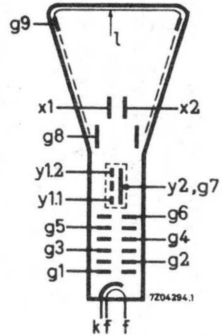
MECHANICAL DATA

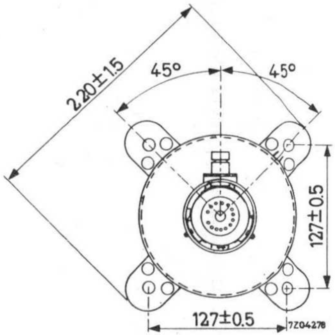
Dimensions in mm

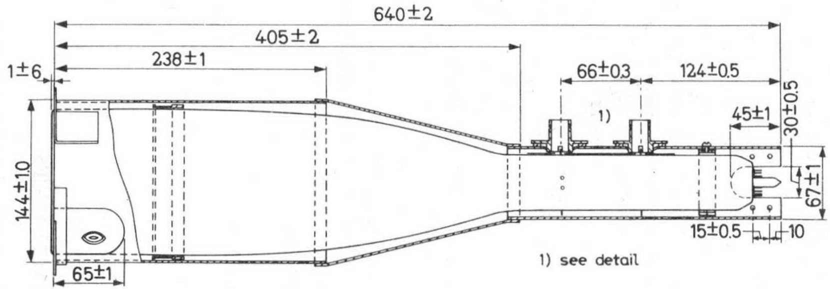


1) Outer conductor
2) Inner conductor
3) Contact springs
4) Coaxial plug
5) Mica
6) Conductive coating









MECHANICAL DATA

Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pin all glass	
Dimensions and connections		
Overall length (mu-metal shield included)	642	mm
Face diameter	max. 134.5	mm
Net weight	approx.	g
Accessories		
Socket	supplied with tube	
Final accelerator contact connector	type 55563	
Side contact connector	supplied with tube	
Mu-metal shield	supplied with tube	

FOCUSING electrostatic

DEFLECTION

Horizontal	electrostatic symmetrical		
Vertical	delay-line system, asymmetrical		
Characteristic impedance of delay-line system	100	Ω	
VSWR	max. 1.25 up to 1000	MHz	1)
Bandwidth	1000	MHz	2)
Rise time	0.35	nsec	3)
Angle between x and y traces	90 ± 2^{o}		

1) 2) and 3) see page 8

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_9}(\ell)$	24000	V
Astigmatism control electrode voltage	V_{g_5}	3000	V [6]
First accelerator voltage	V_{g_2}	3000	V
Beam current	$I(\ell)$	0.5	μA
Line width	l.w.	0.12	mm

HELIX

Post deflection accelerator helix resistance	min.	300	MΩ

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_9}(\ell)$		24000	V
Geometry control electrode voltage	V_{g_8}		3000 ± 200	V
Vertical deflection system shield voltage	V_{g_7}		3000	V [4]
Beam centring electrode voltage	V_{g_6}		3000 ± 40	V [5]
Astigmatism control electrode voltage	V_{g_5}		3000 ± 200	V [6]
Focusing electrode voltage	V_{g_4}		400 to 900	V
Deflection blanking electrode voltage	V_{g_3}		3000	V
Deflection blanking control voltage	ΔV_{g_3}		110	V [7]
First accelerator voltage	V_{g_2}		3000	V [8]
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$		60 to 250	V
Deflection factor, horizontal	M_x	max.	32	V/cm
vertical	M_y	max.	8	V/cm
Useful scan, horizontal		min.	60	mm
vertical		min.	20	mm

[4] [5] [6] [7] and [8] see page 8

LIMITING VALUES

Final accelerator voltage	$V_{g_9(\ell)}$	max.	25000	V
		min.	10000	V
Geometry control electrode voltage	V_{g_8}	max.	4400	V
Vertical deflection system shield voltage	V_{g_7}	max.	4400	V
Beam centring electrode voltage	V_{g_6}	max.	4400	V
Astigmatism control electrode voltage	V_{g_5}	max.	4400	V
		min.	2500	V
Focusing electrode voltage	V_{g_4}	max.	1500	V
Deflection blanking electrode voltage		max.	4400	V
First accelerator voltage	V_{g_2}	max.	4400	V
Control grid voltage,				
negative	$-V_{g_1}$	max.	350	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	max.	200	V
cathode negative	$V_{-k/f+}$	max.	125	V
Cathode current average	$I_{k_{eff}}$	max.	300	mA
Screen dissipation	W_{ℓ}	max.	3	mW/cm^2
Ratio $V_{g_9}(\ell)/V_{g_5}$	$V_{g_9}(\ell)/V_{g_5}$	max.	10	
Ratio V_{g_2}/V_{g_5}	V_{g_2}/V_{g_5}	max.	1	

WARNING

This tube, when in operation, produces X-rays which may constitute a health hazard unless the tube is adequately shielded.

NOTES

1. Measured with coaxial 50 to 100 Ω quarter wavelength transformers with a 50 Ω coaxial precision resistance from Rohde and Schwarz, type RMD 33526/50 as reference standard.

2. The bandwidth is defined as the frequency at which the vertical sensitivity is 3 dB down with respect to that at D.C.

3. The risetime is defined to be the time interval between 10% and 90% of the final value of deflection, when a stepfunction signal is applied to the vertical deflection system.
   The signal source will be built-in step function generator of a Tektronix type 519 oscilloscope with the built-in delay-line included in the signal path and an abrupt 125 to 100 Ω transition between the output of the delay-line and the input of the oscilloscope tube. The output connector of the tube will be terminated with a 100 Ω coaxial resistor type BB 1241. In order to avoid errors due to the angle of traces, two measurements are taken using a positive going and a negative going step function of equal amplitude and the risetime will be taken to be the arithmetic mean of the two values.

4. If the external conductors of the coaxial input and output connectors are not directly connected but capacitively coupled to this electrode, a vertical shift of the display can be obtained by varying the potential of this electrode.

5. The beam centring electrode voltage should be adjusted for equal deflection defocusing and deflection linearity in the x-direction with respect to the electrical centre of the tube.

6. The astigmatism electrode voltage should be corrected for optimum spot shape.

7. For visual extinction of a beam current of 10 μA its potential will not exceed 110 V with respect to V_{g_2}.

8. The delay-line deflection system has been designed for an accelerator voltage of about 3000 V. Deviation from this value will cause deterioration of bandwidth and risetime. The potential of g2 should not vary within the duration of the brightness of the display may occur.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with flat face, side connections to the deflector plates. The high sensitivities of this mesh tube render it suitable for transistorized equipment. The phosphor screen is metal backed.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g_9(\ell)}$	15	kV
Display area		6x10	cm
Deflection factor, horizontal	M_x	max. 11.5	V/cm
vertical	M_y	= 2.9	V/cm

SCREEN

	Colour	Persistence
D13-26GH	green	medium short
D13-26GP	bluish green	medium short

Useful screen diameter	min.	114	mm
Useful scan at $V_{g_9(\ell)}/V_{g_4} = 10$			
horizontal	min.	100	mm
vertical	min.	60	mm

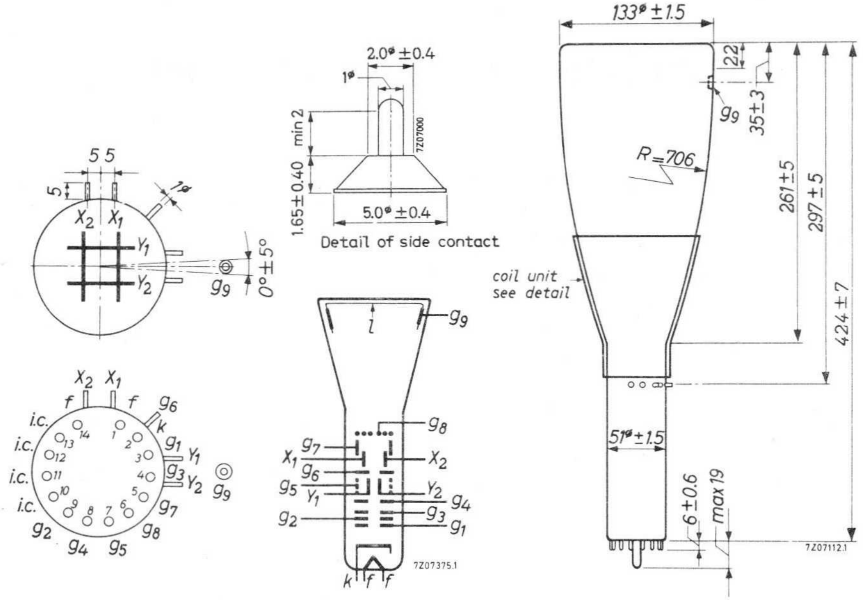
HEATING

Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	= 6.3	V
Heater current	I_f	= 300	mA

MECHANICAL DATA

Dimensions in mm



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pin all-glass		
Dimensions and connections			
Overall length	max.	460	mm
Face diameter	max.	134.5	mm
Net weight	approx.	925	g
Accessories			
Socket	type	55566	
Final accelerator contact connector	type	55563	
Side contact connector	type	55561	
Mu-metal shield	type	55555[1]	

[1]) See page 6.

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.8	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.8	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.7	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.8	pF
Control grid to all other elements	C_{g_1}	=	5.5	pF
Cathode to all other elements	C_k	=	3.0	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces 90° See "Correction coils"

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen

Final accelerator voltage	$V_{g_9(\ell)}$	=	15 000	15 000	V
Astigmatism control electrode voltage	V_{g_4}	=	2400	1500	V[4])
First accelerator voltage	V_{g_2}	=	2400	1500	V
Beam current	$I(\ell)$	=	10	10	μA
Line width	l.w.	=	0.3	0.4	mm

[4]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g9(\ell)}$	=	15 000	V
Post deflection shield voltage (with respect to V_{g7})	V_{g8}	=	−12 to −18	V
Geometry control electrode voltage	V_{g7}	=	1500 ±70	V 2)
Interplate shield voltage	V_{g6}	=	1500	V
Deflection plate shield voltage	V_{g5}	=	1500	V 3)
Astigmatism control electrode voltage	V_{g4}	=	1500 ±70	V 4)
Focusing electrode voltage	V_{g3}	=	375 to 625	V
First accelerator voltage	V_{g2}	=	1500	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	40 to 90	V
Deflection factor				
horizontal	M_x	=	9.4 to 12.5	V/cm
vertical	M_y	=	2.3 to 3.5	V/cm
Deviation of linearity of deflection		=	max. 2	% 5)
Geometry distortion			See note 6	
Useful scan				
horizontal		=	min. 100	mm
vertical		=	min. 60	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	=	250 to 417	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	30 to 56.7	V per kV of V_{g2}
Deflection factor at $V_{g9(\ell)}/V_{g4}$ = 10				
horizontal	M_x	=	6.3 to 8.4	V/cm per kV of V_{g4}
vertical	M_y	=	1.53 to 2.33	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	=	max. 1	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 50	kΩ
Focusing electrode current at a beam current of max. 25 μA	I_{g3}	=	−25 to +25	μA 7)

2)3)4)5)6)7) See page 6.

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g9(\ell)}$	=	max.	16500	V
		=	min.	9000	V
Post deflection shield voltage	V_{g8}	=	max.	2500	V
		=	min.	1350	V
Geometry control electrode voltage	V_{g7}	=	max.	2500	V
		=	min.	1350	V
Interplate shield voltage	V_{g6}	=	max.	2500	V
		=	min.	1350	V
Deflection plate shield voltage	V_{g5}	=	max.	2500	V
		=	min.	1350	V
Astigmatism control electrode voltage	V_{g4}	=	max.	2500	V
		=	min.	1350	V
Focusing electrode voltage	V_{g3}	=	max.	2500	V
First accelerator voltage	V_{g2}	=	max.	2500	V
		=	min.	1350	V
Control grid voltage					
negative	$-V_{g1}$	=	max.	200	V
positive	V_{g1}	=	max.	0	V
Voltage between astigmatism electrode	$V_{g4/x}$	=	max.	500	V
and any deflection plate	$V_{g4/y}$	=	max.	500	V
Cathode to heater voltage					
cathode positive	$V_{+k/f-}$	=	max.	200	V
cathode negative	$V_{-k/f+}$	=	max.	125	V
Screen dissipation	W_ℓ	=	max.	3	mW/cm^2
Ratio $V_{g9(\ell)}/V_{g4}$	$V_{g9(\ell)}/V_{g4}$	=	max.	10	
Cathode current, average	I_k	=	max.	300	μA

1) To avoid damaging the side contacts the narrower end of the mu-metal shield should have an internal diameter of not less than 70 mm.

2) This tube is designed for optimum performance when operating at the ratio $V_{g9(\ell)}/V_{g4}$ = 10. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

3) This voltage should be equal to the mean x- and y plates potential.

4) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

5) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

6) A graticule, consisting of concentric rectangles of 100 mm x 60 mm and 98 mm x 58.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

7) Values to be taken into account for the calculation of the focus potentiometer.

CORRECTION COILS

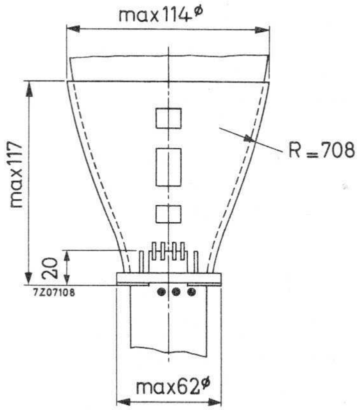
The D13-26.. is provided with a coil unit consisting of a pair of coils for:

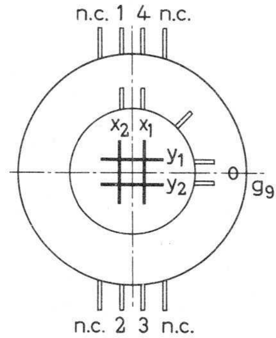
a. Correction of the orthogonality of the x and y traces (which means that at the centre of the screen the angle between the x and y traces can be made exactly 90°).

b. Vertical shift of the scanned area.

DETAIL DRAWING OF COIL UNIT

Dimensions in mm



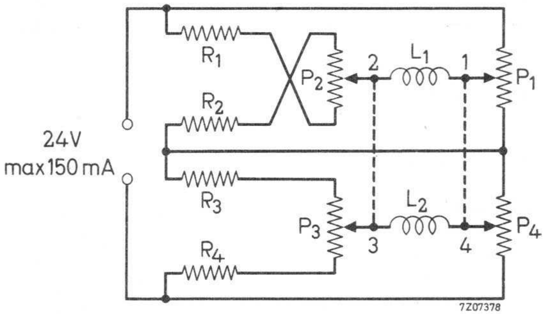


1-2 coil no.1
3-4 coil no.2

The currents required under typical operating conditions, the tube being screened by a mu-metal shield closely surrounding the coils (e.g. 55555), are max. 7 mA per degree of angle correction and max. 4 mA per mm of shift. If no such shield is used these values have to be multiplied by a factor k ($1 < k < 2$), the value of which depends on the diameter of the shield and approaches 2 for the case no shield is present.
The D.C. resistance is approx. 180 Ω per coil.
When designing the supply circuit for these coils it should be considered that the maximum current required in either coil can be 34 mA.

Circuit diagrams

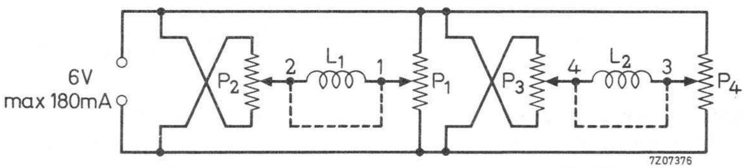
A suitable circuit permitting independent controls of orthogonality correction and vertical shift is given in fig. 1.



P_1, P_4 : Potentiometers 220 Ω, 3 Watt, ganged
P_2, P_3 : Potentiometers 150 Ω, 2 Watt, ganged
R_1, R_2, R_3, R_4 : Resistors 33 Ω, 0, 5 Watt

Fig. 1

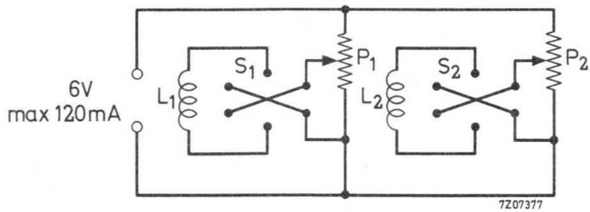
The dissipation in the potentiometers can be reduced considerably if the requirement of independent controls is dropped (see fig. 2).



P_1, P_2 : Potentiometers, 220 Ω, 1 Watt, ganged
P_3, P_4 : Potentiometers, 220 Ω, 1 Watt, ganged

Fig. 2

A further reduction of the dissipation can be obtained by inserting a commutator for each coil (see fig.3).
The procedure of adjustment will then become more complicated, but it should be kept in mind that a readjustment is necessary only when the tube has to be replaced.



P_1, P_2 : Potentiometers, 500 Ω, 0,5 Watt
S_1, S_2 : Commutators

Fig.3

For the adjustment of the currents the following procedure is recommended:

a. With the tube fully scanned in the vertical direction the scanned area must be shifted so that the useful vertical scan on either side of the geometric centre of the screen meets the published value of 30 mm min.
   With the circuit according to fig.1 this is done by means of the ganged potentiometers P_1 and P_4.

b. Adjustment of orthogonality by means of the ganged potentiometers P_2 and P_3 in fig.1. A slight readjustment of P_1 and P_4 may be necessary afterwards.

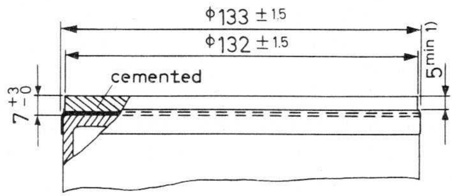
With a circuit according to fig.2 or 3 these corrections have to be performed by means of successive adjustments of the currents in the coils.
The most convenient deflection signal is a square waveform permitting an easy and fairly accurate check of orthogonality.

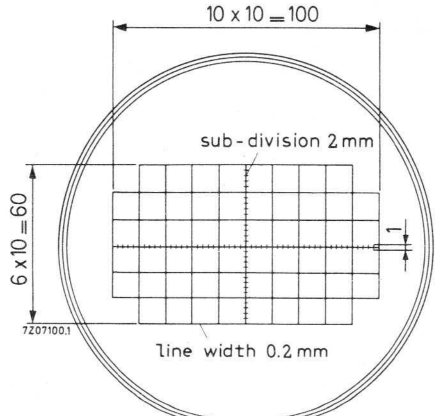
INSTRUMENT CATHODE-RAY TUBE

The D13-26../01 is equivalent to the D13-26.. but features an internal graticule. This graticule can be illuminated.

MECHANICAL DATA

Dimensions in mm





Maximum angle between x-trace and x-axis of the graticule	$\pm 5^{o}$

1) Clear area for light conductor.

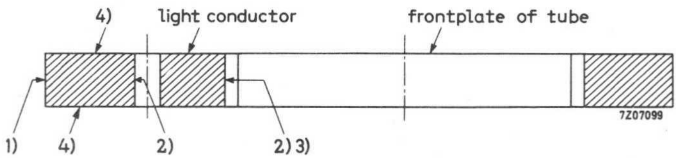
ALIGNMENT

In order to align the x-trace and the x-axis of the graticule an image rotating coil may be used. This coil should be positioned at one third of the cone length, seen from the face end, and can be attached to the inner surface of the mu-metal shield.
Under typical operating conditions maximum 90 ampere-turns are required for alignment.

ILLUMINATION

To illuminate the internal graticule the use of a light conductor (e.g. of Perspex) is obligatory. The following design considerations should be observed:

In order to achieve the most efficient light conductance the holes for the light bulb as well as the contact area with the front plate should be polished. The contact with the edges of the front plate should be as close as possible and the edges of the front plate and the corresponding hole in the light conductor should be parallel to achieve light beams perpendicular to the edges. It is advised to apply reflective material to the outer circumference of the conductor and if possible also to both planes (see drawing).



1) Reflective material.

2) Polished.

3) Close and constant distance to front plate of tube.
It is essential that the light conductor and the front plate of the tube are in plane.

4) If possible reflective material.

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter flat faced short oscilloscope tube (max. 35 cm) with post-deflection acceleration by means of a helical electrode. The tube is provided with deflection blanking.

QUICK REFERENCE DATA				
Final accelerator voltage		$V_{g8(\ell)}$	= 3000	V
Display area			8 cm x full scan	
Deflection factor,	horizontal	M_x	= 24	V/cm
	vertical	M_y	= 11.5	V/cm

SCREEN

	Colour	Persistence
D13-27GH	green	medium short

Useful screen diameter min. 114 mm

Useful scan at $V_{g8(\ell)}/V_{g5} = 2$

horizontal full scan

vertical min. 80 mm

The useful scan may be shifted vertically to a max. of 4 mm with respect to the geometric centre of the faceplate.

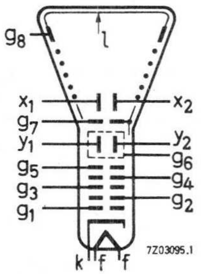
HEATING

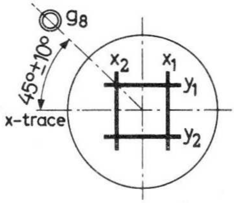
Indirect by A.C. or D.C.; parallel supply

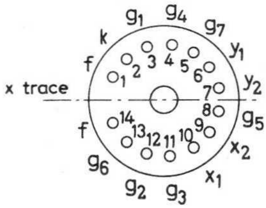
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

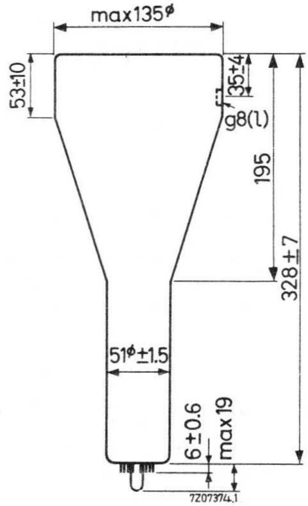
MECHANICAL DATA

Dimensions in mm









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base 14 pin all glass

Dimensions and connections

Overall length (also with socket type 55566)	max.	350	mm
Face diameter	max.	135	mm

Net weight	approx.	680	g

Accessories

Socket (supplied with tube)	type	55566
Final accelerator contact connector	type	55563
Mu metal shield	type	55557

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	5.5	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.5	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.2	pF
Grid No.1 to all other elements	C_{g_1}	=	5.5	pF
Cathode to all other elements	C_k	=	5	pF
Grid No.3 to all other elements	C_{g_3}	=	10	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^{\circ} \pm 1^{\circ}$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_8(\ell)}$	=	3000	V
Astigmatism control electrode voltage	V_{g_5}	=	1500	V [3]
First accelerator voltage	V_{g_2}	=	1500	V
Beam current	$I_{g_8(\ell)}$	=	10	μA
Line width	l.w.	=	0.25	mm

HELIX

Post deflection accelerator helix resistance min. 50 MΩ

The helix is connected between $g_8(\ell)$ and g

---

[3]) See page 5

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g8(\ell)}$	=		3000	V
Geometry control electrode voltage	V_{g7}	=		1500 ± 75	V [1]
Deflection plate shield voltage	V_{g6}	=		1500	V [2]
Astigmatism control electrode voltage	V_{g5}	=		1500 ± 75	V [3]
Focusing electrode voltage	V_{g4}	=	300 to	550	V
Deflection blanking electrode voltage	V_{g3}	=		1500	V
Deflection blanking control voltage	ΔV_{g3}	=	max.	-60	V [4]
First accelerator voltage	V_{g2}	=		1500	V
Control grid voltage for visual extinction of focused spot	V_{g1}	=	-38 to	-135	V
Deflection factor					
horizontal	M_x	=	21 to	27	V/cm
vertical	M_y	=	9.8 to	12.2	V/cm
Deviation of linearity of deflection		=	max.	2	% [5]
Geometry distortion			See note 6		
Useful scan					
horizontal			full scan		
vertical		=	min.	80	mm

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g4}	=	200 to 370	V per kV of V_{g5}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	25 to 90	V per kV of V_{g2}
Deflection factor at $V_{g8(\ell)}/V_{g5} = 2$				
horizontal	M_x	=	14 to 18	V/cm per kV of V_{g5}
vertical	M_y	=	6.5 to 8.2	V/cm per kV of V_{g5}
Control grid circuit resistance	R_{g1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 50	kΩ
Focusing electrode current	I_{g4}	=	-15 to +10	μA [7]

Notes see page 5

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g8(\ell)}$	= max.	3300	V
		= min.	1800	V
Geometry control electrode voltage	V_{g7}	= max.	1700	V
Deflection plate shield voltage	V_{g6}	= max.	1700	V
Astigmatism control electrode voltage	V_{g5}	= max.	1700	V
		= min.	1200	V
Focusing electrode voltage	V_{g4}	= max.	1200	V
Deflection blanking electrode voltage	V_{g3}	= max.	1700	V
First accelerator voltage	V_{g2}	= max.	1700	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	$-V_{g1}$	= min.	0	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g5/x}$	= max.	500	V
	$V_{g5/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Ratio $V_{g8(\ell)}/V_{g5}$	$V_{g8(\ell)}/V_{g5}$	= max.	2	
Cathode current, average	I_k	= max.	300	μA

---

[1] This tube is designed for optimum performance when operating at the ratio $V_{g8(\ell)}/V_{g5} = 2$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

[2] This voltage should be equal to the mean x- and y plates potential.

[3] The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

[4] For beam blanking of a beam current of 10 μA.

[5] The sensitivity at a deflection of less than 75% of the usefull scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

[6] A graticule, consisting of concentric rectangles of 100 mm x 60 mm and 97 mm x 58 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[7] Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter flat faced monoaccelerator oscilloscope tube primarily intended for use in inexpensive oscilloscopes and read-out devices.

QUICK REFERENCE DATA			
Accelerator voltage	$V_{g_2,g_4,g_5(\ell)}$	2000	V
Display area		100 x 80	mm^2
Deflection factor, horizontal	M_x	31	V/cm
vertical	M_y	15	V/cm

SCREEN

	colour	persistence
D13-480GH	green	medium short

Useful screen diameter	min.	114	mm
Useful scan			
horizontal	min.	100	mm
vertical	min.	80	mm

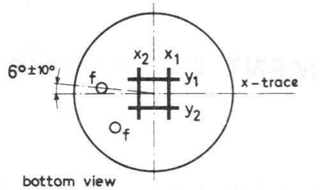
The useful scan may be shifted vertically to a max. of 6 mm with respect to the geometric centre of the faceplate.

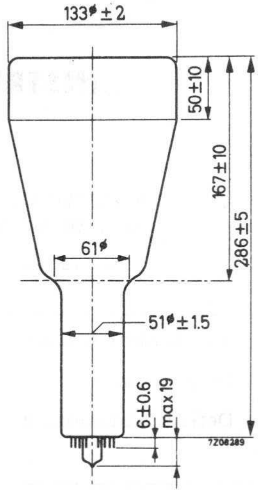
HEATING: Indirect by A.C. or D.C.; parallel supply

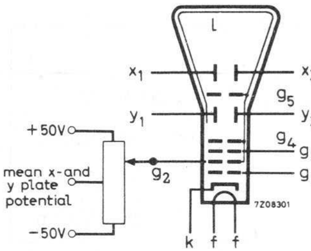
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

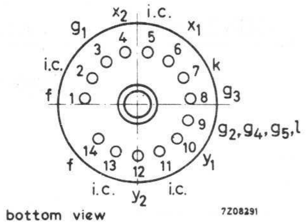
Data based on pre-production tubes

MECHANICAL DATA (Dimensions in mm)









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length	max.	310	mm
Face diameter	max.	135	mm

Base 14 pin all glass

Net weight	approx.	650	g

Accessories

Socket (supplied with tube)	type	55566
Mu-metal shield	type	55580

CAPACITANCES

x_1 to all other elements except x_2	$C_{x1(x2)}$	4	pF
x_2 to all other elements except x_1	$C_{x2(x1)}$	4	pF
y_1 to all other elements except y_2	$C_{y1(y2)}$	3.5	pF
y_2 to all other elements except y_1	$C_{y2(y1)}$	3.5	pF
x_1 to x_2	C_{x1x2}	2.5	pF
y_1 to y_2	C_{y1y2}	1.5	pF
Control grid to all other elements	C_{g1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam, hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90 \pm 1^{\circ}$

LINE WIDTH 3)

Measured with the shrinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current I_ℓ = 10 μA.1)

Line width l.w. 0.30 mm

1) As the construction of this tube does not permit a direct measurement of the beam current, this current should be determined as follows:
a) under typical operating conditions, apply a small raster display (no overscan), adjust V_{g1} for a beam current of approx. 10 μA and adjust V_{g3} and $V_{g2,g4,g5,\ell}$ for optimum spot quality at the centre of the screen.
b) under these conditions, but no raster, the deflection plate voltages should be changed to
$V_{y1} = V_{y2} = 2000$ V; $V_{x1} = 1300$ V; $V_{x2} = 1700$ V, thus directing the total beam current to x2.
Measure the current on x_2 and adjust V_{g1} for $I_{x2} = 10$ μA (being the beam current I_ℓ)
c) set again for the conditions under a), without touching the V_{g1} control. Now a raster display with a true 10 μA screen current is achieved.
d) focus optimally in the centre of the screen (do not adjust the astigmatism control) and measure the line width.

3) See page 4

TYPICAL OPERATING CONDITIONS [3]

Accelerator voltage	$V_{g2,g4,g5,\ell}$		2000	V	
Astigmatism control voltage	$\Delta V_{g2,g4,g5,\ell}$		$\pm$ 50	V	1)
Focusing electrode voltage	V_{g3}	approx.	300	V	
Control grid voltage for visual extinction of focused spot	V_{g1}	approx.max.	-65	V	
Deflection factor, horizontal	M_x		31	V/cm	
vertical	M_y		15	V/cm	
Deviation of linearity of deflection		max.	2	%	2)
Useful scan, horizontal		min.	100	mm	
vertical		min.	80	mm	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g2,g4,g5,\ell}$	max.	2200	V
		min.	1500	V
Focusing electrode voltage	V_{g3}	max.	2200	V
Control grid voltage, negative	$-V_{g1}$	max.	200	V
		min.	0	V
Cathode to heater voltage	V_{kf}	max.	125	V
	$-V_{kf}$	max.	125	V
Grid drive, average		max.	20	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2

---

1) The astigmatism control electrode voltage should once be adjusted for optimum spot shape in the centre of the screen. For any necessary adjustment the control voltage will be within the stated range, if the mean x and certainly the mean y plate potentials are equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

2) The sensitivity at a deflection of less than 75 % of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

3) The mean x and certainly the mean y plate potentials should be equal to $V_{g2,g4,g5,\ell}$ with astigmatism adjustment set to zero.

INSTRUMENT CATHODE-RAY TUBE

14 cm diagonal, rectangular flat faced oscilloscope tube with mesh and metal backed screen.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g7(\ell)}$	10	kV
Display area		100 x 80	mm^2
Deflection factor, horizontal	M_x	15.5	V/cm
vertical	M_y	4.2	V/cm

SCREEN: Metal backed phosphor

	colour	persistence
D14-120GH	green	medium short

Useful screen dimensions	min.	100 x 80	mm^2
Useful scan at $V_{g7(\ell)}/V_{g2,g4}$ = 6.7			
horizontal	min.	100	mm
vertical	min.	80	mm
Spot eccentricity in horizontal and vertical directions		6	mm

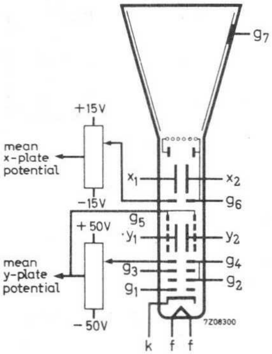
HEATING: Indirect by A.C. or D.C.;parallel supply

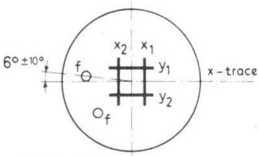
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

Data based on pre-production tubes

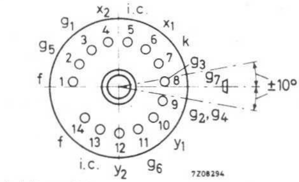
MECHANICAL DATA

Dimensions in mm

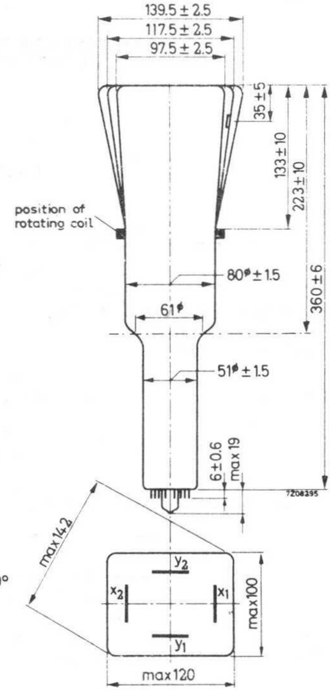




bottom view



bottom view



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Dimensions and connections

See also outline drawing

Overall length (socket included)	max.	385	mm
Face dimensions	max.	100 x 120	mm^2
Net weight	approx.	900	g

Base 14 pin all glass

Accessories

Socket (supplied with tube)	type	55566
Final accelerator contact connector	type	55563
Mu-metal shield	type	55581

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	7	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	7	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	5	pF
x_1 to x_2	$C_{x_1x_2}$	2.5	pF
y_1 to y_2	$C_{y_1y_2}$	1.5	pF
Control grid to all other elements	C_{g_1}	6	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90 \pm 1^{\circ}$

Angle between x trace and the horizontal axis of the face max. 5° [1])

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen under typical operating conditions, adjusted for optimum spot size at a beam current $I_{\ell} = 10\ \mu A$.

Line width l.w. approx. 0.40 mm

[1]) See page 5

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g7(\ell)}$		10000	V	
Interplate shield voltage	V_{g6}		1500	V	
Geometric control voltage	ΔV_{g6}		$\pm$ 15	V	2)
Deflection plate shield voltage	V_{g5}		1500	V	3)
Focusing electrode voltage	V_{g3}	approx.	310	V	
First accelerator voltage	$V_{g2,g4}$		1500	V	
Astigmatism control voltage	$\Delta V_{g2,g4}$		$\pm$ 50	V	4)
Control grid voltage for visual extinction of focused spot	V_{g1}	approx.	- 60	V	
Deflection factor, horizontal	M_x	approx.	15.5	V/cm	
vertical	M_y	approx.	4.2	V/cm	
Useful scan, horizontal		min.	100	mm	
vertical		min.	80	mm	

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g7(\ell)}$	max.	11000	V
		min.	9000	V
Interplate shield voltage and geometry control electrode voltage	V_{g6}	max.	2200	V
Deflection plate shield voltage	V_{g5}	max.	2200	V
Focusing electrode voltage	V_{g3}	max.	2200	V
First accelerator and astigmatism control electrode voltage	$V_{g2,g4}$	max.	2200	V
		min.	1350	V
Control grid voltage	$-V_{g1}$	max.	200	V
		min.	0	V
Cathode to heater voltage	V_{kf}	max.	125	V
	$-V_{kf}$	max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g4/x}$	max.	500	V
	$V_{g4/y}$	max.	500	V
Grid drive, average		max.	20	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2
Ratio $V_{g7(\ell)}/V_{g2,g4}$	$V_{g7(\ell)}/V_{g2,g4}$	max.	6.7	

For notes see page 5

Notes

1) In order to align the x-trace with the horizontal axis of the screen, the whole picture can be rotated by means of a rotation coil. This coil will have 50 amp. turns for the indicated max. rotation of 5^{o} and should be positioned as indicated in the drawing.

2) This tube is designed for optimum performance when operating at a ratio $V_{g7}/V_{g2,g4}$ not higher than 6.7

The geometric electrode voltage should be adjusted within the indicated range (values with respect to the mean x-plate potential).

A negative control voltage will cause some pincushion distrotion and less background light, a positive control voltage will give some barrel distortion and a slight increase of background light.

3) The deflection plate shield voltage should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

4) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

INSTRUMENT CATHODE-RAY TUBE

Low accelerator voltage cathode-ray tube for monitoring purpose

QUICK REFERENCE DATA				
Accelerator voltage	$V_{g_4, g_2, y_2(\ell)}$	=	500	V
Display area	Both directions full scan			
Deflection factor, horizontal	M_x	=	56.5	V/cm
vertical	M_y	=	49	V/cm

SCREEN

	Colour	Persistence
DH3-91	green	medium short

Useful screen diameter min. 28 mm

Useful scan

horizontal full scan

vertical full scan

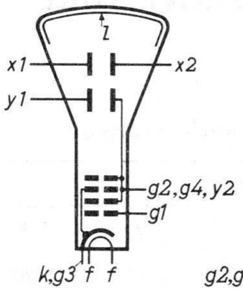
HEATING:

Indirect by A.C. or D.C.; parallel supply

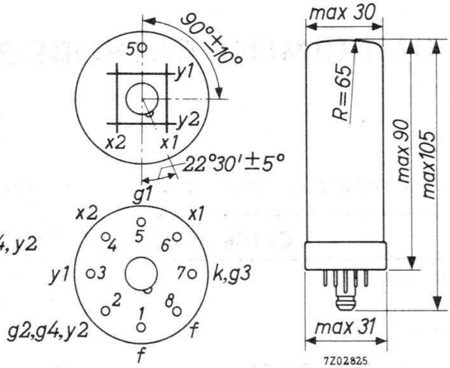
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm



7Z02826



7Z02825

Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube

Base	English Loctal 8 pins		
Dimensions and connections			
See also outline drawing			
Overall length	max.	105	mm
Face diameter	max.	30	mm
Net weight:	approx.	39	g
Accessories			
Socket	type	2422 501 05001	
Mu-metal shield	type	55525	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.5	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.0	pF
Control grid to all other elements	C_{g_1}	=	5.6	pF

FOCUSING electrostatic self focusing

DEFLECTION double electrostatic

x plates symmetrical

y plates asymmetrical

LINE WIDTH

Measured on a circle of 25 mm diameter

Accelerator voltage	$V_{g_4, g_2, y_2(\ell)}$	=	500	V
Beam current	$I(\ell)$	=	0.5	μA
Line width	l.w.	=	0.6	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_4, g_2, y_2(\ell)}$	=	500	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	8 to 27	V
Deflection factor				
horizontal	M_x	=	41 to 72	V/cm
vertical	M_y	=	35 to 63	V/cm
Useful scan				
horizontal			full scan	
vertical			full scan	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g_4, g_2, y_2(\ell)}$	= max.	1000	V
		= min.	350	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
positive peak	$V_{g_{1p}}$	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	16 to 54	V per kV of V_{g_4, g_2, y_2}
Deflection factor				
horizontal	M_x	=	90 to 120	V/cm per kV of V_{g_4, g_2, y_2}
vertical	M_y	=	38.5 to 52.5	V/cm per kV of V_{g_4, g_2, y_2}
Control grid circuit resistance	R_{g_1}	= max.	1	MΩ
Deflection plate circuit resistance	R_x, R_y	= max.	5	MΩ

REMARK

A contrast improving transparent conductive coating connected to the accelerator electrode is present between glass and fluorescent layer. This enables the application of a high potential with respect to earth to the accelerator electrode, without the risk of picture distortion by touching the face (electrostatic body-effect).

INSTRUMENT CATHODE-RAY TUBE

Cathode-ray tube for monitoring purposes.

QUICK REFERENCE DATA				
Accelerator voltage	$V_{g_3(\ell)}$	=	800	V
Display area	Both directions full scan			
Deflection factor, horizontal	M_x	=	62.5	V/cm
vertical	M_y	=	40	V/cm

SCREEN

	colour	persistence
DB7-5	blue	medium short
DG7-5	yellowish green	medium short
DP7-5	yellowish green	long

Useful screen diameter min. 65 mm

Useful scan

horizontal full scan

vertical full scan

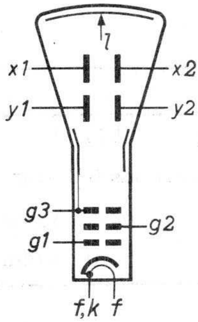
HEATING

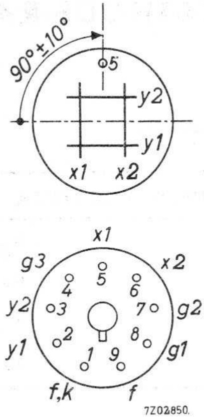
Indirect by A.C. or D.C.; parallel supply

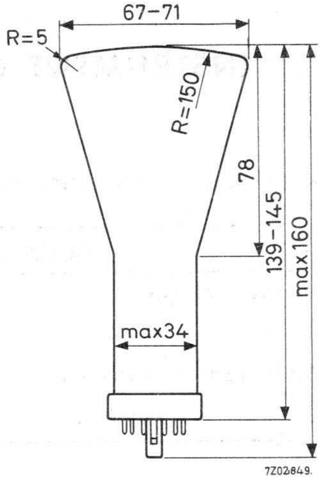
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base English Loctal 9 pins

Dimensions and connections

See also outline drawing

Overall length	max.	160	mm
Face diameter	max.	71	mm

Net weight:	approx.	140	g

Accessories

Socket	type	2422 502 04001
Mu-metal shield	type	55530

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1}(x_2)$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2}(x_1)$	=	2.8	pF
y_1 to all other elements except y_2	$C_{y_1}(y_2)$	=	3.0	pF
y_2 to all other elements except y_1	$C_{y_2}(y_1)$	=	3.3	pF
x_1 to x_2	$C_{x_1x_2}$	=	0.8	pF
y_1 to y_2	$C_{y_1y_2}$	=	0.6	pF
Control grid to all other elements	C_{g_1}	=	7.0	pF
Cathode to all other elements	C_k	=	3.2	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

Angle between x and y traces $90^o \pm 1.5^o$

LINE WIDTH

Measured on a circle of 50 mm diameter

Accelerator voltage	$V_{g_3(\ell)}$	=	800	V
Beam current	$I_{(\ell)}$	=	0.5	μA
Line width	l.w.	=	0.4	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_3(\ell)}$	=	800	V
Focusing electrode voltage	V_{g_2}	=	200 to 300	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	max. 50	V
Deflection factor, horizontal	M_x	=	53 to 72	V/cm
vertical	M_y	=	33 to 45	V/cm
Geometry distortion			See note 1 page 4	
Useful scan, horizontal			full scan	
vertical			full scan	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g3(\ell)}$	= max.	1000	V
		= min.	800	V
Focusing electrode voltage	V_{g2}	= max.	400	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between accelerator electrode and any deflection plate	$V_{g3/x}$	= max.	500	V
	$V_{g3/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g2}	= 250 to 375	V per kV of V_{g3}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	= 0 to 62.5	V per kV of V_{g3}
Deflection factor			
horizontal	M_x	= 66 to 90	V/cm per kV of V_{g3}
vertical	M_y	= 41 to 56	V/cm per kV of V_{g3}
Control grid circuit resistance	R_{g1}	= max. 0.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max. 5	MΩ

[1]) A graticule, consisting of concentric rectangles of 43.2 mm x 43.2 mm and 40 mm x 40 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

INSTRUMENT CATHODE-RAY TUBE

Cathode-ray tube for monitoring purposes.

QUICK REFERENCE DATA				
Accelerator voltage	$V_{g3(\ell)}$	=	800	V
Display area	Both directions full scan			
Deflection factor, horizontal	M_x	=	62.5	V/cm
vertical	M_y	=	40	V/cm

SCREEN

	colour	persistence
DB7-6	blue	medium short
DG7-6	yellowish green	medium short
DP7-6	yellowish green	long

Useful screen diameter min. 65 mm

Useful scan

horizontal full scan

vertical full scan

HEATING

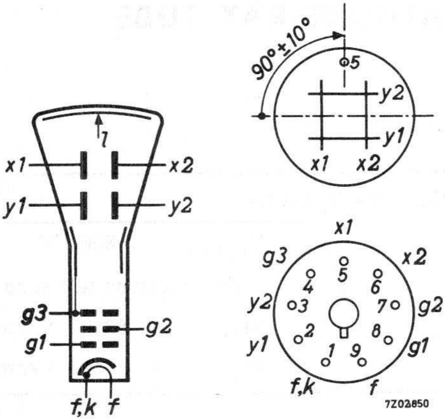
Indirect by A.C. or D.C.; parallel supply

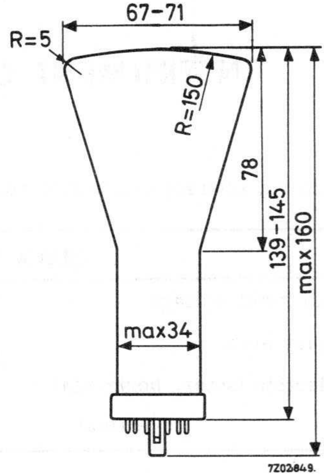
Heater voltage $\underline{V_f = 6.3 \text{ V}}$

Heater current $I_f = 300$ mA

MECHANICAL DATA

Dimensions in mm





Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	English Loctal 9 pins		
Dimensions and connections			
See also outline drawing			
Overall length	max.	160	mm
Face diameter	max.	71	mm
Net weight:	approx.	140	g
Accessories			
Socket	type	2422 502 04001	
Mu-metal shield	type	55530	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	2.8	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	2.8	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.0	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.3	pF
x_1 to x_2	$C_{x_1x_2}$	=	0.8	pF
y_1 to y_2	$C_{y_1y_2}$	=	0.6	pF
Control grid to all other elements	C_{g_1}	=	7.0	pF
Cathode to all other elements	C_k	=	3.2	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates: asymmetrical
x_1 has to be connected to the accelerator electrode. Earthing of the accelerator electrode is recommended.

y plates: symmetrical

Angle between x and y traces $90^o \pm 1.5^o$

LINE WIDTH

Measured on a circle of 50 mm diameter

Accelerator voltage	$V_{g_3(\ell)}$	=	800	V
Beam current	$I_{(\ell)}$	=	0.5	μA
Line width	l.w.	=	0.4	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_3(\ell)}$	=	800	V
Focusing electrode voltage	V_{g_2}	=	200 to 300	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	max. 50	V
Deflection factor, horizontal	M_x	=	53 to 72	V/cm
vertical	M_y	=	33 to 45	V/cm
Geometry distortion			See note 1 page 4	
Useful scan, horizontal			full scan	
vertical			full scan	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g3(\ell)}$	= max.	1000	V
		= min.	800	V
Focusing electrode voltage	V_{g2}	= max.	400	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between accelerator electrode and any deflection plate	$V_{g3/x}$	= max.	500	V
	$V_{g3/y}$	= max.	500	V
Screen dissipation	W_{ℓ}	= max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g2}	= 250 to	375	V per kV of V_{g3}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	0 to 62.5	V per kV of V_{g3}
Deflection factor				
horizontal	M_x	= 66 to	90	V/cm per kV of V_{g3}
vertical	M_y	= 41 to	56	V/cm per kV of V_{g3}
Control grid circuit resistance	R_{g1}	= max.	0.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max.	5	MΩ

[1]) A graticule, consisting of concentric rectangles of 43.2 mm x 43.2 mm and 40 mm x 40 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with 7 cm diameter flat face plate and post deflection acceleration by means of a helical electrode. The low heater consumption together with the high sensitivity render this tube suitable for transistorized equipment.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g_6(\ell)}$	=	1200	V
Display area		=	4.5x6	cm
Deflection factor, horizontal	M_x	=	10.7	V/cm
vertical	M_y	=	3.65	V/cm

SCREEN

	Colour	Persistence
DB7-11	blue	medium short
DH7-11	green	medium short
DN7-11	bluish green	medium short
DP7-11	yellowish green	long

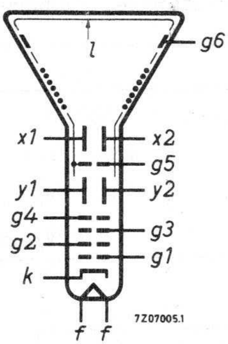
Useful screen diameter	min.	68	mm
Useful scan at $V_{g_6(\ell)}/V_{g_4} = 4$			
horizontal	min.	60	mm
vertical	min.	45	mm

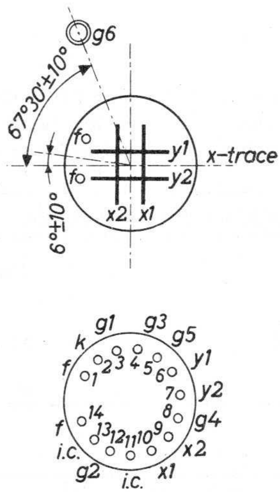
HEATING

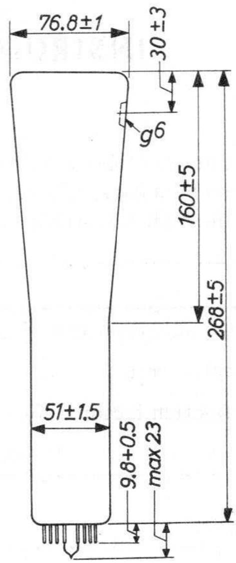
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	95	mA

→ **MECHANICAL DATA** (Dimensions in mm)







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube

Base 14 pins all glass

Dimensions and connections

Overall length	max.	296	mm
Face diameter	max.	77.8	mm

Net weight	approx.	370	g

Accessories

Socket (supplied with tube)	type	40467
Final accelerator contact connector	type	55563
Mu-metal shield	type	55532

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4.0 pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4.0 pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.5 pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.5 pF
x_1 to x_2	$C_{x_1x_2}$	=	1.9 pF
y_1 to y_2	$C_{y_1y_2}$	=	1.7 pF
Control grid to all other elements	C_{g_1}	=	5.7 pF
Cathode to all other elements	C_k	=	3.0 pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^o \pm 1^o$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_6(\ell)}$	=	1200	V
Astigmatism control electrode voltage	V_{g_4}	=	300	V [2]
First accelerator voltage	V_{g_2}	=	1200	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.65	mm

HELIX

Post deflection accelerator helix resistance min. 40 MΩ

[2]) See page 6

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g6(\ell)}$	=	1200	V
Geometry control electrode voltage	V_{g5}	=	300 ± 30	V 1)
Astigmatism control electrode voltage	V_{g4}	=	$300 \pm^{40}_{15}$	V 2)
Focusing electrode voltage	V_{g3}	=	20 to 150	V
First accelerator voltage	V_{g2}	=	1200	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	30 to 80	V
Deflection factor				
horizontal	M_x	=	9.4 to 12	V/cm
vertical	M_y	=	3.2 to 4.1	V/cm
Deviation of linearity of deflection		=	max. 2	% 3)
Geometry distortion			See note 4)	
Useful scan				
horizontal		=	min. 60	mm
vertical		=	min. 40	mm

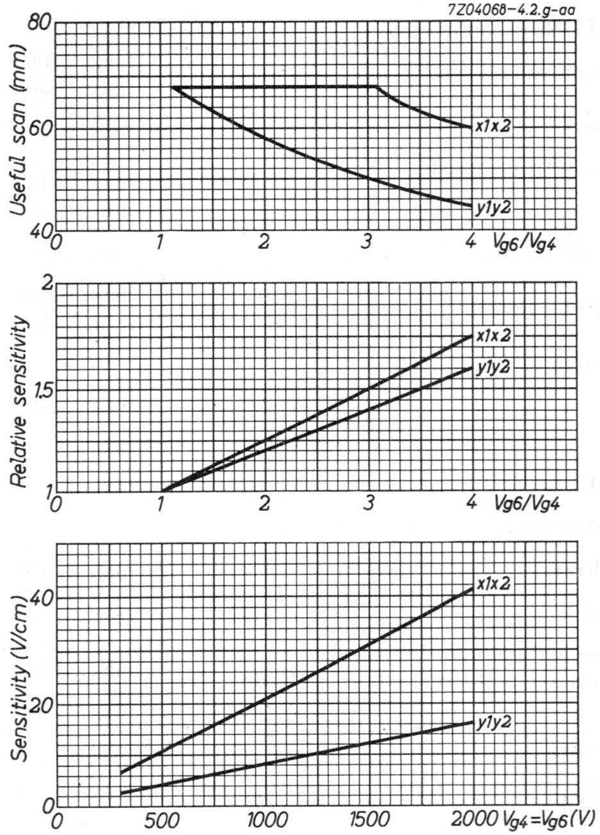
CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	=	35 to 165	V per kV of V_{g4}
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	30 to 60	V per kV of V_{g2}
Deflection factor at $V_{g6(\ell)}/V_{g4} = 4$				
horizontal	M_x	=	31.3 to 40.0	V/cm per kV of V_{g4}
vertical	M_y	=	10.7 to 13.7	V/cm per kV of V_{g4}
Control grid circuit resistance	R_{g1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 50	kΩ
Focusing electrode current	I_{g3}	=	−15 to +10	μA 5)

1)2)3)4)5) See page 6

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_6(\ell)}$	= max.	5000	V
		= min.	1200	V
Geometry control electrode voltage	V_{g_5}	= max.	2200	V
Astigmatism control electrode voltage	V_{g_4}	= max.	2100	V
		= min.	300	V
Focusing electrode voltage	V_{g_3}	= max.	1000	V
First accelerator voltage	V_{g_2}	= max.	1600	V
		= min.	800	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
positive peak	$V_{g_{1p}}$	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	100	V
cathode negative	$V_{-k/f+}$	= max.	15	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g_4/x}$	= max.	500	V
	$V_{g_4/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Ratio $V_{g_6(\ell)}/V_{g_4}$	$V_{g_6(\ell)}/V_{g_4}$	= max.	4	



1) This tube is designed for optimum performance when operating at the ratio $V_{g_6}(\ell)/V_{g_4} = 4$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

3) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

4) A graticule, consisting of concentric rectangles of 40.8 mm x 40.8 mm and 39.2 mm x 39.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

5) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

Low accelerator voltage cathode-ray tube for monitoring purposes.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g4,g2(\ell)}$	=	500	V
Display area	Both directions full scan			
Deflection factor, horizontal	M_x	=	37	V/cm
vertical	M_y	=	21	V/cm

SCREEN

	Colour	Persistence
DG7-31	yellowish green	medium

Useful screen diameter	min. 65 mm
Useful scan	
horizontal	full scan
vertical	full scan

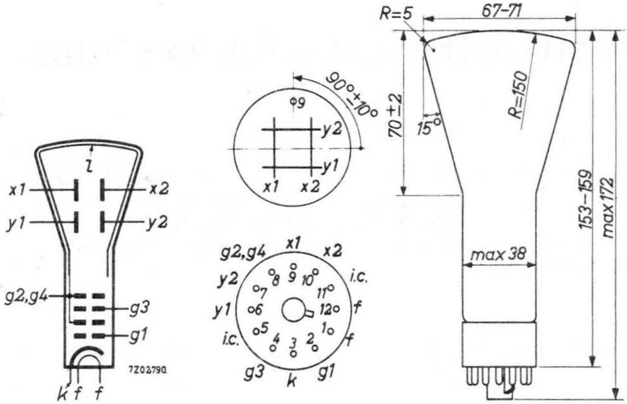
HEATING

Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Duodecal 12 pins

Dimensions and connections

See also outline drawing			
Overall length	max.	172	mm
Face diameter	max.	71	mm

Net weight:	approx.	120	g

Accessories

Socket	type	2422 516 00001
Mu-metal shield	type	55530

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	3.7	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	3.0	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	2.5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	2.5	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.7	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.0	pF
Control grid to all other elements	C_{g_1}	=	7.6	pF
Cathode to all other elements	C_k	=	3.2	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates asymmetrical

y plates symmetrical

Angle between x and y traces $90^o \pm 1.5^o$

LINE WIDTH

Measured on a circle of 50 mm diameter

Accelerator voltage	$V_{g_4,g_2(\ell)}$	=	500	V
Beam current	$I_{(\ell)}$	=	0.5	μA
Line width	l.w.	=	0.4	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_4,g_2(\ell)}$	=	500	V
Focusing electrode voltage	V_{g_3}	=	0 to 120	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	50 to 100	V
Deflection factor, horizontal	M_x	=	33.3 to 41.5	V/cm
vertical	M_y	=	18.8 to 23.2	V/cm
Geometry distortion			See note 1 page 4	
Useful scan, horizontal			full scan	
vertical			full scan	

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g_4,g_2(\ell)}$	= max.	800	V
		= min.	400	V
Focusing electrode voltage	V_{g_3}	= max.	200	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
positive peak	$V_{g_{1p}}$	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between accelerator electrode and any deflection plate	$V_{g_4/x}$	= max.	500	V
	$V_{g_4/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g_3}	=	0 to 240	V per kV of V_g
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	100 to 200	V per kV of V_{g_2}
Deflection factor at $V_{g(\ell)}/V_g$				
horizontal	M_x	=	67 to 83	V/cm per kV of V_g
vertical	M_y	=	37.6 to 46.4	V/cm per kV of V_g
Control grid circuit resistance	R_{g_1}	= max.	0.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max.	5	MΩ
Focusing electrode current	I_g	=	-15 to +10	μA [2]

[1]) A graticule, consisting of concentric rectangles of 43.2 mm x 43.2 mm and 40 mm x 40 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[2]) Values to be taken into account for the calculation of the focus potentiometer.

Remark: A contrast improving transparent conductive coating connected to g_4, g_2 is present between glass and fluorescent layer. This enables the application of a high potential to g_4, g_2 with respect to earth, without the risk of picture distortion by touching the face (electrostatic body-effect)

INSTRUMENT CATHODE-RAY TUBE

Low accelerator voltage cathode-ray tube for monitoring purposes.

QUICK REFERENCE DATA		
Final accelerator voltage	$V_{g_4g_2(\ell)}$ =	500 V
Display area		Both directions full scan
Deflection factor, horizontal	M_x =	37 V/cm
vertical	M_y =	21 V/cm

SCREEN

	Colour	Persistence
DG7-32	yellowish green	medium

Useful screen diameter	min. 65 mm
Useful scan	
horizontal	full scan
vertical	full scan

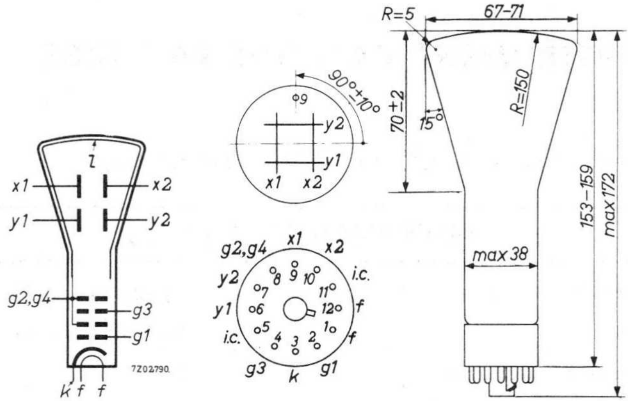
HEATING

Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f = 6.3 V
Heater current	I_f = 300 mA

→ MECHANICAL DATA

Dimensions in mm



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Duodecal 12 pins

Dimensions and connections

See also outline drawing

Overall length	max.	172	mm
Face diameter	max.	71	mm

Net weight:	approx.	120	g

Accessories

Socket	type	2422 516 00001
Mu-metal shield	type	55530

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	= 3.7 pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	= 3.0 pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	= 2.5 pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	= 2.5 pF
x_1 to x_2	$C_{x_1x_2}$	= 1.7 pF
y_1 to y_2	$C_{y_1y_2}$	= 1.0 pF
Control grid to all other elements	C_{g_1}	= 7.6 pF
Cathode to all other elements	C_k	= 3.2 pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

Angle between x and y traces $90^o \pm 1.5^o$

LINE WIDTH

Measured on a circle of 50 mm diameter

Accelerator voltage	$V_{g_4, g_2(\ell)}$	= 500 V
Beam current	$I_{(\ell)}$	= 0.5 μA
Line width	l.w.	= 0.4 mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_4, g_2(\ell)}$	= 500 V
Focusing electrode voltage	V_{g_3}	= 0 to 120 V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 50 to 100 V
Deflection factor, horizontal	M_x	= 33.3 to 41.5 V/cm
vertical	M_y	= 18.8 to 23.2 V/cm
Geometry distortion		See note 1 page 4
Useful scan, horizontal		full scan
vertical		full scan

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g4,g2(\ell)}$	= max.	800	V
		= min.	400	V
Focusing electrode voltage	V_{g3}	= max.	200	V
Control grid voltage				
negative	$-V_{g1}$	= max.	200	V
positive	V_{g1}	= max.	0	V
positive peak	V_{g1p}	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between accelerator electrode and any deflection plate	$V_{g4/x}$	= max.	500	V
	$V_{g4/y}$	= max.	500	V
Screen dissipation	W_{ℓ}	= max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	=	0 to 240	V per kV of V_g
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	=	100 to 200	V per kV of V_{g2}
Deflection factor at $V_{g4g2(\ell)}/V_g$				
horizontal	M_x	=	67 to 83	V/cm per kV of V_g
vertical	M_y	=	37.6 to 46.4	V/cm per kV of V_g
Control grid circuit resistance	R_{g1}	= max.	0.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max.	5	MΩ
Focusing electrode current	I_g	=	-15 to +10	μA [2])

[1]) A graticule, consisting of concentric rectangles of 43.2 mm x 43.2 mm and 40 mm x 40 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[2]) Values to be taken into account for the calculation of the focus potentiometer.

Remark: A contrast improving transparent conductive coating connected to g_4, g_2 is present between glass and fluorescent layer. This enables the application of a high potential to g_4, g_2 with respect to earth, without the risk of picture distortion by touching the face (electrostatic body-effect)

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with 7 cm diameter flat face-plate. The tube is intended for small service oscilloscopes.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g_4g_2(\ell)}$	=	1500	V
Display area		=	5.7 x 6.8	cm
Deflection factor, horizontal	M_x	=	27.3	V/cm
vertical	M_y	=	18.8	V/cm

SCREEN

	Colour	Persistence
DB7-36	blue	medium short
DG7-36	yellowish green	medium
DN7-36	bluish green	medium short

Useful scan

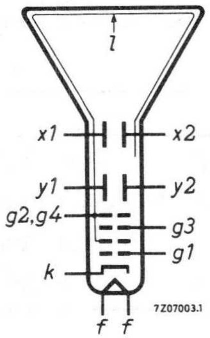
horizontal	min.	68	mm
vertical	min.	57	mm

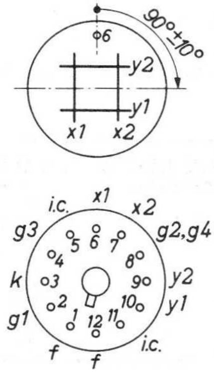
HEATING

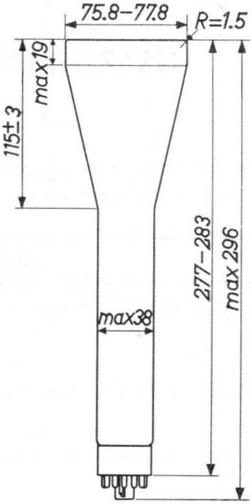
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

→ **MECHANICAL DATA** Dimensions in mm







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base Duodecal 12 pins

Dimensions and connections

See also outline drawing

Overall length	max.	296	mm
Face diameter	max.	77.8	mm
Net weight:	approx.	370	g

Accessories

Socket	type	2422 516 00001
Mu-metal shield	type	55531

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	6.0	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	6.0	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	4.7	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	4.7	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.9	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.7	pF
Control grid to all other elements	C_{g_1}	=	5.7	pF
Cathode to all other elements	C_k	=	3.3	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90^{\circ} \pm 1^{\circ}$

LINE WIDTH

Measured on a circle of 50 mm diameter

Final accelerator voltage	$V_{g_4, g_2(\ell)}$	=	1500	V
Beam current	$I_{(\ell)}$	=	0.5	μA
Line width	l.w.	=	0.4	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_4, g_2(\ell)}$	= 1500	V
Focusing electrode voltage	V_{g_3}	= 247 to 397	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 40 to 80	V
Deflection factor			
horizontal	M_x	= 24.5 to 30	V/cm
vertical	M_y	= 17.0 to 20.5	V/cm
Deviation of linearity of deflection		= max. 2	% [1]
Geometry distortion		See note 2	
Useful scan			
horizontal		= min. 68	mm
vertical		= min. 57	mm

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_4, g_2(\ell)}$	= max. 2500 = min. 1000	V V
Focusing electrode voltage	V_{g_3}	= max. 1000	V
Control grid voltage			
negative	$-V_{g_1}$	= max. 200	V
positive	V_{g_1}	= max. 0	V
positive peak	$V_{g_{1p}}$	= max. 2	V
Cathode to heater voltage			
cathode positive	$V_{+k/f-}$	= max. 200	V
cathode negative	$V_{-k/f+}$	= max. 125	V
Voltage between final accelerator and any deflection plate	$V_{g_4, g_2/x_p}$	= max. 500	V
	$V_{g_4, g_2/y_p}$	= max. 500	V
Screen dissipation	W_ℓ	= max. 3	mW/cm^2

[1][2]) See page 5

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	= 165 to 265	V per kV of $V_{g4,g2}$
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	= 27 to 53	V per kV of $V_{g4,g2}$
Deflection factor			
horizontal	M_x	= 16.3 to 20.0	V/cm per kV of $V_{g4,g2}$
vertical	M_y	= 11.2 to 13.7	V/cm per kV of $V_{g4,g2}$
Control grid circuit resistance	R_{g1}	= max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max. 5	MΩ
Focusing electrode current	I_{g3}	= −15 to +10	μA [3]

[1]) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

[2]) A graticule, consisting of concentric rectangles of 40.8 mm x 40.8 mm and 39.2 mm x 39.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[3]) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

Oscilloscope tube with 7 cm diameter flat faceplate and post deflection acceleration by means of a helical electrode. The tube is intended for small service oscilloscopes.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g6(\ell)}$	=	1200	V
Display area		=	4.5x6	cm
Deflection factor, horizontal	M_x	=	10.7	V/cm
vertical	M_y	=	3.65	V/cm

SCREEN

	Colour	Persistence
DB7-78	blue	medium short
DH7-78	green	medium short
DN7-78	bluish green	medium short
DP7-78	yellowish green	long

Useful screen diameter min. 68 mm

Useful scan at $V_{g6(\ell)}/V_{g4} = 4$

horizontal min. 60 mm

vertical min. 45 mm

HEATING

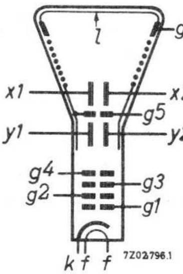
Indirect by A.C. or D.C.; parallel supply

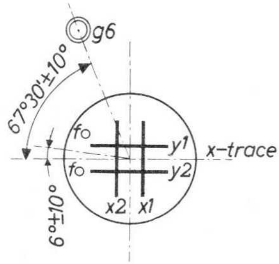
Heater voltage V_f = 6.3 V

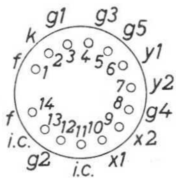
Heater current I_f = 300 mA

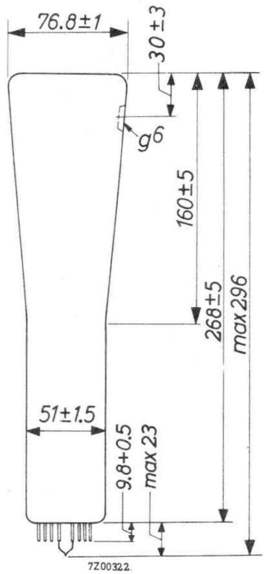
→ **MECHANICAL DATA**

Dimensions in mm









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pins all glass		
Dimensions and connections			
Overall length	max.	296	mm
Face diameter	max.	77.8	mm
Net weight	approx.	370	g
Accessories			
Socket (supplied with the tube)	type	40467	
Final accelerator contact connector	type	55563	
Mu-metal shield	type	55532	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	3.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	3.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.0	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.0	pF
x_1 to x_2	$C_{x_1x_2}$	=	1.7	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.6	pF
Control grid to all other elements	C_{g_1}	=	3.5	pF
Cathode to all other elements	C_k	=	2.6	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90 \pm 1^{\circ}$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_6(\ell)}$	=	1200	V
Astigmatism control electrode voltage	V_{g_4}	=	300	V [2)]
First accelerator voltage	V_{g_2}	=	1200	V
Beam current	$I_{(\ell)}$	=	10	μA
Line width	l.w.	=	0.65	mm

HELIX

Post deflection accelerator helix resistance min. 40 MΩ

2) See page 5

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_6(\ell)}$	= 1200	4000	V	
Geometry control electrode voltage	V_{g_5}	= 300 ± 30	1000 ± 100	V	1)
Astigmatism control electrode voltage	V_{g_4}	= 300 ± 40	1000 ± 50	V	2)
Focusing electrode voltage	V_{g_3}	= 20 to 150	35 to 165	V	
First accelerator voltage	V_{g_2}	= 1200	1000	V	
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 36 to 72	30 to 60	V	
Modulation voltage for $I(\ell) = 10\ \mu A$	V_{g_1}	= max. 25	max. 25	V	
Deflection factor					
horizontal	M_x	= 9.4 to 12	31.3 to 40.0	V/cm	
vertical	M_y	= 3.2 to 4.1	10.7 to 13.7	V/cm	
Deviation of linearity of deflection		= max. 2	max. 2	%	3)
Geometry distortion		See note 4			
Useful scan					
horizontal		= min. 60	60	mm	
vertical		= min. 45	45	mm	

CIRCUIT DESIGN VALUES

Focusing voltage	V_g	= 35 to 165	V per kV of V_{g_4}
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	= 30 to 60	V per kV of V_{g_2}
Deflection factor at $V_{g_6(\ell)}/V_{g_4} = 4$			
horizontal	M_x	= 31.3 to 40.0	V/cm per kV of V_{g_4}
vertical	M_y	= 10.7 to 13.7	V/cm per kV of V_{g_4}
Control grid circuit resistance	R_{g_1}	= max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	= max. 50	kΩ
Focusing electrode current	I_{g_3}	= −15 to +10	μA 5)

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_6(\ell)}$	= max.	5000	V
		= min.	1200	V
Geometry control electrode voltage	V_{g_5}	= max.	2200	V
Astigmatism control electrode voltage	V_{g_4}	= max.	2100	V
		= min.	300	V
Focusing electrode voltage	V_{g_3}	= max.	1000	V
First accelerator voltage	V_{g_2}	= max.	1600	V
		= min.	800	V
Control grid voltage				
negative	$-V_{g_1}$	= max.	200	V
positive	V_{g_1}	= max.	0	V
positive peak	$V_{g_{1p}}$	= max.	2	V
Cathode to heater voltage				
cathode positive	$V_{+k/f-}$	= max.	200	V
cathode negative	$V_{-k/f+}$	= max.	125	V
Voltage between astigmatism control electrode and any deflection plate	$V_{g_4/x}$	= max.	500	V
	$V_{g_4/y}$	= max.	500	V
Screen dissipation	W_ℓ	= max.	3	mW/cm^2
Ratio $V_{g6(\ell)}/V_{g4}$	$V_{g6(\ell)}/V_{g4}$	= max.	4	

---

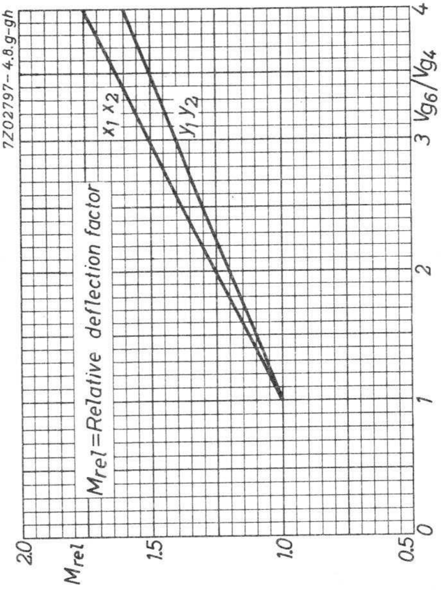
[1]) This tube is designed for optimum performance when operating at the ratio $V_{g_6(\ell)}/V_{g_4} = 4$. Operating at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

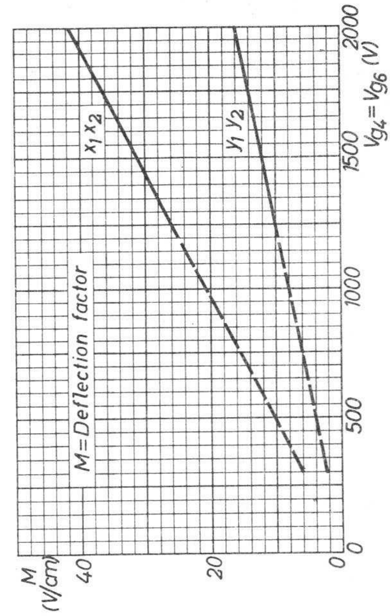
[2]) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

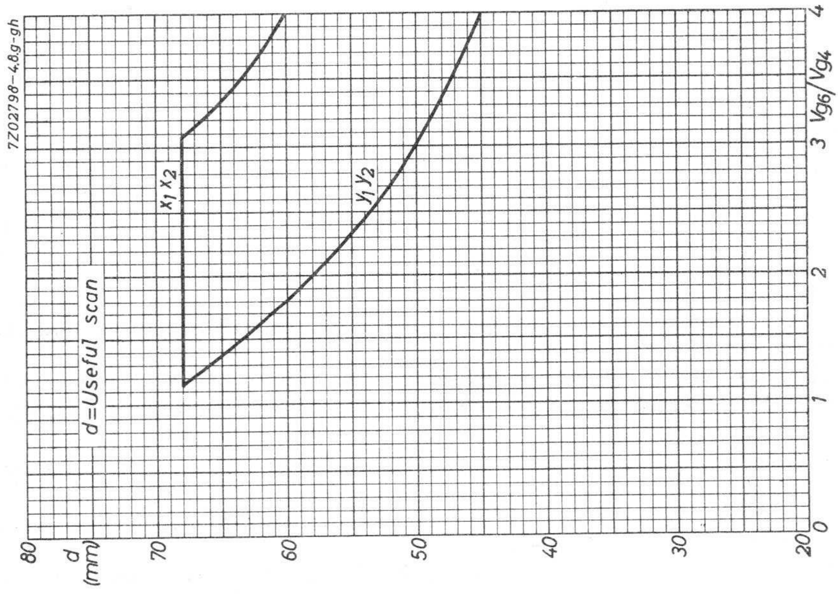
[3]) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

[4]) A graticule, consisting of concentric rectangles of 40.8 mm x 40.8 mm and 39.2 mm x 39.2 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[5]) Values to be taken into account for the calculation of the focus potentiometer.


7Z02797-4.8.g-gh
M_{rel}=Relative deflection factor
$x_1 x_2$
$y_1 y_2$
M_{rel}
2.0
1.5
1.0
0.5
0
1
2
3
4
V_{g6}/V_{g4}


M=Deflection factor
$x_1 x_2$
$y_1 y_2$
M (V/cm)
40
20
0
0
500
1000
1500
2000
$V_{g4}=V_{g6}$ (V)


7Z02798-4.8.g-gh
d=Useful scan
$x_1 x_2$
$y_1 y_2$
d (mm)
80
70
60
50
40
30
20
0
1
2
3
4
V_{g6}/V_{g4}

INSTRUMENT CATHODE-RAY TUBE

SCREEN

	colour	persistence
DB10-6 DG10-6 DP10-6	blue yellowish green yellowish green	medium short medium long

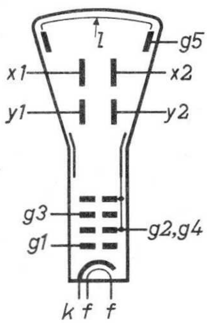
HEATING: Indirect by A.C. or D.C.; parallel supply

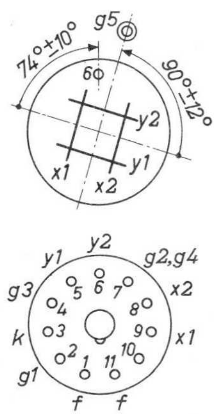
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

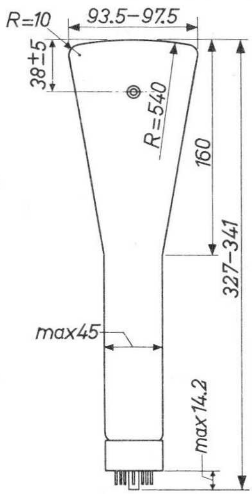
MECHANICAL DATA

Dimensions in mm

Base: Magnal







Accessories

Socket type 2422 515 00001

FOCUSING	electrostatic	
DEFLECTION	double electrostatic	
x plates	symmetrical	
y plates	symmetrical	
Angle between x and y traces		$90 + 1.5^{o}$

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_5(\ell)}$	4000	V
First accelerator voltage	V_{g_4,g_2}	2000	V
Focusing electrode voltage	V_{g_3}	400 to 720	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	45 to 100	V
Deflection factor, horizontal	M_x	40 to 52.5	V/cm
vertical	M_y	32 to 40	V/cm

LIMITING VALUES

Final accelerator voltage	$V_{g_5(\ell)}$	max. 5000	V
First accelerator voltage	V_{g_4,g_2}	max. 2500	V

INSTRUMENT CATHODE-RAY TUBE

SCREEN

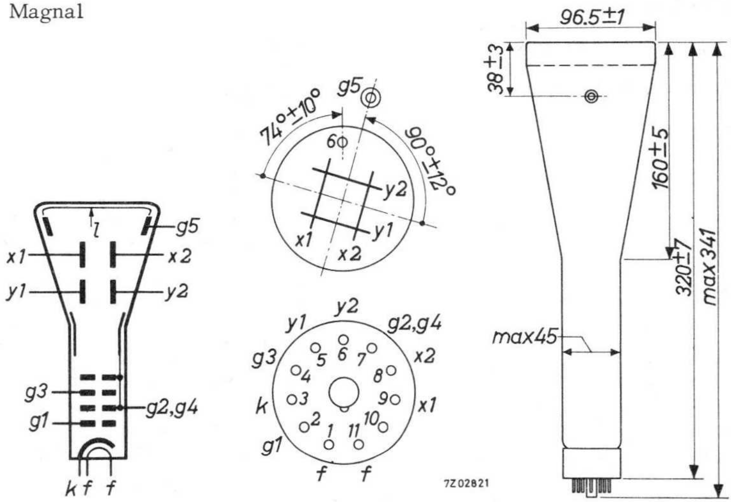
	colour	persistence
DB10-74	blue	medium short
DG10-74	yellowish green	medium
DP10-74	yellowish green	long

HEATING: Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

MECHANICAL DATA Dimensions in mm

Base: Magnal



Accessories

Socket type 2422 515 00001

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates	symmetrical	
y plates	symmetrical	
Angle between x and y traces		$90 + 1.5^{o}$

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g5(\ell)}$	4000	V
First accelerator voltage	$V_{g4,g2}$	2000	V
Focusing electrode voltage	V_{g3}	400 to 720	V
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	45 to 100	V
Deflection factor, horizontal	M_x	40 to 52.5	V/cm
vertical	M_y	32 to 40	V/cm

LIMITING VALUES

Final accelerator voltage	$V_{g5(\ell)}$	max. 5000	V
First accelerator voltage	$V_{g2,g4}$	max. 2500	V

INSTRUMENT CATHODE-RAY TUBE

General purpose cathode-ray tube with flat face and post deflection acceleration by means of a helical electrode.

QUICK REFERENCE DATA				
Final accelerator voltage	$V_{g(\ell)}$	=	4	kV
Display area		=	55x75	mm^2
Deflection factor, horizontal	M_x	=	34	V/cm
vertical	M_y	=	11	V/cm

SCREEN

	Colour	Persistence
DB10-78	blue	medium short
DH10-78	green	medium short
DN10-78	bluish green	medium short
DP10-78	yellowish green	long

Useful scan diameter min. 90 mm

Useful scan at $V_{g_6(\ell)}/V_{g_4,g_2} = 4$

horizontal	min.	75	mm
vertical	min.	55	mm

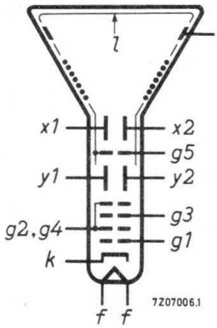
HEATING

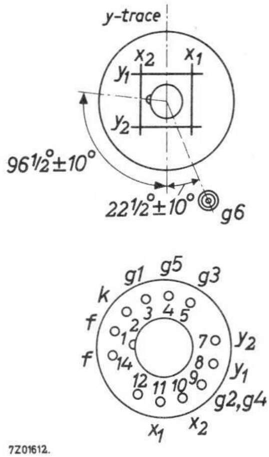
Indirect by A.C. or D.C.; parallel supply

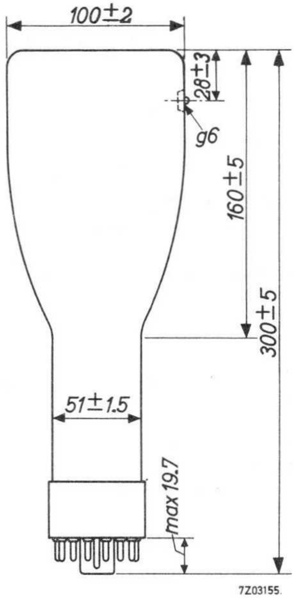
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

MECHANICAL DATA

Dimensions in mm







Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Diheptal 12 pins		
Dimensions and connections			
Overall length	max.	305	mm
Face diameter	max.	102	mm
Net weight	approx.	660	g
Accessories			
Socket	type	2422 517 00001	
Final accelerator contact connector	type	55560	
Mu-metal shield	type	55541	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	=	4	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	=	4	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	=	3.5	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	=	3.5	pF
x_1 to x_2	$C_{x_1x_2}$	=	2.1	pF
y_1 to y_2	$C_{y_1y_2}$	=	1.7	pF
Control grid to all other elements	C_{g_1}	=	5.0	pF
Cathode to all other elements	C_k	=	3.4	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

Is use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angle between x and y traces $90 \pm 1^{\circ}$

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_6(\ell)}$	=	4000	V
Astigmatism control electrode voltage	V_{g_4, g_2}	=	1000	V [2]
Beam current	$I(\ell)$	=	10	μA
Line width	l.w.	=	0.35	mm

HELIX

Post deflection accelerator helix resistance min. 50 MΩ

[2] See page 5

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_6(\ell)}$	=	4000	V
Geometry control electrode voltage	V_{g_5}	=	1000 $\pm$100	V [1])
Astigmatism control electrode voltage	V_{g_4, g_2}	=	1000 $\pm$ 50	V [2])
Focusing electrode voltage	V_{g_3}	=	150 to 350	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	22.5 to 37.5	V
Deflection factor				
horizontal	M_x	=	29 to 39	V/cm
vertical	M_y	=	9.4 to 12.6	V/cm
Deviation of linearity of deflection		=	max. 2	% [3])
Geometry distortion		=	See note 4	
Useful scan				
horizontal		=	min. 75	mm
vertical		=	min. 55	mm

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_6(\ell)}$	=	max. 8000	V
		=	min. 1500	V
Geometry control electrode voltage	V_{g_5}	=	max. 2200	V
Astigmatism control electrode voltage	V_{g_4, g_2}	=	max. 2100	V
		=	min. 1000	V
Focusing electrode voltage	V_{g_3}	=	max. 1500	V
Control grid voltage,				
negative	$-V_{g_1}$	=	max. 200	V
positive	V_{g_1}	=	max. 0	V
positive peak	$V_{g_{1p}}$	=	max. 2	V
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	=	max. 200	V
cathode negative	$V_{-k/f+}$	=	max. 125	V
Voltage between astigmatism control electrode	$V_{g_4, g_2/x}$	=	max. 500	V
and any deflection plate	$V_{g_4, g_2/y}$	=	max. 500	V
Screen dissipation	W	=	max. 3	mW/cm^2
Ratio $V_{g_6(\ell)}V_{g_4, g_2}$	$V_{g_6(\ell)}/V_{g_4, g_2}$	=	max. 4	

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g_3}	=	150 to 350	V per kV of V_{g_4, g_2}
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	=	22.5 to 37.5	V per kV of V_{g_4, g_2}
Deflection factor at $V_{g_6(\ell)}/V_{g_4, g_2} = 4$				
horizontal	M_x	=	29 to 39	V/cm per kV of V_{g_4, g_2}
vertical	M_y	=	9.4 to 12.6	V/cm per kV of V_{g_4, g_2}
Control grid circuit resistance	R_{g_1}	=	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	=	max. 1	MΩ
Focusing electrode current	I_g	=	+15 to −30	μA [5]

---

1) This tube is designed for optimum performance when operating at the ratio $V_{g_6(\ell)}/V_{g_4, g_2} = 4$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

3) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

4) A graticule, consisting of concentric rectangles of 51 mm x 51 mm and 49 mm x 49 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

5) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

The DG13-2 is a 13 cm spherical faced cathode ray tube primarily intended for inexpensive service oscilloscopes.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g_5}(\ell)$	4	kV
Display area	Both directions full scan		
Deflection factor, horizontal	M_x	31	V/cm
vertical	M_y	26.5	V/cm

SCREEN

	colour	persistence
DB 13-2	blue	medium short
DG13-2	yellowish green	medium
DP 13-2	yellowish green	long

Useful screen diameter	min.	114	mm
Useful scan, horizontal	full scan		
vertical	full scan		

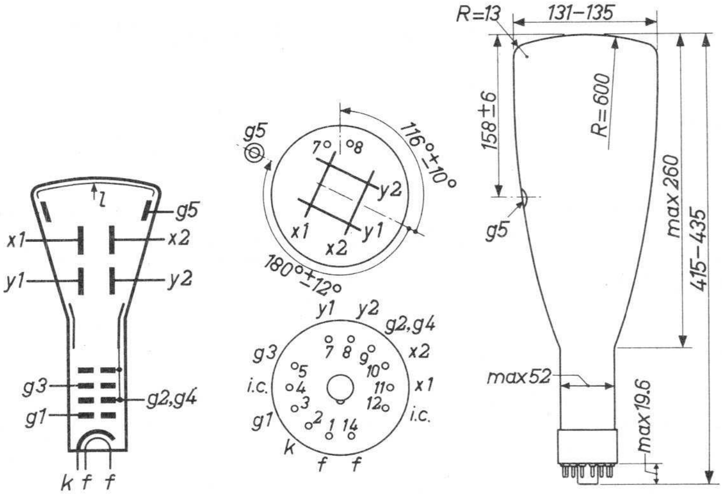
HEATING

Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

MECHANICAL DATA

Dimensions in mm



Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Diheptal		
Dimensions and connections			
Overall length	max.	435	mm
Face diameter	max.	135	mm
Accessories			
Socket	type	2422 517 00001	
Final accelerator contact connector	type	55560	
Mu-metal shield	type	55550	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	5.5	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	5.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	4.7	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	4.7	pF
x_1 to x_2	$C_{x_1x_2}$	2.5	pF
y_1 to y_2	$C_{y_1y_2}$	1.9	pF
Control grid to all other elements	C_{g_1}	4.6	pF
Cathode to all other elements	C_k	6.0	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

Angle between x and y traces $90 \pm 1^{\circ}$

LINE WIDTH

Measured on a circle of 50 mm diameter

Final accelerator voltage	$V_{g_5(\ell)}$	4000	V
First accelerator voltage	V_{g_4,g_2}	2000	V
Beam current	$I(\ell)$	0.5	μA
Line width	l.w.	0.3	mm

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_5}(\ell)$	4000	V
First accelerator voltage	V_{g_4, g_2}	2000	V
Focusing electrode voltage	V_{g_3}	400 to 720	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	45 to 100	V
Deflection factor, horizontal	M_x	27 to 35	V/cm
vertical	M_y	24 to 29	V/cm
Useful scan, horizontal		full scan	
vertical		full scan	

LIMITING VALUES

Final accelerator voltage	$V_{g_5}(\ell)$	max.	5000	V
Final accelerator voltage	V_{g_4, g_2}	max.	2500	V
Focusing electrode voltage	V_{g_3}	max.	1000	V
Control grid voltage,				
negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	2	V
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	200	V
cathode negative	$V_{-k/f+}$	max.	125	V
Voltage between accelerator and any deflection plate	$V_{g_4/x}$	max.	500	V
	$V_{g_4/y}$	max.	500	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter oscilloscope tube for inexpensive oscilloscopes.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g4,g2(\ell)}$	2	kV
Display area	Both directions full scan		
Deflection factor, horizontal	M_x	26	V/cm
vertical	M_y	21	V/cm

SCREEN

	colour	persistence
DG13-32	yellowish green	medium

Useful screen diameter	min.	114	mm
Useful scan			
horizontal	full scan		
vertical	full scan		

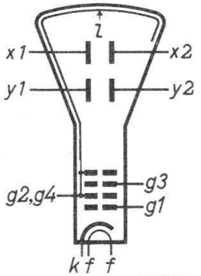
HEATING

Indirect by A.C. or D.C.; parallel supply

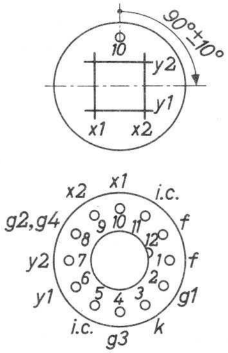
Heater voltage	V_f	6.3	V
Heater current	I_f	600	mA

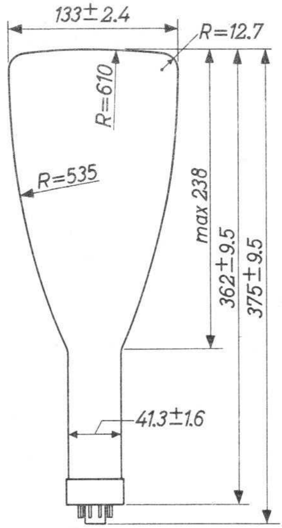
MECHANICAL DATA

Dimensions in mm



7Z02809





7Z02808

Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Duodecal 12 p		
Dimensions and connections			
Overall length	max.	384.5	mm
Face diameter	max.	135.4	mm
Net weight	approx.	790	g
Accessories			
Socket	type	2422 516 00001	
Final accelerator contact connector	type	55560	
Mu-metal shield	type	55550	

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	9.3	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	5.0	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	4.6	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	4.6	pF
x_1 to x_2	$C_{x_1x_2}$	2.0	pF
y_1 to y_2	$C_{y_1y_2}$	1.5	pF
Control grid to all other elements	C_{g_1}	4.3	pF
Cathode to all other elements	C_k	6.5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates	symmetrical
y plates	symmetrical
Angle between x and y traces	90 ± 1^{o}

LINE WIDTH

Measured on a circle of 50 mm diameter.

Accelerator voltage	$V_{g_4,g_2(\ell)}$	2000	V
Beam current	$I(\ell)$	0.5	μA
Line width	l.w.	0.4	mm

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_4,g_2(\ell)}$	2000	V
Focusing electrode voltage	V_{g_3}	340 to 640	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	max. 90	V
Deflection factor, horizontal	M_x	22 to 30	V/cm
vertical	M_y	18.2 to 24.2	V/cm
Useful scan, horizontal		full scan	
vertical		full scan	

LIMITING VALUES

Final accelerator voltage	$V_{g4,g2(\ell)}$	max.	2500	V
Focusing electrode voltage	V_{g3}	max.	1000	V
Control grid voltage,				
negative	$-V_{g1}$	max.	200	V
positive	V_{g1}	max.	0	V
positive peak	V_{g1p}	max.	2	V
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	200	V
cathode negative	$V_{-k/f+}$	max.	125	V
Voltage between and any deflection plate	$V_{g4/x}$	max.	500	V
	$V_{g4/y}$	max.	500	V
Screen dissipation	W_ℓ	max.	3	mW/cm^2

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g3}	170 to	320	V per kV of V_g.
Control grid voltage for visual extinction of focused spot	$-V_{g1}$	max.	45	V per kV of $V_{g4,g2}$
Deflection factor				
horizontal	M_x	11 to	15	V/cm per kV of $V_{g4,g2}$
vertical	M_y	9.1 to	12.1	V/cm per kV of $V_{g4,g2}$
Control grid circuit resistance	R_{g1}	max.	1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	max.	5	MΩ
Focusing electrode current	I_{g3}	-15 to	+15	μA [1])

[1]) Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

13 cm diameter flat faced oscilloscope tube for general purpose oscilloscopes.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g_5(\ell)}$	4	kV
Display area		10.2 x 10.2	cm
Deflection factor, horizontal	M_x	23.7	V/cm
vertical	M_y	17.7	V/cm

SCREEN

	colour	persistence
DB 13-34	blue	medium short
DG13-34	yellowish green	medium short
DP 13-34	yellowish green	long

Useful screen diameter	min.	114	mm
Useful scan at $V_{g_5(\ell)}/V_{g_4,g_2} = 2$			
horizontal	min.	102	mm
vertical	min.	102	mm

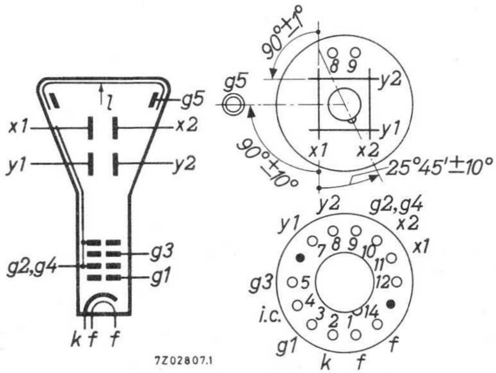
HEATING

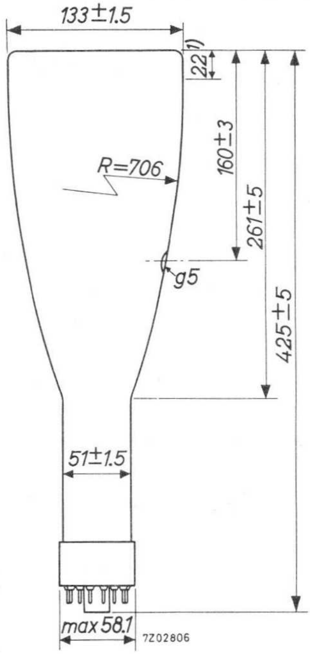
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	6.3	V
Heater current	I_f	600	mA

MECHANICAL DATA

Dimensions in mm





Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Diheptal 12 p		
Dimensions and connections			
Overall length	max.	430	mm
Face diameter	max.	134.5	mm
Net weight	approx.	1100	g
Accessories			
Socket	type	2422 517 00001	
Final accelerator contact connector	type	55560	
Mu-metal shield	type	55550	

1) Lower side of straight part.

CAUTION HIGH VACUUM TUBE IS DANGEROUS TO HANDLE, REFER SERVICING AND DISPOSAL TO QUALIFIED PERSONNEL. DISCHARGE EHT COMPLETELY BEFORE TOUCHING.

TUBE MAY PRODUCE X-RAYS WHEN OPERATED AT HIGH ACCELERATING VOLTAGE. SEE DATA SHEET FOR MAXIMUM RATINGS.

Made in the Netherlands

CRT Heerlen B.V.

CAPACITANCES

x_1 to all other elements except x_2	$C_{x_1(x_2)}$	4	pF
x_2 to all other elements except x_1	$C_{x_2(x_1)}$	4	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	4	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	4	pF
x_1 to x_2	$C_{x_1x_2}$	2.5	pF
y_1 to y_2	$C_{y_1y_2}$	1.1	pF
Control grid to all other elements	C_{g_1}	5	pF
Cathode to all other elements	C_k	4	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

Angel between x and y traces 90 ± 1^o

LINE WIDTH

Measured on a circle of 50 mm diameter.

Final accelerator voltage	$V_{g_5(\ell)}$	4000	V
First accelerator voltage	V_{g_4, g_2}	2000	V
Beam current	$I(\ell)$	0.5	μA
Line width	l.w.	0.3	mm

TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_5(\ell)}$	4000	V
First accelerator voltage	V_{g_4,g_2}	2000	V
Focusing electrode voltage	V_{g_3}	400 to 690	V
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	45 to 75	V
Deflection factor, horizontal	M_x	21.2 to 26.2	V/cm
vertical	M_y	15.8 to 19.6	V/cm
Deviation of linearity of deflection	max.	2	% [1]
Geometry distortion		see note 2	
Useful scan, horizontal	min.	102	mm
vertical	min.	102	mm

LIMITING VALUES

Final accelerator voltage	$V_{g_5(\ell)}$	max.	6000	V
		min.	1000	V
First accelerator voltage	V_{g_4,g_2}	max.	2600	V
Focusing electrode voltage	V_{g_3}	max.	1000	V
Control grid voltage,		min.	1000	V
negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	2	V
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	200	V
cathode negative	$V_{-k/f+}$	max.	125	V
Voltage between and any deflection plate	$V_{g_4/x}$	max.	500	V
	$V_{g_4/y}$	max.	500	V
Cathode current	$I_{k_{eff}}$	max.		mA
Screen dissipation	W_ℓ	max.	3	W/cm^2
Ratio $V_{g_5}(\ell)/V_{g_4,g_2}$	$V_{g_5}(\ell)/V_{g_4,g_2}$	max.	2.3	

CIRCUIT DESIGN VALUES

Focusing voltage	V_{g_3}	200 to 345	V per kV of V_{g_4, g_2}
Control grid voltage for visual extinction of focused spot	$-V_{g_1}$	22.5 to 37.5	V per kV of V_{g_4, g_2}
Deflection factor at $V_{g_5}(\ell)/V_{g_4} = 2$			
horizontal	M_x	10.6 to 13.1	V/cm per kV of V_{g_4, g_2}
vertical	M_y	7.9 to 9.8	V/cm per kV of V_{g_4, g_2}
Control grid circuit resistance	M_{g_1}	max. 1.5	MΩ
Deflection plate circuit resistance	R_x, R_y	max. 1	MΩ
Focusing electrode current	I_{g_3}	−15 to +15	μA [3]

[1] The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

[2] A graticule, consisting of concentric rectangles of 81.6 mm x 81.6 mm and 78.4 mm x 78.4 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

[3] Values to be taken into account for the calculation of the focus potentiometer.

INSTRUMENT CATHODE-RAY TUBE

10 cm diameter flat faced double gun oscilloscope tube, post-deflection acceleration by means of a helical electrode and low interaction between traces. The tube features beam-blanking.

QUICK REFERENCE DATA			
Final accelerator voltage	$V_{g_8(\ell)}$	3000	V
Display area	horizontal full scan		
	vertical	7	cm
Deflection factor, horizontal	M_x	15	V/cm
vertical	M_y	7	V/cm

SCREEN

	colour	persistence
E10-12BE	blue	medium short
E10-12GH	green	medium short
E10-12GM	yellowish green	long
E10-12GP	bluish green	medium short

Useful screen diameter	min.	85 mm
Useful scan (each gun) at $V_{g_8}(\ell)/V_{g_5} = 3$		
horizontal	full scan	
vertical	min.	70 mm

The useful scan may vertically be shifted to a max. of 5 mm with respect to the geometric centre of the face plate.

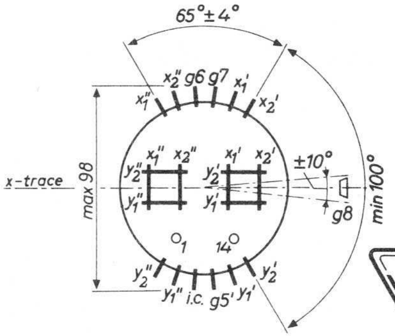
HEATING

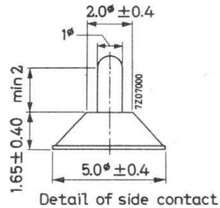
Indirect by A.C. or D.C.; parallel supply

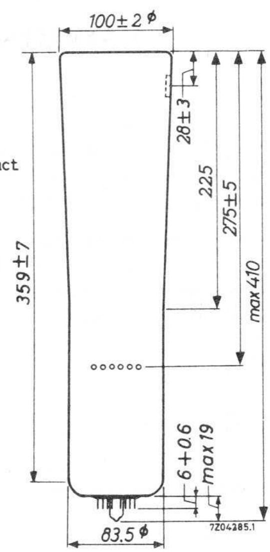
Heater voltage	each gun	V_f	6.3	V
Heater current	each gun	I_f	300	mA

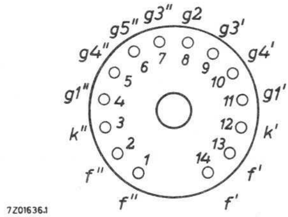
MECHANICAL DATA

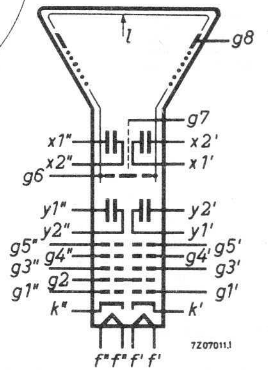
Dimensions in mm











Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pin all glass		
Dimensions and connections			
Overall length	max.	410	mm
Face diameter	max.	102	mm
Net weight	approx.	800	g
Accessories			
Socket, supplied with tube	type	55566	
Final accelerator contact connector	type	55563	
Side contact connector	type	55561	
Mu-metal shield	type	55545	

CAPACITANCES (each gun)

x_1' to all elements except x_2'	$C_{x_1'(x_2')}$	4.5	pF
x_2' to all elements except x_1'	$C_{x_2'(x_1')}$	3	pF
x_1'' to all other elements except x_2''	$C_{x_1''(x_2'')}$	3	pF
x_2'' to all other elements except x_1''	$C_{x_2''(x_1'')}$	4.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	2	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	2	pF
x_1 to x_2	$C_{x_1x_2}$	2	pF
y_1 to y_2	$C_{y_1y_2}$	1.5	pF
Grid No.1 to all other elements	C_{g_1}	5.2	pF
Cathode to all other elements	C_k	5	pF

FOCUSING electrostatic

DEFLECTION double electrostatic

x plates symmetrical

y plates symmetrical

Angle between x and y traces $90 \pm 1^{\circ}$

Corresponding traces of each gun align within 1.5°

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

LINE WIDTH

Measured with the shrinking raster method in the centre of the screen.

Final accelerator voltage	$V_{g_8(\ell)}$	3000	V
Astigmatism control electrode voltage	V_{g_5}	1000	V [3]
First accelerator voltage	V_{g_2}	1000	V
Beam current	$I_{g_8(\ell)}$	10	μA
Line width	l.w.	0.50	mm

HELIX

Post deflection accelerator helix resistance: min. 100 MΩ

[3]) See page 6.

TYPICAL OPERATING CONDITIONS(each gun)

Final accelerator voltage	$V_{g_8(\ell)}$	3000	V
Intergun shield voltage	V_{g_7}	1000±100	V [1]
Geometry control electrode voltage	V_{g_6}	1000±100	V [1]
Deflection plate shield voltage	V_{g_6}	1000	V [2]
Astigmatism control electrode voltage	V_{g_5}	1000±100	V [3]
Focusing electrode voltage	V_{g_4}	180 to 380	V
Deflection blanking electrode voltage	V_{g_3}	1000	V
Deflection blanking control voltage for beam blanking of a current $I_{g_9(\ell)} = 10\ \mu A$	ΔV_{g_3}	max. 40	V
First accelerator voltage	V_{g_2}	1000	V
Control grid voltage for visual extinction of focused spot	V_{g_1}	-25 to -90	V
Deflection factor, horizontal	M_x	10 to 20	V/cm
vertical	M_y	6 to 8	V/cm
Deviation of linearity of deflection		max. 2.5	% [4]
Geometry distortion		See note 5	
Interaction factor		2.10^{-3}	mm/Vdc [6]
Tracking error		1.5	mm [7]

[1][2][3][4][5][6][7] See page 6

LIMITING VALUES (each gun, if applicable) (Absolute max. rating system)

Final accelerator voltage	$V_{g_8}(\ell)$	max.	3300	V
		min.	2700	V
Intergun shield voltage	V_{g_7}	max.	1200	V
Geometry control electrode voltage	V_{g_6}	max.	1200	V
Deflection plate shield voltage	V_{g_6}	max.	1200	V
Astigmatism control electrode voltage	V_{g_5}	max.	1200	V
		min.	800	V
Focusing electrode voltage	V_{g_4}	max.	1200	V
Beam blanking electrode voltage	V_{g_3}	max.	1200	V
First accelerator voltage	V_{g_2}	max.	1200	V
		min.	200	V
Control grid voltage,				
negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	2	V
Cathode to heater voltage,				
cathode positive	V_{kf}	max.	200	V
cathode negative	$-V_{kf}$	max.	125	V
Average cathode current	I_k	max.	300	μA
Screen dissipation	W_ℓ	max.	3	mW/cm^2
Ratio $V_{g_8}(\ell)/V_{g_5}$	$V_{g_8}(\ell)/V_{g_5}$	max.	3	

CIRCUIT DESIGN VALUES (each gun, if applicable)

Focusing voltage	V_{g_4}	180 to 380	V/kV of V_{g_2}
Control grid voltage for visual cut-off focused spot	V_{g_1}	25 to −90	V/kV of V_{g_2}
Deflection factor $V_{g_8}(\ell)/V_{g_5} = 3$			
horizontal	M_x	10 to 20	V/cm per kV of V_{g_5}
vertical	M_y	6 to 8	V/cm per kV of V_{g_5}
Focusing electrode current	I_{g_4}	−15 to +10	μA
Control grid circuit resistance	R_{g_1}	max. 1.5	MΩ

---

1) This tube is designed for optimum performance when operating at the ratio $V_{g_8}(\ell)/V_{g_5} = 3$. Operation at other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage and the intergunshield voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) This voltage should be equal to the mean x- and y plates potential.

3) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

4) The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

5) A graticule consisting of concentric rectangles of 60 mm x 60 mm and 57 mm x 57 mm is aligned with electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum potentials applied.

6) The deflection of one beam when balanced dc voltage are applied to the deflection plates of the other beam, will not be greater than the indicated value.

7) With 50 mm vertical traces superimposed at the tube face centre and deflected horizontally ± 4 cm by voltages proportional to the relative deflection factors, horizontal separation of the corresponding points of the traces shall not be greater than the indicated value.

INSTRUMENT CATHODE-RAY TUBE

10 cm diameter metal-backed flat-faced double gun oscilloscope tube with post-deflection acceleration by means of a helical electrode and low interaction between beams.

QUICK REFERENCE DATA		
Final accelerator voltage	$V_{g_8(\ell)}$	4000 V
Display area	horizontal vertical	full scan 7 cm
Deflection factor, horizontal	M_x	17 V/cm
vertical	M_y	7.4 V/cm

SCREEN

	Colour	Persistence
E10-130BE	blue	medium short
E10-130GH	green	medium short
E10-130GM	yellowish green	long
E10-130GP	bluish green	medium short

Useful screen diameter		min. 85 mm
Useful scan (each gun) at $V_{g_8(\ell)}/V_{g_5} = 4$	horizontal	full scan
	vertical	min. 70 mm

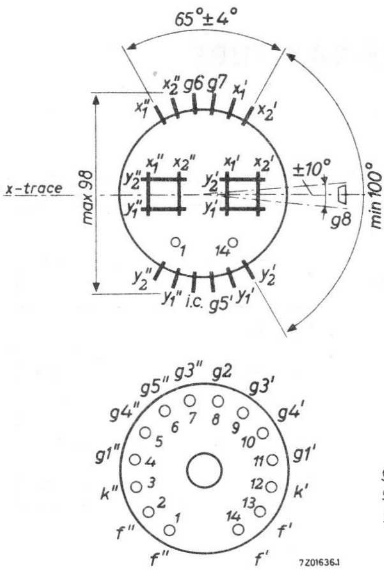
The useful scan may be shifted vertically to a maximum of 5 mm with respect to the geometric centre of the face plate.

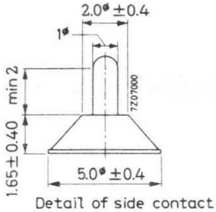
HEATING

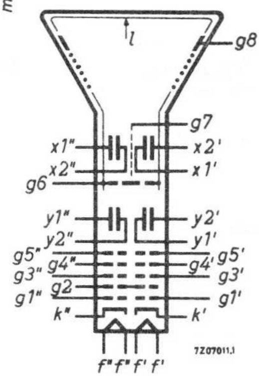
Indirect by A.C. or D.C.; parallel supply

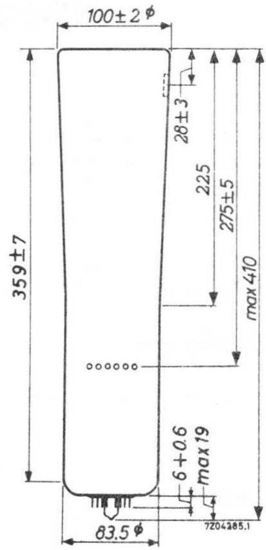
Heater voltage	V_f	6.3 V
Heater current	I_f	300 mA

MECHANICAL DATA









Mounting position: any

The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	14 pin, all glass		
Dimensions and connections			
Overall length	max.	410	mm
Face diameter	max.	102	mm
Net weight	approx.	800	g
Accessories			
Socket, supplied with tube	type	55566	
Final-accelerator contact connector	type	55563	
Side contact connector	type	55561	
Mu-metal shield	type	55545	

CAPACITANCES

x_1' to all other elements except x_2'	$C_{x_1'(x_2')}$	4.5	pF
x_2' to all other elements except x_1'	$C_{x_2'(x_1')}$	3	pF
x_1" to all other elements except x_2"	$C_{x_1''(x_2'')}$	3	pF
x_2" to all other elements except x_1"	$C_{x_2''(x_1'')}$	4.5	pF
y_1 to all other elements except y_2	$C_{y_1(y_2)}$	2	pF
y_2 to all other elements except y_1	$C_{y_2(y_1)}$	2	pF
x_1 to x_2	$C_{x_1x_2}$	2	pF
y_1 to y_2	$C_{y_1y_2}$	1.5	pF
Grid No.1 to all other elements	C_{g_1}	5.2	pF
Cathode to all other elements	C_k	5	pF

FOCUSING Electrostatic

DEFLECTION Double electrostatic

x plates	symmetrical		
y plates	symmetrical		
Angle between x and y traces (each gun)		90 ± 1	°
Angle between corresponding x traces at the centre of the screen	max.	0.6	°
Angle between corresponding y traces at the centre of the screen	max.	1	°

If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam; hence a low impedance deflection plate drive is desirable.

LINE WIDTH

Measured with the shrinking-raster method in the centre of the screen.

Final accelerator voltage	$V_{g_8(\ell)}$	4000	V
Astigmatism-control electrode voltage	V_{g_5}	1000	V 2)
First accelerator voltage	V_{g_2}	1000	V
Beam current	$I_{g_8(\ell)}$	10	μA
Line width	l.w.	0.4	mm

HELIX

Post-deflection accelerator helix resistance	min.	100	MΩ

2) See page 5

TYPICAL OPERATING CONDITIONS (each gun, if applicable)

Final accelerator voltage	$V_{g_8}(\ell)$		4000	V	
Intergun shield voltage	V_{g_7}		1000±100	V	1)
Geometry-control electrode voltage	V_{g_6}		1000±100	V	1)
Astigmatism-control electrode voltage	V_{g_5}		1000±100	V	2)
Focusing electrode voltage	V_{g_4}		200 to 320	V	
Deflection-blanking electrode voltage	V_{g_3}		1000	V	
Deflection-blanking control voltage for blanking a beam current $I_{g_8}(\ell)$ = 10 μA	ΔV_{g_3}	max.	40	V	
First accelerator voltage	V_{g_2}		1000	V	
Control grid voltage for extinction of focused spot	V_{g_1}		-25 to -90	V	
Deflection factor, horizontal	M_x		14 to 20	V/cm	
vertical	M_y		6.4 to 8.4	V/cm	
Deviation of linearity of deflection		max.	2	%	3)
Geometry distortion			see note 4		
Interaction factor		max.	2.10^{-3}	mm/V_{DC}	5)
Tracking error			1.2	mm	6)

LIMITING VALUES (each gun, if applicable) (Absolute max. rating system)

Final accelerator voltage	$V_{g_8}(\ell)$	max.	5000	V
		min.	2700	V
Intergun shield voltage	V_{g_7}	max.	1200	V
Geometry control electrode voltage	V_{g_6}	max.	1200	V
Astigmatism control electrode voltage	V_{g_5}	max.	1200	V
		min.	800	V
Focusing electrode voltage	V_{g_4}	max.	1200	V
Beam blanking electrode voltage	V_{g_3}	max.	1200	V
First accelerator voltage	V_{g_2}	max.	1200	V
		min.	200	V
Control grid voltage, negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
Cathode to heater voltage,				
cathode positive	V_{kf}	max.	125	V
cathode negative	$-V_{kf}$	max.	125	V
Average cathode current	I_k	max.	300	μA
Screen dissipation	W_ℓ	max.	3	mW/cm^2
Ratio $V_{g_8}(\ell)/V_{g_5}$	$V_{g_8}(\ell)/V_{g_5}$	max.	4	

1) 2) 3) 4) 5) 6) See page 5

CIRCUIT DESIGN VALUES (each gun, if applicable)

Focusing voltage	V_{g_4}	200 to 320 V	per kV of V_{g_2}
Control grid voltage for extinction of focused spot	V_{g_1}	-25 to -90 V	per kV of V_{g_2}
Deflection factor at $V_{g_8}(\ell)/V_{g_5} = 4$			
horizontal	M_x	14 to 20 V/cm	per kV of V_{g_5}
vertical	M_y	6.4 to 8.4 V/cm	per kV of V_{g_5}
Focusing electrode current	I_{g_4}	-15 to +10 μA	
Control grid circuit resistance	R_{g_1}	max. 1.5 MΩ	

1) This tube is designed for optimum performance when operating at the ratio $V_{g_8}(\ell)/V_{g_5} = 4$. Operation at higher ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage and the intergun shield voltage should be adjusted for optimum performance. For any necessary adjustment its potential will be within the stated range.

2) The astigmatism control electrode voltage should be adjusted for optimum spot shape. For any necessary adjustment its potential will be within the stated range.

3) The sensitivity at a deflection of $\leq 75\%$ of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than the indicated value.

4) A graticule consisting of concentric rectangles of 60 mm x 60 mm and 57.5 mm x 57.5 mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum potentials applied.

5) The deflection of one beam when balanced DC voltages are applied to the deflection plates of the other beam, will not be greater than the indicated value.

6) With 50 mm vertical traces superimposed at the tube face centre and deflected horizontally ± 4 cm by voltages proportional to the relative deflection factors, horizontal separation of the corresponding points of the traces will not be greater than the indicated value.

MONITOR TUBE

21 cm rectangular television tube with metal-backed screen primarily intended for use as a precision monitor.

QUICK REFERENCE DATA	
Deflection angle	90 ^{o}
Focusing	electrostatic
Resolution	min. 650 lines
Overall length	max. 222 mm

SCREEN

Metal backed phosphor

Lumenescence	white
Useful diagonal	min. 195 mm
Useful width	min. 180 mm
Useful height	min. 135 mm

HEATING

Indirect by A.C. or D.C.; parallel supply

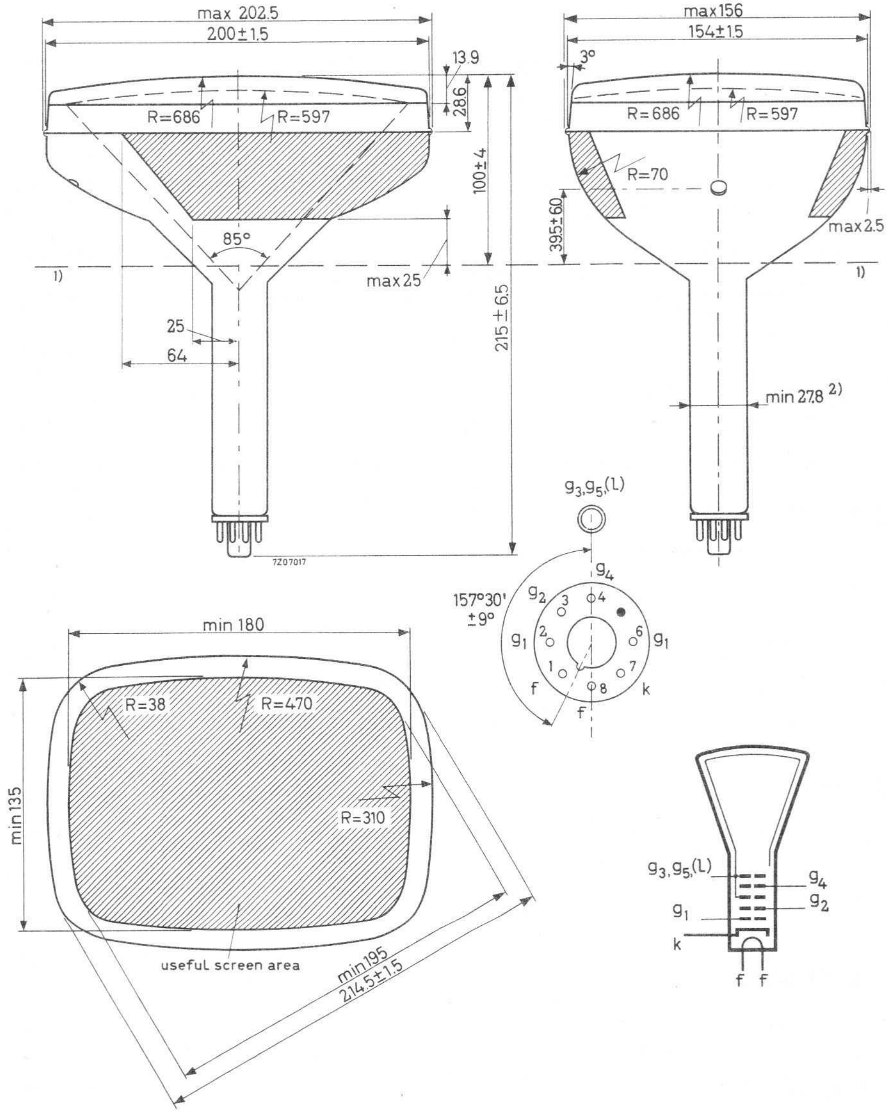
heater voltage	V_f	=	11	V $\pm$ 10 %
heater current	I_f	=	70	mA

CAPACITANCES

Final accelerator to external conductive coating	$C_{g3,g5(\ell)/m}$	=	max. 375	pF
Cathode to all other elements	C_k	=	5.0	pF
Grid No.1 to all other elements	C_{g_1}	=	9.0	pF

MECHANICAL DATA

Dimensions in mm



Mounting position: any

Except vertical with the screen downward and the axis of the tube making an angle of less than 20 ^{o} with the vertical.

MECHANICAL DATA (continued)

Base: Neo Eightar (B8H)

Cavity contact CT8

Accessories

Final accelerator connector type 55563

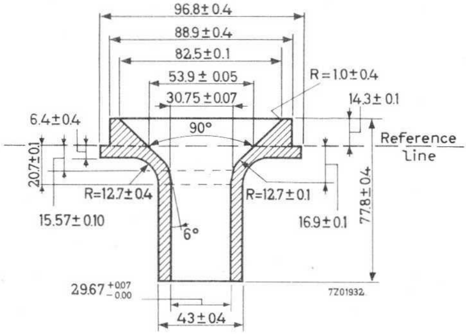
FOCUSING electrostatic

The range of focus voltage shown under "Typical operating conditions" results in optimum focus at a beam current of 100 μA.

DEFLECTION magnetic

Diagonal deflection angle 90°

REFERENCE LINE GAUGE Dimensions in mm



TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_3, g_5(\ell)}$	=	12	kV
Focusing electrode voltage	V_{g_4}	=	0 to 400	V
First accelerator voltage	V_{g_2}	=	400	V
Grid No.1 voltage for visual extinction of focused raster (grid drive service)	$-V_{g_1}$	=	32 to 69	V
Cathode voltage for visual extinction of focused raster (cathode drive service)	V_k	=	29 to 62	V

[1]) Reference line

[2]) The maximum dimension is determined by the reference line gauge

RESOLUTION

Resolution at screen centre			min.	650	lines
Measured at:	$V_{g_3,g_5(\ell)}$	=		12	kV
	V_{g_2}	=		400	V

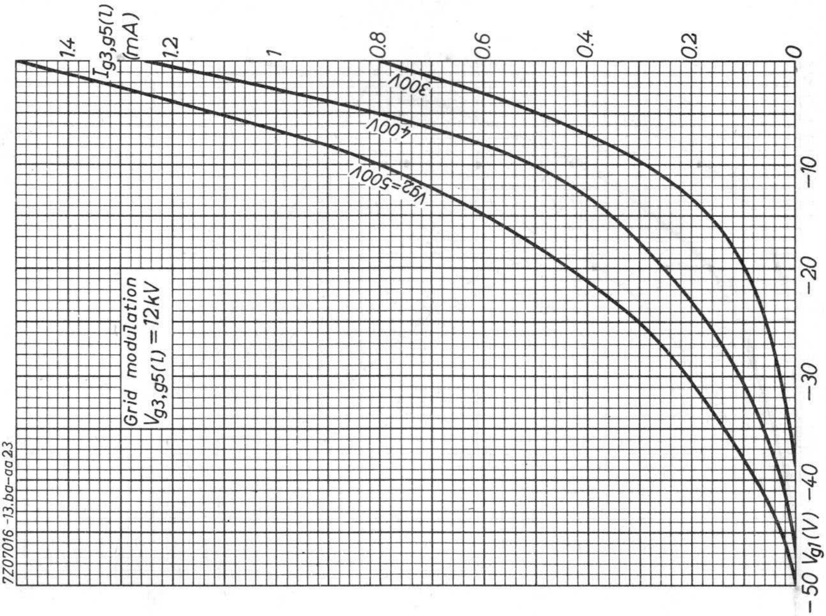
This tube will resolve 650 lines measured at a brightness of 340 Nits based on a picture height of 135 mm.
The focus voltage is adjusted to obtain the smallest roundest spot. For optimum overall resolution an external centring magnet may be required.

LIMITING VALUES (Absolute max. rating system)

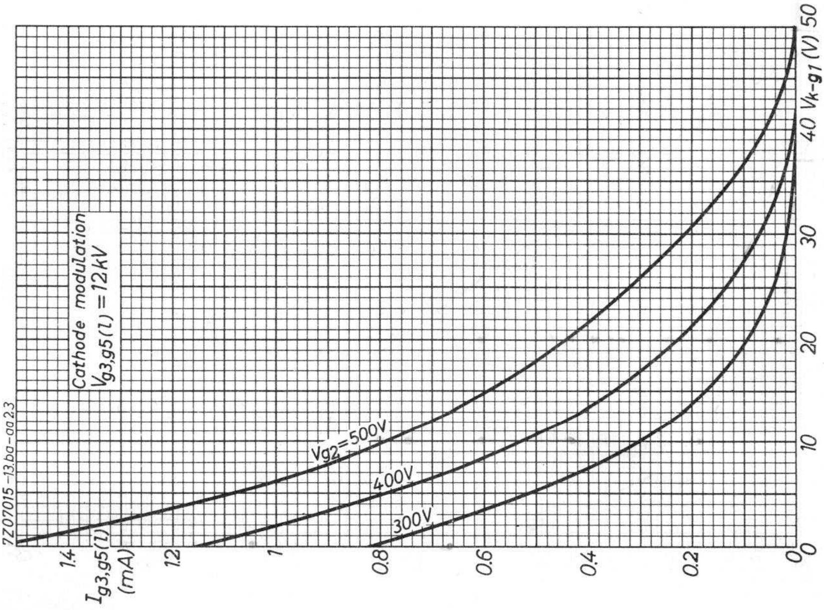
Final accelerator voltage	$V_{g_3,g_5(\ell)}$	=	max.	16	kV
		=	min.	9	kV
Focus voltage					
positive	V_{g_4}	=	max.	1000	V
negative	$-V_{g_4}$	=	max.	500	V
First accelerator voltage	V_{g_2}	=	max.	800	V
Grid No.1 voltage					
positive	V_{g_1}	=	max.	0	V
positive peak	$V_{g_{1p}}$	=	max.	2	V
negative	$-V_{g_1}$	=	max.	180	V
Cathode to heater voltage					
positive	V_{k-f}	=	max.	80	V
positive peak	V_{k-f_p}	=	max.	130	V
Focusing electrode current	I_{g_4}	=	max.	$\pm$25	μA
Accelerator current	I_{g_2}	=	max.	$\pm$ 5	μA

MAXIMUM CIRCUIT VALUES

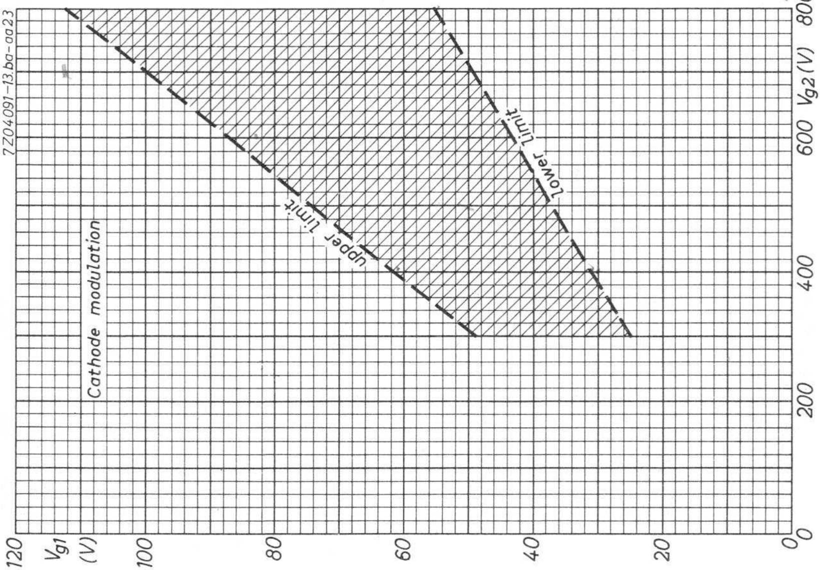
Resistance between cathode and heater	$R_{k/f}$	=	max.	1	MΩ
Impedance between cathode and heater	$Z_{k/f}$ (50 Hz)	=	max.	500	kΩ
Impedance between cathode and earth	Z_k (50 Hz)	=	max.	100	kΩ
Grid No.1 circuit resistance	R_{g_1}	=	max.	1.5	MΩ
Grid No.1 circuit impedance	Z_{g_1} (50 Hz)	=	max.	500	kΩ
Accelerator circuit resistance	R_{g_2}	=	max.	1	MΩ
Focusing electrode circuit resistance	R_{g_4}	=	max.	3	MΩ

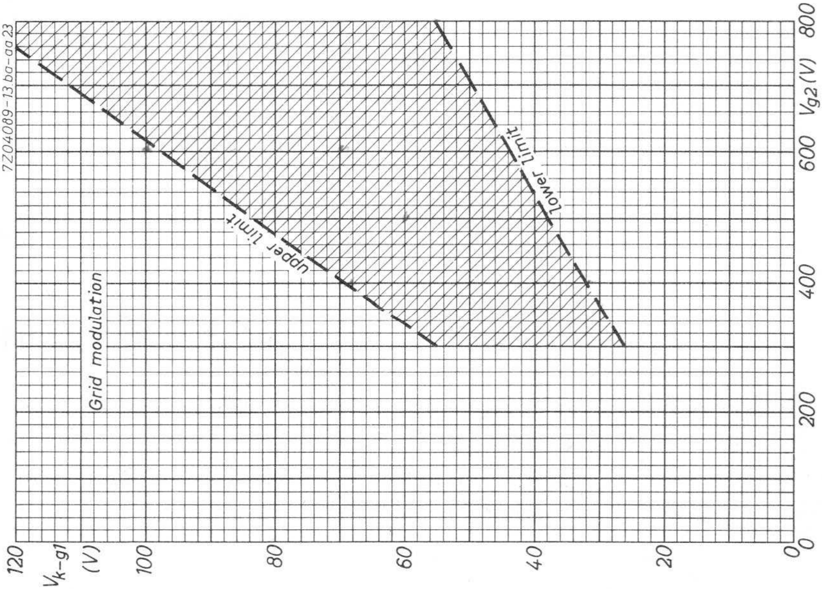


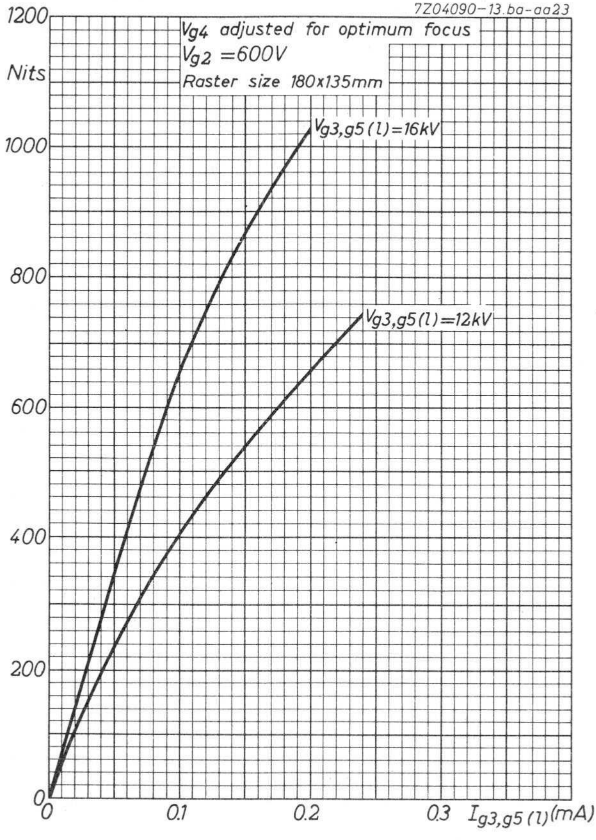
Grid modulation
$V_{g3,g5(l)} = 12kV$
$I_{g3,g5(l)}$ (mA)
V_{g1} (V)
V_{g2}=500V
400V
300V
7Z07016-13.ba-aa2.3



Cathode modulation
$V_{g3,g5(l)} = 12kV$
$I_{g3,g5(l)}$ (mA)
V_{k-g1} (V)
V_{g2}=500V
400V
300V
7Z07015-13.ba-aa2.3


7Z04091-13.ba-aa23
Cathode modulation
upper limit
lower limit
V_{g1} (V)
V_{g2} (V)
120
100
80
60
40
20
0
0
200
400
600
800


7Z04089-13.ba-aa23
Grid modulation
upper limit
lower limit
V_{k-g1} (V)
V_{g2} (V)
120
100
80
60
40
20
0
0
200
400
600
800


7Z04090-13.ba-aa23
V_{g4} adjusted for optimum focus
V_{g2} =600V
Raster size 180x135mm
$V_{g3,g5(l)}$=16kV
$V_{g3,g5(l)}$=12kV
1200
Nits
1000
800
600
400
200
0
0
0.1
0.2
0.3
$I_{g3,g5(l)}$(mA)

MONITOR TUBE

21 cm rectangular television tube with metal backed screen primarily intended for use as a picture monitor tube.

QUICK REFERENCE DATA		
Deflection angle	110	$^{\circ}$
Focusing	electrostatic	
Resolution	625	lines
Overall length	max. 205	mm

SCREEN

Metal backed phosphor

Lumenescence		white	
Light transmission of face glass		80	%
Useful diagonal	min.	200	mm
Useful width	min.	190.5	mm
Useful height	min.	149.2	mm

HEATING

Indirect by A.C. or D.C.; parallel supply

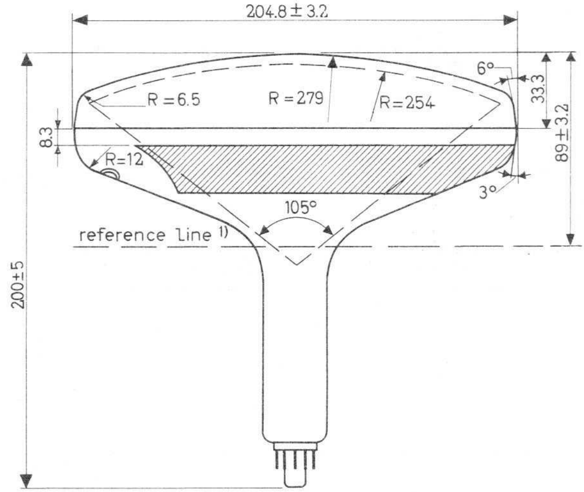
Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	300	mA

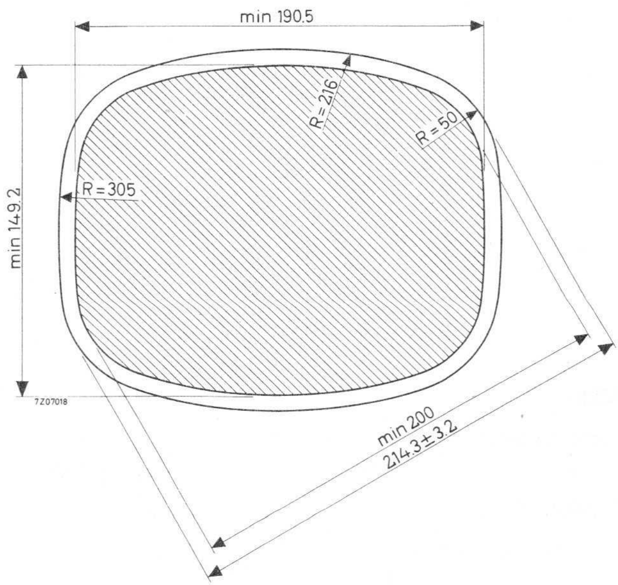
CAPACITANCES

Final accelerator to external conductive coating	$C_{g_3,g_5(\ell)/m}$	=	250	pF
Cathode to all other elements	C_k	=	4.0	pF
Grid No.1 to all other elements	C_{g_1}	=	7.0	pF

MECHANICAL DATA

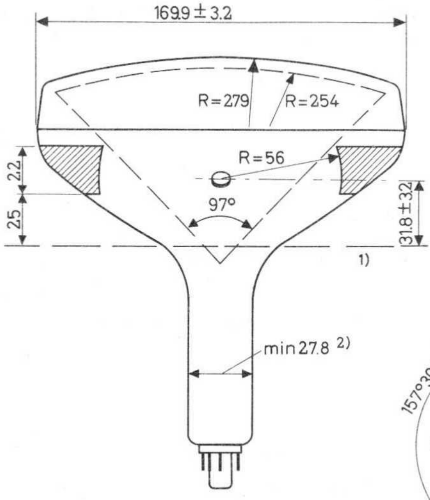
Dimensions in mm

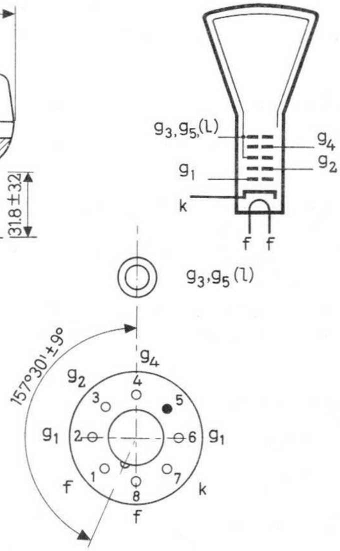




MECHANICAL DATA (continued)

Dimensions in mm





Mounting position: any

Except vertical with the screen downward and the axis of the tube making an angle of less than 20° with the vertical.

Base:	Neo Eightar (B8H)
Cavity contact	CT8
Accessories	
Final accelerator connector	type 55563

---

[1]) Reference line, determined by the plane of the upper edge of the flange of the reference line gauge JEDEC 126 when the gauge is resting on the cone.

[2]) The maximum dimension is determined by the reference line gauge.

FOCUSING electrostatic

The range of focus voltage shown under "Typical operating conditions" results in optimum focus at a beam current of 100 μA.

DEFLECTION magnetic

Diagonal deflection angle 110°

PICTURE CENTRING MAGNET

Field intensity perpendicular to the tube axis adjustable from 0 to 79.6 A/m (0 to 10 Oerstedt).
Adjustment of the centring magnet should not be such that a general reduction in brightness or shading of the raster occurs.

TYPICAL OPERATION

Final accelerator voltage	$V_{g_3, g_5(\ell)}$	=	16	kV
Focusing electrode voltage	V_{g_4}	=	0 to 400	V [1]
First accelerator voltage	V_{g_2}	=	300	V
Grid No.1 voltage for extinction of focused raster	V_{g_1}	=	-35 to -72	V

RESOLUTION

Resolution at screen centre measured at $V_{g_3, g_5(\ell)}$ = 16 kV, V_{g_2} = 300 V	625	lines

BRIGHTNESS

Brightness at $V_{g_3, g_5(\ell)}$ = 16 kV, $I_{g_3, g_5(\ell)}$ = 80 μA measured with a raster of 14 x 14 cm^2	450	Nit

[1]) With the small change in focus spot size with variation of focus voltage, the limit of 0 to 400 V is such that an acceptable focus quality is obtained within this range. If it is required to pass through the point of focus, a voltage of at least -100 to +500 V will be required.

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_3, g_5(\ell)}$	= max. 20 kV = min. 13 kV	
Focusing electrode voltage	V_{g_4} $-V_{g_4}$	= max. 1 kV = max. 500 V	
First accelerator voltage	V_{g_2}	= max. 450 V = min. 200 V	
Cathode to heater voltage	$V_{+k/f-}$	= max. 200 V	
	$V_{+k/f-p}$	= max. 300 V	1)
	$V_{-k/f+}$	= max. 125 V	
	$V_{-k/f+p}$	= max. 250 V	
Grid No.1 voltage			
positive	V_{g_1}	= max. 0 V	2)
positive peak	$V_{g_{1p}}$	= max. 2 V	
negative	$-V_{g_1}$	= max. 150 V	
Focusing electrode current	I_{g_4}	= max. ±25 μA	
First accelerator current	I_{g_2}	= max. ± 5 μA	

CIRCUIT DESIGN VALUES

Resistance between cathode and heater	R_{kf}	= max. 1 MΩ
Impedance between cathode and heater	Z_{kf} (50 Hz)	= max. 0.5 MΩ
Impedance between cathode and earth	Z_k (50 Hz)	= max. 0.1 MΩ
Grid No.1 circuit resistance	R_{g_1}	= max. 1.5 MΩ
Grid No.1 circuit impedance	Z_{g_1}(50 Hz)	= max. 0.5 MΩ
First accelerator circuit resistance	R_{g_2}	= max. 1 MΩ
Focusing electrode circuit resistance	R_{g_4}	= max. 3 MΩ

---

1) During a warm-up period not exceeding 45 s the heater may be 410 V negative with respect to the cathode.

2) The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +1 V. The maximum positive excursion of the video signal must not exceed +2 V, and at this voltage the grid current may be expected to be approximately 2 mA.

MONITOR TUBE

The M28-12W is a rectangular 28 cm 90° deflection angle direct viewing picture tube primarily intended as a monitor tube.

QUICK REFERENCE DATA		
Face diagonal	28	cm (11 inch)
Deflection angle	90°	
Overall length	245	mm
Neck length	105.5	mm
Neck diameter	20	mm
Light transmission of face glass	50	%
Focusing		electrostatic
Bulb		reinforced
Heating	11 V, 68	mA
Resolution	min. 850	lines

SCREEN

Metal backed phosphor			
Luminescence	white		
Light transmission of face glass		50	%
Useful diagonal	min.	262.5	mm
Useful width	min.	228	mm
Useful height	min.	171	mm

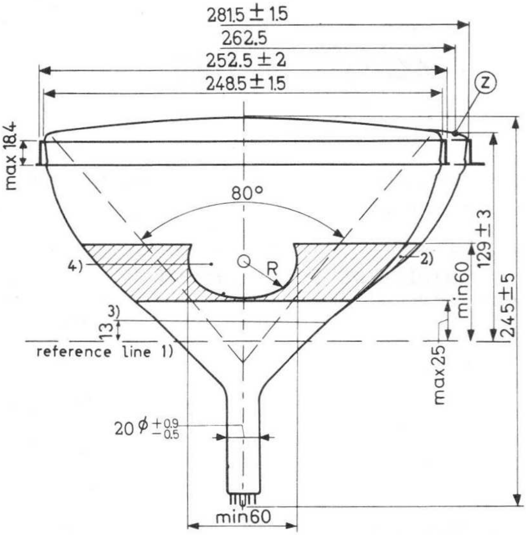
HEATING

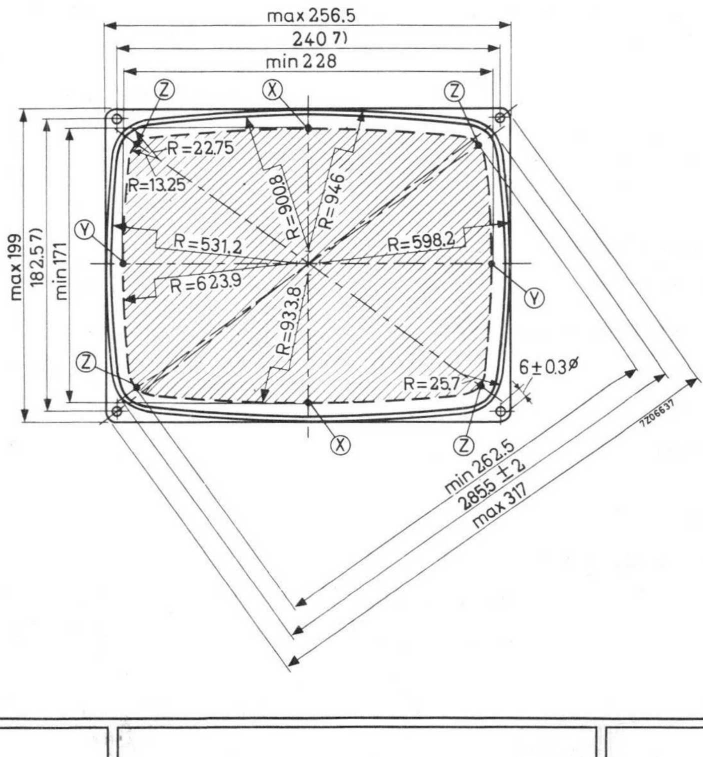
Indirect by A.C. or D.C.

Heater voltage	V_f	11	V
Heater current	I_f	68	mA

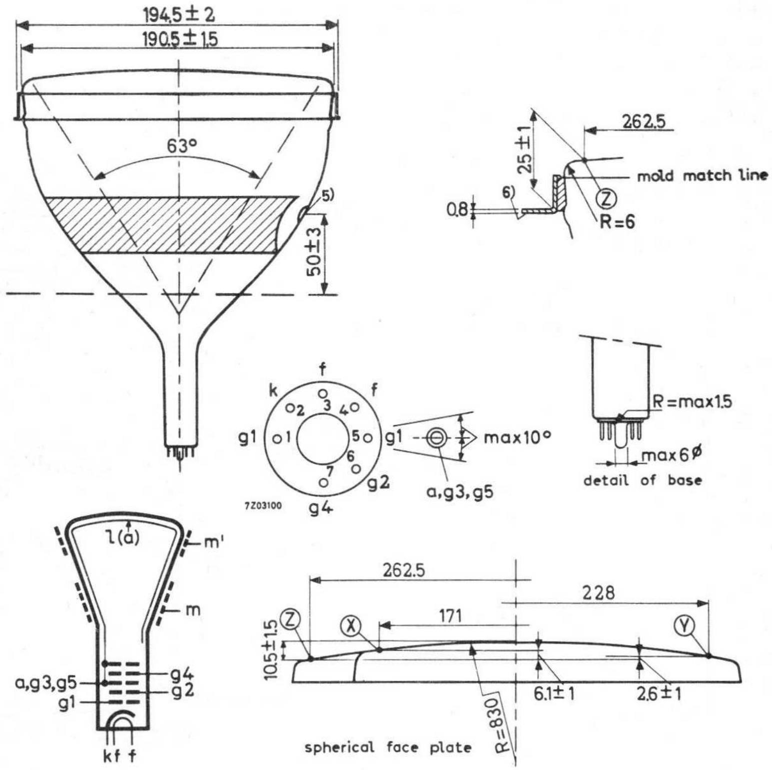
MECHANICAL DATA

Dimensions in mm





MECHANICAL DATA (continued) Dimensions in mm



Mounting position: any

Base : 7 pins miniature, with pumping stem

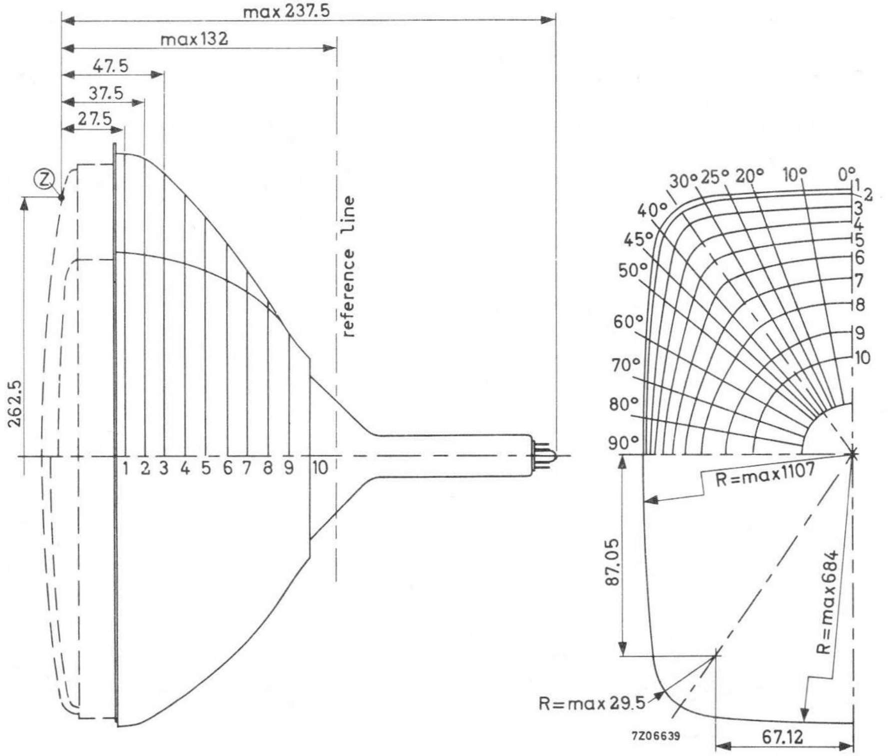
Net weight : approx. 2.2 kg

The socket for the base should not be rigidly mounted; it should have flexible leads and be allowed to move freely.

For notes see page 5

MAXIMUM CONE CONTOUR DRAWING

(Dimensions in mm)



Section	Nom. distance from point Z	Distance from centre (max. values)												
		Long axis 0°	10°	20°	25°	30°	34°40° Diag.	40°	45°	50°	60°	70°	80°	Short axis 90°
1	27.5	130.00	131.62	136.64	140.59	145.50	147.50	144.87	136.81	127.86	114.90	106.84	102.41	101.00
2	37.5	127.35	128.90	133.85	137.70	142.40	144.90	141.80	133.30	124.85	112.60	105.15	101.15	99.90
3	47.5	121.10	122.60	126.85	130.45	134.70	137.55	133.90	125.55	118.45	108.25	102.00	98.95	97.90
4	57.5	114.05	115.15	118.70	121.65	125.25	127.30	124.50	117.50	111.55	103.10	98.10	95.75	95.20
5	67.5	106.35	107.20	110.00	112.25	114.85	116.40	114.25	108.85	104.00	97.20	93.50	92.00	91.75
6	77.5	97.60	98.25	100.05	101.45	103.30	104.45	102.80	98.80	95.10	90.00	87.45	86.85	86.95
7	87.5	87.40	87.75	88.85	89.70	90.70	91.40	90.25	87.70	85.15	81.70	80.40	80.50	81.00
8	97.5	75.05	75.35	76.15	76.70	76.95	76.85	76.05	74.90	73.85	72.45	72.15	72.75	73.40
9	107.5	60.65	60.65	60.65	60.65	60.65	60.65	60.65	60.55	60.35	60.20	60.60	61.00	61.35
10	117.5	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00

CAPACITANCES

Final accelerator to external conductive coating	$C_{a,g_3,g_5/m}$	< 850 > 550	pF pF
Final accelerator to metal band	$C_{a,g_3,g_5/m}$	150	pF
Cathode to all	C_k	3	pF
Grid No.1 to all	C_{g_1}	7	pF

FOCUSING electrostatic

DEFLECTION magnetic

Diagonal deflection angle	90^o
Horizontal deflection angle	80^o
Vertical deflection angle	63^o

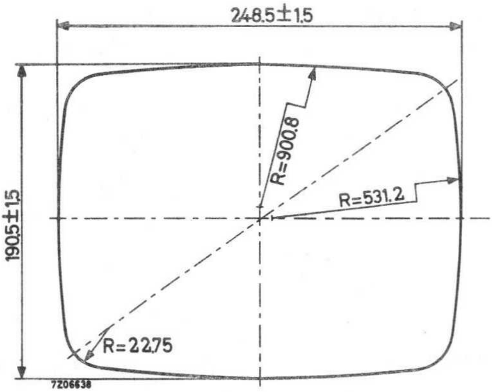
PICTURE CENTRING MAGNET

Field intensity perpendicular to the tube axis adjustable from 0 to 800 A/m (0 to 10 Oerstedt).
Maximum distance between centre of field of this magnet and reference line: 55mm. The centring magnet should be mounted as close to the deflection coils as possible.

NOTES TO OUTLINE DRAWING

1. The reference line is determined by the plane of the upper edge of the flange of the reference line gauge when the gauge is resting on the cone.
2. The configuration of the external conductive coating is optional but contains the contact area shown in the drawing.
   The external conductive coating must be earthed.
3. End of guaranteed contour. The maximum neck and cone contour is given by the reference line gauge.
4. This area must be kept clean.
5. Recessed cavity contact.
6. Maximum unflatness of the rim is 1 mm.
7. The mounting screws in the cabinet must be situated inside a circle with a diameter of 5 mm drawn around the corner points of a geometrical rectangle of 240 mm x 182.5 mm.

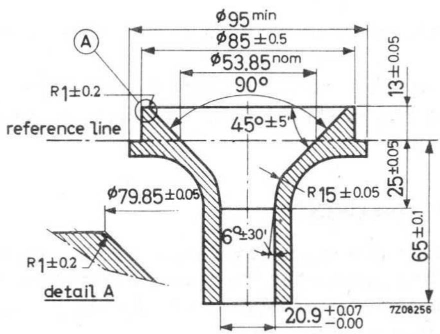
FACE PLATE CONTOUR



Dimensions of the outer contour of the face plate on the mold match line.

REFERENCE LINE GAUGE

Dimensions in mm



The reference line is determined by the plane of the upper edge of the flange of the reference line gauge when the gauge is resting on the cone.

TYPICAL OPERATING CONDITIONS

Grid drive service

Final accelerator voltage	$V_{a,g_3,g_5(\ell)}$	11	13	kV
Focusing electrode voltage	V_{g_4}	0 to 350	50 to 400	V 1)
Grid No.2 voltage	V_{g_2}	250	350	V
Grid No.1 voltage for visual extinction of focused raster	V_{g_1}	-35 to -69	-46 to -91	V

Cathode drive service

Voltages are specified with respect to grid No.1

Final accelerator voltage	$V_{a,g_3,g_5(\ell)}$	11	13	kV
Focusing electrode voltage	V_{g_4}	0 to 350	50 to 400	V 1)
Grid No.2 voltage	V_{g_2}	200 to 350	350	V
Cathode voltage for visual extinction of focused raster	V_k	approx. 45	44 to 80	V

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{a,g_3,g_5(\ell)}$	max.	14	kV
		min.	7.5	kV
Grid No.4 voltage	V_g			
positive	V_{g_4}	max.	500	V
negative	$-V_{g_4}$	max.	50	V
Grid No.2 voltage	V_{g_2}	max.	350	V
		min.	200	V
Grid No.2 to grid No.1 voltage	V_{g_2}/V_{g_1}	max.	450	V
Grid No.1 voltage				
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	2	V
negative	$-V_{g_1}$	max.	100	V
negative peak	$-V_{g_{1p}}$	max.	350	V 2)

1) Voltage range to obtain optimum overall focus at 100 μA beam current.

2) Maximum pulse duration 22% of a cycle but max. 1.5 ms.

LIMITING VALUES (continued)

Cathode to grid No.1 voltage		
positive	V_{k/g_1}	max. 100 V
positive peak	$V_{k/g_{1p}}$	max. 350 V [1]
negative	$-V_{k/g_1}$	max. 0 V
negative peak	$-V_{k/g_{1p}}$	max. 2 V
Cathode to heater voltage		
positive	$V_{k/f}$	max. 110 V
positive peak	V_{k/f_p}	max. 130 V

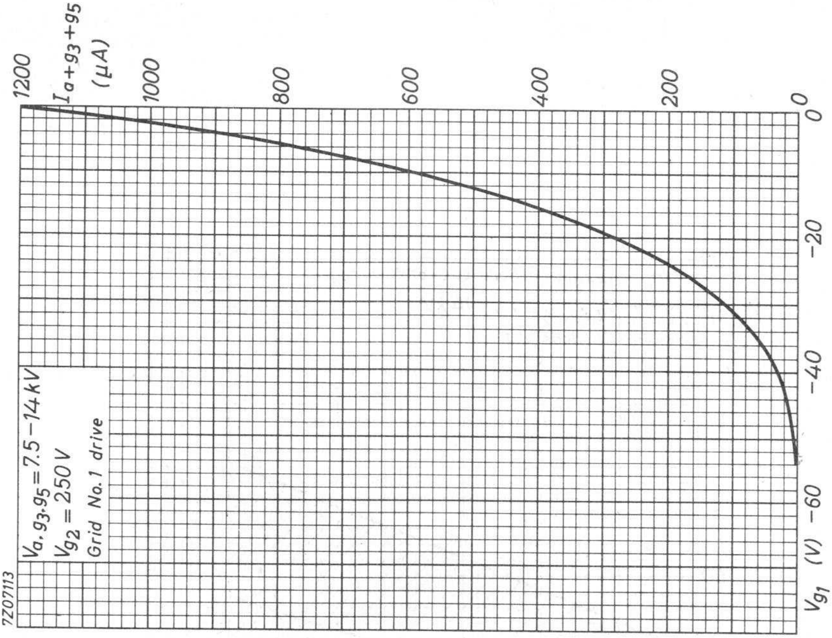
CIRCUIT DESIGN VALUES

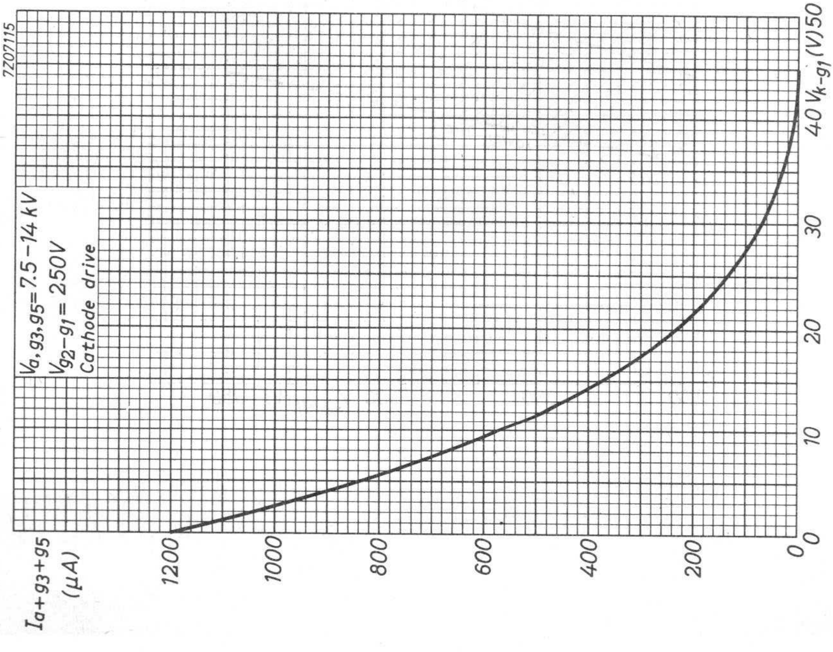
Grid No.4 current		
positive	I_{g_4}	max. 25 μA
negative	$-I_{g_4}$	max. 25 μA
Grid No.2 current		
positive	I_{g_2}	max. 5 μA
negative	$-I_{g_2}$	max. 5 μA

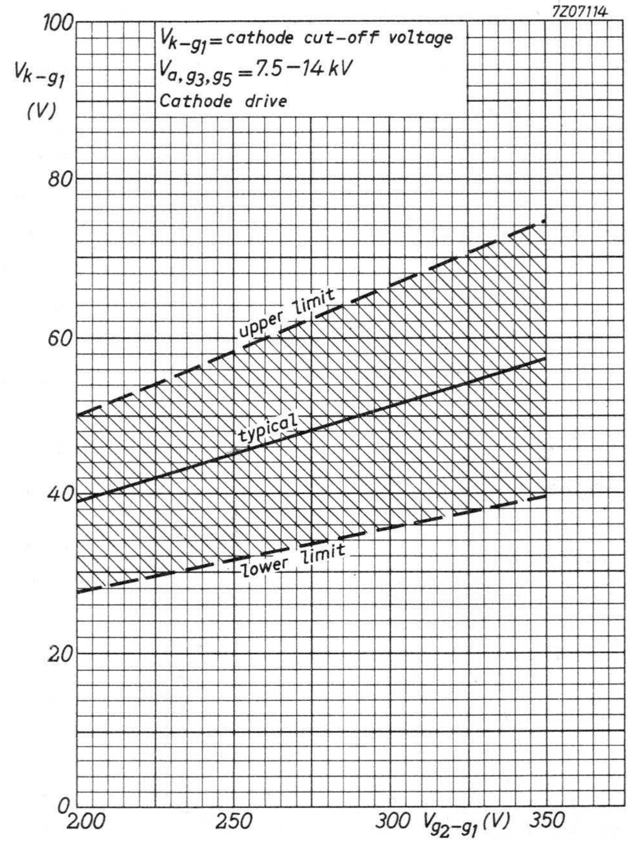
MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	$R_{k/f}$	max. 1 MΩ
Impedance between cathode and heater	$Z_{k/f}$ (50 Hz)	max. 0.1 MΩ
Grid No.1 circuit resistance	R_{g_1}	max. 1.5 MΩ
Grid No.1 circuit impedance	Z_{g_1} (50 Hz)	max. 0.5 MΩ
Resistance between external conductive coating and rimband	$R_{m/m'}$	max. 2 MΩ

[1]) Maximum pulse duration 22% of a cycle but max. 1.5 ms.


7Z07113
$V_{a,g_3,g_5} = 7.5 - 14$ kV
$V_{g_2} = 250$ V
Grid No.1 drive
$I_{a+g_3+g_5}$ (μA)
1200
1000
800
600
400
200
0
0
−20
−40
−60
V_{g_1} (V)


7Z07115
$V_{a,g_3,g_5} = 7.5 - 14$ kV
$V_{g_2-g_1} = 250$ V
Cathode drive
$I_{a+g_3+g_5}$ (μA)
1200
1000
800
600
400
200
0
0
10
20
30
40
V_{k-g_1} (V)
50



7Z07114
V_{k-g_1} = cathode cut-off voltage
V_{a,g_3,g_5} = 7.5 − 14 kV
Cathode drive
100
V_{k-g_1}
(V)
80
60
40
20
0
upper limit
typical
lower limit
200
250
300
$V_{g_2-g_1}$ (V)
350

MONITOR TUBE

36 cm rectangular television tube with metal backed screen primarily intended for use as a precision monitor.

QUICK REFERENCE DATA	
Deflection angle	90 ^{o}
Focusing	electrostatic
Resolution	min. 650 lines
Overall length	max. 317 mm

SCREEN

Metal backed phosphor

Lumenescence	white	
Useful diagonal	min.	329 mm
Useful width	min.	304.5 mm
Useful height	min.	241 mm

HEATING

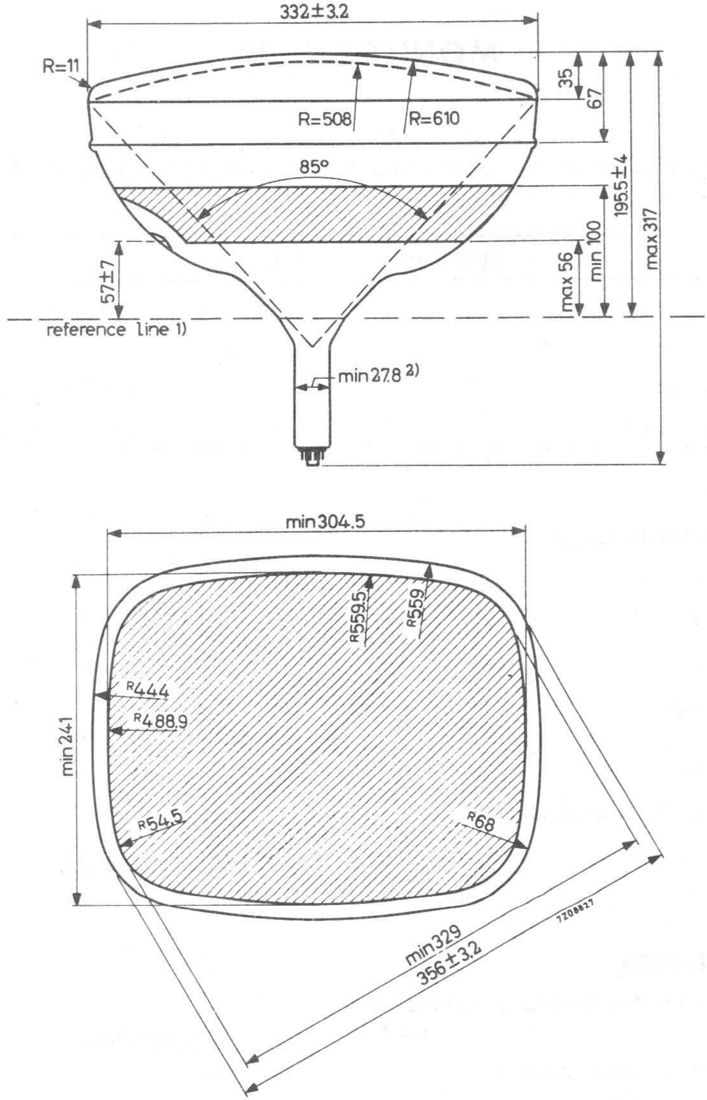
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	=	11 V	±10 %
Heater current	I_f	=	68 mA	

CAPACITANCES

Final accelerator to external conductive coating	$C_{g_3, g_5(\ell)/m}$	=	800 pF
Cathode to all other elements	C_k	=	5.0 pF
Grid No.1 to all other elements	C_{g_1}	=	9.0 pF

→ **MECHANICAL DATA** Dimensions in mm

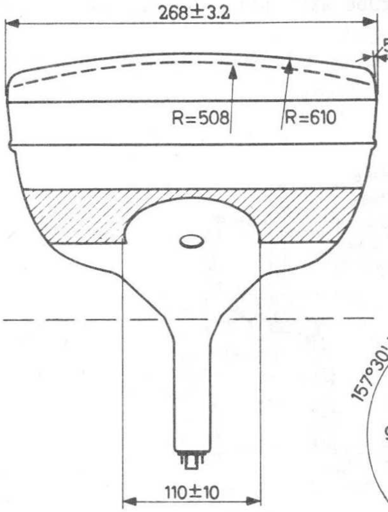


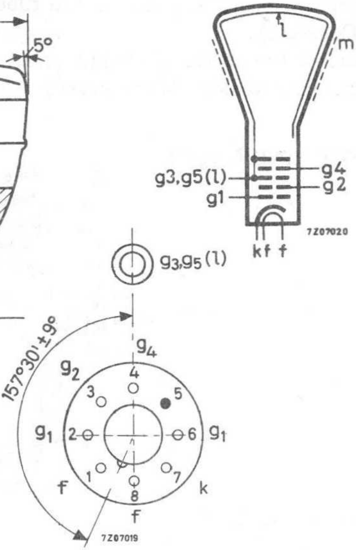
1) Reference line is determined by the plane of the upper edge of the flange of the reference line gauge when the gauge is resting on the cone.

2) The maximum dimension is determined by the reference line gauge.

MECHANICAL DATA (continued)

Dimensions in mm





Mounting position: any

Except vertical with the screen downward and the axis of the tube making an angle of less than 20° with the vertical.

Base:	Neo Eightar (B8H)
Cavity contact	CT8
Accessories:	
Socket	2422 501 06001
Final accelerator contact connector	type 55563

FOCUSING electrostatic

The range of focus voltage shown under typical operating conditions results in optimum focus at a beam current of 100 μA.

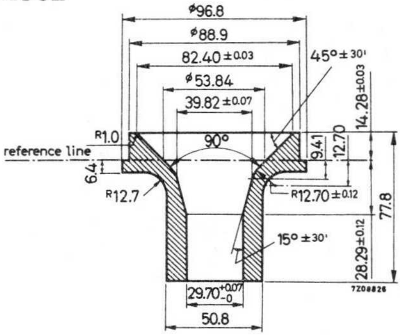
DEFLECTION magnetic

Diagonal deflection angle 90°

PICTURE CENTRING MAGNET

Field intensity perpendicular to the tube axis adjustable from 0 to 79.6 A/m (0 to 10 Oerstedt).
Adjustment of the centring magnet should not be such that a general reduction in brightness or shading of the raster occurs.

REFERENCE LINE GAUGE



TYPICAL OPERATION

Final accelerator voltage	$V_{g3,g5(\ell)}$	=	16	kV
Focusing electrode voltage	V_{g4}	=	0 to 500	V [1]
First accelerator voltage	V_{g2}	=	600	V
Grid No.1 voltage for extinction of focused raster (grid drive service)	$-V_{g1}$	=	43 to 98	V
Cathode voltage for extinction of focused raster (cathode drive service)	V_k	=	40 to 90	V

RESOLUTION

Resolution at screen centre			min. 650	lines
Measured at:	$V_{g3,g5(\ell)}$	=	16	kV
	V_{g2}	=	600	V

This tube will resolve 650 lines measured at a brightness of 340 Nits based on a picture height of 237 mm.
The focus voltage is adjusted to obtain the smallest roundest spot. For optimum overall resolution an external centring magnet may be required.

---

[1]) With the small change in focus spot size with variation of focus voltage, the limit of 0 to 500 V is such that an acceptable focus quality is obtained within this range. If it is required to pass through the point of focus, a voltage of at least −100 V to +600 V will be required.

LIMITING VALUES (Absolute max. rating system)

Final accelerator voltage	$V_{g_3,g_5(\ell)}$	= max.	18 kV
		= min.	12 kV
Focusing electrode voltage	V_{g_4}	= max.	1 kV
	$-V_{g_4}$	= max.	500 V
First accelerator voltage	V_{g_2}	= max.	800 V
Grid No.1 voltage			
positive	V_{g_1}	= max.	0 V [1]
positive peak	$V_{g_{1p}}$	= max.	2 V
negative	$-V_{g_1}$	= max.	180 V
Cathode to heater voltage	$V_{k/f}$	= max.	80 V
Cathode to heater peak voltage	V_{k/f_p}	= max.	130 V
Focusing electrode current	I_{g_4}	= max.	$\pm$25 μA
First accelerator current	I_{g_2}	= max.	$\pm$ 5 μA

MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	$R_{k/f}$	= max.	1 MΩ
Impedance between cathode and heater	$Z_{k/f}$ (50 Hz)	= max.	500 kΩ
Impedance between cathode and earth	$Z_{k/f}$ (50 Hz)	= max.	100 kΩ
Grid No.1 circuit resistance	R_{g_1}	= max.	1.5 MΩ
Grid No.1 circuit impedance	Z_{g_1} (50 Hz)	= max.	500 kΩ
First accelerator circuit resistance	R_{g_2}	= max.	1 MΩ
Focusing electrode circuit resistance	R_{g_4}	= max.	3 MΩ

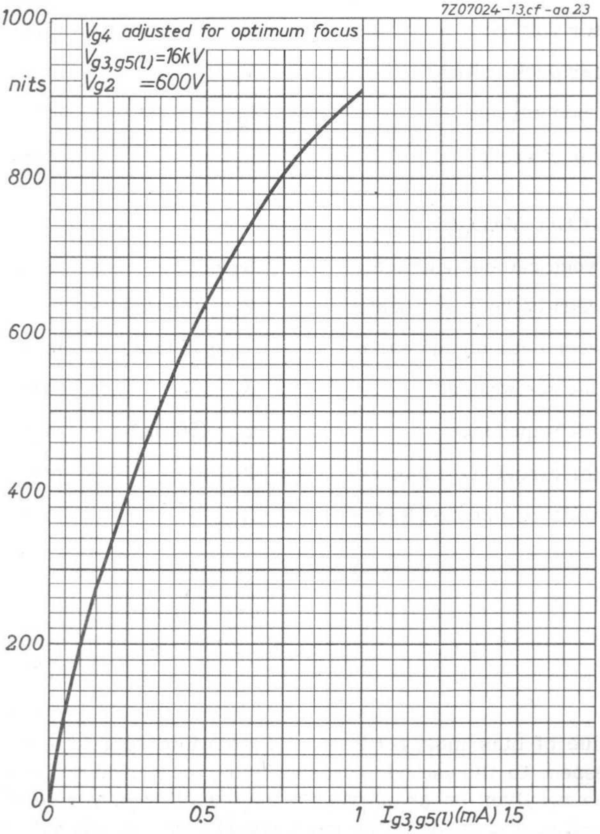
[1]) The d.c. value of bias must not be such as to allow the grid to become positive with respect to the cathode, except during the period immediately after switching the receiver on or off when it may be allowed to rise to +1 V. The maximum positive excursion of the video signal must not exceed +2 V, and at this voltage the grid current may be expected to be approximately 2 mA.

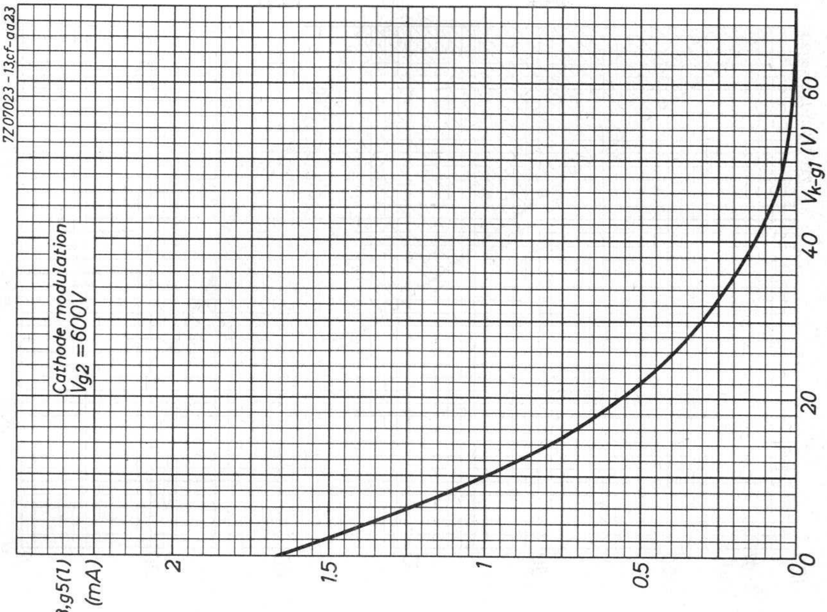
EXTERNAL CONDUCTIVE COATING

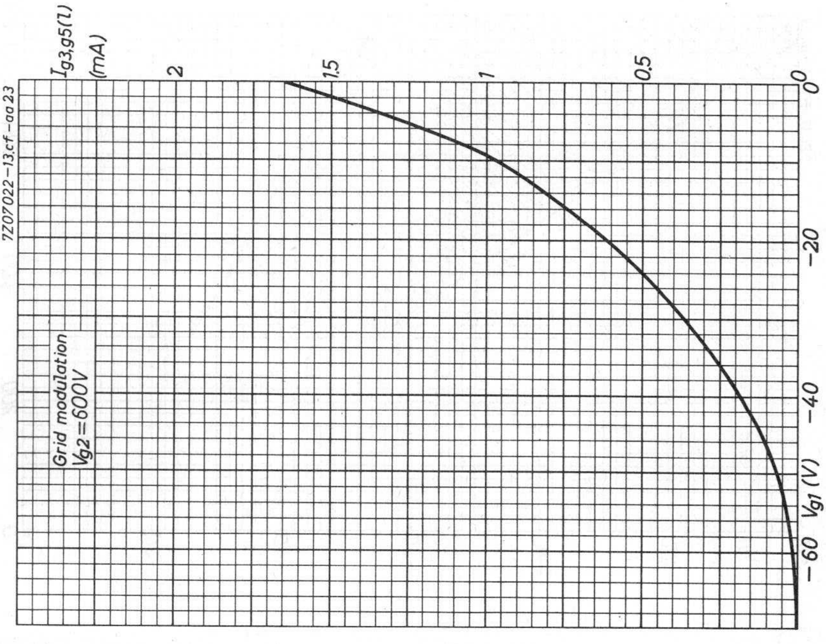
This tube has an external conductive coating, m, which must be earthed and the capacitance of this to the final electrode is used to provide smoothing for the e.h.t. supply. The tube marking and warning labels are on the side of the cone opposite the final electrode connector and this side should not be used for making contact to the external conductive coating.

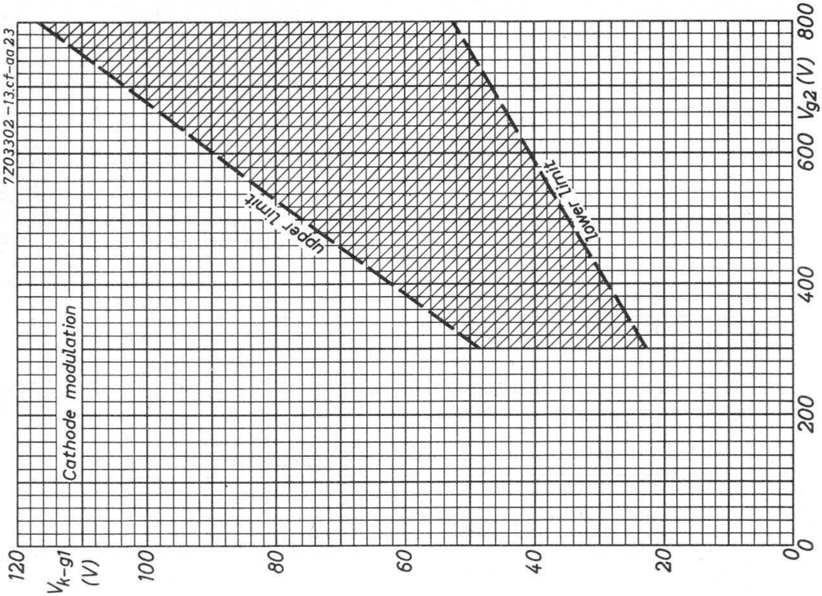
WARNING

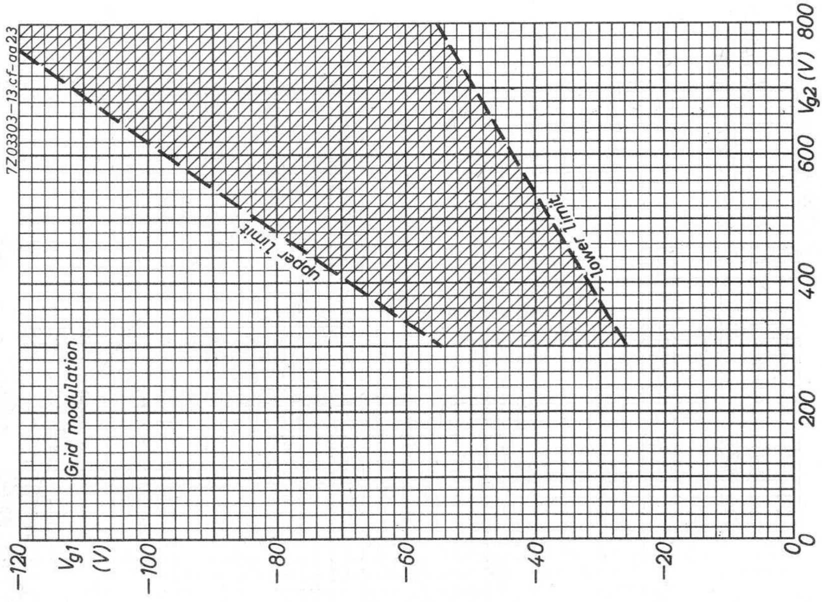
X-ray shielding is advisable to give protection against danger of personal injury arising from prolonged exposure at close range to this tube,




7Z07023-13.cf-aa23
Cathode modulation
V_{g2} =600V
$I_{g3,g5(l)}$
(mA)
2
1.5
1
0.5
0
0
20
40
60
V_{k-g1} (V)


7Z07022-13.cf-aa23
Grid modulation
V_{g2} =600V
$I_{g3,g5(l)}$
(mA)
2
1.5
1
0.5
0
0
−20
−40
−60
V_{g1} (V)


7Z03302-13.cf-aa23
Cathode modulation
upper limit
lower limit
V_{k-g1} (V)
120
100
80
60
40
20
0
0
200
400
600
800
V_{g2} (V)


7Z03303-13.cf-aa23
Grid modulation
upper limit
lower limit
V_{g1} (V)
−120
−100
−80
−60
−40
−20
0
0
200
400
600
800
V_{g2} (V)

MONITOR TUBE

The M36-13W is a 36 cm diameter rectangular television tube with metal backed screen primarily intedned for use as a monitor tube.

QUICK REFERENCE DATA		
Deflection angle		110°
Focusing		electrostatic
Resolution	min.	625 lines
Overall length	max.	268.5 mm

SCREEN

Metal backed

Colour	white		
Useful screen diagonal	min.	333.4	mm
Useful screen width	min.	314.3	mm
Useful screen height	min.	250.8	mm

HEATING

Indirect by A.C. or D.C.; parallel or series supply

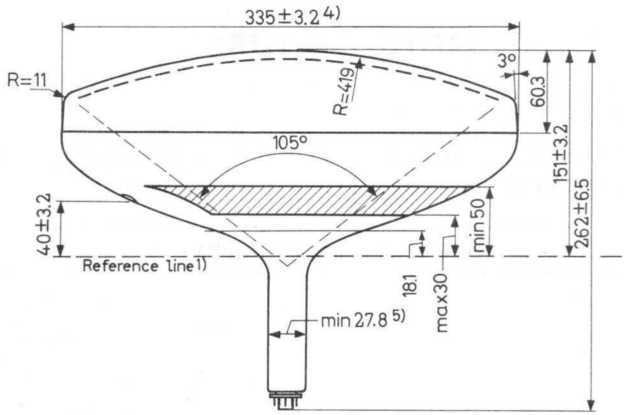
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

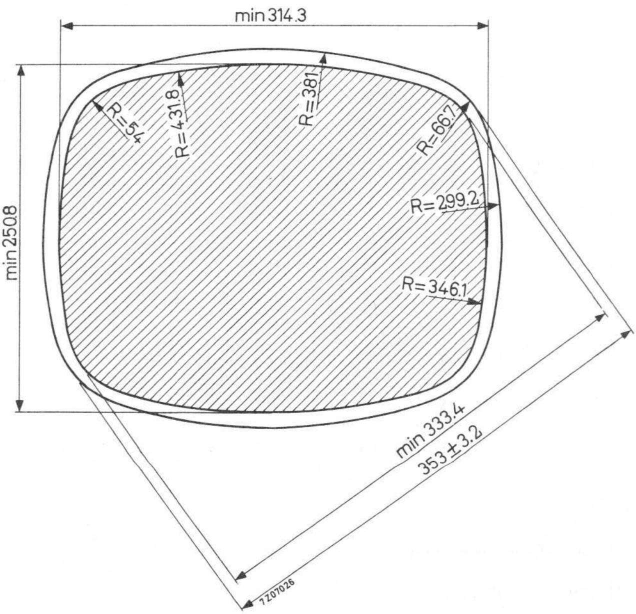
CAPACITANCES

Control grid to all other elements	C_{g_1}	7.0	pF
Cathode to all other elements	C_k	4.0	pF
Final accelerator to external conductive coating	$C_{g_3,g_5(\ell)/m}$	800	pF

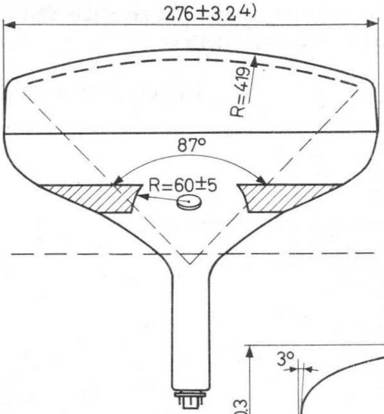
MECHANICAL DATA

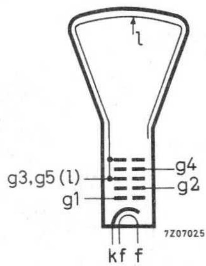
Dimensions in mm

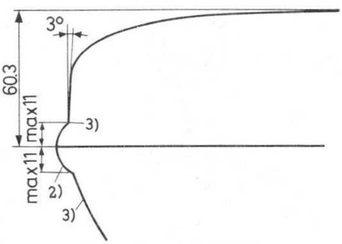




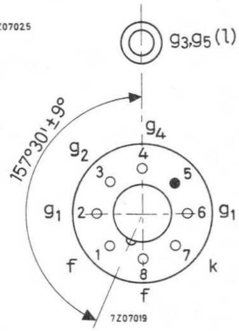
MECHANICAL DATA (continued) Dimensions in mm







Detail of panel



Mounting position: any, except vertical with the screen downward and the axis of the tube making an angle of less than 20^{o} with the vertical.

Base	Neo eightar (B8H)
Cavity contact	CT8
Accessories	
Final accelerator contact connector	type 55563

FOCUSING electrostatic

The range of focus voltage shown under "Typical operating conditions" results in optimum focus at a beam current of 100 μA.

DEFLECTION double magnetic

diagonal deflection angle 110^{o}

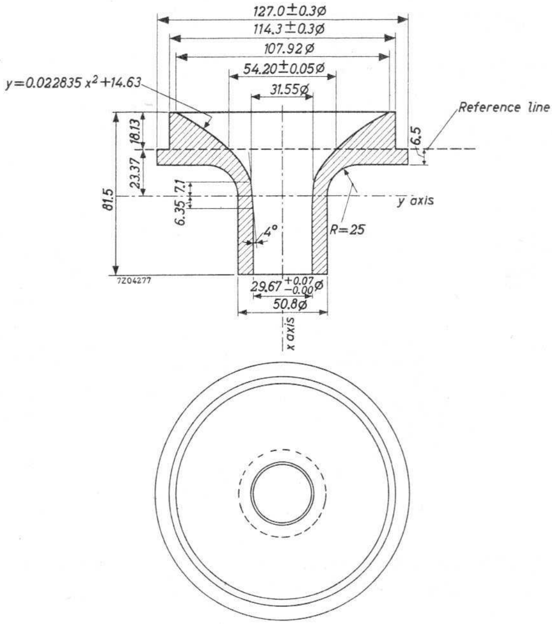
1) 2) 3) 4) 5) See page 6.

PICTURE CENTRING MAGNET

Field intensity perpendicular to the tube axis adjustable from 0 to 79.6 A/m (0 to 10 Oerstedt). Adjustment of the centring magnet should not be such that a general reduction in brightness or shading of the raster occurs.

REFERENCE LINE GAUGE

Dimensions in mm



TYPICAL OPERATING CONDITIONS

Final accelerator voltage	$V_{g_3,g_5(\ell)}$	16	kV
Focusing electrode voltage	V_{g_4}	0-400	V [1])
First accelerator voltage	V_{g_2}	400	V
Grid No.1 voltage for visual extinction of a focused raster	$-V_{g_1}$	40 to 85	V
Resolution at screen centre		min. 625	lines
Measured at	$V_{g_3,g_5(\ell)}$	16	kV
	V_{g_2}	400	V

This tube will resolve 625 lines measured at a brightness of 340 Nits based on a picture height of 237 mm.
The focus voltage is adjusted to obtain the smallest roundest spot. For optimum overall resolution an external centring magnet may be required.

LIMITING VALUES (Absolute max. rating system)

Measured with respect to cathode

Final accelerator voltage	$V_{g_3, g_5(\ell)}$	max.	18	kV
		min.	13	kV
Focusing electrode voltage	V_{g_4}	max.	1	kV
	$-V_{g_4}$	max.	500	V
First accelerator voltage	V_{g_2}	max.	550	V
		min.	350	V
Control grid voltage,				
negative	$-V_{g_1}$	max.	150	V
positive	V_{g_1}	max.	0	V
Focusing electrode current	I_{g_4}	max.	± 25	μA
Grid No. 2 current	I_{g_2}	max.	± 5	μA
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	250	V
	$V_{+k/f-p}$	max.	300	V
cathode negative	$V_{-k/f+}$	max.	135	V
	$V_{-k/f+p}$	max.	180	V
Resistance between heater and cathode	R_{kf}	max.	1	MΩ
Resistance between grid No. 1 and earth	R_{g_1}	max.	1.5	MΩ
Impedance between heater and cathode (f = 50 Hz)	Z_{kf}	max.	500	kΩ
Impedance between cathode and earth (f = 50 Hz)	Z_k	max.	100	kΩ

[1]) With the small change in focus spot size with variation of focus voltage the limit of 0-400 V is such that an acceptable focus quality is obtained within this range. If it is required to pass through the point of focus, a voltage of at least −100 V to +500 V will be required.

WARNING

X-ray shielding is advisable to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operated above 16 kV.

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating (m), which must be earthed and capacitance of this to the final electrode is used to provide smoothing for the EHT supply. The tube marking and warning labels are on the side of the cone opposite the final electrode connector and this side should not be used for making contact to the external conductive coating.

NOTES TO OUTLINE DRAWING

1) The reference line is determined by the plane of the upper edge of the flange of the reference line gauge, (JEDEC 126) when the gauge is resting on the cone.

2) Bulge at splice-line seal may increase the indicated maximum value for envelope width, diagonal and height by not more than 6.4 mm, but at any point around the seal, the bulge will not protrude more than 3.2 mm beyond the envelope surface at the location specified for dimensioning the envelope width, diagonal and height.

3) The tube should be supported on both sides of the bulge. The mechanism used should provide clearance for the maximum dimensions of the bulge.

4) Measured 12 + 1 mm from the centre-line of the screen-cone seal.

5) The maximum dimension is determined by the reference line gauge.

FLYING SPOT SCANNER TUBE

The M.13-36 is a 13 cm diameter cathode-ray tube intended for flying spot applications.

QUICK REFERENCE DATA		
Accelerator voltage	25	kV
Deflection angle	40^{o}	
Resolution	1000	lines

SCREEN

Metal backed

	Colour	Persistence
MC13-16	Purplish blue	Very short
MK13-16	Green	Short

Useful screen diameter min. 108 mm

HEATING

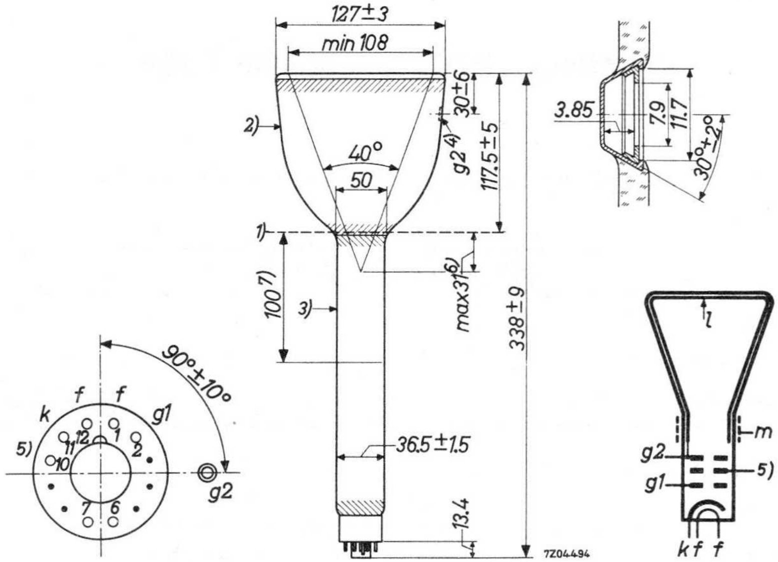
Indirect by A.C. or D.C.; series or parallel supply

Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

CAPACITANCES

Grid No.1 to all other electrodes	C_{g1}	6.5	pF
Cathode to all other electrodes	C_k	6.5	pF
Accelerator to outer conductive coating	$C_{g_2(\ell)/m}$	250 to 450	pF

→ **MECHANICAL DATA** Dimensions in mm



Mounting position: any, except with screen downwards and the axis of the tube making an angle of less than 50° with the vertical.

Base Duodecal 7p.

---

1) Reference line, determined by the plane of the upper edge of the reference line gauge when the gauge is resting on the cone.

2) Insulating outer coating; should not be in close proximity to any metal part.

3) Conductive outer coating; to be grounded.

4) Recessed cavity contact.

5) Spark trap; to be grounded.

6) The distance between the deflection centre and the reference line should not exceed 31 mm.

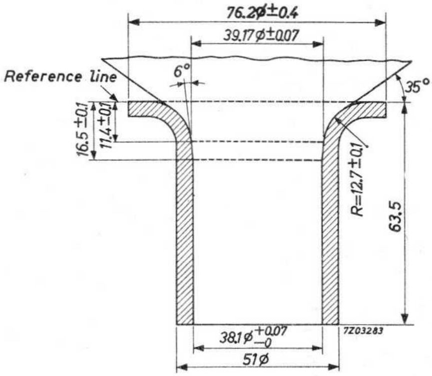
7) Distance between the centre of the magnetic length of the focusing unit and the reference line.

FOCUSING magnetic

Focusing coil — type AT1997

DEFLECTION magnetic

REFERENCE LINE GAUGE — Dimensions in mm



OPERATING CHARACTERISTICS

Accelerator voltage	$V_{g2(\ell)}$	25	kV
Beam current	I_ℓ	50 to 150	μA
Negative grid No.1 cut-off voltage	$-V_{g1}(I_\ell=0)$	50 to 100	V

Resolution at centre of screen better than 1000 lines [1])

[1]) With focusing coil AT1997

LIMITING VALUES (Absolute max. rating system)

Accelerator voltage	$V_{g_2(\ell)}$	max.	27	kV
		min.	20	kV
Grid No.1 voltage,				
negative value	$-V_{g_1}$	max.	200	V
positive value	$+V_{g_1}$	max.	0	V
peak positive value	$+V_{g_{1p}}$	max.	2	V
Cathode current	I_k	max.	150	μA
Voltage between heater and cathode [1]				
cathode negative	V_{kf} (k neg.)	max.	125	V
cathode positive	V_{kf} (k pos.)	max.	200	V
peak value, cathode positive	V_{kf_p} (k pos.)	max.	410	V [2]
External resistance between heater and cathode	R_{kf}	max.	1	MΩ
External grid No.1 resistance	R_{g_1}	max.	1.5	MΩ
External grid No.1 impedance at a frequency of 50 Hz	Z_{g_1} (f = 50 Hz)	max.	0.5	MΩ

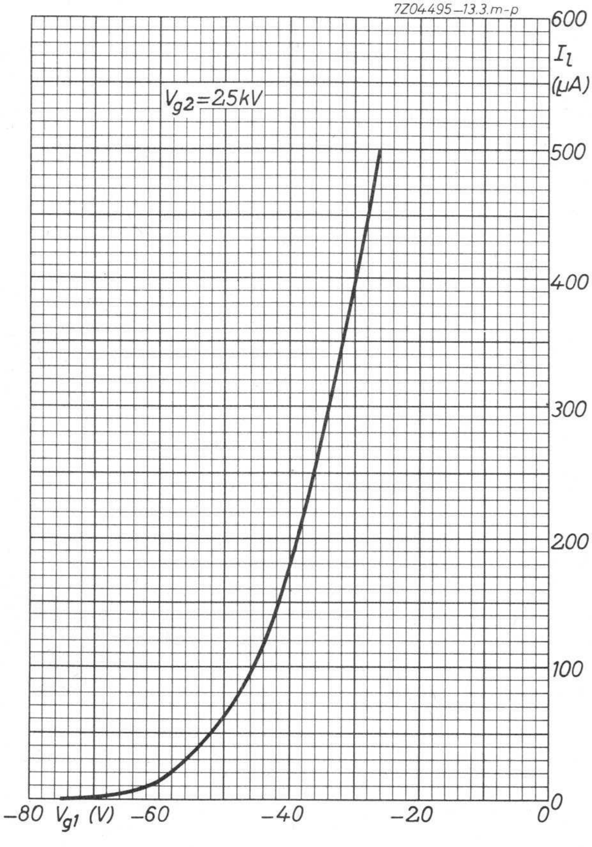
REMARKS

Measures should be taken for the beam current to be switched off immediately when one of the time-base circuits becomes defective.

An X-ray radiation shielding with an equivalent lead thickness of 0.5 mm is required to protect the observer.

[1] In order to avoid excessive hum, the A.C. component of the heater to cathode voltage should be as low as possible and should not exceed 20 V_{RMS}.

[2] During a heating-up period not exceeding 45 sec.


7Z04495-13.3.m-p
600
I_l
(μA)
V_{g2}=2,5kV
500
400
300
200
100
0
-80
V_{g1} (V)
-60
-40
-20
0

PROJECTION TUBE

The M.13-38 are 13 cm diameter projection tubes.
The tubes are designed for large screen projection of colour TV displays.

QUICK REFERENCE DATA	
Final accelerator voltage	50 kV
Deflection angle	47^{o}
Focusing	magnetic

SCREEN

Type	MG13-38	MU13-38	MY13-38
Colour	green	blue	yellow
Colour point	x=0.19 y=0.72	x=0.17 y=0.13	x=0.661 y=0.331

Useful area min. 92×69 mm^2

Brightness

MG13-38	2000	mcd/cm^2
MU13-38	290	mcd/cm^2
MY13-38	600	mcd/cm^2

measured at V_{g_2} = 50 kV
I_{ℓ} = 500 μA
raster size 92×69 mm^2

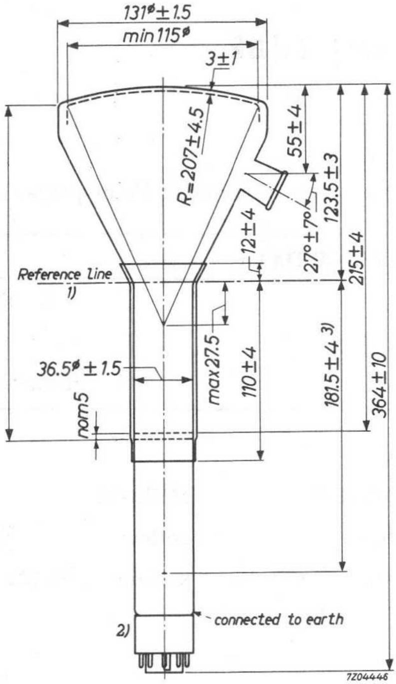
HEATING

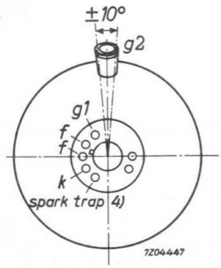
Indirect by A.C. or D.C.; parallel or series supply

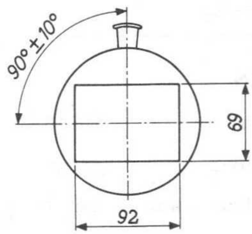
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

MECHANICAL DATA

Dimensions in mm







1) Reference line is determined by position where a gauge 38.1 $^{+0.05}_{-0.00}$ mm diameter and 50 mm long will rest on bulb cone.

2) Socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. Bottom circumference of base shell will fall within circle concentric with cone axis and having a diameter of 50 mm.

3) Distance reference line - top centre of grid.

4) This pin must be connected to earth.

MECHANICAL DATA (continued)

Mounting position: any, except with screen downwards with the axis at an angle of less than 50° to the vertical.
The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Duodecal 7 p
Dimensions and connections	
Overall length	max. 374 mm
Face diameter	max. 132.5 mm
Net weight	approx. 950 g
Accessories	
Socket	type 5912/20
Final accelerator contact connector	supplied with tube

CAPACITANCES

Control grid to all other elements	C_{g_1}	max.	10	pF
Cathode to all other elements	C_k	max.	9	pF

FOCUSING magnetic

Distance from the centre of the air gap of the focusing coil to the front of the screen 240 mm

DEFLECTION double magnetic

deflection angle 47°

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_2(\ell)}$	50	kV
Negative grid No.1 voltage for visual extinction of focused raster	$-V_{g_1}$	100 to 170	V
Peak accelerator current	$I_{g_{2p}}$	max. 2500	μA

LIMITING VALUES (Absolute max. rating system)

Measured with respect to cathode

Accelerator voltage	$V_{g_2(\ell)}$	max. min.	55 40	kV kV
Control grid voltage,				
negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	0	V
Grid No. 2 current	I_{g_2}	max.	500	μA [1]
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	100	V
cathode negative	$V_{-k/f+}$	max.	50	V [2]
Resistance between heater and cathode	R_{kf}	max.	20	kΩ
Resistance between grid and earth	R_{g_1}	max.	1.5	MΩ
Impedance between grid and earth (f = 50 Hz)	Z_{g_1}	max.	0.5	MΩ

[1] In order to prevent the possible occurrence of cracked faces, for images with concentrated bright areas (high screen loads) the g_2 current should be kept lower than the indicated value. This is especially the case as for as stationary pictures are concerned.

[2] In order to avoid excessive hum, the A.C. component of the heater to cathode voltage should be as low as possible and must not exceed 20 V_{RMS}.

GENERAL OBSERVATIONS

It is essential that means be provided for the instantaneous removal of the beam current in the event of a failure of either one or both of the time bases. Unless such a safety device is incorporated a failure of this type will result in the immediate destruction of the screen of the tube.

Shielding equivalent to a lead thickness of 1 mm is required to protect the observer against X radiation.

The raster dimensions should not come below the minimum of 69x72 mm^2. The screen shall be given adequate cooling by applying a continuous airblast onto the screen of approx. 0.06 m^3/sec.

In order to prevent damage of the tube caused by a momentary internal arc a resistor of 50 kΩ has to be connected between anode contact and the power supply.

Before removing the tube, the screen and the cone should be discharged.

The spark trap and the outer coating of the tube must be connected to earth.

It is necessary to centre the focusing coil to get optimum sharpness.

It is recommended to use the E.H.T. connector, which is delivered with each tube.

PROJECTION TUBE

The MW13-38 is a 13 cm diameter projection tube.
The brightness of the tube is such that it can be used for large screen projection of TV displays.

QUICK REFERENCE DATA	
Final accelerator voltage	50 kV
Deflection angle	47^{o}
Focusing	magnetic

SCREEN

Metal backed

Colour	white
Useful screen area	92 x 69 mm^2
Brightness	min. 870 mcd/cm^2

measured at V_{g_2} = 50 kV
I_l = 500 μA
raster size 92 x 69 mm^2

HEATING

Indirect by A.C. or D.C.; parallel or series supply

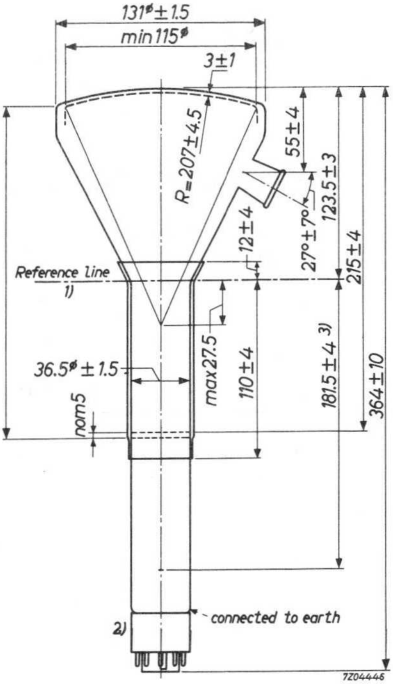
Heater voltage	V_f	6.3	V
Heater current	I_f	300	mA

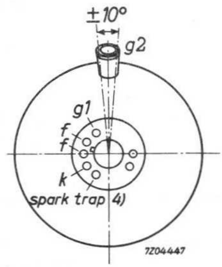
CAPACITANCES

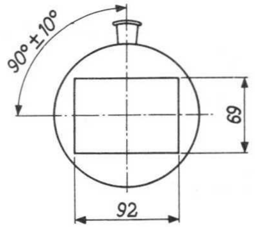
Control grid to all other elements	C_{g_1}	max.	10	pF
Cathode to all other elements	C_k	max.	9	pF

MECHANICAL DATA

Dimensions in mm







---

1) Reference line is determined by position where a gauge $38.1^{+0.05}_{-0.00}$ mm diameter and 50 mm long will rest on bulb cone.

2) Socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. Bottom circumference of base shell will fall within circle concentric with cone axis and having a diameter of 50 mm.

3) Distance reference line - top centre of grid.

4) This pin must be connected to earth.

MECHANICAL DATA (continued)

Mounting position: any, except screen downwards with the axis at an angle of less than 50^{o} to the vertical.
The tube should not be supported by the base alone and under no circumstances should the socket be allowed to support the tube.

Base	Duodecal 7 p
Dimensions and connections	
Overall length	max. 374 mm
Face diameter	max. 132.5 mm
Net weight	approx. 950 g
Accessories	
Socket	type 5912/20
Final accelerator contact connector	supplied with tube

FOCUSING magnetic

Distance from the centre of the air gap of the focusing coil to the front of the screen 240 mm

DEFLECTION double magnetic

deflection angle 47^{o}

TYPICAL OPERATING CONDITIONS

Accelerator voltage	$V_{g_2(\ell)}$	50	kV
Negative grid No.1 voltage for visual extinction of a focused raster	$-V_{g_1}$	100 to 170	V
Peak accelerator current	$I_{g_{2p}}$	min. 2500	μA

LIMITING VALUES (Absolute max. rating system)

Measured with respect to cathode

Accelerator voltage	$V_{g_2(\ell)}$	max.	55	kV
		min.	40	kV
Control grid voltage,				
negative	$-V_{g_1}$	max.	200	V
positive	V_{g_1}	max.	0	V
positive peak	$V_{g_{1p}}$	max.	0	V
Grid No.2 current	I_{g_2}	max.	500	μA [1]
Cathode to heater voltage,				
cathode positive	$V_{+k/f-}$	max.	100	V [2]
cathode negative	$V_{-k/f+}$	max.	50	V
Magnification maximum			40	x
Resistance between heater and cathode	R_{kf}	max.	20	kΩ
Resistance between grid and earth	R_{g_1}	max.	1.5	MΩ
Impedance between grid and earth (f = 50 Hz)	Z_{g_1}	max.	0.5	MΩ

[1]) In order to prevent the possible occurrence of cracked faces, for images with concentrated bright areas (high screen loads) the g_2 current should be kept lower than the indicated value. This is especially the case as for as stationary pictures are concerned.

[2]) In order to avoid excessive hum, the A.C. component of the heater to cathode voltage should be as low as possible and must not exceed 20 V_{RMS}.

GENERAL OBSERVATIONS

It is essential that means be provided for the instantaneous removel of the beam current in the event of a failure of either one or both of the time bases. Unless such a safety device is incorporated a failure of this type will result in the immediate destruction of the screen of the tube.

Shielding equivalent to a lead thickness of 1 mm is required to protect the observer against X radiation.

The raster dimensions should not come below the minimum of 69x72 mm^2. The screen shall be given adequate cooling by applying a continuous airblast onto the screen of approx. 0.06 m^3/sec.

In order to prevent damage of the tube caused by a momentary internal arc a resistor of 50 kΩ has to be connected between anode contact and the power supply.

Before removing the tube, the screen and the cone should be discharged.

The spark trap and the outer coating of the tube must be connected to earth.

It is recommended to use the E.H.T. connector, which is delivered with each tube.

It is necessary to centre the focusing coil to get optimum sharpness.

Camera tubes

RATING SYSTEM

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

7Z2 8269

VIDICONS

The 55850, 55851 and 55852 series are superseded by the XQ1040 and XQ1050 series. Data will be issued in the course of 1968.

CAMERA TUBE

Vidicon with low heater current intended for use in black-and-white or colour TV cameras in industrial, medical and broadcast applications.

QUICK REFERENCE DATA		
Resolution	600 to 900	TV lines
Focusing	magnetic	
Deflection	magnetic	
Diameter	25.4	mm (1 inch)
Length	158	mm ($6\frac{1}{4}$ inch)
Heater	6.3 V, 90	mA

The 55850 has 5 grades:

- 55850 AM: low cost tube for experiments, amateur use etc.
- 55850 F : for use in film scanners
- 55850 N : for normal industrial applications
- 55850 S : for industrial and broadcast applications in which a higher picture quality is required
- 55850 SR : for use in X-ray medical equipment

The electrical and mechanical properties of the 5 grades are identical, main differences being found in the degree of uniformity and freedom of blemishes of the photoconductive layers.

OPTICAL

Diagonal of quality rectangle on photoconductive layer (aspect ratio 3 : 4) max. 16 mm

Orientation of image on photoconductive layer:
horizontal scan should be essentially parallel to the plane passing through tube axis and short index pin. The masking is for orientation only and does not define the proper scanned area of the photoconductive layer.

Spectral response See page 12

HEATING

Indirect by A.C. or D.C., series or parallel supply

Heater voltage	V_f	6.3	V +10%
Heater current	I_f	90	mA

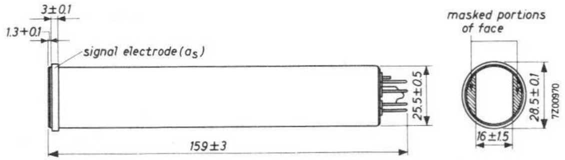
When the tube is used in a series heater chain the heater voltage must not exceed 9.5 V_{rms} when the supply is switched on.

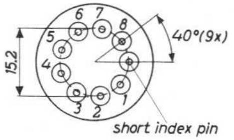
CAPACITANCES

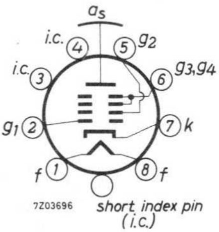
Signal electrode to all	C_{a_s}	4.5	pF [1]

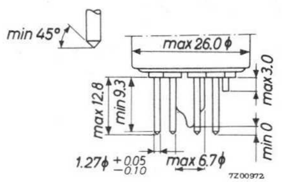
MECHANICAL DATA

Base: JEDEC No. E8-11 Dimensions in mm









FOCUSING magnetic

DEFLECTION magnetic

MOUNTING POSITION: any

NET WEIGHT approx. 65 g

---

[1] This capacitance, which effectively is the output impedance of the 55850, is increased by about 3 pF when the tube is inserted into the deflection and focusing coil-assembly. The resistive component of the output impedance is in the order of 100 MΩ.

ACCESSORIES

Socket — Cinch No. 54A18088 or equivalent

Focusing and deflection coil assembly: AT1101, AT1102 or equivalent.

LIMITING VALUES (Absolute max. rating system)
for scanned area of 9.6 mm x 12.8 mm (3/8" x 1/2") [1]

Signal electrode voltage	V_{a_s}	max.	100	V [2]
Grid No.4 and grid No.3 voltage	V_{g_4,g_3}	max.	800	V
Grid No.2 voltage	V_{g_2}	max.	350	V
Grid No.1 voltage,				
negative	$-V_{g_1}$	max.	125	V
positive	$+V_{g_1}$	max.	0	V
Signal electrode current, peak	$I_{a_{s_p}}$	max.	0.6	μA [3]
Faceplate illumination		max.	5000	lux
Faceplate temperature	t	max.	80	^{o}C [4]
Cathode to heater voltage, peak				
cathode positive	V_{kf_p}	max.	125	V
cathode negative	V_{kf_p}	max.	10	V
Dark current, peak	I_{d_p}	max.	0.25	μA

[1] "Full-size scanning", i.e. scanning of a 9.6 mm x 12.8 mm area of the photoconductive layer should always be applied. The use of a mask having these dimensions is recommended. Underscanning, i.e. scanning of an area less than 9.6 mm x 12.8 mm may cause permanent damage to the specified full-size area.

[2] The signal-electrode voltage should never exceed 100 V, either during heating-up or stand-by, or during operation. An excessive signal-electrode voltage may cause permanent damage to the photoconductive layer.

[3] Video-amplifiers should be capable of handling signal-electrode currents of this magnitude without amplifier overload or picture distortion.

[4] Absolute maximum for shelf-life and operation. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infra-red filters should be applied.

OPERATING CONDITIONS AND PERFORMANCE

For scanned area of 9.6 mm x 12.8 mm and faceplate temperature of 25-35 ^{o}C

A. PICK-UP FROM LIMITED-MOTION LIVE SCENES

Conditions

Grid No.3 and grid No.4 (beam focus electrode) voltage		250 - 300	V [1]
Grid No.2 voltage		300	V
Grid No.1 voltage adjusted for sufficient beam currents to stabilise highlights			
Minimum peak-to-peak blanking voltage			
when applied to grid No.1		75	V
when applied to the cathode		20	V [2]
Field strength at centre of focusing coil	approx.	40	Oerstedt [3]
Field strength of adjustable alignments coils		0 - 4	Oerstedt [4]

[1] Beam focus is obtained by the combined effect of the grid No.3 voltage, which should be adjustable over the indicated range and a focusing coil having an average field strength of 40 Oerstedt.
Definition, focus uniformity and picture quality decrease with decreasing grid No.3 voltage. In general, grid No.3 should be operated above 250 V.

[2] In transistorized cameras cathode blanking will be preferable. The cathode impedance is in the order of 30 kΩ.

[3] The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

[4] The alignment coil assembly should be located on the tube so that its centre is at a distance of approx. 94 mm (3 11/16") from the face of the tube and be positioned so that its axis coincides with the axis of the tube, the deflecting yoke and the focusing coil.

OPERATING CONDITIONS AND PERFORMANCE (continued)

Performance

Signal-electrode voltage for dark current of 0.02 μA,	range	20 - 100	V [1]
	typical	40	V
Grid No.1 voltage for picture cut-off		-30 to -100	V [2]
Signal output current, faceplate illumination 8 lux	typical	0.150	μA [3]
	minimum	0.075	μA
Resolution capability in picture centre (see page 13)		600	TV lines [4]
Decay: 8 lux on layer, V_{a_s} adjusted for dark current of 0.02 μA, residual signal after dark pulse of 200 msec	typical	10	%
Average gamma of transfer characteristic for signal output currents between 0.01 and 0.3 μA		0.6	
Visual equivalent signal-to-noise ratio	approx.	300 : 1	[5]

---

[1] The deflection circuits must provide sufficiently linear scanning for good black-level reproduction. The dark-current signal being proportional to the velocity of scanning, any change in this velocity will produce a black-level error.

[2] With no blanking voltage on grid No.1.

[3] Defined as the component of the signal-electrode current after the dark current has been subtracted.

[4] With a video-amplifier system having 7.5 Mc/s bandwidth (-3 dB points).

[5] Measured with a peak signal output current of 0.2 μA into a high-gain, cascode-input type of amplifier with an own noise of 0.002 μA r.m.s. and a bandwidth of 5 Mc/s. Because the noise in such a system is predominantly of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of the highlight video-signal current to the r.m.s. noise current multiplied by a factor of 3.

OPERATING CONDITIONS AND PERFORMANCE (continued)

B. PICK-UP FROM FILM (MINIMUM-LAG OPERATION)

Conditions

As under "Pick-up from limited-motion live scenes" with the exception of:

Faceplate illumination (highlight)		500	lux

Performance

As under "Pick-up from limited-motion live scenes" with the exception of:

Signal-electrode voltage for a dark current of 0.005 μA		10 - 20	V
Signal output current	typical	0.3	μA
Decay: peak white signal of 0.3 μA, residual signal after dark pulse of 200 msec	typical	3	%

C. OPERATION FOR MAX. RESOLUTION

Conditions

As under "Pick-up from limited-motion live scenes" or "Pick-up from film", with the exception of:

Grid No.3 and grid No.4 voltage		750	V
Field strength at centre of focusing coil	approx.	70	Oerstedt [1][2]

Performance

As in "Pick-up from limited-mottion live scenes" or "Pick-up from film", with the exception of:

Resolution capability in picture centre	approx.	900	TV lines

For further details see text and pages 13 and 14

[1]) The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

[2]) With this mode of operation beam-landing errors, resulting in parabolic shading and dark corners, increase. The deflecting and focusing coils should be designed to eliminate these errors.
The increased-power requirements for these coils will increase the tube temperature, adequate provisions for cooling should be made.

PRINCIPLE OF OPERATION

SCHEMATIC ARRANGEMENT

The schematic arrangement of the vidicon 55850 with its accessories is shown in Fig.1.

The vidicon may be assumed to consist of three sections, namely the electron gun, the scanning section, and the target section.

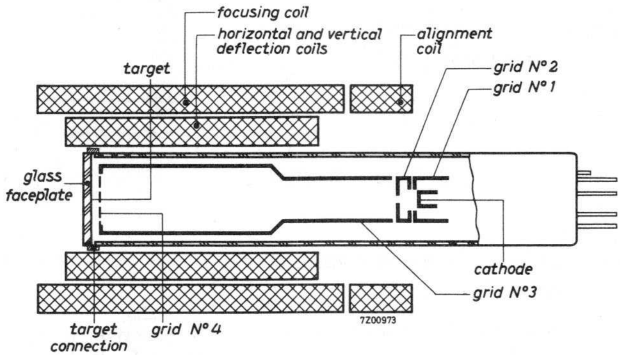


Fig. 1 Schematic electrode and coil arrangement

The electron gun contains a thermionic cathode, a grid g_1 controlling the amount of beam, and a limiter anode g_2 which accelerates the electrons and releases them in a fine beam through its diaphragm.

The scanning section. The electron beam released by g_2 enters the space enclosed by the cylindrical anode g_3. By means of the combined action of the adjustable electrical field of g_3 (beam focus control) and a fixed axial magnetic field produced by the focusing coil, the electrons are focused in one loop on to the target.

The far end of the g_3 cylinder is closed with a fine metal mesh, g_4, electrically connected to g_3, which produces a uniform, decelerating field in front of the target. The focused beam is magnetically deflected by two pairs of deflection coils so that it scans the target. Proper alignment of the beam with the axial magnetic field is achieved by either an adjustable magnet, or, as shown in Fig.1, by two sets of alignment coils producing an adjustable transverse magnetic field.

The target section is illustrated in Fig.2. It consists of:
- an optically flat glass faceplate,
- a transparent conductive film on the inner surface of the faceplate, connected electrically to the external signal-electrode ring.
- a thin layer of photoconductive material deposited on the conductive film. In the dark this material has a high specific resistance, which decreases with increasing illumination.

PRINCIPLE OF OPERATION (continued)

The optical image to be televised is focused on the conductive film by means of a lens system.

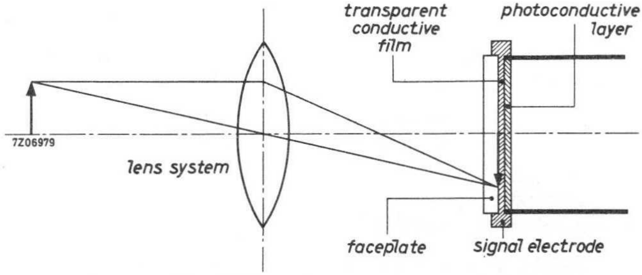


Fig. 2 Target section

OPERATING

The external signal-electrode ring is connected via a load resistor to a positive voltage in the order of 30 V (see Fig. 3).

The target may be assumed to consist of a large number of target elements, corresponding to the number of picture elements, each consisting of a small capacitor (C_e), connected on one side to the signal electrode via the transparent conductive film and shunted by a light-dependent resistor (R_{ld}, see Fig. 3).

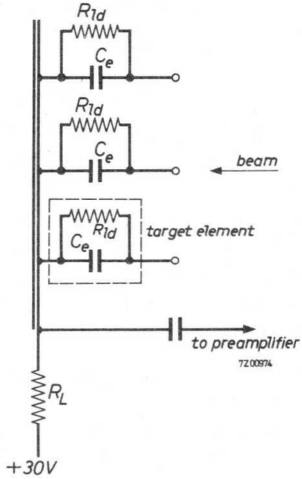


Fig. 3

When the target is scanned by the beam its surface will be stabilised at approximately the cathode potential (low-velocity stabilisation) and a potential difference will be established across the photoconductive layer, in other words, each elementary capacitor will be charged to nearly the same potential as applied to the electrode ring.

In the dark, the photoconductive material is a fairly good insulator, so that only a minute fraction of the charge of the elementary capacitors will leak away between successive scans. This charge will be restored by the beam; the resulting current to the signal electrode is termed "dark current".

When an optical image is focused on to the target, those target elements which are illuminated will become more conductive and will be partly discharged. As a consequence a pattern of positive charges corresponding to the optical image will be produced on the side of target facing the gun section.

OPERATION (continued)

When scanning this charge pattern the electron beam will deposit electrons on the positive elements until the latter are restored to their original cathode potential, causing a capacitive current to the signal electrode and hence a voltage across the load resistor R_L. This voltage, negative going for the highlights, is the video signal and is fed to the pre-amplifier.

A vidicon is called "stabilised" when the magnitude of the beam current applied is just sufficient to restore the scanned surface to cathode potential, so that all elementary capacitors, including those at the highlights in the image, are recharged successively.

During the retrace times the beam electrons should be prevented from landing on the target since otherwise the scan retraces will appear as dark lines in the picture obtained on the monitor. This may be achieved either by cutting off the beam with suitable negative blanking pulses on the control grid or by cutting off the target with adequate positive blanking pulses applied to the cathode.

EQUIPMENT DESIGN AND OPERATING CONSIDERATIONS

The signal-electrode connection is made by a spring contact, which bears against the metal ring at the face end of the tube. The spring contact may be provided as part of the focusing coil design.

The deflection yoke and the focus coil used with the 55850 must be so designed that the beam lands perpendicularly to the target at all points of the scanned area, to ensure high uniformity of sensitivity and focus.

The deflection circuits must provide constant scanning speeds in order to obtain good black-level reproduction. The dark-current signal being proportional to the velocity of scanning, any change in this velocity will produce a black-level error.

The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

The alignment coil assembly should be located on the tube so that its centre is at a distance of approx. 94 mm (3 11/16") from the face of the tube and be positioned so that its axis coincides with the axis of the tube, the deflecting yoke and the focusing coil.

The temperature of the faceplate should never exceed 80 °C, either during operation or storage of the 55850. Operation at a faceplate temperature of 25 to 35 °C is recommended.

The effect of the faceplate temperature on sensitivity and dark current of a typical 55850, measured with illumination level and signal-electrode voltage as fixed parameters, is illustrated on page 15.

EQUIPMENT DESIGN AND OPERATING CONSIDERATIONS (continued)

The temperature of the faceplate is determined by the heating effects of the incident illumination, the associated components, the environmental conditions and to a minor extent by the tube itself.

To reduce these heating effects and to permit operation in the preferred temperature range under conditions of high light levels, respectively high ambient temperatures, the use of an infra-red filter between object and camera lens, or a flow of cooling air directed across the faceplate, is recommended.

As the signal-electrode voltage is increased, the dark current and the sensitivity also increase. See page 16.

Signal output and light-transfer characteristics
The typical signal output as a function of a uniform 2870 ^{o}K tungsten illumination on the photoconductive layer is shown on page 17.

The average "gamma" of the light-transfer characteristic is approx. 0.6. This value is relatively constant over a signal output range of 0.01 to 0.3 μA.

Sufficient uniformity in the value of gamma is maintained to ensure satisfactory performance of colour cameras, in which the signal output currents of three 55850's, with the aud of γ-correcting circuitry, must match closely over a wide range of scene illumination.

The spectral response of a typical 55850 is shown on page 12.

The resolution capability of the 55850 is illustrated on page 13.

In general the resolution decreases with decreasing grid No.3 voltage. The voltage range will depend on the design of the focusing coil, which should be such as to provide a field strength within the range of 36 to 44 Oerstedt. Definition, focus uniformity and picture quality decrease with decreasing grid No.3 and No.4 voltage. In general grid No.3 and grid No.4 should be operated above 250 V.

As shown on pages 13 and 14, a substantial increase in both limiting resolution and amplitude response of the 55850 may be obtained by increasing the operating voltage of grids No.3 and No.4 to 750 V. With this mode of operation, the focusing field strength must be increased to approx. 70 Oerstedt.

Since beam-landing errors increase with increasing grid No.3 and grid No.4 voltage, such operation will show a reduced signal output in the corners of the scanned area. When the 55850 is operated in this manner, the deflecting and focusing coils employed must be designed to eliminate beam-landing errors.

Compensation of beam-landing errors can be obtained by supplying modulating voltages of parabolic shape and of both horizontal and vertical scanning frequencies to the cathode and additionally, in order to prevent beam-modulation, to grid No.1, No.2, No.3 and No.4.

EQUIPMENT DESIGN AND OPERATING CONSIDERATIONS (continued)

A suitable amplitude for this mixed parabolic waveform is approximately 4 V peak-to-peak. The polarity should be chosen such that the potential of the cathode is lowered as the beam approaches the edges of the scanned area. The use of this modulating waveform also improves the centre-to-edge focus of the vidicon.

Care must be taken that identical waveforms are applied to the relevant electrodes of each of the three tubes when using the 55850 in 3-colour vidicon cameras to ensure good registration of all signals over the entire scanned area.

Operation with grid No.3 and grid No.4 voltage at 750 V and a field strength of 70 Oerstedt demands increased-power requirements for the deflecting and focusing coils, which will increase tube temperature unless adequate provisions for cooling are made.

Scanning amplitude

Full-size scanning of the 9.6 mm x 12.8 mm area of the photoconductive layer should always be applied. To obtain this condition, first adjust the deflection circuits to overscan the photoconductive layer sufficiently so that the edges of the sensitive area can just be seen on the monitor, which itself should not be overscanned.

Then, after centring the image on the sensitive area (see Fig.4), reduce the scanning amplitudes in both directions with 15%.

In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It should be noted that overscanning of the photoconductive layer produces a picture on the monitor that is smaller than normal.

Underscanning of the photoconductive layer, i.e. scanning of an area of less than 9.6 mm x 12.8 mm or failure of scanning for even the shortest duration should always be avoided, since this may cause permanent damage to the specified full-size area.

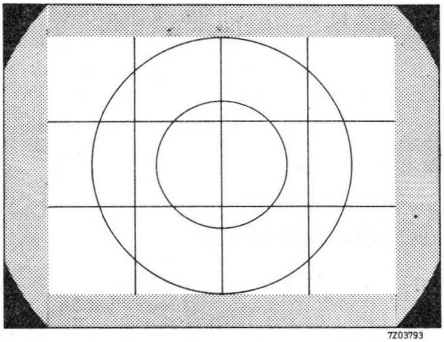
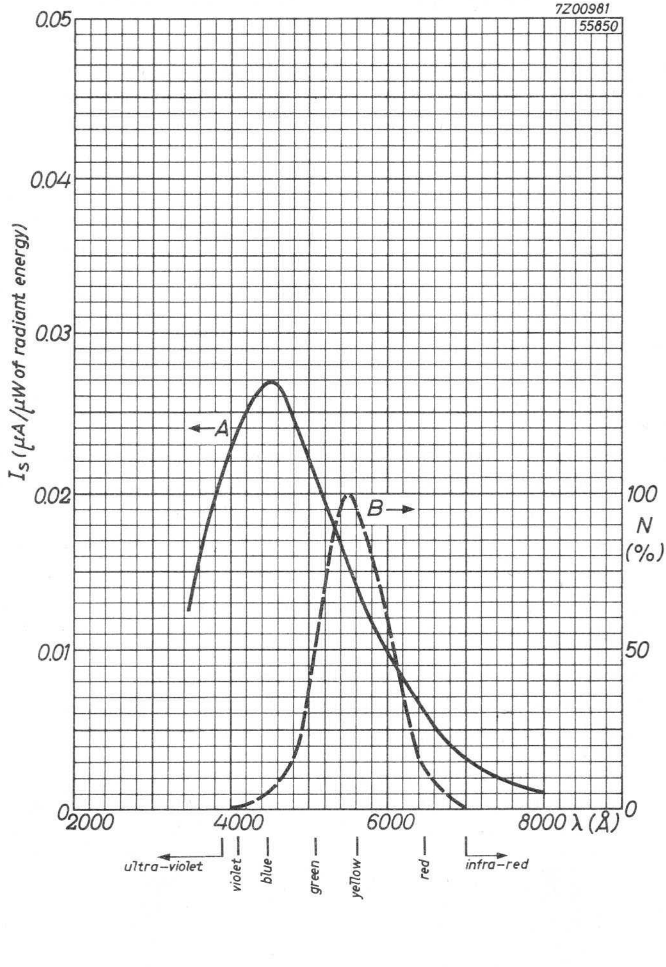


Fig.4 Positioning of the image on the sensitive area

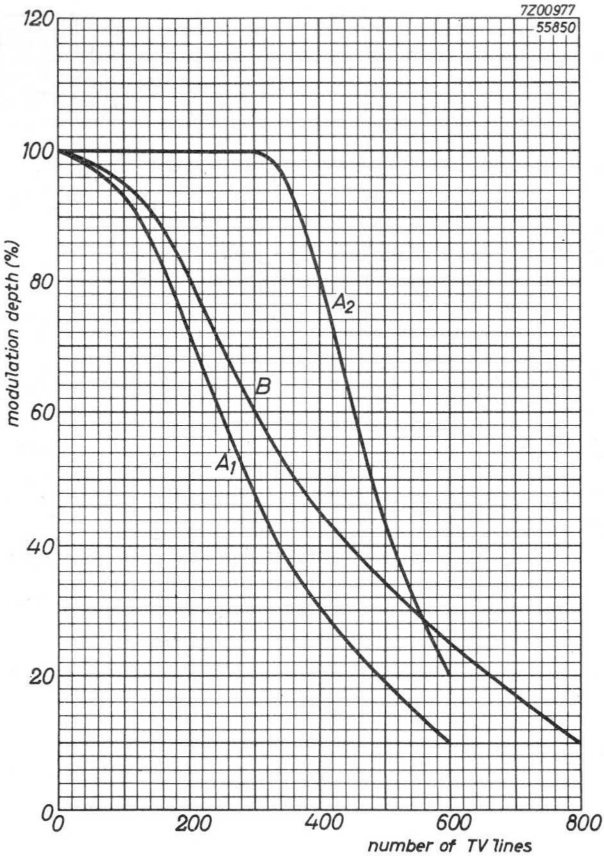


A: Spectral sensitivity of 55850

Scanned area = 12.8 mm x 9.6 mm

Signal current I_S = 0.02 μA

B: Relative spectral sensitivity of the human eye (N).



Horizontal square-wave response in picture centre of a typical 55850.

Highlight signal current = 0.3 μA.

Test pattern: transparent square-wave resolution wedge.

A_1: Uncompensated	$V_{g3,g4}$ = approx. 285 V,
A_2: Compensated	focusing field strength = 40 Oerstedt
B : Uncompensated	$V_{g3,g4}$ = 750 V, focusing field strength = approx. 70 Oerstedt

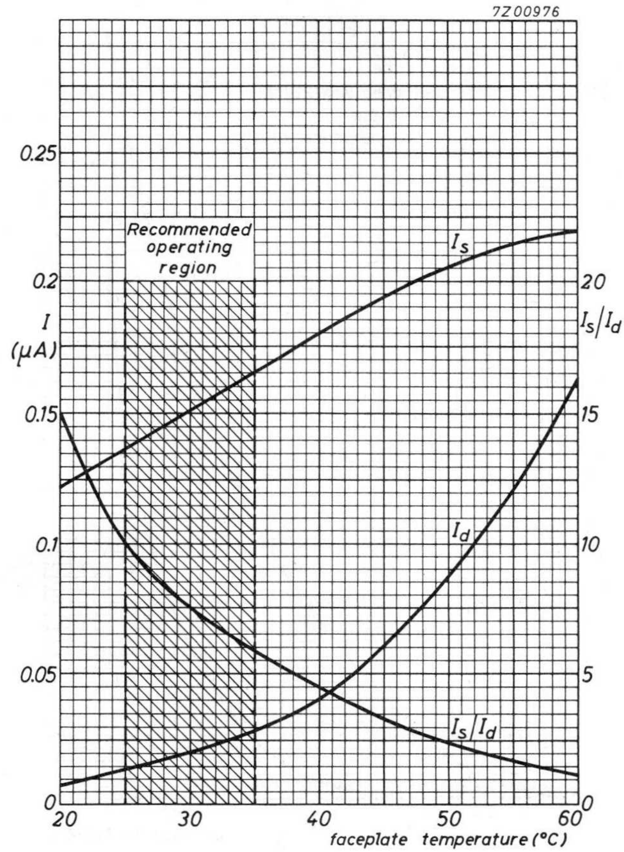
Uncompensated horizontal square-wave response at 400 TV lines as a function of the focusing magnetic field strength of an average 55850.

Curve A: Highlight signal current = 0.1 μA

Dark current = 0.02 μA

Curve B: Highlight signal current = 0.3 μA

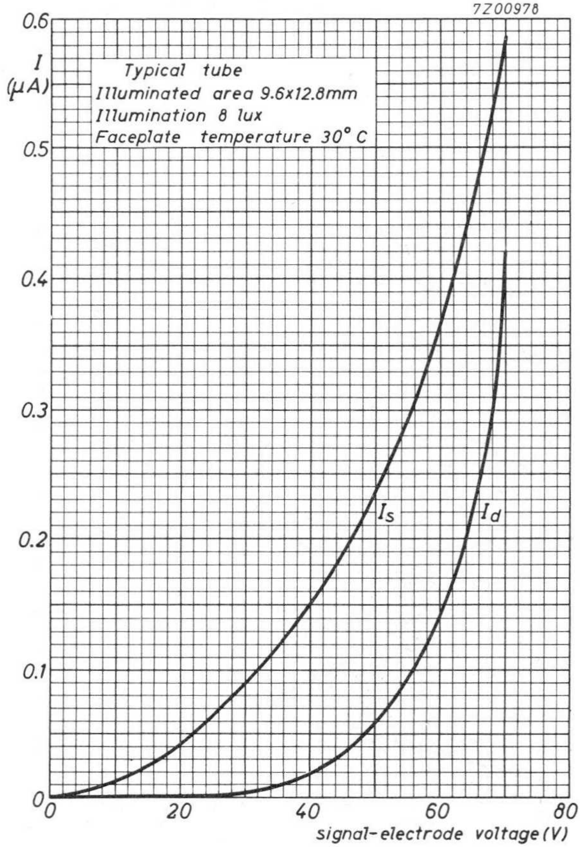
Dark current = 0.02 μA



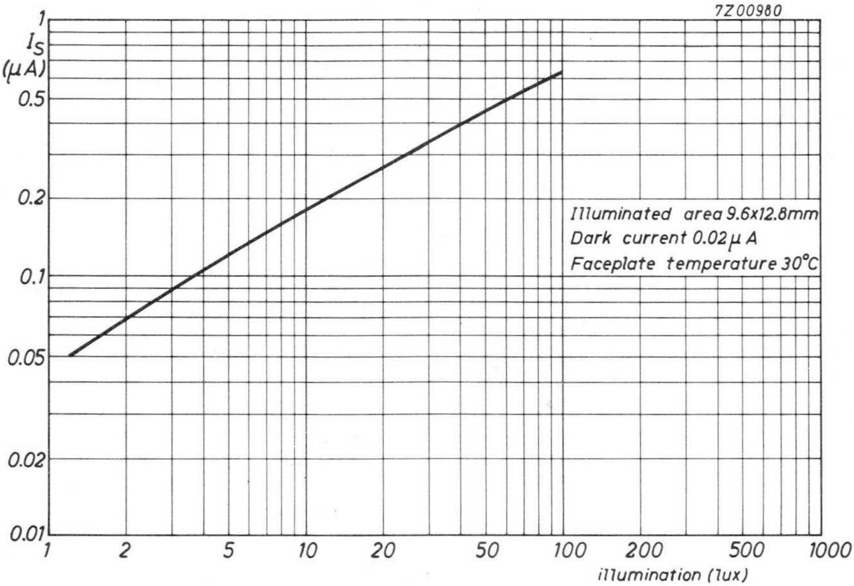
Signal current, dark current and ratio signal current: dark current as a function of the faceplate temperature.

Typical tube

Signal-electrode voltage and illumination level adjusted for a dark current (I_d) of 0.02 μA and a signal current (I_s) of 0.15 μA at a faceplate temperature of 30 °C.



Signal current and dark current as a function of the signal-electrode voltage.



Average signal current as a function of the illumination on the photoconductive layer.

CAMERA TUBE

Vidicon, television camera tube with low heater consumption, magnetic focusing, magnetic deflection and 1" diameter for low-cost industrial cameras, experiments in camera development and for amateur use.

QUICK REFERENCE DATA		
Resolution	600 to 900	TV lines
Focusing	magnetic	
Deflection	magnetic	
Diameter	25.4	mm (1 inch)
Length	158	mm ($6\frac{1}{4}$ inch)
Heater	6.3 V, 90	mA

OPTICAL

Diagonal of quality rectangle on photoconductive layer (aspect ratio 3 : 4) max. 16 mm

Orientation of image on photoconductive layer:
horizontal scan should be essentially parallel to the straight sides of the masked portions of the faceplate. The masking is for orientation only and does not define the proper scanned area of the photo-conductive layer.

CAPACITANCE

Signal electrode to all C_{a_s} 4.5 pF [1])

[1]) This capacitance, which effectively is the output impedance of the tube, is increased by about 3 pF when the tube is inserted into the deflection and focusing coil-assembly. The resistive component of the output impedance is in the order of 100 MΩ.

HEATING

Indirect by A.C. or D.C., series or parallel supply

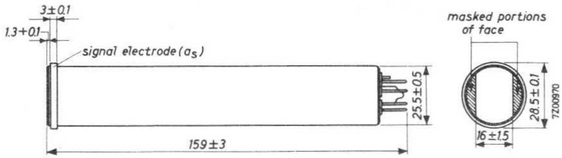
Heater voltage	V_f	6.3	V $\pm$10%
Heater current	I_f	90	mA

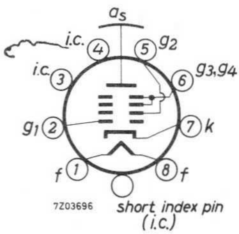
When the tube is used in a series heater chain the heater voltage must not exceed 9.5 V_{rms} when the supply is switched on.

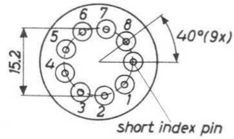
MECHANICAL DATA

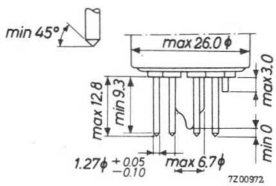
Base: JEDEC No. E8-11

Dimensions in mm









FOCUSING
magnetic

DEFLECTION
magnetic

MOUNTING POSITION
:any

NET WEIGHT
approx. 65 g

ACCESSORIES

Socket	Cinch No. 54A18088 or equivalent
Focusing and deflection coil assembly	AT1101, AT1102 or equivalent

LIMITING VALUES (Absolute max. rating system)
for scanned area of 9.6 mm x 12.8 mm (3/8" x ½") [1]

Grid No.3 and grid No.4 voltage	V_{g_3,g_4}	max.	800	V
Grid No.2 voltage	V_{g_2}	max.	350	V
Grid No.1 voltage				
Negative bias	$-V_{g_1}$	max.	125	V
Positive bias	$+V_{g_1}$	max.	0	V
Peak heater-cathode voltage				
Heater neg. with respect to cathode	V_{kf_p}	max.	125	V
Heater pos. with respect to cathode	V_{kf_p}	max.	10	V
Signal-electrode voltage	V_{a_s}	max.	100	V [2]
Peak signal-electrode current	$I_{a_{s\,p}}$	max.	0.6	μA [3]
Faceplate illumination		max.	5000	lux
Faceplate temperature		max.	80	°C [4]
Dark current, peak	I_{d_p}	max.	0.25	μA

---

1) "Full-size scanning", i.e. scanning of a 9.6 mm x 12.8 mm area of the photoconductive layer should always be applied. The use of a mask having these dimensions is recommended. Underscanning, i.e. scanning of an area less than 9.6 mm x 12.8 mm may cause permanent damage to the specified full-size area.

2) The signal-electrode voltage should never exceed 100 V, either during heating-up or stand-by, or during operation. An excessive signal-electrode voltage may cause permanent damage to the photoconductive layer.

3) Video-amplifiers should be capable of handling signal-electrode currents of this magnitude without amplifier overload or picture distortion.

4) Absolute maximum for shelf-life and operation. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infra-red filters should be applied.

OPERATING CONDITIONS AND PERFORMANCE

For scanned area of 9.6 mm x 12.8 mm and faceplate temperature of 25-35 °C

PICK-UP FROM LIMITED-MOTION LIVE SCENES

Conditions

Grid No.3 and grid No.4 (beam focus electrode) voltage		250-300 V [1]
Grid No.2 voltage		300 V
Grid No.1 voltage adjusted for sufficient beam current to stabilise highlights		
Peak-to-peak blanking voltage		
when applied to grid No.1	>	75 V
when applied to the cathode	>	20 V [2]
Field strength at centre of focusing coil		40 Oerstedt [3]
Field strength of adjustable alignment coils		0-4 Oerstedt [4]

---

1) Beam focus is obtained by the combined effect of the grid No.3 voltage, which should be adjustable over the indicated range and a focusing coil having an average field strength of 40 Oerstedt.
Definition, focus uniformity and picture quality decrease with decreasing grid No.3 voltage. In general, grid No.3 should be operated above 250 V.

2) In transistorized cameras cathode blanking will be preferable. The cathode impedance is in the order of 30 kΩ.

3) The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

4) The alignment coil assembly should be located on the tube so that its centre is at a distance of approx. 94 mm (3 11/16") from the face of the tube and be positioned so that its axis coincides with the axis of the tube, the deflecting yoke and the focusing coil.

OPERATING CONDITIONS AND PERFORMANCE (continued)

Performance

Signal-electrode voltage for dark current of 0.02 μA	range	20 to 100	V	
	typical	40	V	1)
Negative grid No.1 voltage for picture cut-off		20-110	V	2)
Signal output current, faceplate illumination 10 lux	>	0.075	μA	3)
Resolution capability in picture centre	>	600	lines	4) 5)
Decay: 10 lux on layer, V_{as} adjusted for dark current of 0.02 μA, residual signal after dark pulse of 200 msec	<	20	%	
Average gamma of transfer characteristic for signal output currents between 0.01 and 0.3 μA	=	0.6		
Visual equivalent signal-to-noise ratio		300:1		6)
Spurious signals: Shading		see note 7		
Spots and blemishes		see note 8		

---

1) The deflection circuits must provide sufficiently linear scanning for good black-level reproduction. The dark-current signal being proportional to the velocity of scanning, any change in this velocity will produce a black-level error.

2) With no blanking voltage on grid No.1.

3) Defined as the component of the signal-electrode current after the dark current has been subtracted.

4) With a video-amplifier system having 7.5 Mc/s bandwidth (-3 dB points).

5) A resolution capability of approx. 900 TV lines can be achieved with the grid No.3 and grid No.4 voltage adjusted to 750 V and a focusing field strength of approx. 70 Oerstedt.
With this mode of operation beam-landing errors, resulting in parabolic shading and dark corners, increase.

(Note 5 continued)

The deflecting and focusing coils should be designed to eliminate these errors. Since higher power requirements for these coils will increase the tube temperature, adequate provisions for cooling should be made.

6) Measured with a peak signal output current of 0.2 μA into a high-gain, cascode-input type of amplifier with an own noise of 0.002 μA r.m.s. and a bandwidth of 5 Mc/s. Because the noise in such a system is predominantly of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of the highlight video-signal current to the r.m.s. noise current multiplied by a factor of 3.

7) Target voltage adjusted to obtain a dark current of 0.02 μA. Camera directed towards a uniformly illuminated white background, light level adjusted to produce a signal output current (note 3, page 5) of 0.2 μA. The composite video signal when viewed at horizontal rate on a waveform oscilloscope will fall within an envelope having a width of 50% of the peak signal.

8) Target voltage adjusted to obtain a dark current of 0.02 μA. Camera focused at a uniformity illuminated two-zone test pattern with the centre zone (1) diameter equal to raster height. Light level adjusted to produce a signal output current of 0.2 μA. Scanning amplitudes of rectangular monitor adjusted to obtain a raster with aspect ratio of 3 : 4. Monitor set-up and contrast control adjusted for faint raster when lens of camera is capped, and for non-blooming bright raster when lens of camera is uncapped.
Under the above conditions number and size of the spots observable in the monitor picture will not exceed the limits stated below:

Spot size in % of raster height	Max. number of spots zone 1	Max. number of spots zone 2	
> 1 %	none	none	To be considered as a black or as a white spot, its contrast ratio must be greater than 2 to 1. Black spots as well as white ones must be counted as spots.
1 - 0.6 %	1	3	
0.6 - 0.2 %	4	6	
< 0.2 %	9)	9)	

9) Do not count spots of this size unless concentration causes a smudgy appearance.

CAMERA TUBE

Vidicon provided with separate mesh intended for industrial, medical and broadcast applications.

QUICK REFERENCE DATA			
Resolution		up to 1000	TV lines
Focusing		magnetic	
Deflection		magnetic	
Diameter		25.4	mm (1 inch)
Length		158	mm ($6\frac{1}{4}$ inch)
Provided with particle trap			
Heater	55851	6.3 V, 90	mA
	55852	6.3 V, 300	mA

GENERAL

Advantages of vidicons with separate grid No. 4 connection over conventional vidicons like 55850:

- Increased resolution - up to 1000 T.V. lines
- Higher amplitude response at 400 T.V. lines
- More uniform resolution over whole picture area
- Stabilisation for peaked highlights possible without appreciable loss in resolution

55851 Target properties identical to 55850. Provided with low power heater of 0.6 W, primarily intended for transistorized camera's, in which heat dissipation should be kept at a minimum.

55852 Target properties identical to 55850. Provided with 2 W heater.

Both types will be available in 5 grades, namely:

N - for normal industrial applications
S - for industrial and broadcast applications in which a higher picture quality is required
SR - for use in X-ray medical equipment
F - for use in film-scanners
AM - low cost tube for experiments, amateur use etc.

The electrical and mechanical properties of the five grades are essentially identical, main differences being found in the degree of uniformity and freedom of blemishes of the photoconductive layers.

OPTICAL

Diagonal of quality rectangle on photoconductive layer (aspect ratio 3 : 4)	max.	16 mm

Orientation of image on photoconductive layer:
horizontal scan should be essentially parallel to plane passing through tube axis and short index pin.

Spectral response	See data 55850

HEATING

Indirect by A.C. or D.C.; series or parallel supply

Heater voltage		V_f	6.3	V ±10%
Heater current	55851	I_f	90	mA
	55852	I_f	300	mA

When the tube is used in a series heater chain the heater voltage must not exceed 9.5 V_{rms} when the supply is switched on.

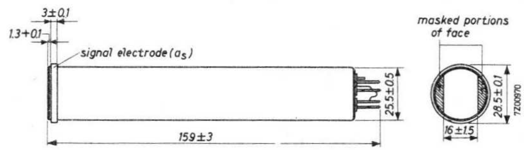
CAPACITANCES

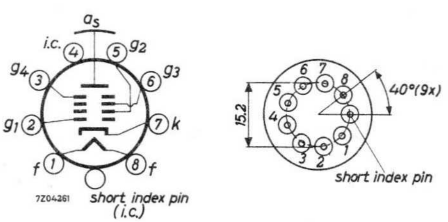
Signal electrode to all	C_{a_s}	4.5	pF [1]

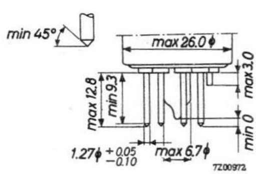
MECHANICAL DATA

Dimensions in mm

Base: JEDEC No. E8-11







[1]) This capacitance, which effectively is the output impedance, is increased by about 3 pF when the tube is inserted into the deflection and focusing coil assembly. The resistive component of the output impedance is in the order of 100 MΩ.

FOCUSING magnetic

DEFLECTION magnetic

MOUNTING POSITION: any

NET WEIGHT approx. 75 g

ACCESSORIES

Socket Cinch No. 54A18088 or equivalent

Focusing and deflection coil assembly: AT1101, AT1102 or equivalent

LIMITING VALUES (Absolute max. rating system)
for scanned area of 9.6 mm x 12.8 mm (3/8" x 1/2") 1)

Signal electrode voltage	V_{a_s}	max.	100	V 2)
Grid No.4 voltage	V_{g_4}	max.	1000	V
Grid No.3 voltage	V_{g_3}	max.	850	V
Grid No.2 voltage	V_{g_2}	max.	450	V
Grid No.1 voltage, negative bias	$-V_{g_1}$	max.	125	V
positive bias	$+V_{g_1}$	max.	0	V
Signal electrode current, peak	$I_{a_{s_p}}$	max.	0.6	μA 3)
Faceplate illumination		max.	5000	lux
Faceplate temperature	t	max.	80	°C 4)
Cathode to heater voltage, peak				
cathode positive	V_{kf_p}	max.	125	V
cathode negative	V_{kf_p}	max.	10	V
Dark current, peak	I_{d_p}	max.	0.25	μA

1) "Full-size scanning", i.e. scanning of a 9.6 mm x 12.8 mm area of the photoconductive layer should always be applied. The use of a mask having these dimensions is recommended. Underscanning, i.e. scanning of an area less than 9.6 mm x 12.8 mm may cause permanent damage to the specified full-size area.

2) The signal electrode voltage should never exceed 100 V, either during heating-up or stand-by, or during operation. An excessive signal electrode voltage may cause permanent damage to the photoconductive layer.

3) Video amplifiers should be capable of handling signal-electrode currents of this magnitude without amplifier overload or picture distortion.

4) Absolute maximum for shelf-life and operation. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended, when televising flames and furnaces appropriate infra-red filters should be applied.

TYPICAL OPERATION AND PERFORMANCE both types

CONDITIONS	Normal operation		Operation for max. resolution
V_{g_4} (mesh) voltage	265 to 400 V 1)		575 to 850 V 1)
V_{g_3} (beam focus) voltage	250 to 300 V		550 to 650 V
V_{g_2} voltage	300 Volts		300 Volts
V_{g_1}, grid No.1 voltage, adjusted for sufficient beam current to stabilize highlights			
P.t.p. blanking voltage when applied to grid No.1 when applied to cathode		> 75 Volts > 20 Volts	
Field strength at centre of focus-coil	app.40 Oerstedt		app. 60 Oerstedt 2)
Field strength of adjustable alignments coils	0 - 4 Oerstedt		0 - 6 Oerstedt
PERFORMANCE			
Signal-electrode voltage for dark-current of 0.02 μA typical		20 - 100 V 45 Volts	
Grid No.1 voltage for picture cut-off		-30 to -100 V	
Signal output current, faceplate illumination 8 lux, typical		0.15 μA	
Resolution capability in picture centre	750 T.V. lines 3)		1000 T.V. lines 3)
Mod. depth at 400 T.V. lines in picture centre	50 % 4)		70 % 4)
Decay: 8 lux on faceplate, V_{as} adjusted for dark current of 0.02 μA, residual signal after dark pulse of 200 msec typical		10 %	
Average gamma of transfer characteristics for signal currents between 0.01 and 0.3 μA		0.6	
Visual equivalent S/N ratio		app. 200:1	

NOTES

1. Under no circumstances should grid No.4 (field mesh) be allowed to operate at a voltage level below the actual grid No.3, V_{g3}, level as needed for beam focus, since this may damage the target.
   Minimum voltage difference between V_{g4} and V_{g3} (g4 positive to g3) to produce an attractive gain in resolution: 15 Volts. The optimal voltage of grid No.4 for maximum resolution and optimal uniformity of resolution and white level will depend on the type of coil unit used and will be within the range 1.05 to 1.3 times the actual grid No.3 voltage.
   It should be noted that with increasing V_{g4} voltage also an increase in deflecting power will be needed.

2. The higher voltage operation will necessitate an increase in focusing and deflecting power. Provisions should be made for proper cooling of the tube in these increased power conditions.

3. With a video amplifier system having flat response to 10 Mc/s.

4. Typical values, measured under conditions of peak-signal current $I_s = 0.15\,\mu A$ and beam current sufficient to stabilize 0.5 μA of signal current.

CAMERA TUBE

Plumbicon, sensitive high definition pick-up tube with photoconductive target and low velocity stabilisation.
The 55875 is intended for use in black and white-, the 55875R, G, B for use in colour studio cameras.

QUICK REFERENCE DATA	
Focusing	magnetic
Deflection	magnetic
Diameter	30 mm

OPTICAL

Dimensions of quality rectangle on photoconductive layer (aspect ratio 3:4)	12.0 mm x 16.0		mm	1)
Orientation of image on photoconductive layer	see note 2			
Sensitivity at colour temperature of illumination = 2850 °K				
type: 55875	min.	275	μA/lumen	
55875R	min.	60	μA/lumen	3)
55875G	min.	100	μA/lumen	3)
55875B	min.	32	μA/lumen	3)
Gamma of transfercharacteristic		0.95 ± 0.05		4)
Spectral response; max. response at	approx.	5000	Å	

HEATING

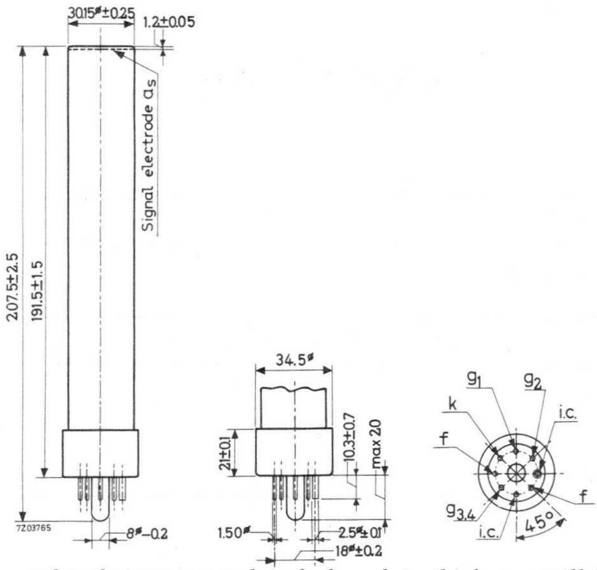
Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	6.3	V ± 5%
Heater current	I_f	90	mA

1)2)3)4) See page 5

MECHANICAL DATA

Dimensions in mm



When indium seal technique is employed, faceplate thickness will be increased to 2.3 mm.
At some date to be indicated by the manufacturer the faceplate thickness maybe increased with a 6 mm glass stud to reduce internal reflections.

MOUNTING POSITION any

WEIGHT

Net weight	approx.	100	g

ACCESSORIES

Socket	type	56020
Focusing and deflection coil assembly		
for 55875	type	AT 1132
for 55875R, G, B	type	AT 1112

CAPACITANCES

Signal electrode to all	C_{a_s}	4 to 6	pF [5]

FOCUSING magnetic [6]

DEFLECTION magnetic [6]

[5][6] See page 5

CHARACTERISTICS

Grid No.1 voltage for cut-off at V_{g_2} = 300 V	V_{g_1}		-30 to -100	V [7]
Blanking voltage, peak to peak				
on grid No.1	$V_{g_{1p-p}}$	min.	40	V
on cathode	$V_{k_{p-p}}$	min.	15	V
Grid No.2 current at normally required beam currents	I_{g_2}	max.	1	mA
Dark current at V_{a_s} = 45 V	I_{a_s}	max.	0.003	μA

LIMITING VALUES (Absolute max. rating system)

Signal electrode voltage	V_{a_s}	max.	50	V [8]
Grid No.4 and No.3 voltage	V_{g_4, g_3}	max.	750	V [8]
Grid No.2 voltage	V_{g_2}	max.	450	V [8]
Grid No.1 voltage				
positive	V_{g_1}	max.	0	V [8]
negative	$-V_{g_1}$	max.	125	V [8]
Cathode current	I_k	max.	3	mA
Cathode to heater voltage				
positive peak	$V_{+k/f-p}$	max.	125	V
negative peak	$V_{-k/+fp}$	max.	10	V
Ambient temperature	t_{amb}	max.	50	°C
(storage and operation)		min.	-30	°C
Face plate illumination		max.	500	lux [9]
Face plate temperature	t	max.	50	°C
(storage and operation)		min.	-30	°C

[7] [8] [9] See page 5

OPERATING CONDITIONS AND PERFORMANCE

Cathode voltage	V_k	0	V
Grid No.2 voltage	V_{g_2}	300	V
Signal electrode voltage	V_{a_s}	15-45	V [10]
Beam current	I_{beam}	See note 11	
Focusing coil current		See note 12	
Line- resp. frame deflection coil current		See note 12	
Face-plate illumination		See notes 13 and 14	
Face plate temperature	t	20-45	°C

Resolution

Modulation depth, i.e. uncompensated horizontal amplitude response at 400 TV lines, in picture centre. See note 15.

	55875	55875R	55875G	55875B	
Highlight signal current I_s	0.3	0.15	0.3	0.15	µA
V_{g_3}, V_{g_4} = 250 to 300 V See note 16	35	30	35	45	%
V_{g_3}, V_{g_4} = 550 to 650 V See note 16	40	35	40	50	%

Limiting resolution > 600 TV lines

Signal to noise ratio [17]
at a signal current of 0.15 µA approx. 200 : 1

Persistence (or lag)
Low persistence renders tube very suitable for live studio monochrome and colour applications.
Persistence is basically independent of illumination level.

Decay
Measured with 100% signal current of 0.1 µA and with a light source with a c.t. of 2850 °K.
Appropriate filter inserted in light-path for tubes 55875R, G, B.

Residual signal after dark pulse of 60 ms	max.	5	%
Residual signal after dark pulse of 200 ms	max.	2	%

[10] [11] [12] [13] [14] [15] [16] [17] See pages 5 and 6

NOTES

1. a) Underscanning of the specified useful target-area of 12.0 mm x 16.0 mm or failure of scanning, should be avoided since this may cause damage to the photo-conductive layer.
   b) The area beyond the 12.0 mm x 16.0 mm optical image preferably to be covered by a mask to reduce the effects of internal reflections in the face-plate.

2. For proper orientation of the image on the photo-conductive layer the vertical scan should be essentially parallel to the plane passing through the tube axis and the mark on the tube base.

3. As measured under following conditions:

   Tubes are exposed to 5.2 lux illumination of black body colour temperature of 2850 ^{o}K. The appropriate filter is inserted in the light path. The signal current obtained in nano-amperes denotes the colour sensitivity expressed in terms of micro-amperes per lumen of white light before the filter.
   Filters used:

55875R	Schott	OG2	thickness	3 mm
55875G	Schott	VG9	thickness	1 mm
55875B	Schott	BG12	thickness	3 mm

   See page 10

4. a) Gamma is, to a certain extent, dependent on the wavelength of the illumination applied.
   b) The use of gamma-stretching circuitry is recommended.

5. Cap. Cas to all, which effectively is the output impedance, increases by approx. 5 pF when the tube is inserted into the deflecting/focusing assembly.

6. For focusing/deflection coil assembly, see under "Accessories".

7. With no blanking voltage on g1.

8. At V_k = 0 V.

9. For short intervals. During storage and idle periods of camera the tube-face shall be covered with plastic hood provided, respectively lens be capped.

10. The signal electrode voltage should be adjusted to 45 V unless otherwise indicated by the tube manufacturer on the test-sheet as delivered with each individual tube.

11. The beam current shall be adjusted for correct stabilisation for the highlight signal currents stated in the tabel.
    Operation of the tube with beam currents I_b not sufficient to stabilize the brightest highlight picture-elements should be avoided in order to prevent loss of highlight-detail and/or "sticking" effects. Operation at excessively high beam currents will result in loss of resolution. Operation in the high voltage mode will permit the use of beam current of twice the minimum amount as needed for stabilisation without appreciable loss of resolution.

12. Black/white coil assembly AT 1132

	focus current	line current mApp	frame current mApp	
$V_{g3,g4}$: 300 V	17	160	25	approx values
$V_{g3,g4}$: 600 V	25	235	35	
Colour coil assembly AT 1112				
$V_{g3,g4}$: 300 V	75	160	25	
$V_{g3,g4}$: 600 V	100	235	35	

13. Faceplate illumination level for the 55875 typically needed to produce 0.3 μA signal current will be approx. 5 lux. The signal currents stated for the colour tubes 55875R, G and B respectively will be obtained with an incident white light-level (2850 $^{\circ}$K) on the filter of approx. 12 lux. These figures are based on the use of the following typical filters:

for 55875R	Schott	OG2	thickness	3 mm
55875G	Schott	VG9	thickness	1 mm
55875B	Schott	BG 12	thickness	1 mm

These figures are based on the use of the filters described in note 3, for filter BG12 however a thickness of 1 mm is chosen.

14. Illumination on the photo-conductive layer, B_{ph}, in the case of a black/white camera is related to scene-illumination, B_{sc}, by the formula:

$$B_{ph} = B_{sc} \frac{R.T.}{4F^2 (m+1)^2}$$

in which R represents the scene-reflexivity (average or the object under consideration, whichever is relevant), T the lens transmissionfactor, F the lens aperture and m the linear magnification from scene to target.
A similar formula may be derived for the illumination level on the photoconductive layers of the respective R, G, and B tubes in which the effects of the various components of the complete optical system have been taken into account.

15. The figures shown represent the typical horizontal amplitude responses of the tubes proper after correction for faults introduced by the optical system. Horizontal amplitude response can be raised by the application of suitable correction circuits. Such compensation, however, does not affect vertical resolution, nor does it influence the limiting resolution.

16. Grid No.3 and No.4 voltage adjusted for optimum focus. See also note 12.

17. The stated ratio represents the "visual equivalent signal-to-noise ratio", which is taken as the ratio of highlight vidio-signal current to R.M.S. noise-current, multiplied by a factor of 3. (Assuming an R.M.S. noise-current of the video pre-amplifier of 2.10^{-9} A, bandwidth 5 MHz).

GENERAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE

TRANSPORT, HANDLING, STORAGE

During transport, handling or storage the longitudinal axis must either be in a horizontal position or be kept vertically with the face-plate of the tube up.

GENERAL

1. Signal-electrode connection is made by a suitable spring-contact, executed as part of the focusing coil, against the metallic coating at the face end of the tube.
2. Electrostatic shielding of the signal-electrode is required in order to avoid interference effects in the picture. Effective shielding is provided by grounding shields on the inside of the face-plate end of the focusing coil and on the inside of the deflecting yoke.
3. The Plumbicon as described in these data has been provided with tungsten base pins. It is recommended to avoid mechanical force and shocks to these pins and to insert the tube into its socket, type 56020, with care.
4. In some cases the properties of the photo-conductive layer as used in the Plumbicon maybe found to have slightly deteriorated during long idle periods, such as encountered between the last test in our works and actual delivery to the user.

   It is therefore recommended to operate the tube directly after receipt under normal voltage settings, in overscanned position with evenly illuminated target and a signal current of 0.15 μA for some hours after which the initial properties will have been fully restored.
5. The light-transfer characteristic of the Plumbicon being characterized by a gamma near unity, it may be desirable for broadcast applications to incorporate a gamma correcting circuitry in the video-amplifier system with an adjustable gamma of 0.5 to 1.

   It is suggested to design this gamma correcting circuitry such that an extra compression can be introduced by manual control in the video signal range of 75 to 100% of normal peak white level.

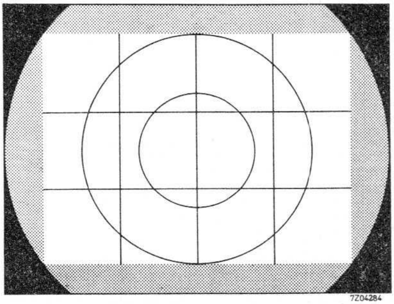
   This provision will prevent the video amplifier system from becoming overloaded when the Plumbicon with its near unity gamma transfer-characteristic is exposed to scenes containing small peaked highlights as caused by reflections of shiny objects.
6. The Plumbicon not generating own noise to any noticeable extent, the signal to noise ratio will mainly be determined by the entrance noise of the video amplifier system.

   The high sensitivity of the Plumbicon warrants pictures with excellent signal-to-noise ratio under normal studio lighting conditions provided its output is fed into a well-designed input stage of the video-amplifier system. In such a system an aperture correction may be incorporated to ensure an attractive gain in resolving power without visually impairing the signal-to-noise ratio.

INSTRUCTIONS FOR USE

1. Insert the tube in the deflection unit in such a way that the mark at the base of the tube is uppermost.
2. Clean the face-plate of the tube and press the socket gently onto the base-pins.
3. Cap lens and close iris.
4. Set: a) Grid No.1 basis-control at max. negative bias (beam cut-off)
   b) Signal electrode voltage to the value as indicated on the tube's test sheet.
   c) Scanning amplitudes to max. scan.
5. Switch on camera equipment and monitor, allow a few minutes for heating-up.
6. Adjust monitor to produce a faint - non overscanned - raster.
7. Direct camera to the scene to be televised and uncap lens.
8. Turn grid No.1 bias-control slowly till a picture is produced on the monitor. If the picture is too faint, increase lens aperture.
9. Adjust grid No.3 and grid No.4 voltage control (beam focus) and optical focus alternately for max. focus.
10. Align the beam of the Plumbicon by either of the two following methods:
    a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when grid No.3 and No.4 voltage (beam focus) is varied.
    b) Reduce signal-electrode potential to a few tenths of a volt only. Adjust alignment fields till most uniform picture is obtained as observed on monitor or waveform oscilloscope.
11. Adjust scanning amplitudes:
    a) By means of a mask of 12.0 mm x 16.0 mm, which is in contact with and centred at the face-plate. Decrease horizontal and vertical deflecting currents till the periphery of this mask is just outside the raster on the monitor. This procedure may be facilitated by small adjustments of the centring controls.

11. b) If no mask available direct the camera to a test chart having correct aspect ratio of 3 : 4 and adjust the centring controls in such a way that the target ring is just visible in the corners of the picture.



7Z04284

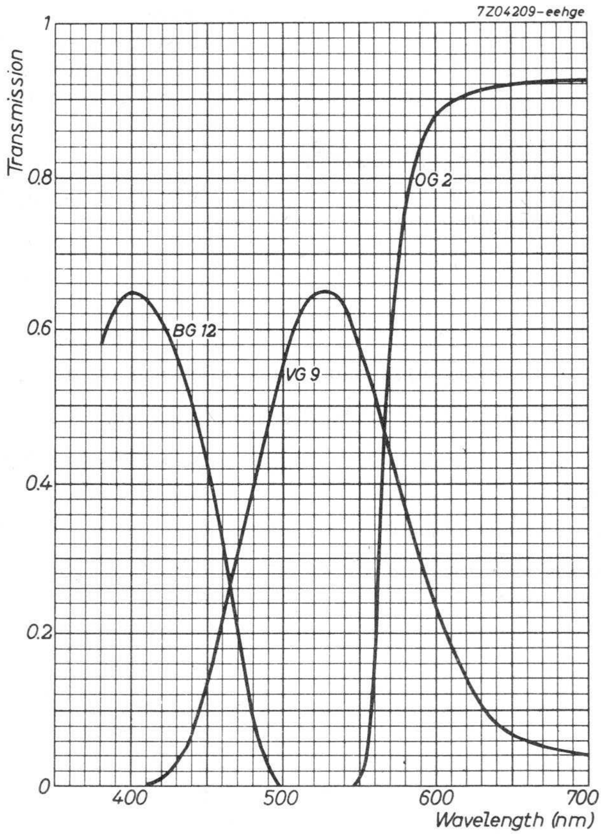
Adjust distance from camera to test chart and optical focus alternately till the picture of the test chart positioned on the faceplate as indicated on the adjoining figure.
Decrease both scanning amplitudes till the picture of the test chart completely fills the scanned raster on the monitor.

12. Adjust iris for a picture of sufficient contrast and adjust the beam current to such a value that all highlights are stabilized.

13. Check alignment, beam focus and optical focus.

ALWAYS:

- use full size (12.0 x 16.0 mm) scanning of the target and avoid underscanning.
- adjust sufficient beam current to stabilize the picture highlights.
- make sure that the deflection circuits are operative before adjusting beam current.
- avoid focusing camera directly to the sun.
- keep lens capped when transporting camera.


7Z04209-eehge
Transmission
1
0.8
0.6
0.4
0.2
0
400
500
600
700
Wavelength (nm)
BG 12
VG 9
OG 2

CAMERA TUBE

Plumbicon, pick-up tube with photoconductive target and low velocity stabilisation exclusively intended for use with X-ray image intensifier in medical equipment.

QUICK REFERENCE DATA	
Focusing	magnetic
Deflection	magnetic
Diameter	30 mm

OPTICAL

Image dimensions on photoconductive layer	circle of 17.0 mm diameter [1][2]			
Sensitivity, measured with a fluorescent light source having P20 distribution	min.	175	µA/lumen	
Gamma of transfer characteristic		0.9 ± 0.1		[3]
Spectral response, region of max. response		4300 to 5200	Å	

HEATING

Indirect by A.C. or D.C.; parallel supply

Heater voltage	V_f	6.3	V ±10%
Heater current	I_f	90	mA

[1] All underscanning of the specified useful target-area of 17.0 mm diameter or failure of scanning, for even the shortest duration, should be carefully avoided, since this may cause permanent damage to the photoconductive layer.

[2] The area beyond the 17.0 mm circular optical image preferably to be covered by a mask.

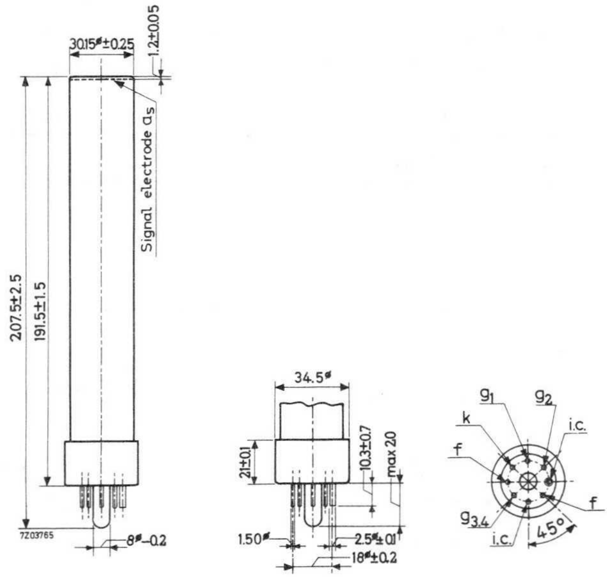
[3] The near unity gamma of the 55876 ensures good contrast when televising low contrast X-ray image-intensifier pictures as encountered in radiology. Further contrast improvement may be obtained when an adjustable gamma expansion circuitry is incorporated in the video amplifier system.

CAPACITANCES

Signal electrode to all	C_{a_s}	4 to 6 pF 1)

MECHANICAL DATA

Dimensions in mm



When Indium seal technique is used, face plate thickness will be increased to 2.3 mm

FOCUSING magnetic

DEFLECTION magnetic

MOUNTING POSITION any

ACCESSORIES

Socket	type	56020
Focusing and deflection coil assembly	type	AT1122

NET WEIGHT approx. 100 g

1) Cap. a_s-rest, which effectively is the output impedance, increases by approx. 5 pF when the tube is inserted into the deflection/focusing coil assembly.

CHARACTERISTICS

Grid No.1 voltage for cut-off at V_{g_2} = 300 V	V_{g_1}		-30 to -100	V [1]
Blanking voltage, peak to peak				
on grid No.1	$V_{g_{1p-p}}$	min.	40	V
on cathode	$V_{k_{p-p}}$	min.	15	V
Grid No.2 current at normally required beam current	I_{g_2}	max.	1	mA
Dark current	I_d	max.	0.003	μA [2]

LIMITING VALUES (Absolute max. rating system)

Signal electrode voltage	V_{a_s}	max.	50	V [3]
Grid No.4 and grid No.3 voltage	V_{g_4}, V_{g_3}	max.	750	V [3]
Grid No.2 voltage	V_{g_2}	max.	450	V [3]
Grid No.1 voltage				
positive	V_{g_1}	max.	0	V [3]
negative	$-V_{g_1}$	max.	125	V [3]
Cathode current	I_k	max.	3	mA
Cathode to heater voltage				
positive peak	V_{kf_p}	max.	125	V
negative peak	V_{kf_p}	max.	10	V
Ambient temperature (storage and operation)	t_{amb}	max.	50	^{o}C
		min.	-30	^{o}C
Face-plate illumination		max.	100	lux
Face-plate temperature (storage and operation)	t	max.	50	^{o}C
		min.	-30	^{o}C

[1]) With no blanking voltage on g_1

[2]) The target voltage should be adjusted to the value indicated by the tube manufacturer on the test sheet as delivered with each individual tube.

[3]) At V_k = 0 V

OPERATING CONDITIONS AND PERFORMANCE

Cathode voltage	V_k	0	V
Grid No.2 voltage	V_{g_2}	300	V
Grid No.4 and grid No.3 voltage	V_{g_4}, V_{g_3}	250 to 300	V [1]
Signal electrode voltage	V_{a_s}	15 to 45	V [2]
Beam current	I_{beam}	See note 3	
Focusing coil current		17 mA (AT1122)	
Highlight signal electrode current	I_{a_s}	0.1 to 0.6	μA [4]
Average signal output		approx. 0.06	μA [4]
Face-plate temperature	t	25 to 40	°C
Face-plate illumination		approx. 2	lux [5]

1) Grid No.4 and No.3 voltage adjusted for optimum picture focus. Preferred focus-coil current approx. 17 mA.

2) The target voltage should be adjusted to the value indicated by the tube manufacturer on the test sheet as delivered with each individual tube.

3) Operation of the tube with beam currents I_b not sufficient to stabilize the brightest highlight picture elements must be carefully avoided in order to prevent loss of highlight-detail and/or "sticking" effects.
Operation at excessively high beam currents will result in loss of resolution.

4) Substraction of dark current is unnecessary because of the extremely small value.

5) Illumination on the photoconductive layer, B_{ph}, is related to scene-illumination, B_{sc}, by the formula:

$$B_{ph} = B_{sc} \frac{R.T.}{4.F^2.(m+1)^2}$$

in which R represents the scene-reflexivity (average or of the object under consideration, whichever is relevant), T the lens transmissionfactor, F the lens aperture and m the linear magnification from scene to target.

OPERATING CONDITIONS AND PERFORMANCE (continued)

Resolution		
Modulation depth, i.e. uncompensated horizontal amplitude response (see note 1) at 5 Mc/s in picture centre (625 lines, 50 fields system)		> 30 % [2]
Signal to noise ratio		
at a signal current of 0.15 μA	approx.	200 : 1
Persistence (or lag)		
Low persistence renders tube very suitable for medical X-ray applications in combination with X-ray image intensifier		
Persistence is basically independent of illumination level		
Decay		
Measured with 100% video signal current of 0.1 μA to zero signal after 5 s peak video signal. Fluorescent light source having P20 distribution.		
Residual signal after dark pulse of 100 ms	max.	10 %
Residual signal after dark pulse of 500 ms	max.	1 %

[1]) With a signal current of 0.10 μA and a beam current of 0.20 μA.

[2]) Horizontal amplitude response can be raised by the application of suitable phase-and-aperture correction circuits. Such compensation, however, does not affect vertical resolution, nor does it influence the limiting resolution.

[3]) The specified ratio represents the "visual equivalent signal-to-noise ratio", which is taken as the ratio of highlight video-signal current to R.M.S. noise-current, multiplied by a factor of 3. (Assuming an R.M.S. noise-current of the video pre-amplifier of 2.10^{-9} A, bandwidth 5 Mc/s.)

GENERAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE

MOUNTING, WORKING POSITION:

1. Any
2. During transport, handling or storage the longitudinal axis must either be in a horizontal position or be kept vertically with the face-plate of the tube up.

GENERAL

1. Signal-electrode connection is made by a suitable spring-contact which is executed as part of the focusing coil.
2. Electrostatic shielding of the signal-electrode is required in order to avoid interference effects in the picture. Effective shielding is provided by grounding shields on the inside of the face-plate end of the focusing coil and on the inside of the deflecting yoke.
3. The Plumbicon as described in these data has been provided with tungsten base pins. It is recommended to avoid mechanical force and shocks to these pins and to insert the tube into its socket with care.
4. In some cases the properties of the photoconductive layer as used in the Plumbicon may be found to have slightly deteriorated during long idle periods, such as encountered between the last test in our works and actual delivery to the user.
   It is therefore recommended to operate the tube directly after receipt under normal voltage settings, in overscanned position with evenly illuminated target and a signal current of 0.15 μA for some hours after which the initial properties will have been fully restored.
5. The Plumbicon not generating own noise to any noticeable extent, the signal to noise ratio will mainly be determined by the entrance noise of the video amplifier system.
   The high sensitivity of the Plumbicon warrants pictures with excellent signal-to-noise ratio, provided its output is fed into a well-designed input stage of the video-amplifier system. In such a system an aperture correction may be incorporated to ensure an attractive gain in resolving power without impairing the visual signal-to-noise ratio.

INSTRUCTIONS FOR USE

1. Clean face-plate.
2. Insert tube into deflection unit.
3. Place mask with 17.0 mm diameter aperture in front of and in close contact with face-plate.
4. Press socket gently onto the base pins.
5. Set a) grid No.1 bias control at max. neg. bias (beam cut-off)
   b) signal electrode voltage at zero volts
   c) scanning amplitudes to max. scan.
6. Switch on camera equipment and monitor and allow to heat up for a minimum of 30 seconds.
7. Adjust monitor to produce a faint - non overscanned - raster.
8. Remove camerahead from image-intensifier unit.
9. Direct camera to lightbox or place suitable lightbox on objective holder. Switch on light and adjust illumination level to correspond to appr. 0.3 ft.cdl for the whites of the testchart on the face-plate.
10. Adjust signal-electrode voltage to the value as indicated on the tube's testsheet.
11. Turn grid No.1 control slowly till a picture is produced on the monitor, increase beam-current in order to fully discharge the picture highlights.
12. Adjust grid No.3 and grid No.4 voltage control (beam focus) and optical focus for best picture detail.
13. Align the beam of the plumbicon by either of the two following methods:
    A) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when grid No.3 and No.4 voltage (beam focus) is varied.
    B) Reduce signal-electrode potential to a few tenths of a volt only. Adjust alignment field till most uniform picture is obtained as observed on monitor or waveform oscilloscope. Restore signal-electrode voltage to value as indicated on the tube's testsheet.
14. Decrease scanning amplitudes till perfect circular picture is produced on monitor, with diameter equal to height of monitor raster. This procedure may be facilitated by small adjustment of the vertical centring control. Adjust horizontal centring control till circular picture is properly centred at centre of monitor raster.
15. Remove lightbox and attach camera head to image intensifier unit.
16. Place suitable image-intensifier testchart in front of image-intensifier. Switch on image-intensifier and X-ray source.
17. Adjust optical focus and beam focus for max. picture detail.

ALWAYS:

- keep face-plate capped during transport and shelf-life
- avoid underscanning
- apply sufficient beam current to stabilize picture whites
- make certain that the deflection circuits are operative before applying beam current
- avoid focusing camera head directly to the sun or to reflecting objects
- keep lens capped when transporting camera head

Photo tubes

LIST OF SYMBOLS

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

GENERAL OPERATIONAL RECOMMENDATIONS
PHOTOTUBES

1. GENERAL

1.1 Photo tubes are photo-electric devices of the emissive type, as distinct from the barrier-layer and photo-conductive cells. They may be divided into two groups:

1. High-vacuum photo tubes,
2. Gas-filled photo tubes

Each of these groups can be subdivided into red sensitive and blue sensitive photo tubes; the spectral response depending upon the photocathode material.
For the blue sensitive photo tubes the "A" type of cathode is used (caesium-antimony).
For the red sensitive photo tubes the "C" type of cathode is used (caesium-oxidised silver).
Spectral response curves for each type of cathode are given at the end of these recommendations.

2. OPERATING CHARACTERISTICS

For a vacuum photo tube, the anode current for a fixed quantity of light, is reasonably constant at anode voltages above a certain low value known as the "saturation voltage".
The gas-filled photo tube contains a quantity of inert gas, the ionising potential of which is generally somewhat higher than the saturation voltage of an equivalent vacuum photo tube so that the anode current is substantially constant between the saturation voltage and the voltage at which ionisation commences. Above this voltage range, ionisation increases, resulting in a progressive increase in anode current.
Since a gas-filled photo tube operates at a higher voltage than the ionising potential it will have a greater sensitivity than a similar vacuum photo tube.
Within the operating ranges of both groups of photo tubes the anode current is directly proportional to the quantity of light incident on the cathode surface.

2.1 Luminous sensitivity. The response of a photo tube to light falling on its cathode is termed its luminous sensitivity; this is expressed in micro-amperes per lumen.
The sensitivity of all types is dependent upon the colour temperature of the light source and in some cases upon the portion of the cathode that is illuminated.

The sensitivity of gas-filled photo tubes moreover is dependent upon the anode voltage; the sensitivity of vacuum photo tubes in the "saturation region" in which region the tube mainly operates, is practically independent of the anode voltage.
Unless otherwise stated, the values given in the data sheets have been obtained by illuminating the total useful cathode area with an incandescent lamp having a colour temperature of 2700 ^{o}K.
The values given for sensitivity on the data sheets are the initial values for average photo tubes. The ratio between the maximum and minimum initial sensitivity of photo tubes of a given type will not exceed 3 to 1.

2.2 Dark current. This is the current which flows between photocathode and anode when the photo tube is in total darkness. The tube is in total darkness when no radiation within the spectral sensitivity curve of the photocathode is present. This current is caused mainly by electrical leakage and thermionic emission from the photocathode and will therefore increase with temperature and voltage.

2.3 Frequency response. The sensitivity of a vacuum photo tube is constant for frequencies of light modulation up to those generally met in practice. Only at very high frequencies, at which transit time limitations occur, the sensitivity becomes dependent upon the frequency.
The sensitivity of gas-filled photo tubes, however, decreases with the frequency. At a frequency of 15 000 Hz this decrease is about 3 dB, as is shown in the accompanying curve.

3. THERMAL DATA

Ambient temperature. The temperature of the photocathode may not be too high otherwise evaporation of the emissive cathode layer may result, with consequent reduction in sensitivity and life. As it is difficult to measure this temperature a limiting value for the ambient temperature is given on the published data sheets.
It must be considered, however, that even in case the ambient temperature in the immediate vicinity of the photo tube is not beyond the limit, an excessive temperature rise of the photocathode can be caused e.g. by infrared heat radiation. If the possibility of this radiation exists, a suitable filter should be inserted in the optical path to minimize this effect.

4. OPERATIONAL NOTES

Stability during life. Where a gas-filled photo tube is continuously operated at its maximum rated voltage its sensitivity may fall by as much as 50%, during 500 hours.
Vacuum photo tubes on the other hand are inherently more stable.

The stability of both types of photo tubes will be improved if the current density of the photocathode is reduced (e.g. by reducing the incident light or enlarging the illuminated area of the photocathode).
Particularly in the case of gas-filled photo tubes reduction of the anode voltage will improve the stability.

Also in the inoperative periods photo tubes must not be exposed to strong radiation such as direct sunlight.

A loss of sensitivity of both vacuum and gas-filled photo tubes during operation will be wholly or partially restored during the inoperative periods.

Prevention of glow discharge. Gas-filled photo tubes must not be operated above the published maximum voltage since a glow discharge, indicated by a faint blue glow in the bulb, may occur which adversely affects the good operation of the photo tube and even can result in rapid destruction of the photocathode. If accidental over-running can be expected the anode resistance should have a value of at least 0.1 MΩ.
Where it is necessary to use the maximum operating voltage a stabilized supply is recommended.

5. MOUNTING

If no restrictions are made on the individual published data sheets photo tubes may be mounted in any position.

6. STORAGE

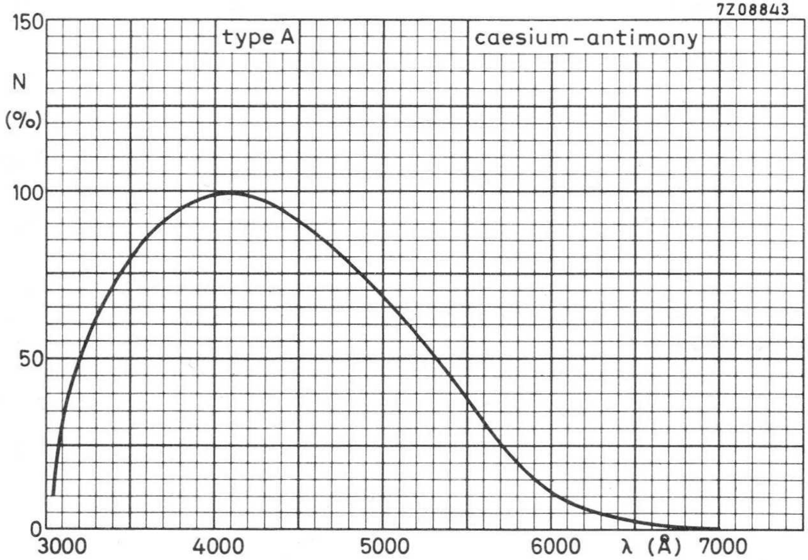
It is necessary that phototubes be always stored in the dark.

7. LIMITING VALUES

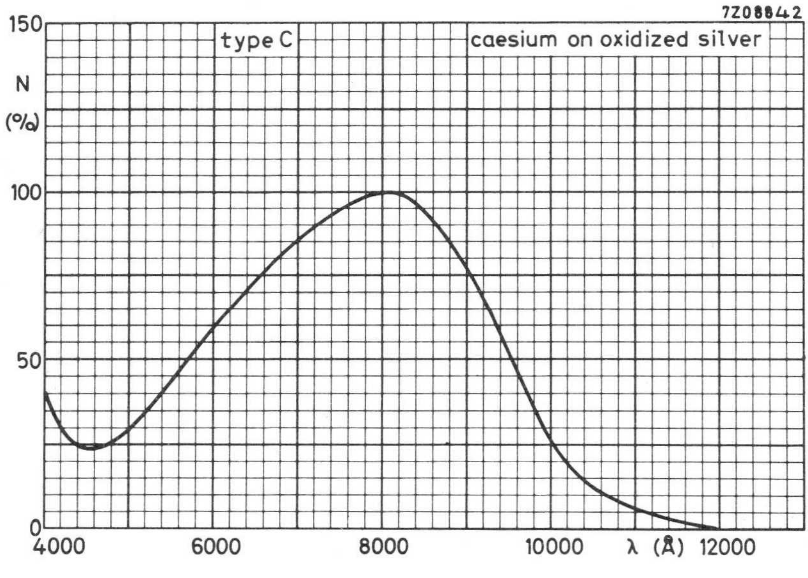
The limiting values of photo tubes are given in the absolute max. rating system.

8. OUTLINE DIMENSIONS

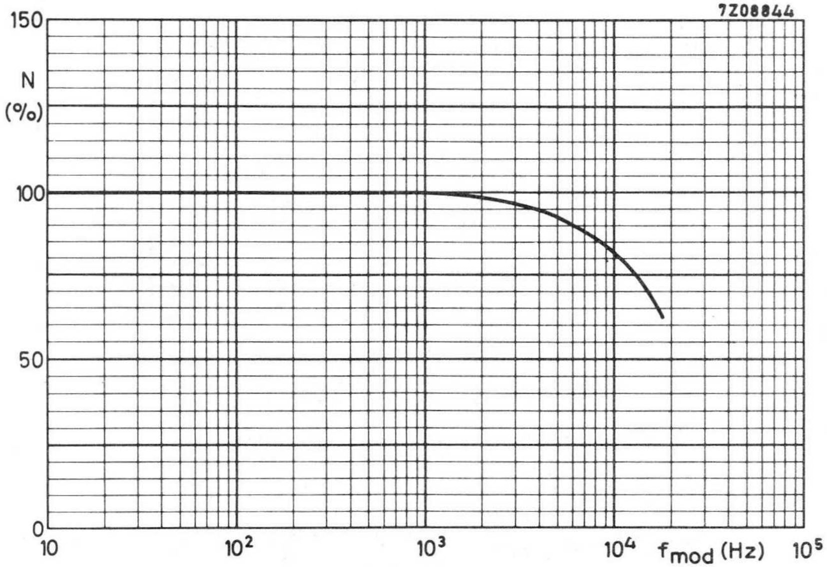
The outline dimensions are given in mm.



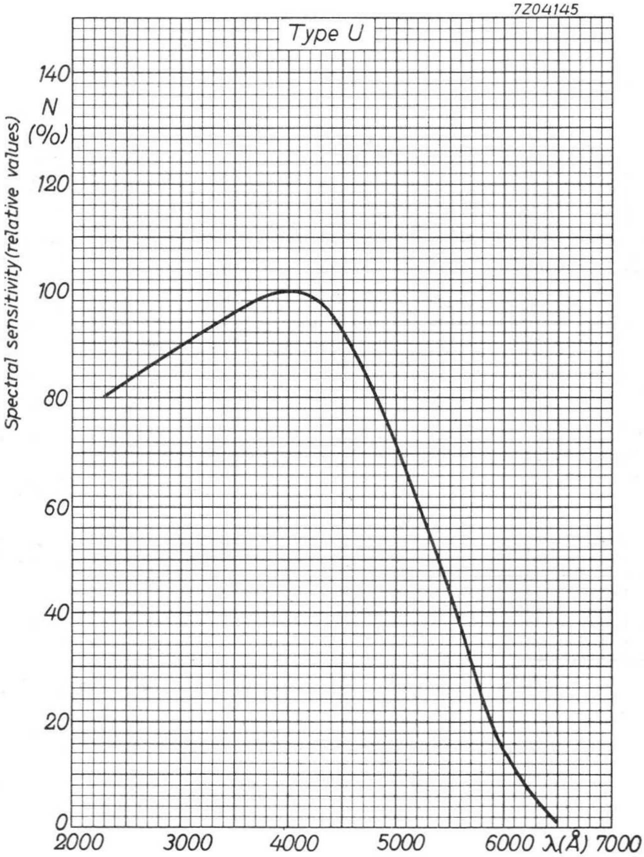
Reletive spectral response curve type A



Relative spectral response curve type C



Frequency response curve (see also 2.3)


7Z04145
Type U
140
N
(%)
120
100
80
60
40
20
0
Spectral sensitivity (relative values)
2000
3000
4000
5000
6000
λ(Å)
7000

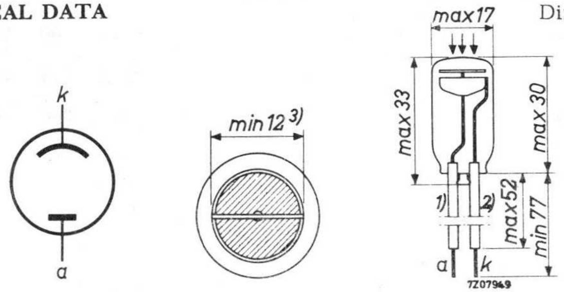
GAS FILLED PHOTOTUBE

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

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		100	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 17 dia. x 30		mm

MECHANICAL DATA

Dimensions in mm



The arrows show the direction of the incident radiation

Photocathode

Surface	Caesium on oxidised silver
Projected sensitive area	1.1 cm^2

[1]) Red

[2]) Black

[3]) Sensitive cathode area shown shaded

ELECTRICAL DATA

Operating characteristics

Anode supply voltage	V_b		85	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 ^oK	N		100	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

Capacitance

Anode to cathode	C_{ak}		3.0	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	1.5	μA
Ambient temperature	t_{amb}	max.	100	^oC

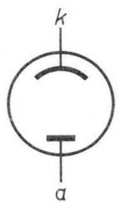
VACUUM PHOTOTUBE

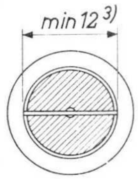
Vacuum phototube particularly sensitive to incandescent light sources, and to near infra-red radiation

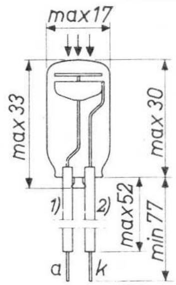
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	250	V
Luminous sensitivity	N		20	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 17 dia. x 30		mm

MECHANICAL DATA

Dimensions in mm







The arrows show the direction of the incident radiation

Photocathode

Surface	Ceasium on oxidised silver
Projected sensitive area	1.1 cm^2

---

1) Red

2) Black

3) Sensitive cathode area shown shaded

ELECTRICAL DATA

Operating characteristics

Anode supply voltage	V_b		50	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode illuminated by a lamp of colour temperature 2700 ^oK	N		20	μA/lumen
Dark current (at V_a = 100 V)	I_{dark}	max.	0.05	μA

Capacitance

Anode to cathode	C_{ak}		3.0	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	250	V
Cathode current	I_k	max.	3	μA
Ambient temperature	t_{amb}	max.	100	^oC

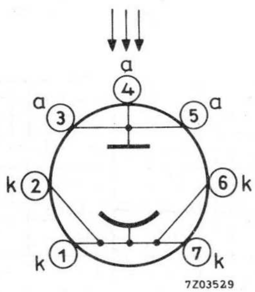
VACUUM PHOTOTUBE

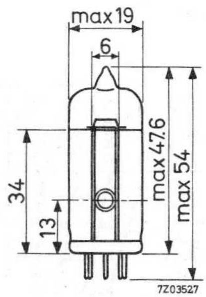
Vacuum phototube, particularly sensitive to daylight and to light radiation with a blue predominance.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	100	V
Luminous sensitivity	N		45	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 together

Photo cathode

Surface	caesium antimony
Projected sensitive area	4 cm^2

ELECTRICAL DATA

Operating characteristics

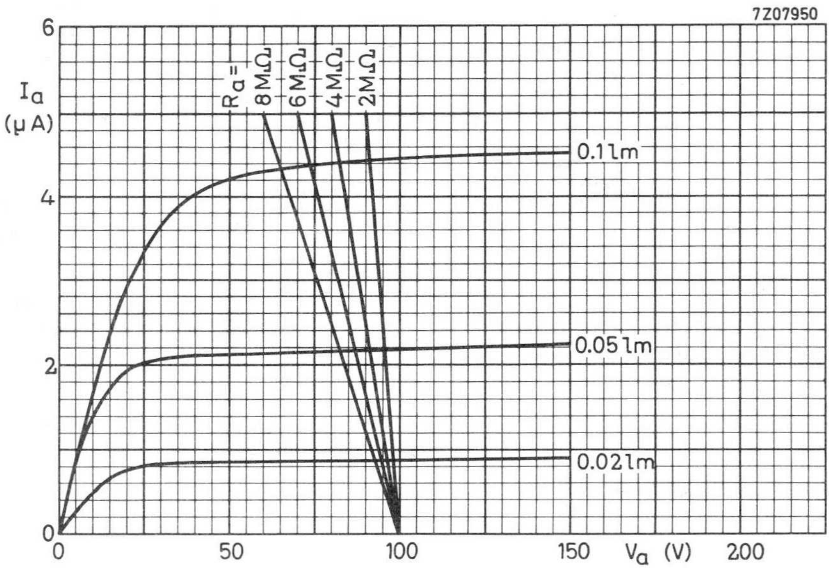
Anode supply voltage	V_b		100	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 ^{o}K	N		45	μA/lumen
Dark current	I_{dark}	max.	0.05	μA

Capacitance

Anode to cathode	C_{ak}		0.7	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	100	V
Cathode current	I_k	max.	5	μA
Ambient temperature	t_{amb}	max.	70	^{o}C



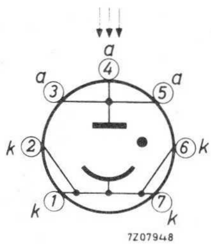
GAS FILLED PHOTOTUBE

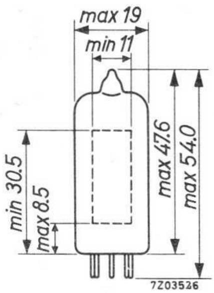
Gas filled phototube particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		125	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium on oxidized silver
Projected sensitive area	3.0 cm^2

ELECTRICAL DATA

Operating characteristics

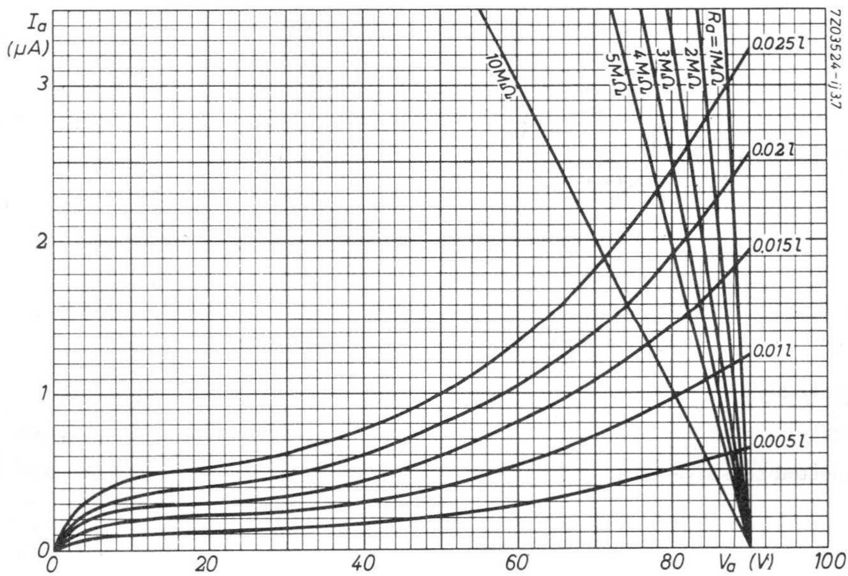
Anode supply voltage	V_b		90	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		125	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

Capacitance

Anode to cathode	C_{ak}		1.1	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	2.0	μA
Ambient temperature	t_{amb}	max.	100	°C



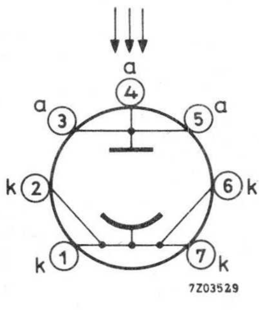
VACUUM PHOTOTUBE

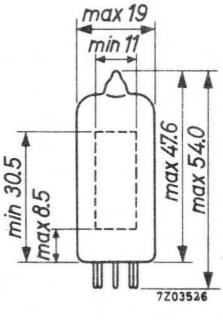
Vacuum phototube, particularly sensitive to incandescent light sources, and to near infra-red radiation.

QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	250	V
Luminous sensitivity	N		20	μA/lumen
Spectral response curve		type C		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photo cathode

Surface	Ceasium on oxidised silver
Projected sensitive area	3.0 cm^2

7Z2 5213

ELECTRICAL DATA

Operating characteristics

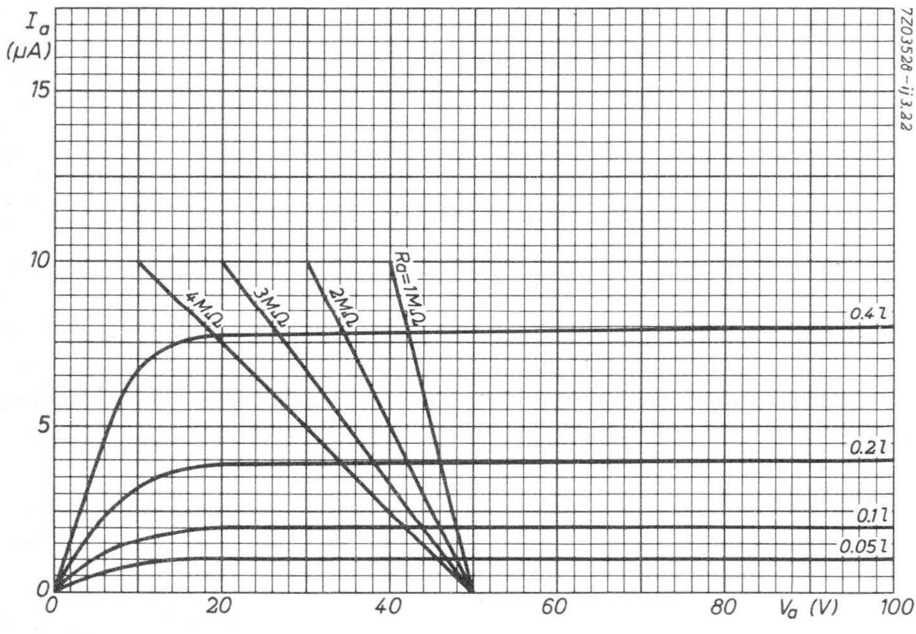
Anode supply voltage	V_b		50	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		20	µA/lumen
Dark current (at V_a = 100 V)	I_{dark}	max.	0.05	µA

Capacitance

Anode to cathode	C_{ak}		0.8	pF

LIMITING VALUES (Absolute max. rating system)

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



GAS FILLED PHOTOTUBE

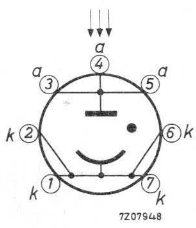
Gas-filled phototube particularly sensitive to daylight and to radiation having a blue predominance.

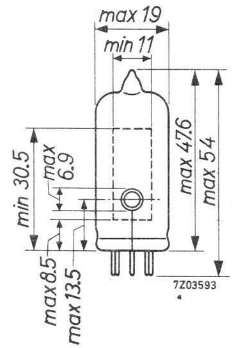
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	90	V
Luminous sensitivity	N		130	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA

Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface	Caesium antimony
Projected sensitive area	2.1 cm^2

ELECTRICAL DATA

Operating characteristics

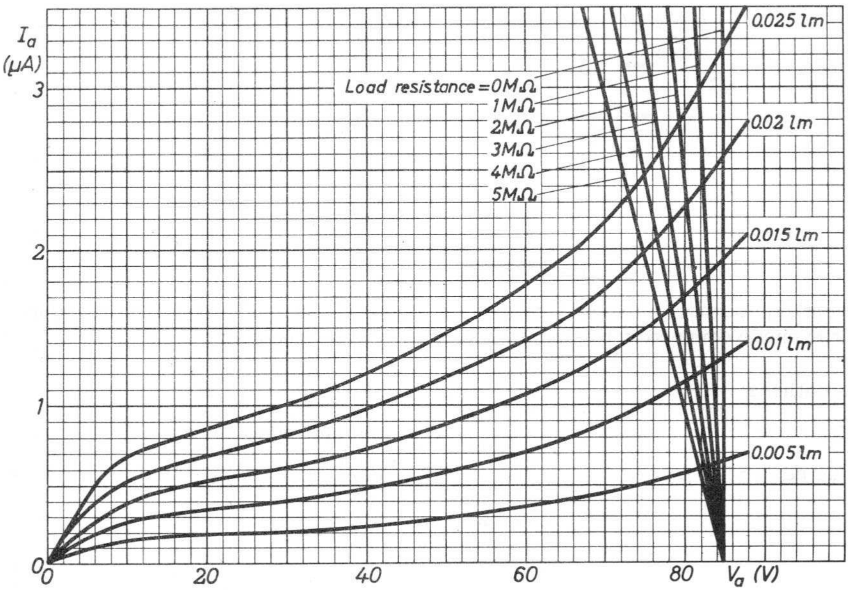
Anode supply voltage	V_b		85	V
Anode series resistor	R_a		1	MΩ
Luminous sensitivity measured with the whole cathode area illuminated by a lamp of colour temperature 2700 °K	N		130	μA/lumen
Dark current	I_{dark}	max.	0.1	μA

Capacitance

Anode to cathode	C_{ak}	0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	90	V
Cathode current	I_k	max.	0.0125	μA/mm2
Ambient temperature	t_{amb}	max.	70	°C



VACUUM PHOTOTUBE

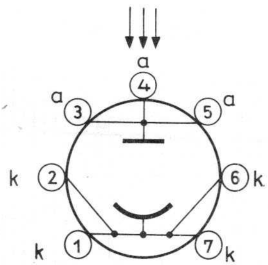
Vacuum phototube particularly sensitive to daylight and to light radiation with a blue predominance.

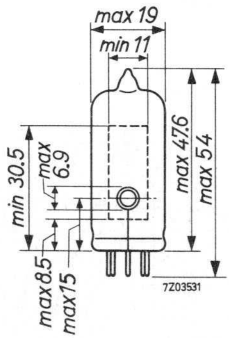
QUICK REFERENCE DATA				
Anode supply voltage	V_b	max.	100	V
Luminous sensitivity	N		45	μA/lumen
Spectral response curve		type A		
Outline dimensions		max. 19 dia. x 54		mm

MECHANICAL DATA

Dimensions in mm

Base: Miniature





The arrows show the direction of the incident radiation.

The cathode connection should be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

Photocathode

Surface — caesium antimony

Projected sensitive area — 2.1 cm^2

ELECTRICAL DATA

Operating characteristics

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

Capacitance

Anode to cathode	C_{ak}	0.9	pF

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_b	max.	100	V
→ Cathode current	I_k	max.	0.025	μA/mm²
Ambient temperature	t_{amb}	max.	70	°C

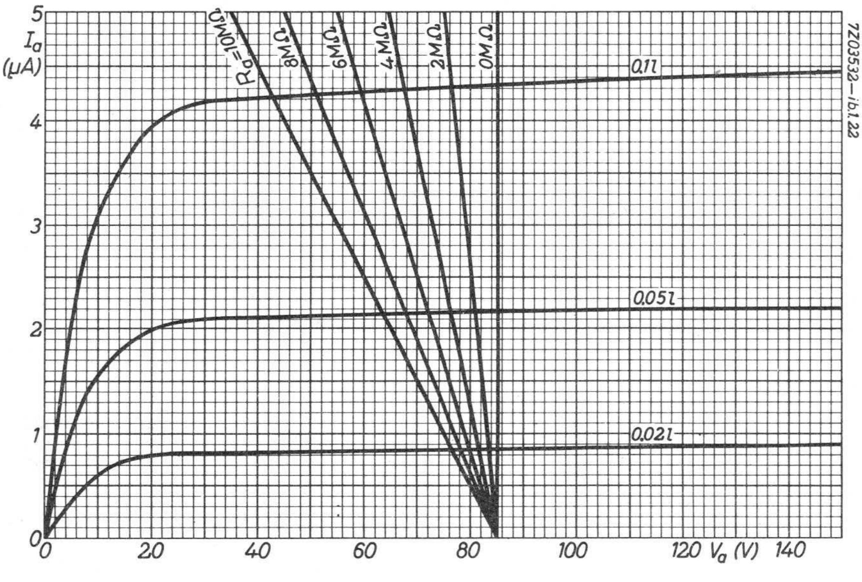
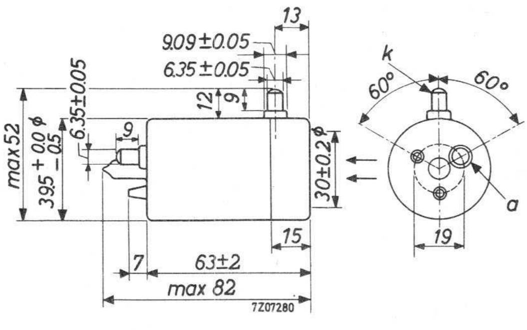


PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA			
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Average current	I_a	max. 50×10^{-9}	A
Peak current	I_{ap}	max. 35×10^{-6}	A
Sensitivity	N	60×10^{-6}	A/lumen
Rise time		14	ns
Spectral response		type A	
Outline dimensions		max. 52 x 82	mm

MECHANICAL DATA Dimensions in mm



Mounting position: any

Photocathode

Cathode material	Caesium-antimony		

The cathode material has been deposed on the inner surface of the window. This window is optically plane and polished.
It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	30	mm
Spectral response	type A		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °C	typical	60×10^{-6}	A/lumen
	min.	35×10^{-6}	A/lumen

Each tube is marked with its sensitivity

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5 %.

CAPACITANCE

Anode to cathode	C_{ak}		13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen			< 6	$V_{D.C.}$
luminous flux 1 lumen			< 70	$V_{D.C.}$
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Dark current	I_{ao}	max.	10^{-12}	A
Linearity [1]			0.1	‰
Insulation resistance	r_{ins}	min.	10^{15}	Ω
Rise time	T_r		14	ns

[1] The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm^2 of cathode area, peak	I_{k_p}	max.	50×10^{-9}	A/mm^2
average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm^2
Cathode current, peak [1]	I_{k_p}	max.	35×10^{-6}	A
average (T_{av} = 1 s)	I_k	max.	50×10^{-9}	A
Envelope temperature	t_{bulb}	min.	-90	^{o}C
	t_{bulb}	max.	+60	^{o}C

LIFE EXPECTANCY

With an average cathode current of 50×10^{-9} A, the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to –90 ^{o}C.

APPLICATION

The currents allowed through 150AV are so low that amplification will always be necessary. To maintain the precision of the signal coming from the phototube is often the main problem.

This problem may be divided into four parts:

1. Distortion due to capacitive shunting:

The signal on the input of the amplifier is

$$v = \frac{i}{\sqrt{\frac{1}{R^2} + \omega^2 C^2}}$$

in which v = signal in V
i = current through phototube in A
R = part of series-resistance (in Ω) from which the signal is taken
ω = 2πX frequency of the signal in Hz
C = total capacitance of cathode of phototube + input-capacitance of amplifier + stray capacitance of wiring in F. The value of C will not easily be kept below 20 pF.

[1] With the cathode uniformly illuminated.

If a certain distortion only is accepted the maximum frequency of the signal to be transferred will limit the value of the resistance from which the signal will be taken and by this limit the value of the signal on the input of the amplifier.

2. Noise:

The level of the signal on the input of the amplifier shall be above the noise level.
The 3 main sources of noise are:

a. Shot noise in the phototube which follows the formula:

$$I_{noise} = \sqrt{2ei \times B} \text{ in } A_{R.M.S.}$$

$$V_{noise} = R x I_{noise}$$

in which e = 1.6×10^{-19} in As
i = the current through the phototube in A
B = the bandwidth in Hz
R = value of resistor from which signal is taken in Ω

b. Resistance noise of that part of the series-resistor from which the input signal for the amplifier is taken.
This part of the noise follows the formula:

$$V_{noise} = \sqrt{4\,k\,T\,R\,B}$$

in which k = 1.35×10^{-23}
T = temperature in ^{o}K
R = value of resistor in Ω
B = bandwidth in Hz

c. Input-noise of the amplifier

In such cases where an electron tube is used in the input of the amplifier, the noise-voltage follows the formula

$$V_{noise} = \sqrt{\sum V^2_{eq}\, \Delta B}$$

The value of V_{eq} as a function of frequency is different for each type of tube, but for frequencies above 1000 Hz V_{eq} does not change much with the frequency allowing the formula to be reduced to

$$V_{noise} = V_{eq}\sqrt{B}$$

In that case V_{eq} can be approximated within a factor 2 to 3 by

$$V_{eq} = \frac{3 \times 10^{-9}\sqrt{I_a}}{S}$$

in which I_a is the anode current of the tube in A and S is the transconductance in A/V.

Bringing the formulas shown in items 1 and 2 together gives:
The square of the signal to noise ratio on the input of the amplifier will be:

$$\left\{\frac{\text{signal}}{\text{noise}}\right\}^2 = \frac{i}{2\,e\,i\,B + 4\,T\,\frac{1}{R}\,B + V_{eq}^2\,B\,(\frac{1}{R^2} + \omega^2\,C^2)}$$

in which i is the current through the phototube in Amperes

3. Input current of the amplifier

The input-current of the amplifier should be low compared with the signal current through the phototube.

4. Linearity of the amplifier

The amplifier should have a feedback so that the stability and the distortion of the signal is not impaired.

If the circumstances are such that the signal to noise ratio cannot be kept within acceptable limits - usually there where low incident illumination levels combine with high frequencies - use of this type of phototube should be abandoned in preference to photomultipliers where the distortion due to capacitive shunting and noise sources other than shot noise are of smaller relative importance.

Examples:

An example for a simple circuit which is useful for many purposes of static light measurements is shown in fig.1.

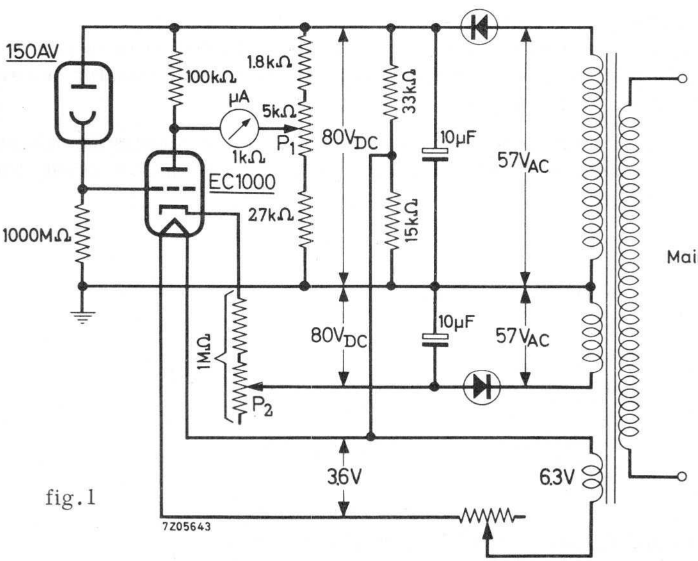


fig.1

In this circuit the μA meter with 50 μA f.s.d. may be calibrated in milli-lumen or - if the whole of the cathode is illuminated - in lux. Assuming that the pointer of the μA meter will not move with frequencies above 20 Hz, for calculation of the noise level frequencies below 20 Hz are of interest only.
For currents of 5×10^{-9} A through the phototube the signal on the input of the amplifier is of a level of 5 V, the shot noise on a level of 10^{-4} V, the resistance noise on a level of 10^{-5} V, the equivalent noise voltage on the input of EC1000 on a level of 10^{-6} V.

The feedback of this system is about 1000 times, so the accuracy is solely determined by the accuracy of the μA meter, all other sources being small.

Mains voltage variations of +10% and -15% are of no influence on the measuring result.

The circuit of Fig.1 is calibrated as follows:
Adjust P_2 so that the total cathode resistance of the EC1000 is $\frac{A \times R_1}{50 \times 1000}$ Ω

in which R_1 is the value of the series resistance of the 150AV and
A is the actual sensitivity in μA/lumen of the 150AV as marked on the tube.

Disconnect the connection between the phototube and the grid of the EC1000 and connect the grid of EC1000 to earth. Connect the circuit to the mains and adjust P_1 so that the μA meter indicates zero.

The circuit is now restored and has been calibrated for 0.02 mlumen per μA deflection of the μA meter.

For measurements of rapidly changing phenomena the series-resistor in Fig.1 of 150AV should be adapted for an acceptable signal to noise ratio and acceptable distortion while the μA meter should be replaced by a resistor shunted by the input of an oscilloscope.

Depending on the frequency further adaptations of the circuit may be necessary, e.g. further smoothing of the D.C. voltages and a D.C. heater supply for the EC1000.

Remark P_1 and P_2 should be wirewound resistors.

For extremely rapid changes when all time constants of the circuit have to be reduced as far as possible a circuit as shown in fig.2 may be used on which laser light flashes can be recorded with a rise time of the signal on the oscilloscope of 20 ns.

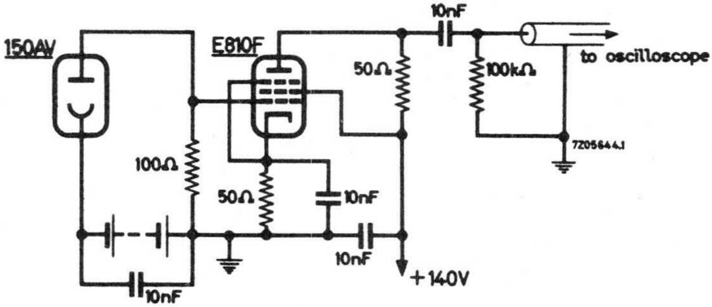


fig.2

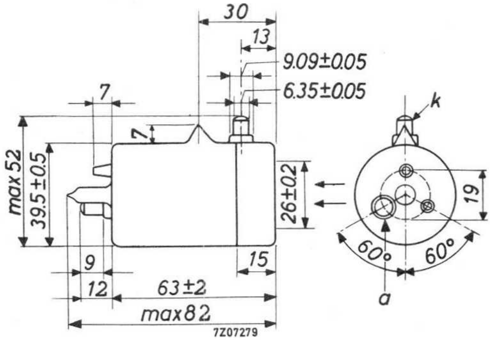
PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision/photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA				
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Average current	I_a	max.	35×10^{-9}	A
Peak current	I_{ap}	max.	25×10^{-6}	A
Sensitivity	N		20×10^{-6}	A/lumen
Rise time			14	ns
Spectral response			type C	
Outline dimensions		max.	52 x 85	mm

MECHANICAL DATA

Dimensions in mm



Mounting position: any

Photocathode

Cathode material	Caesium on oxidized silver		

The cathode material has been deposed on the inner surface of the window. This window is optically plane and polished.
It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	26	mm
Spectral response	type C		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °K	typical	20×10^{-6}	A/lumen
	min.	14×10^{-6}	A/lumen

Each tube is marked with its sensitivity.

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5%.

CAPACITANCE

Anode to cathode	C_{ak}	13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen			< 6	$V_{D.C.}$
luminous flux 1 lumen			< 70	$V_{D.C.}$
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Dark current	I_{a_o}	max.	10^{-9}	A
Linearity [1]			0.1	‰
Insulation resistance	r_{ins}	min.	10^{15}	Ω
Rise time	T_r		14	ns

[1]) The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm^2 of cathode area, peak	I_{k_p}	max.	50×10^{-9}	A/mm^2
average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm^2
Cathode current, peak [1])	I_{k_p}	max.	25×10^{-6}	A
average (T_{av} = 1 s)	I_k	max.	35×10^{-9}	A
Envelope temperature	t_{bulb}	min.	-90	^oC
	t_{bulb}	max.	+60	^oC

LIFE EXPECTANCY

With an average cathode current of 35×10^{-9} A, the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to $-90\ ^oC$.

APPLICATION

Please refer to data of 150AV.

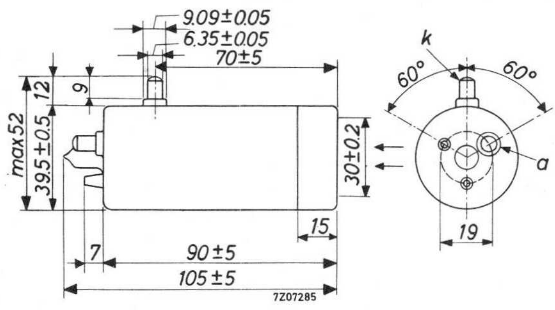
PHOTO TUBE

Vacuum phototube with high stability and linearity intended for use in high precision photometry (maximum intensity 1 lux) and for measurements of quickly changing light phenomena (maximum light intensity approx. 1000 lux).

QUICK REFERENCE DATA				
Anode voltage	V_a		6 to 90	$V_{D.C.}$
Average current	I_a	max.	50×10^{-9}	A
Peak current	I_{ap}	max.	35×10^{-6}	A
Sensitivity	N		35×10^{-6}	A/lumen
Rise time			14	ns
Spectral response			type U	
Outline dimensions		max.	53 x 110	mm

MECHANICAL DATA

Dimensions in mm



Mounting position: any

Photocathode

Cathode material	Caesium-antimony		

The cathode material has been deposed on the inner surface of the quartz window. This window is optically plane and polished. It therefore allows the luminous source to be at close and narrowly reproducable distance from the cathode.

Useful cathode area	dia.	30	mm
Spectral response	type U		

The spectral response curve shown is a nominal curve and considerable variation between individual tubes may be expected.

Sensitivity measured with a tungsten ribbon lamp having a c.t. of 2850 °K	typical	60×10^{-6}	A/lumen
	min.	35×10^{-6}	A/lumen

Each tube is marked with its sensitivity.

An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity not more than 5 %.

CAPACITANCE

Anode to cathode	C_{ak}	13	pF

TYPICAL CHARACTERISTICS

Saturation voltage, luminous flux 0.05 lumen		< 6	$V_{D.C.}$
luminous flux 1 lumen		< 70	$V_{D.C.}$
Anode voltage	V_a	6 to 90	$V_{D.C.}$
Dark current	I_{a_o}	max. 10^{-12}	A
Linearity [1]		0.1	‰
Insulation resistance	r_{ins}	min. 10^{15}	Ω
Rise time	T_r	14	ns

[1] The relation between the incident luminous flux and the tube current is linear within measuring errors, provided the anode voltage is higher than the saturation voltage.

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	100	$V_{D.C.}$
Cathode current per mm^2 of cathode area, peak	I_{kp}	max.	50×10^{-9}	A/mm^2
average (T_{av} = 1 s)	I_k	max.	70×10^{-12}	A/mm^2
Cathode current, peak [1])	I_{kp}	max.	35×10^{-6}	A
average (T_{av} = 1 s)	I_k	max.	50×10^{-9}	A
Envelope temperature	t_{bulb}	min.	-90	^oC
	t_{bulb}	max.	+60	^oC

LIFE EXPECTANCY

With an average cathode current of 50×10^{-9} A, the sensitivity will not decrease more than 10% of its initial value between zero and 500 operating hours.

At lower cathode currents a higher stability may be expected.

REMARKS

- The cathode should not be exposed to direct sunlight.
- In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to $-90\ ^oC$.

APPLICATION

Please refer to data of 150AV.

PHOTOCELL

Top sensitive gas-filled phototube, sensitive to ultra-violet radiation, intended for use as an on-off device in flame failure circuits.

QUICK REFERENCE DATA			
Supply voltage	V_b	220	V_{RMS}

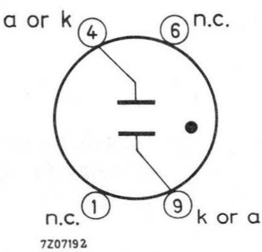
OPERATING PRINCIPLE

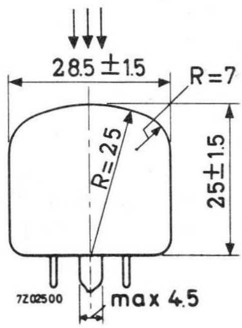
When photons of sufficient energy strike the cathode of the device electrons may be released. Provided the tube voltage is sufficiently high, these electrons may initiate a discharge. The probability that this will occur is dependent amongst other things on the value of the supply voltage and the ultra-violet radiation intensity.
The discharge will extinguish as soon as the instantaneous value of the tube voltage falls below the maintaining voltage.
It should be noted that most sources of visible light (e.g. the sun, fluorescent lamps) are at the same time sources of U.V. radiation.
Where the level of such radiation affects the reliable operation of the circuit, adequate shielding or filtering should be provided.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval 4 pins





The arrows show the required direction of incident radiation for highest sensitivity.

Mounting position: any

7Z2 8043

MOUNTING

A noval socket with a centre hole diameter of at least 5.4 mm should be used. Pins 1 and 6 should be connected to pins 9 and 4 respectively on the socket.

CHARACTERISTICS

Spectral response		0.2 to 0.29 μm (2000 to 2900 Å) See also page A
Maintaining voltage	V_m	180 to 220 V

RECOMMENDED CIRCUITS

I. DIRECT RELAY CIRCUIT (t_{amb} = max. 70 °C)

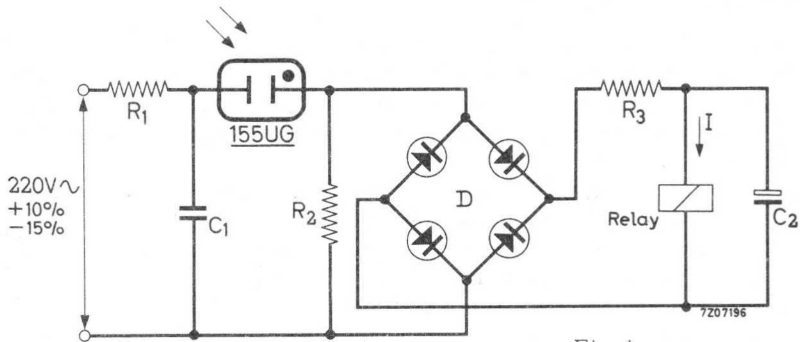


Fig. 1

R_1	100 Ω ± 10 %
R_2	220 kΩ ± 10 %
R_3	270 Ω ± 10 %
D	4 diodes
C_1	12 nF ± 15 %
C_2	25 μF ± 15 %

Relay:

R		12 kΩ ± 10 %
I_{on}	<	3 mA
I_{off}		0.5 to 1.5 mA
W_{max}	>	1.2 W

Notes

1. The filter R_1 C_1 reduces the effects of high voltage transients on the mains.
2. Incidental discharges of the tube will not activate the relay for any value of the mains voltage within the range 220 V + 10 % to −15 %.

Sensitivity

Under the worst probable conditions of supply voltage (190 V) component variation and characteristic variation of the tube during 10.000 hours, the tube will activate the relay when a "standard radiation source" (candle, see fig.4) is at a distance < 50 mm from the tube.

7Z2 8044

RECOMMENDED CIRCUITS (continued)

II. INDIRECT RELAY CIRCUITS (t_{amb} = max. 100 °C)

IIa

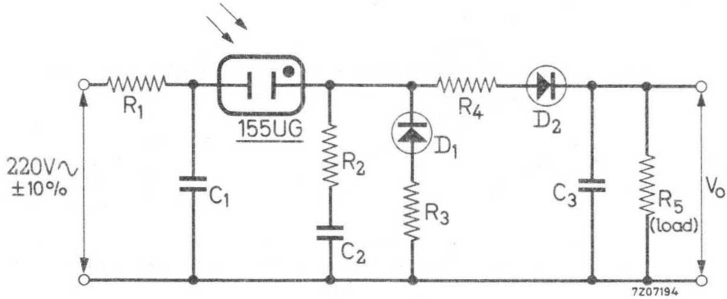


Fig.2

R_1	100 Ω ±10%	C_1	12 nF ±15%
R_2	100 Ω ±10%	C_2	12 nF ±15%
R_3	120 kΩ ±10%	C_3	2.2 μF ±15%
R_4	120 kΩ ±10%	D_1, D_2	diodes
R_5	470 kΩ ±10%		

Note

The filter R_1 C_1 reduces the effects of high voltage transients on the mains.

Sensitivity

The curve on page B shows the relationship between the output voltage V_o and the distance between the tube and the "standard radiation source" (see fig.4) under the worst probable conditions of supply voltage (198 V) and component variation for the least sensitive new tube.
After the first 10 000 hours of operation the sensitivity will have decreased, but will in all cases be better than indicated by the curve on page B provided the radiation source is doubled (two candles according to fig.4).

7Z2 8045

RECOMMENDED CIRCUITS (continued)

IIb

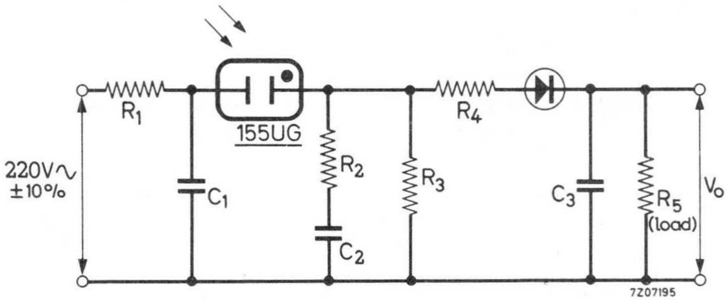


Fig.3

R_1	100 Ω ±10%	C_1	12 nF ±15%
R_2	100 Ω ±10%	C_2	12 nF ±15%
R_3	330 kΩ ±10%	C_3	2.2 μF ±15%
R_4	150 kΩ ±10%	D_1	diode
R_5	470 kΩ ±10%		

Note

The filter R_1 C_1 reduces the effects of high voltage transients on the mains.

Sensitivity

The curve on page B shows the relationship between the output voltage V_o and the distance between the tube and the "standard radiation source" (see fig.4) under the worst probable conditions of supply voltage (198 V) and component variation for the least sensitive new tube.
After the first 10 000 hours of operation the sensitivity will have decreased, but will in all cases be better than indicated by the curve on page B provided the radiation source is doubled (two candles according to fig.4).

LIMITING VALUES

Ambient temperature, operating	t_{amb}	min.	−25	°C	
		max.	70	°C	when used in circuit fig.1
		max.	100	°C	when used in circuits fig.2 and 3
storage	t_{stg}	min.	−50	°C	
		max.	+50	°C	

7Z2 8046

Warning

Designers of flame failure detectors are strongly advised not to depart from the recommended circuits. Any such departure may result in an unsafe operating mode which is likely to cause an internal short in the tube before its rated useful life has expired.

Application notes

To ensure that the intensity of radiation incident on the built-in tube will be sufficient throughout its service life (10 000 hours in the case of a new tube) the following procedure should be observed:

For circuit fig. 1

Place a "standard radiation source" at a distance of 50 mm from the tube and measure the average voltage across the relay.
In actual operation the same tube should be mounted at a distance from the flame such that the average voltage across the relay is at least equal to that obtained under irradiation from the "standard radiation source" at 50 mm.
Care should be taken that the value of the mains voltage is the same during both measurements.
The flame used during this measurement should be the minimum flame which has to be detected. No further readjustment of the distance between tube and flame will be necessary when the tube has to be replaced.

For circuits fig. 2 and fig. 3

The output power from the circuits in fig. 2 and 3 is too low for direct tripping of a relay. For effective discrimination, the voltage on the input of the added amplifier must attain a certain threshold value when the U.V. energy emitted by the flame attains a certain critical intensity.
The implication is that steps must be taken to ensure that the output voltage V_o from the recommended circuit will remain above this threshold value throughout the life of the tube. This is done in the following way.
Read from the dotted curve on page B the distance d corresponding to the required minimum output voltage V_o.
Place two "standard radiation sources" at the distance d from the tube and connect the circuit output to a d.c. voltmeter with a high input resistance; observe the average output voltage V_o. (The mean value around which the needle swings.)
In actual operation the same tube should be mounted at a distance from the flame such that the average output voltage V_o is at least equal to that obtained under irradiation from the two "standard irradiation sources" at the distance d.

7Z2 8047

Care should be taken that the value of the mains voltage is the same during both measurements.
The flame used during this measurement should be the minimum flame which has to be detected.
No further readjustment of the distance between tube and flame is necessary when the tube has to be replaced.

Above procedures do of course not include allowance for dirt deposited on the tube during life.

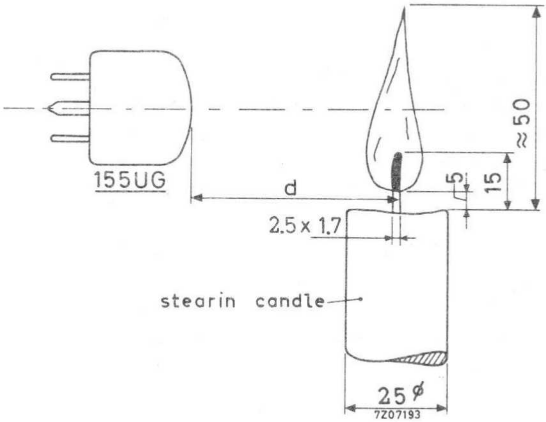
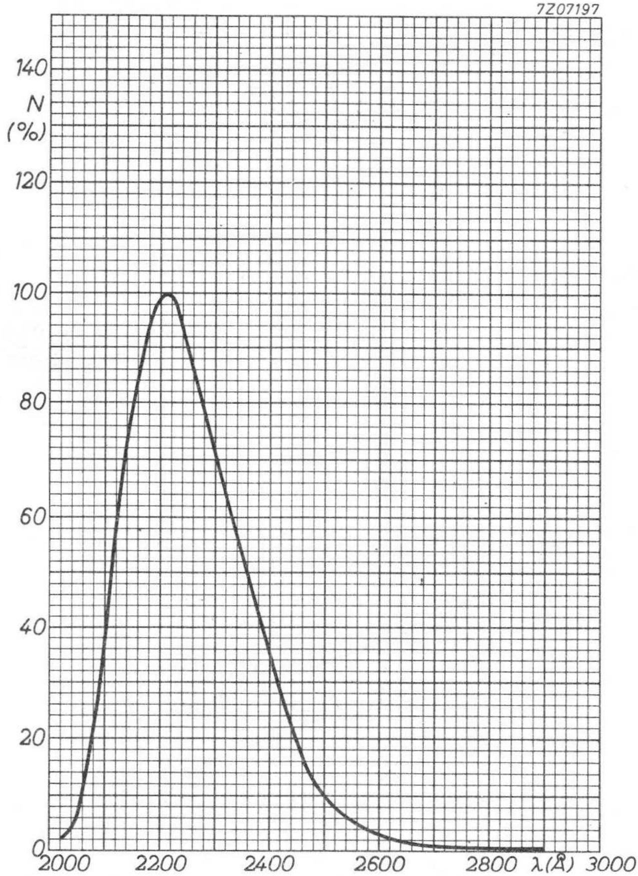
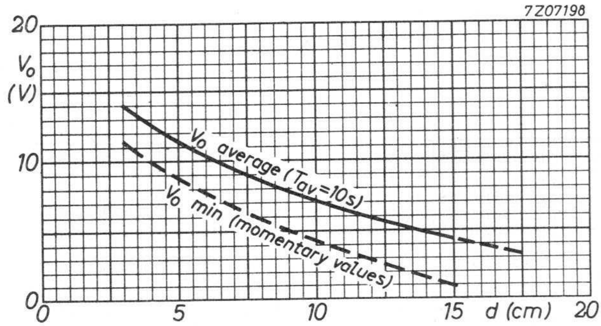


Fig.4

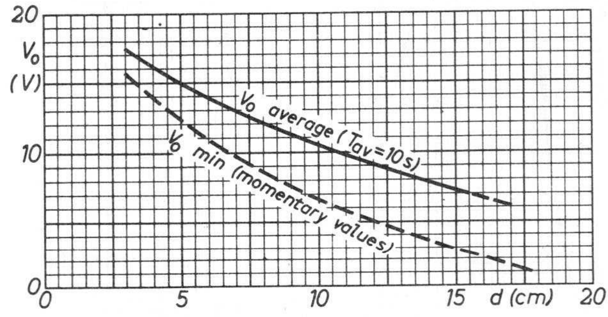
"Standard radiation source"

7Z2 8048


7Z07197
140
N
(%)
120
100
80
60
40
20
0
2000
2200
2400
2600
2800
λ(Å)
3000



The output voltage as a function of the distance between radiation source and the least sensitive tube in the circuit of fig.3.
The curve is valid at 0 hours when the tube is irradiated by one "standard radiation source" and at 10 000 hours when irradiated by two "standard radiation sources".



The output voltage as a function of the distance between radiation source and the least sensitive tube in the circuit of fig.2.
The curve is valid at 0 hours when the tube is irradiated by one "standard radiation source" and at 10 000 hours when irradiated by two "standard radiation sources".

Photoconductive devices

CADMIUM SULPHIDE PHOTOCONDUCTIVE DEVICES

LIST OF SYMBOLS

Cell voltage	V
Cell current	I
Illumination current	I_l
Initial illumination current	I_{lo}
Equilibrium illumination current	I_{le}
Dark current	I_d
Initial dark current	I_{do}
Equilibrium dark current	I_{de}
Illumination resistance	r_l
Initial illumination resistance	r_{lo}
Equilibrium illumination resistance	r_{le}
Dark resistance	r_d
Initial dark resistance	r_{do}
Equilibrium dark resistance	r_{de}
Current rise time	t_{ri}
Current decay time	t_{fi}
Resistance rise time	t_{rr}
Resistance decay time	t_{fr}
Pulse time	t_{imp}
Averaging time	t_{av}
Pulse repetition rate	p_{rr}

7Z2 5151

Illumination sensitivity	N
Illumination response	γ
Voltage response	α
Ambient temperature	T_{amb}
Thermal resistance	K
Temperature of CdS tablet	T_{tablet}
Colour temperature	T_K
Dissipation	P
Illumination	E
Initial drift	D_o

7Z2 5152

GENERAL OPERATIONAL RECOMMENDATIONS PHOTOCONDUCTIVE DEVICES

1. GENERAL

1.1 These application directions are valid for all types of photoconductive cells, unless otherwise stated on the individual technical data sheets.

1.2 A photoconductive device is a light-sensitive device whose resistance varies with the illumination on the device.

1.3 Where the term illumination is used in the following sections it shall be taken to mean the radiant energy which is normally used to excite the device.

1.4 Also in the following sections, history is taken to mean the duration of the specified conditions plus a sufficient description of previous conditions.

2. OPERATING CHARACTERISTICS

2.1 The data given on the individual technical data sheets are based on the devices being uniformly illuminated.

2.2 The illumination resistance is the ratio of the voltage across the device to the current through the device when illumination is applied to the device.

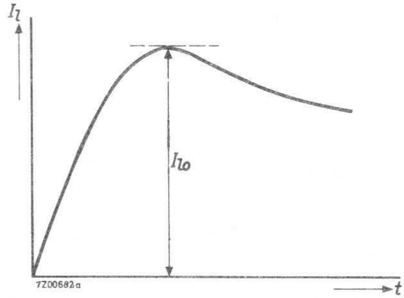
2.2.1 For a particular set of conditions the equilibrium illumination resistance is the illumination resistance after such a time under these conditions that the rate of change of the illumination resistance is less than 1% per 5 minutes.

2.2.2 For a particular set of conditions the initial illumination resistance is the first virtually constant value of the illumination resistance after a period of storage or other operating conditions.
The initial illumination resistance usually occurs after a few seconds under the specified conditions.

2.3 The illumination current is the current which passes when a voltage and illumination are applied to the device.

2.3.1 For a particular set of conditions the equilibrium illumination current is the illumination current after such a time under these conditions that the rate of change of the illumination current is less than 1% per 5 minutes.

2.3.2 For a particular set of conditions the initial illumination current is the first virtually constant value of the illumination current after a period of storage or other operating conditions.
The initial illumination current usually occurs after a few seconds under the specified conditions.



2.4 The dark resistance is the resistance of the device in the absence of illumination.

2.4.1 For a particular set of conditions the equilibrium dark resistance is the dark resistance after such a time under these conditions that the rate of change of the dark resistance is less than 2% per 5 minutes.

2.4.2 For a particular set of conditions the initial dark resistance is the dark resistance after a specified time under these conditions following a specified history.

2.5 The dark current is the current which passes when a voltage is applied to the device in the absence of illumination.

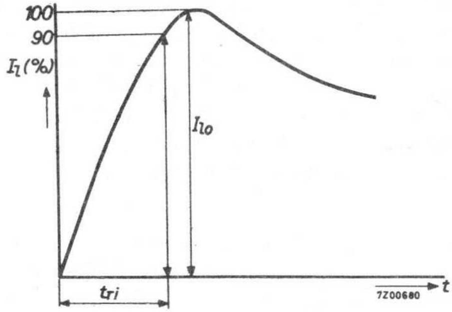
2.5.1 For a particular set of conditions the equilibrium dark current is the dark current after such a time under these conditions that the rate of change of the dark current is less than 2% per 5 minutes.

2.5.2 For a particular set of conditions the initial dark current is the dark current after a specified time under these conditions immediately following a specified history.

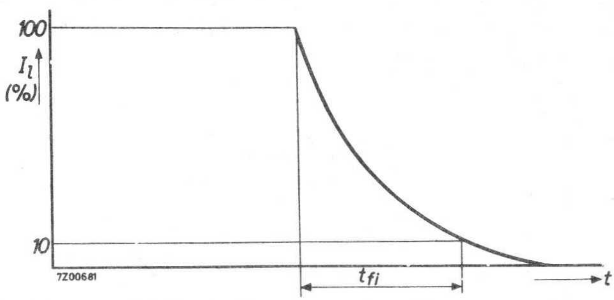
2.6.1 For a particular set of conditions and history the resistance decay time is the time taken for the resistance of the device to fall to a specified value measured from the instant of starting the illumination.

2.6.2 For a particular set of conditions and history the resistance rise time is the time taken for the resistance of the device to rise to a specified value measured from the instant of stopping the illumination.

2.7.1 For a particular set of conditions and history the current rise time is the time taken for the current through the device to rise to 90% ot its initial illumination current measured from the instant of starting the illumination.



2.7.2 For a particular set of conditions and history the current decay time is the time taken for the current through the device to fall to 10% of its value at the instant of stopping the illumination, measured from that instant.



2.8 The illumination sensitivity is the quotient of illumination current by the incident illumination.

2.9 The illumination resistance (current) temperature response is the relationship between the illumination resistance (current) and the ambient temperature of the device under constant illumination and voltage conditions.

2.10 For a particular set of conditions the initial drift is the difference between the equilibrium and initial illumination current, expressed as a percentage of the initial illumination current.

2.11 The illumination response is the relationship between the initial illumination resistance and the illumination, defined as $\frac{\Delta \log r_{lo}}{\Delta \log E}$

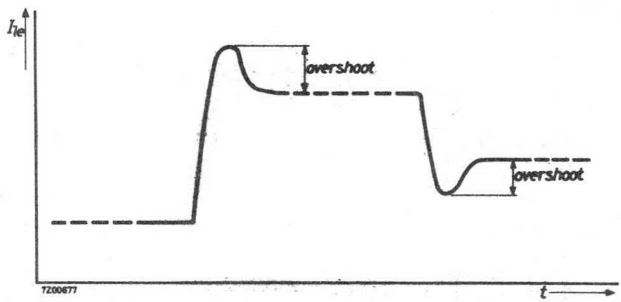
3. THERMAL DATA

3.1 Ambient temperature. The ambient temperature of a device is the temperature of the surrounding air of that device in its practical situation, which means that other elements in the same space or apparatus must have their normal maximum dissipation and that the same apparatus envelope must be used. This ambient temperature can normally be measured by using a mercury thermometer the mercury container of which has been blackened, placed at a distance of 5 mm from the envelope in the horizontal plane through the centre of the effective area of the CdS tablet.
It shall be exposed to substantially the same radiant energy as that incident on the CdS tablet.

3.2 The thermal resistance of a device is defined as the temperature difference between the hottest point of the device and the dissipating medium, divided by the power dissipated in the device.

4. OPERATIONAL NOTES

4.1 When a photoconductive device is subjected to a change of operating conditions there may be a transient change of current in excess of that due to the difference between the equilibrium illumination currents. This transient change is called overshoot.



4.2 Direct sunlight irradiation should be avoided.

5. MOUNTING

5.1 If no restrictions are made on the individual published data sheets, the device may be mounted in any position.

5.2 Most of the photoconductive devices may be soldered directly into the circuit, which is indicated on the individual published data sheets. However, the heat conducted to the seal of the device should be kept to a minimum by the use of a thermal shunt. If not otherwise indicated, the device may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 seconds up to a point 5 mm from the seals.

6. **STORAGE**

It is recommended that the devices be stored in the dark. At any rate direct sunlight irradiation should be avoided.

7. **LIMITING VALUES**

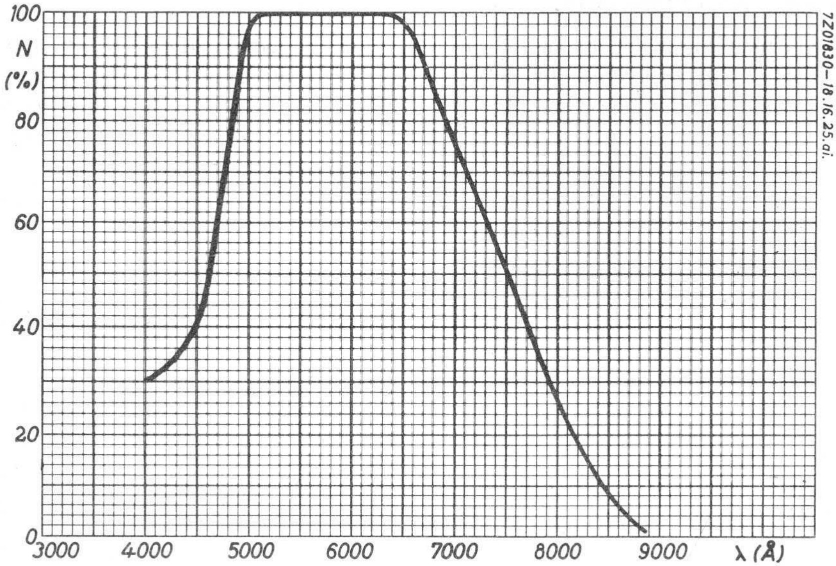
The limiting values of photoconductive devices are given in the absolute maximum rating system.

8. **OUTLINE DIMENSIONS**

The outline dimensions are given in mm.

9. **SHOCK AND VIBRATION**

The conditions for shock and vibration given on the individual data sheets are intended only to give an indication of the mechanical quality of the device. It is not advisable to subject the device to such conditions.


100
N
(%)
80
60
40
20
0
3000
4000
5000
6000
7000
8000
9000
λ (Å)
7Z01830–18.16.25.ai.

TYPE D

RATING SYSTEM

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

7Z2 8269

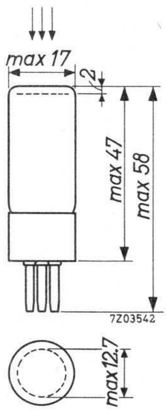
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

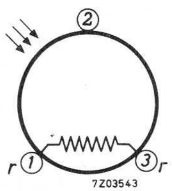
Cadmium sulphide photoconductive cell with top sensitivity intended for use in flame failure, smoke detection circuits and general industrial applications.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	400	mW
Cell voltage, d.c. and repetitive peak	V	max.	300	V
Cell resistance at 50 lux, 2700 °K colour temperature	r		1700	Ω
Spectral response curve		type D		
Outline dimensions		max. 17 dia. x 58		mm

MECHANICAL DATA

Dimensions in mm





Sensitive area 1.25 cm^2.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery. 1)

	symbol	min.	typical	max.	unit
Equilibrium dark resistance measured with 300 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	8			MΩ
Initial illumination resistance measured at 10 V d.c. and illumination = 50 lux, after 16 hrs in darkness. 2) 3)	r_{lo}	750	1500	3000	Ω
Equilibrium illumination resistance measured at 10 V d.c. and illumination = 50 lux, after 15 minutes under the measuring conditions. 3)	r_{le}		1700		Ω
Resistance decay time	t_{fr}	see sheet 6			
Resistance rise time	t_{rr}	see sheet 5			

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max.	300	V
Power dissipation at T_{amb} = 25 °C (see also sheet 4)	P	max.	400	mW
Power dissipation at T_{amb} = 70 °C (see also sheet 4)	P	max.	100	mW
Ambient temperature, storage and operating	T_{amb}	min.	-40	°C
operating (< 1 lux)	T_{amb}	max.	+50	°C
operating (≥ 1 lux)	T_{amb}	max.	+70	°C 4)

---

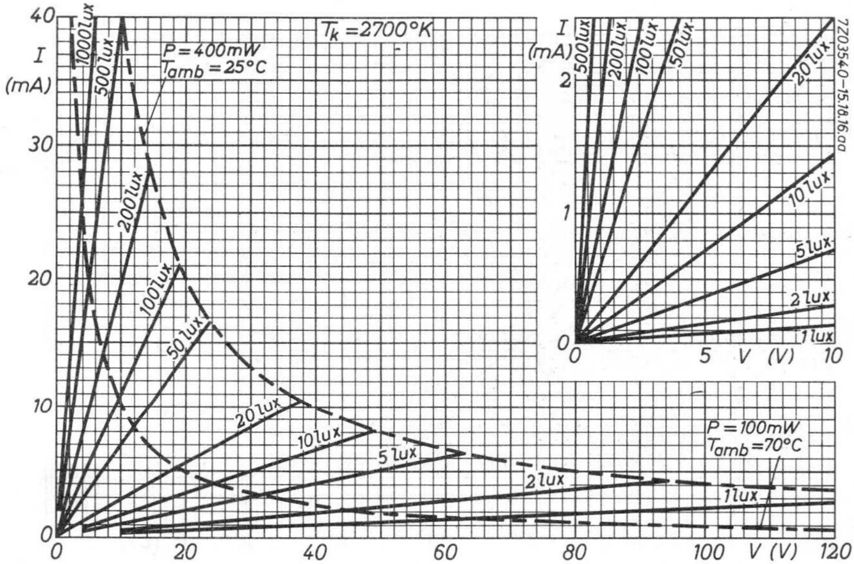
1) For sources of illumination other than a lamp of colour temperature 2700 °K, the cell resistance should be multiplied by the following approximate factors.

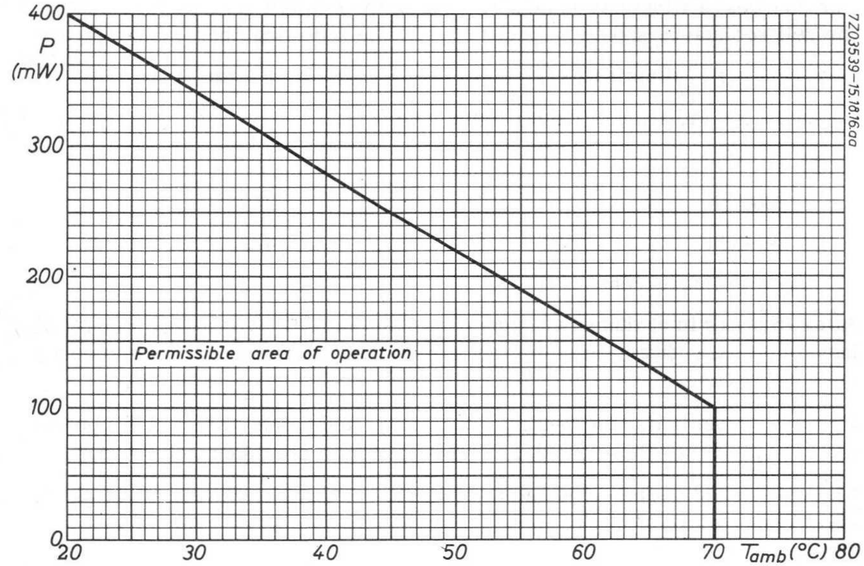
Source of illumination	Factor
Incandescent radiation at colour temperature of:	
1500 °K	1/2
2000 °K	2/3
Sunlight	4/3
White fluorescent	2

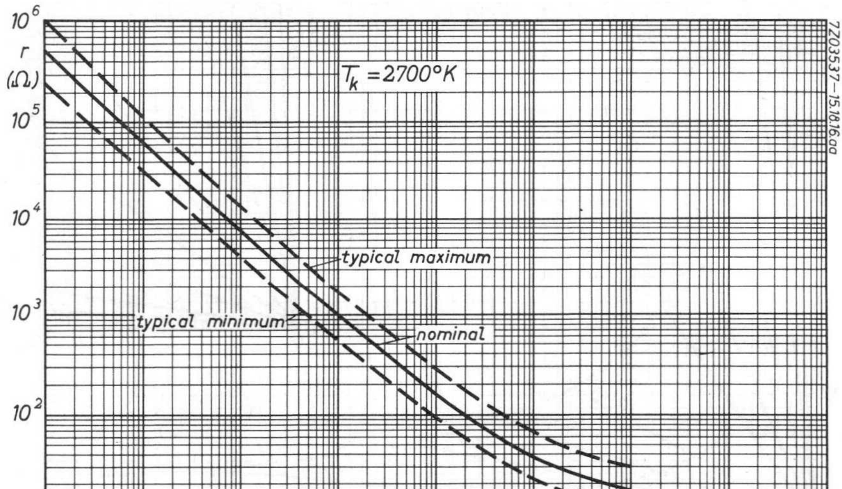
2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

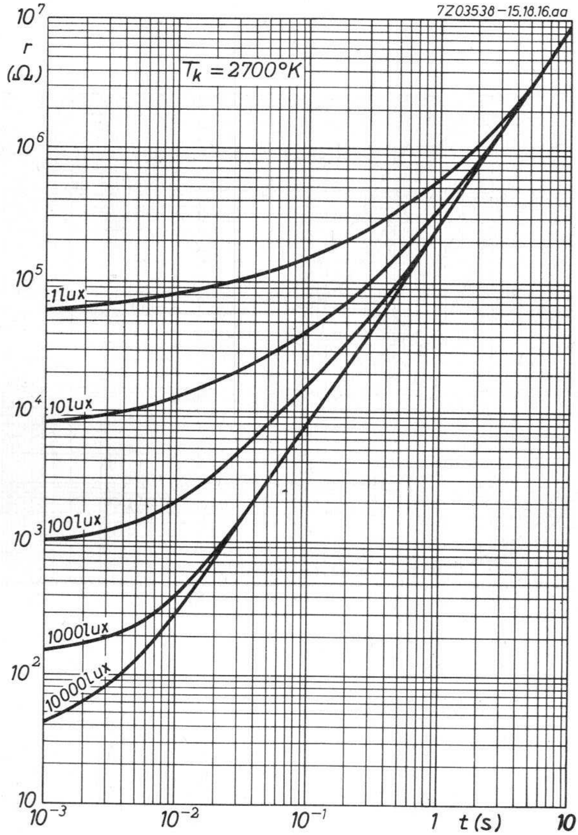
3) For a.c. conditions, the nominal and limit resistance values are approximately 1.1 times those for d.c. The a.c. values are taken to be r.m.s.

4) The cell should not be subjected to high relative humidity levels above an ambient temperature of 50 °C.

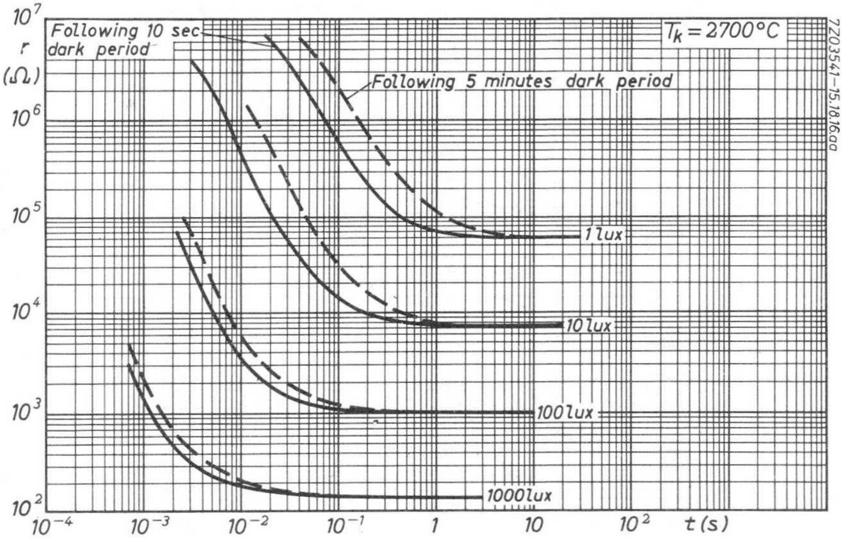



400
P
(mW)
300
200
100
0
20
30
40
50
60
70
T_{amb}(°C)
80
Permissible area of operation
7Z03539-15.18.16.aa


10^6
r
(Ω)
10^5
10^4
10^3
10^2
10
10^{-1}
1
10
10^2
10^3
10^4
10^5
E (lux)
T_k = 2700°K
typical maximum
typical minimum
nominal
7Z03537-15.18.16.aa



7Z03538−15.18.16.aa
T_k = 2700°K
r (Ω)
10^7
10^6
10^5
10^4
10^3
10^2
10
1lux
10lux
100lux
1000lux
10000lux
10^{-3}
10^{-2}
10^{-1}
1
t (s)
10



10^7
r
(Ω)
10^6
10^5
10^4
10^3
10^2
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t (s)
Following 10 sec dark period
Following 5 minutes dark period
$T_k = 2700°C$
1 lux
10 lux
100 lux
1000 lux
7Z03541-15.18.16.aa

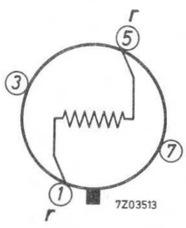
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

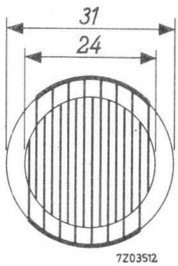
Cadmium sulphide photoconductive cell with top sensitivity intended for use in flame control, smoke detection and industrial on-off switching applications.

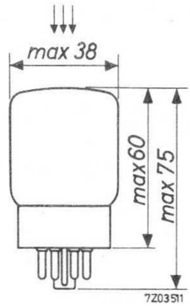
QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 ^{o}C	P	max.	1.2	W
Cell voltage, d.c. and repetitive peak	V	max.	350	V
Cell resistance at 50 lux, 2700 ^{o}K colour temperature	r		330	Ω
Spectral response curve		type D		
Outline dimensions		max. 38 dia. x 75		mm

MECHANICAL DATA

Dimensions in mm







Base: Octal

Total area to be illuminated	7.5	cm^2
Sensitive part of this area	4.5	cm^2

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery. 7Z2 5156

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Equilibrium dark current measured with 300 V d.c. applied via 1 MΩ, 15 minutes after switching off the illumination	I_{de}			5	μA
Initial illumination current measured at 10 V d.c. and illumination = 50 lux, after 16 hrs in darkness [1]	I_{lo}	11	30	47	mA
Initial illumination current measured at 10 V d.c., illumination = 50 lux and colour temperature = 1500 °K, after 16 hrs in darkness	I_{lo}	24	60	96	mA
Current rise time	t_{ri}		see sheet B		
Current decay time	t_{fi}		see sheet B		
Sensitivity at 50 lux, with 10 V d.c. applied.	N		0.6		mA/lux

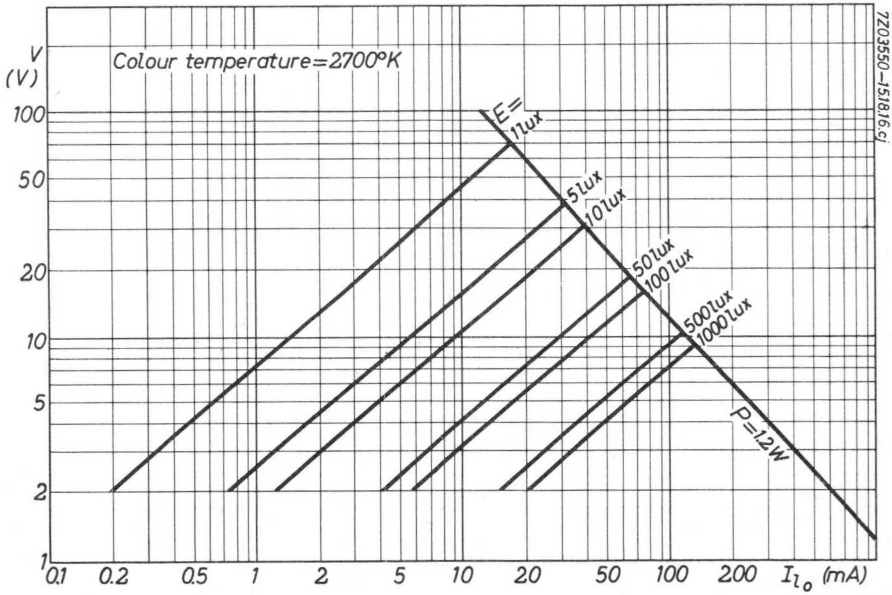
LIMITING VALUES (Absolute max. rating system)

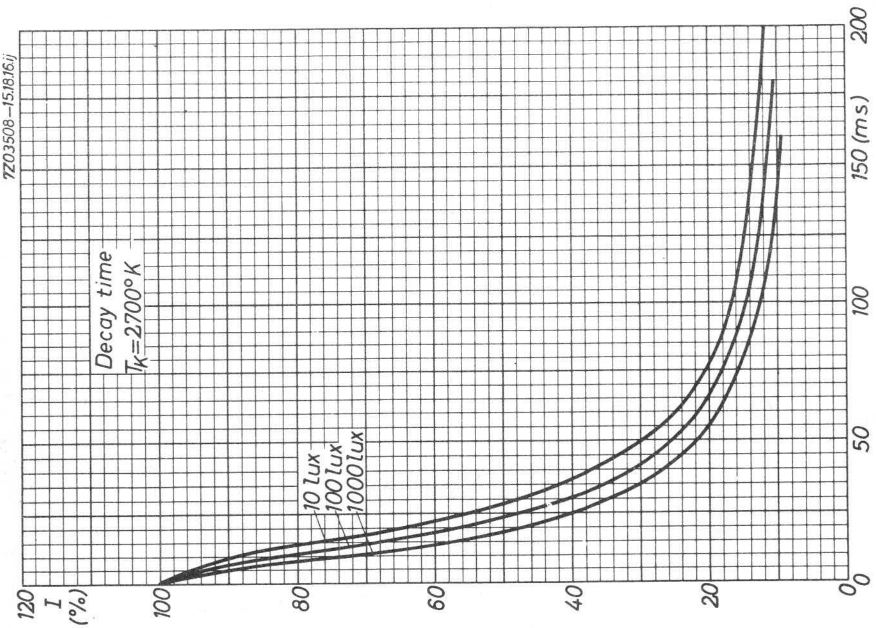
Cell voltage, d.c. and repetitive peak		V	max.	350	V
Power dissipation at T_{amb} = 25 °C	See also sheet C	P	max.	1.2	W
Power dissipation at T_{amb} = 70 °C	See also sheet C	P	max.	0.35	W
Ambient temperature, storage and operating		T_{amb}	min.	-40	°C
storage		T_{amb}	max.	+50	°C [2]
operating		T_{amb}	max.	+70	°C

[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

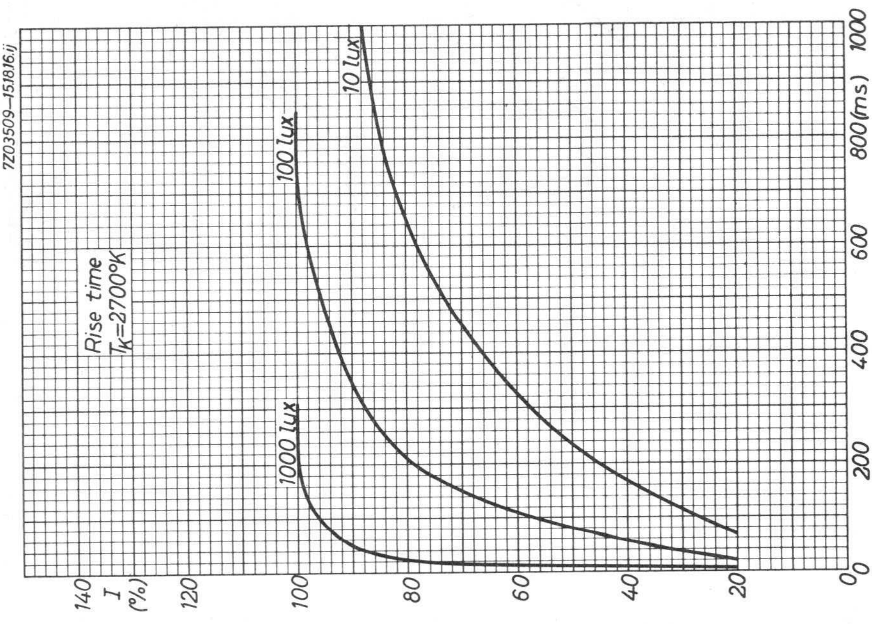
[2]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

7Z2 5157

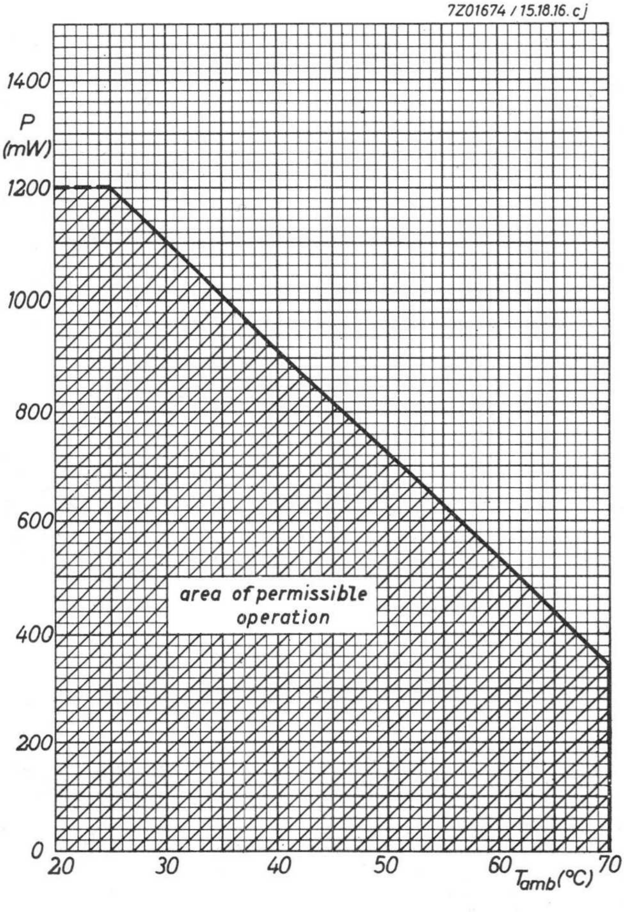

V
(V)
Colour temperature = 2700°K
E= 1lux
5lux
10lux
50lux
100lux
500lux
1000lux
P=1.2W
100
50
20
10
5
2
1
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_{l_0} (mA)
7Z03550-15.1.8.16.cj



7Z03508–15.18.16.ij
Decay time
T_K=2700°K
10 lux
100 lux
1000 lux
I
(%)
120
100
80
60
40
20
0
0
50
100
150 (ms)
200



7Z03509–15.18.16.ij
Rise time
T_K=2700°K
1000 lux
100 lux
10 lux
140
I
(%)
120
100
80
60
40
20
0
0
200
400
600
800 (ms)
1000


7Z01674 / 15.18.16. cj
1400
P
(mW)
1200
1000
800
600
400
200
0
20
30
40
50
60
70
Tamb(°C)
area of permissible
operation

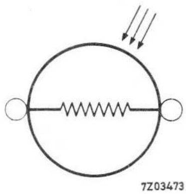
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

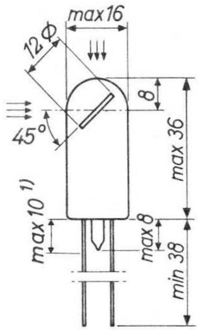
Cadmium sulphide photoconductive cell with top and side sensitivity.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	0.4	W
Cell voltage, d.c. and repetitive peak	V	max.	300	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{lo}		2700	Ω
Spectral response curve		type D		
Outline dimensions		max. 16 dia. x 44		mm

MECHANICAL DATA

Dimensions in mm





Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 10 mm from the seals.

1) Not tin plated

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery.

	symbol	min.	typical	max.	unit
Equilibrium dark resistance measured with 300 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	8			MΩ
Initial illumination resistance measured at 20 V d.c. and illumination = 50 lux, after 16 hrs in darkness [1]	r_{lo}	1300	2700	6200	Ω
Equilibrium illumination resistance measured at 20 V d.c. and illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}		3400		Ω
Resistance decay time Time to reach 7 kΩ measured from the instant of starting the illumination of 50 lux, after 16 hrs in darkness	t_{fr}		350		ms
Resistance rise time Time to reach 25 kΩ measured from the instant of stopping the illumination, after 15 minutes or longer illumination of 50 lux	t_{rr}		75		ms

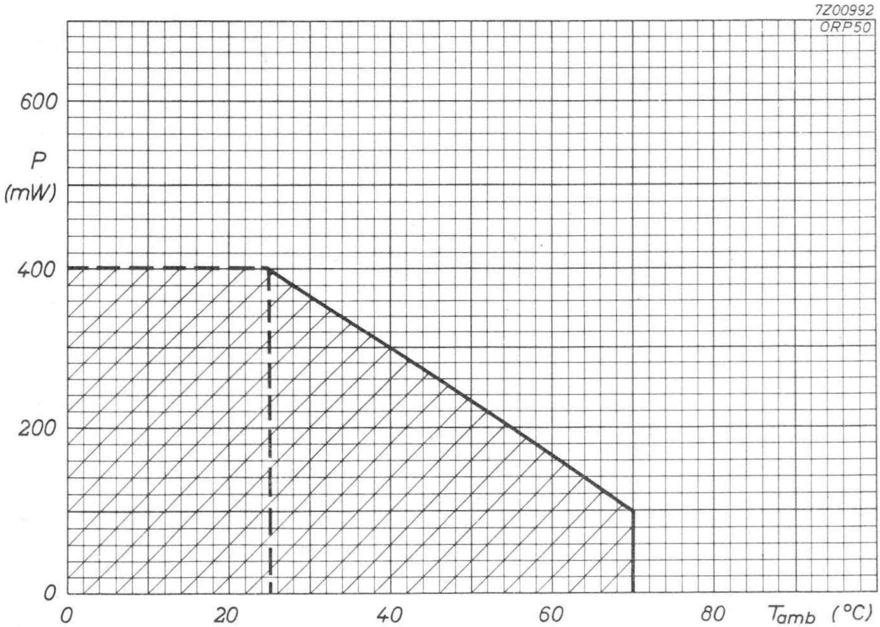
[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

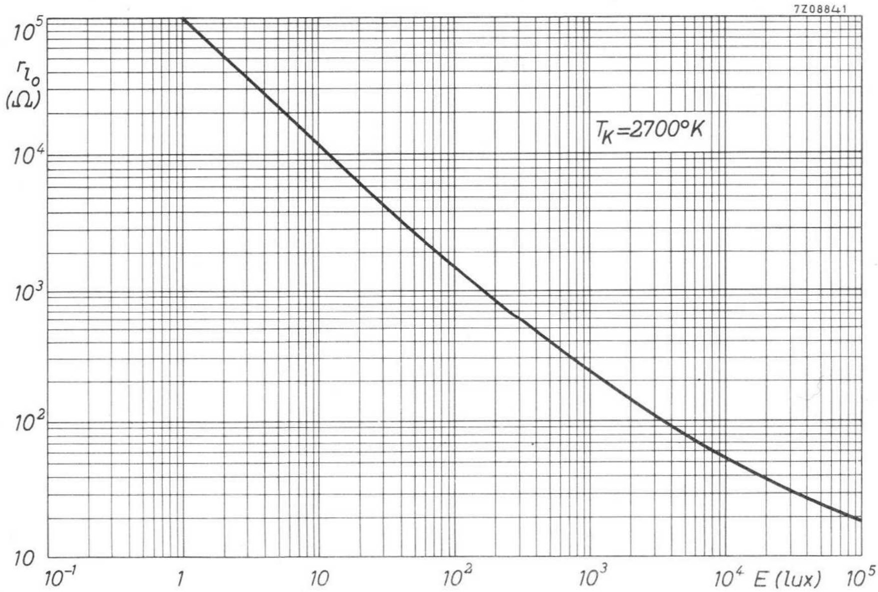
DESIGN CONSIDERATIONS

Apparatus with CdS devices should be designed so that changes in resistance values of the CdS cells during life from −30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak		V	max.	300	V
Power dissipation at T_{amb} = 25 °C	See also sheet 4	P	max.	0.4	W
Power dissipation at T_{amb} = 70 °C		P	max.	0.1	W
Ambient temperature, storage and operating		T_{amb}	min.	−40	°C
storage		T_{amb}	max.	+50	°C
operating (< 1 lux)		T_{amb}	max.	+50	°C
operating (≥ 1 lux)		T_{amb}	max.	+70	°C


7Z00992
ORP50
600
P
(mW)
400
200
0
0
20
40
60
80
Tamb (°C)


7Z08841
10^5
rlo
(Ω)
10^4
10^3
10^2
10
T_K=2700°K
10^-1
1
10
10^2
10^3
10^4 E (lux)
10^5

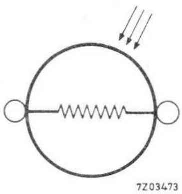
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

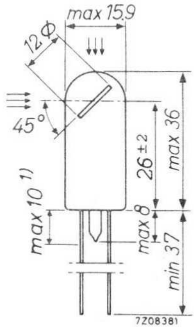
Cadmium sulphide photoconductive cell with top and side sensitivity intended for use in industrial on-off applications such as flame failure equipment. The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	400	mW
Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{l_0}		1200	Ω
Spectral response curve		type D		
Outline dimensions		max. 15.9 dia x 44		mm

MECHANICAL DATA

Dimensions in mm





Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 10 mm from the seals.

1) Not tinned.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 200 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	4		[1]	MΩ
Equilibrium dark resistance measured with 200 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	100		[1]	MΩ
Initial illumination resistance measured at 10 V d.c., illumination = 50 lux, after 16 hours in darkness [2]	r_{lo}	750	1200	3000	Ω
Equilibrium illumination resistance measured at 10 V d.c., illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}	750	1500	4100	Ω
Current rise time Time to reach 90% of the max. value, measured from the instant of starting the illumination of 50 lux, at 10 V d.c. after 16 hours in darkness	t_{ri}			1.5	s

[1] The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

[2] After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

Basic characteristics at T_{amb} = 25 ^{o}C, illumination with colour temperature of 2700 ^{o}K and at delivery (continued)

	symbol	min.	typical	max.	unit
Current decay time Time to reach 10% of the max. value, measured from the instant of stopping the illumination after 16 hours darkness and 10 sec. illumination of 50 lux, at 10 V d.c.	t_{f_i}			0.15	s
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.17		mA/lux
Negative temperature response of illumination resistance	$\Delta r1/\Delta T$		0.2	0.5	%/^{o}C
Voltage response $\frac{\text{r at 0.5 V}}{\text{r at 10 V}}$	α		1.05		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max.	+85	^{o}C
Thermal resistance from CdS tablet to ambient, device free in air	K		150	^{o}C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from −30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

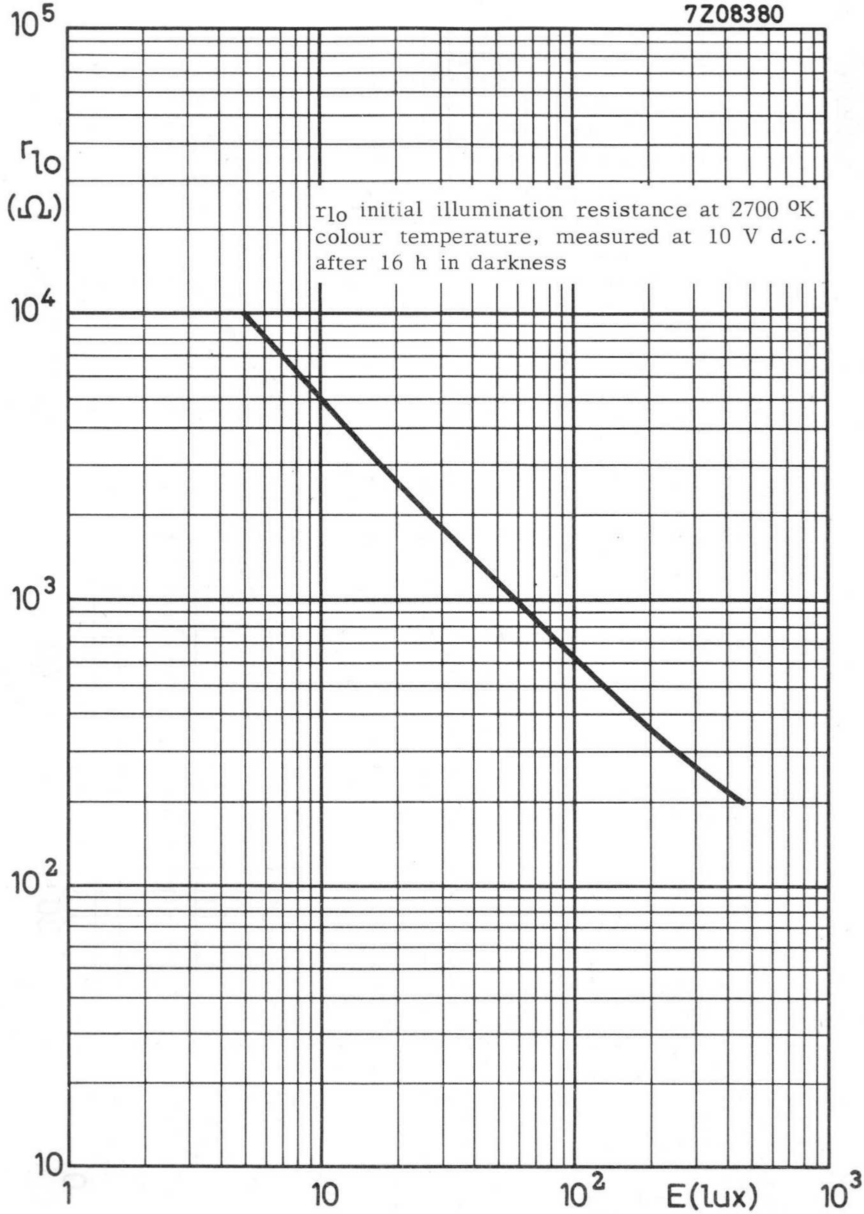
Vibration

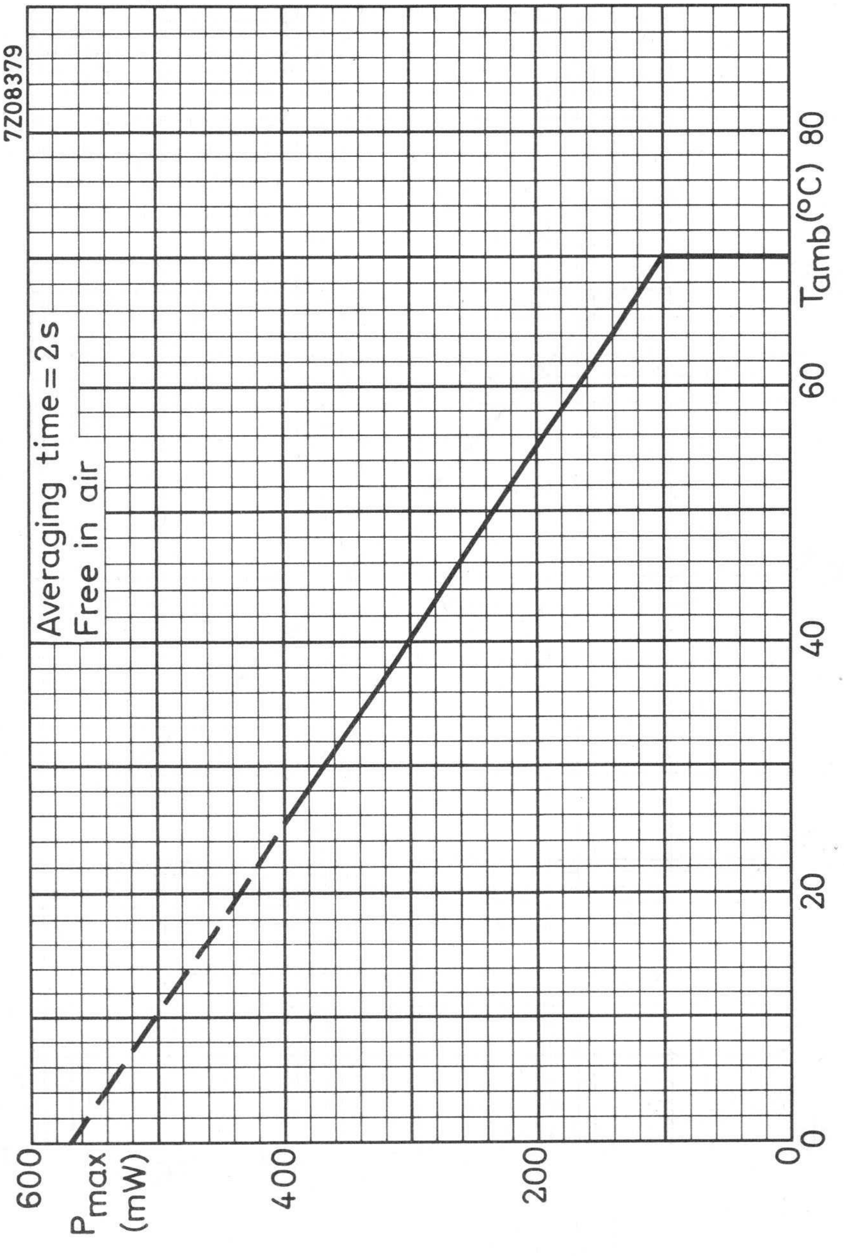
2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell voltage, pulse, t_{imp} = max. 5 ms p.r.r. = max. once per minute	V_p	max.	500	V
Power dissipation, t_{av} = 2 s	P	See sheet B		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	100	mA
Illumination	E	max.	50 000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	85	°C
Ambient temperature, storage and operating	T_{amb}	min.	-40	°C
storage	T_{amb}	max.	+50	°C [1]
operating	T_{amb}	max.	+70	°C

[1]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z08380
10^5
r_{lo}
(Ω)
r_{lo} initial illumination resistance at 2700 °K colour temperature, measured at 10 V d.c. after 16 h in darkness
10^4
10^3
10^2
10
1
10
10^2
E(lux)
10^3


7Z08379
Averaging time = 2 s
Free in air
T_{amb} (°C)
0
20
40
60
80
P_{max} (mW)
600
400
200
0

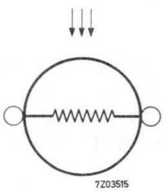
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

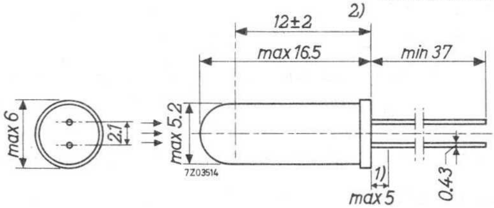
Cadmium sulphide photoconductive cell with top sensitivity intended for use in flame control and other industrial applications as well as for automatic brightness and contrast control in TV receivers.
The cell is shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	70	mW
Cell voltage, d.c. and repetitive peak	V	max.	350	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{lo}		60	kΩ
Spectral response curve		type D		
Outline dimensions		max. 6 dia. x 16.5		mm

MECHANICAL DATA

Dimensions in mm





Sensitive area 0.25 mm^2

Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

---

1) Not tin plated

2) Centre of sensitive area

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark current measured at 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	I_{do}			1.5	μA
Initial illumination current measured at 30 V d.c. and illumination = 50 lux, after 16 hrs in darkness [1])	I_{lo}	200	500	800	μA
Sensitivity at 50 lux, with 30 V d.c. applied	N		10		μA/lux

End of life characteristics at T_{amb} = 25 °C

Life test conditions: Illumination 50 to 100 lux, colour temperature about 2500 °K, P = 60 mW, T_{amb} = 35 °C

None of the end of life values stated under this heading are expected to be reached before 2500 operating hours under the following conditions:

Initial dark current measured at 300 V d.c., 20 s after switching off the illumination	I_{do}	max. 3	μA
Change of initial illumination current during life measured at 30 V d.c., illumination = 50 lux and colour temperature = 2700 °K, after 16 hrs in darkness	ΔI_{lo}	max. 60	%

[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

SHOCK AND VIBRATION

An indication for the ruggedness of the device is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 3000 shock in one of the three positions of the cell.

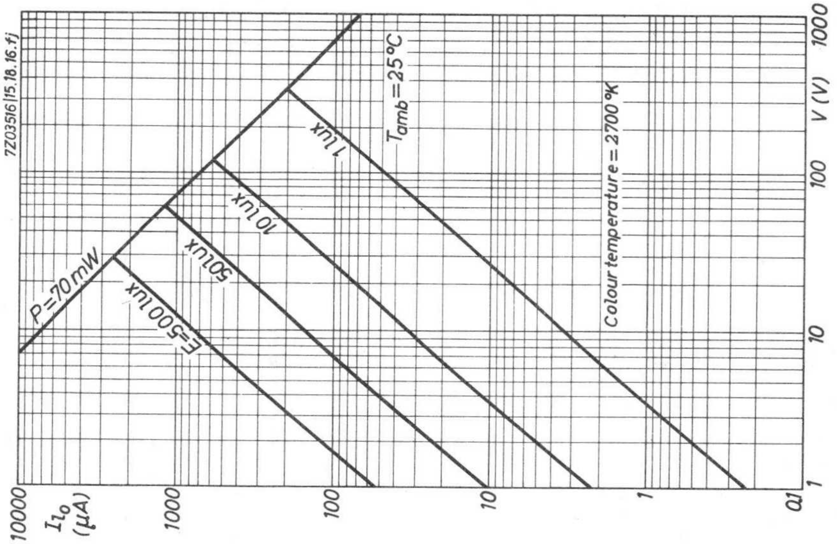
Vibration

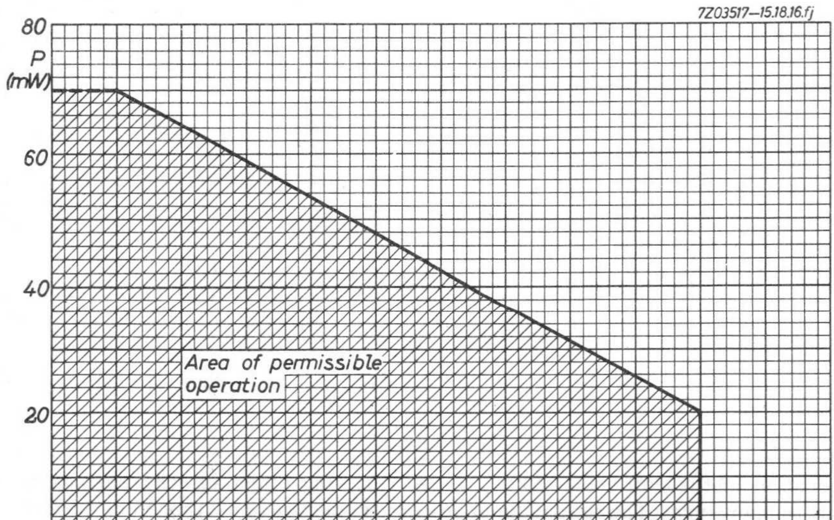
2.5 g_{peak}, 50 Hz during 32 hours in each of the three positions of the cell.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak		V	max.	350	V
Power dissipation at T_{amb} = 25 °C	See also sheet 4	P	max.	70	mW
Power dissipation at T_{amb} = 70 °C		P	max.	20	mW
Cell current, d.c. and repetitive peak		I	max.	7.5	mA
Ambient temperature, storage and operating		T_{amb}	min.	−40	°C
storage		T_{amb}	max.	+50	°C [1]
operating		T_{amb}	max.	+70	°C

[1]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z03516|15.18.16.fj
T_{amb} = 25 °C
Colour temperature = 2700 °K
P = 70 mW
1 lux
10 lux
50 lux
E = 500 lux
V (V)
1000
100
10
1
I_{lo} (μA)
10000
1000
100
10
1
0.1


7Z03517–15.18.16.fj
P (mW)
80
60
40
20
0
Area of permissible operation
20
30
40
50
60
70
80
T_{amb} (°C)

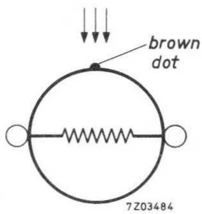
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

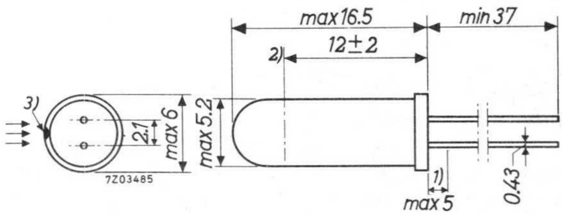
Cadmium sulphide photoconductive cell with side sensitivity intended for use in flame control and other industrial applications as well as for automatic brightness and contrast control in TV receivers.
The cell is shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	70	mW
Cell voltage, d.c. and repetitive peak	V	max.	350	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{lo}		60	kΩ
Spectral response curve		type D		
Outline dimensions		max. 6 dia. x 16.5		mm

MECHANICAL DATA

Dimensions in mm





Sensitive area 0.25 mm^2

Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

1) Not tin plated

2) Centre of sensitive area

3) Brown dot

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark current measured at 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	I_{do}			1.5	μA
Initial illumination current measured at 30 V d.c. and illumination = 50 lux, after 16 hrs in darkness [1]	I_{lo}	200	500	800	μA
Sensitivity at 50 lux, with 30 V d.c. applied	N		10		μA/lux

End of life characteristics at T_{amb} = 25 °C

Life test conditions: Illumination 50 to 100 lux, colour temperature about 2500 °K, P = 60 mW, T_{amb} = 35 °C

None of the end of life values stated under this heading are expected to be reached before 2500 operating hours under the following conditions:

Initial dark current measured at 300 V d.c., 20 s after switching off the illumination	I_{do}	max. 3	μA
Change of initial illumination current during life measured at 30 V d.c., illumination = 50 lux and colour temperature = 2700 °K, after 16 hrs in darkness	ΔI_{lo}	max. 60	%

[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

SHOCK AND VIBRATION

An indication for the ruggedness of the device is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 3000 shocks in one of the three positions of the cell.

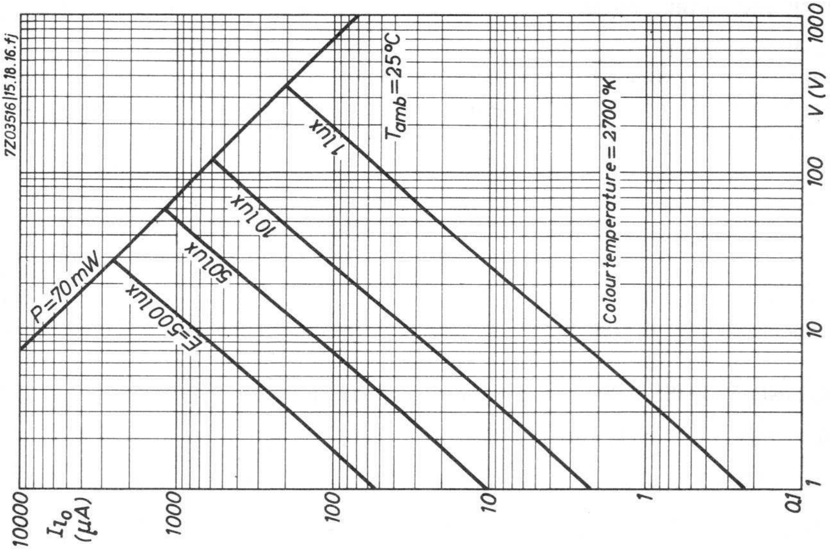
Vibration

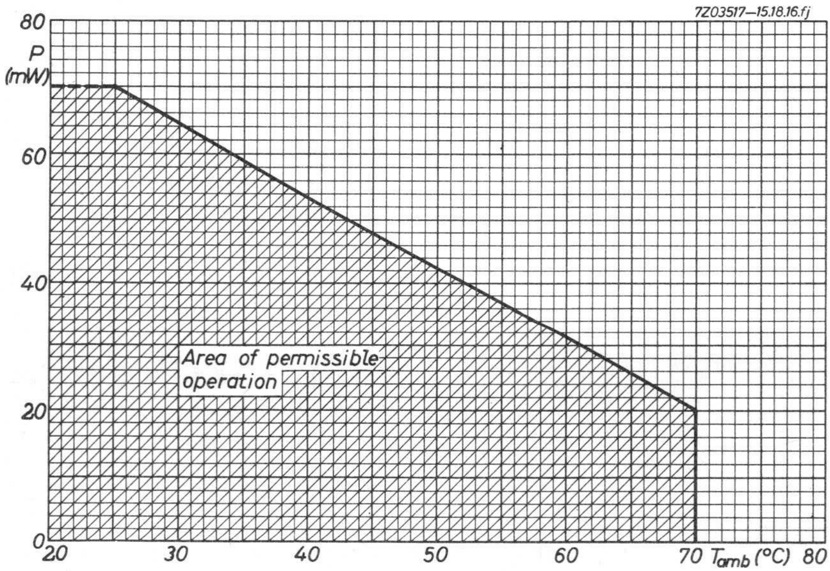
2.5 g_{peak}, 50 Hz during 32 hours in each of the three positions of the cell.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max. 350	V
Power dissipation at T_{amb} = 25 °C (See also sheet 4)	P	max. 70	mW
Power dissipation at T_{amb} = 70 °C (See also sheet 4)	P	max. 20	mW
Cell current, d.c. and repetitive peak	I	max. 7.5	mA
Ambient temperature, storage and operating	T_{amb}	min. -40	°C
storage	T_{amb}	max. +50	°C [1]
operating	T_{amb}	max. +70	°C

[1]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z03516|15.18.16.fj
T_{amb} = 25 °C
Colour temperature = 2700 °K
1 lux
10 lux
50 lux
E=5000 lux
P=70 mW
V (V)
1
10
100
1000
I_{Lo} (µA)
10000
1000
100
10
1
0.1


7Z03517—15.18.16.fj
P (mW)
80
60
40
20
0
Area of permissible operation
20
30
40
50
60
70
T_{amb} (°C)
80

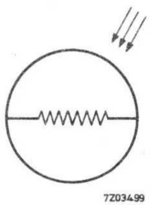
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

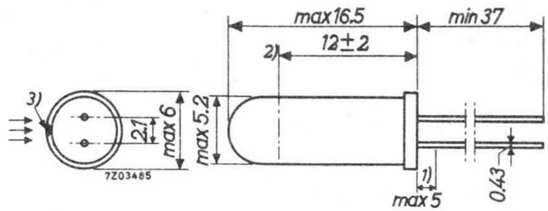
Cadmium sulphide photoconductive cell with side sensitivity intended for use in industrial on-off applications such as flame failure circuits.
The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	100	mW
Cell voltage, d.c. and repetitive peak	V	max.	350	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{l_0}		45	kΩ
Spectral response curve		type D		
Outline dimensions		max. 6 dia x 16.5		mm

MECHANICAL DATA

Dimensions in mm





Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

---

1) Not tinned

2) Centre of sensitive area

3) Red dot

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery.

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{d_o}	150		1)	MΩ
Initial illumination resistance measured at 30 V d.c., illumination 50 lux, after 16 h in darkness 2)	r_{l_o}	30	45	100	kΩ
Equilibrium illumination resistance measured at 30 V d.c., illumination 50 lux, after 15 min. under the measuring conditions	r_{l_e}	30	60	170	kΩ
Current rise time	t_{r_i}		see page C		
Current decay time	t_{f_i}		see page D		
Sensitivity at 50 lux, with 30 V d.c. applied	N		13		μA/lux
Negative temperature response of illumination resistance	$\Delta r_l/\Delta T$		0.2	0.5	%/°C
Voltage respons $\frac{\text{r at 0.5 V d.c.}}{\text{r at 30 V d.c.}}$			1.4		

1) The spread of the dark resistance is large and values higher than 1000 MΩ are possible for the initial dark resistance.

2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the current rise time.

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max. + 85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K	600	°C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from −30 % to + 70 % do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10000 shocks in one of the three positions of the cell.

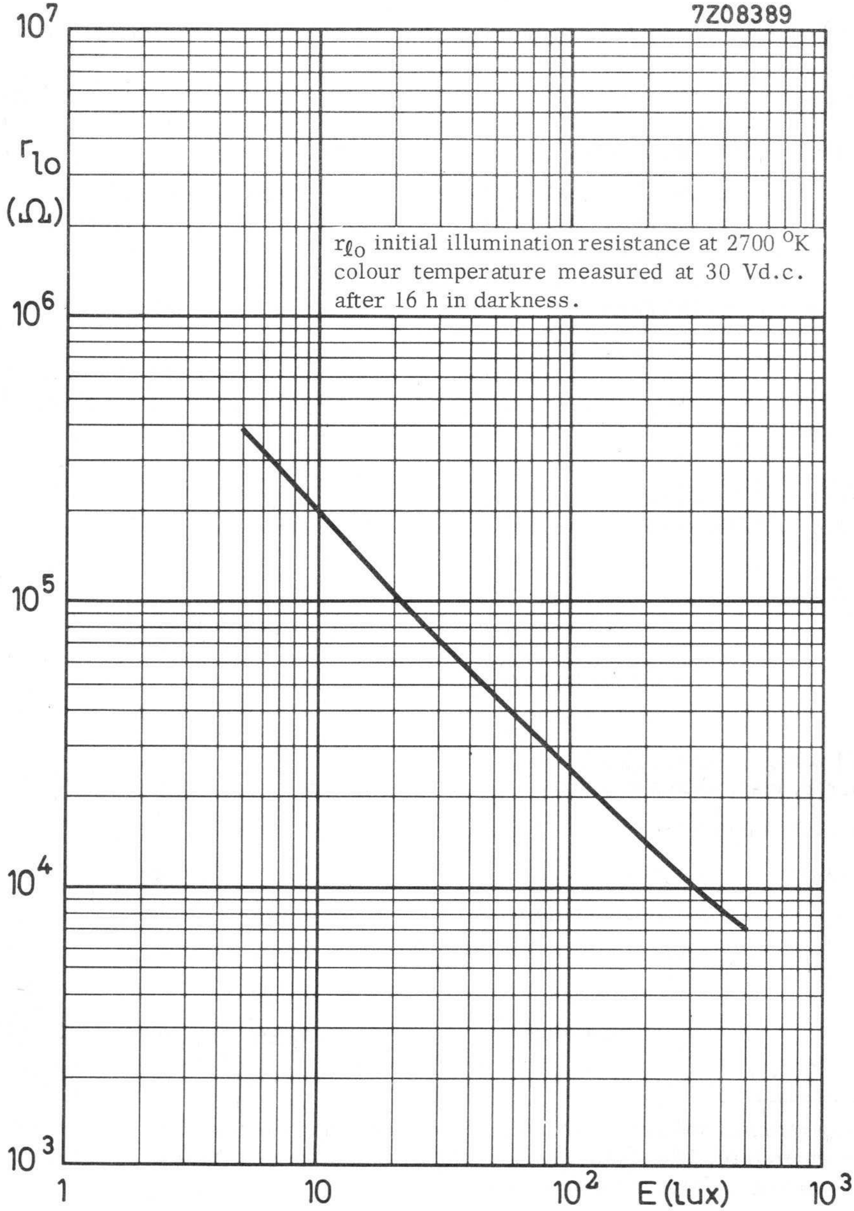
Vibration

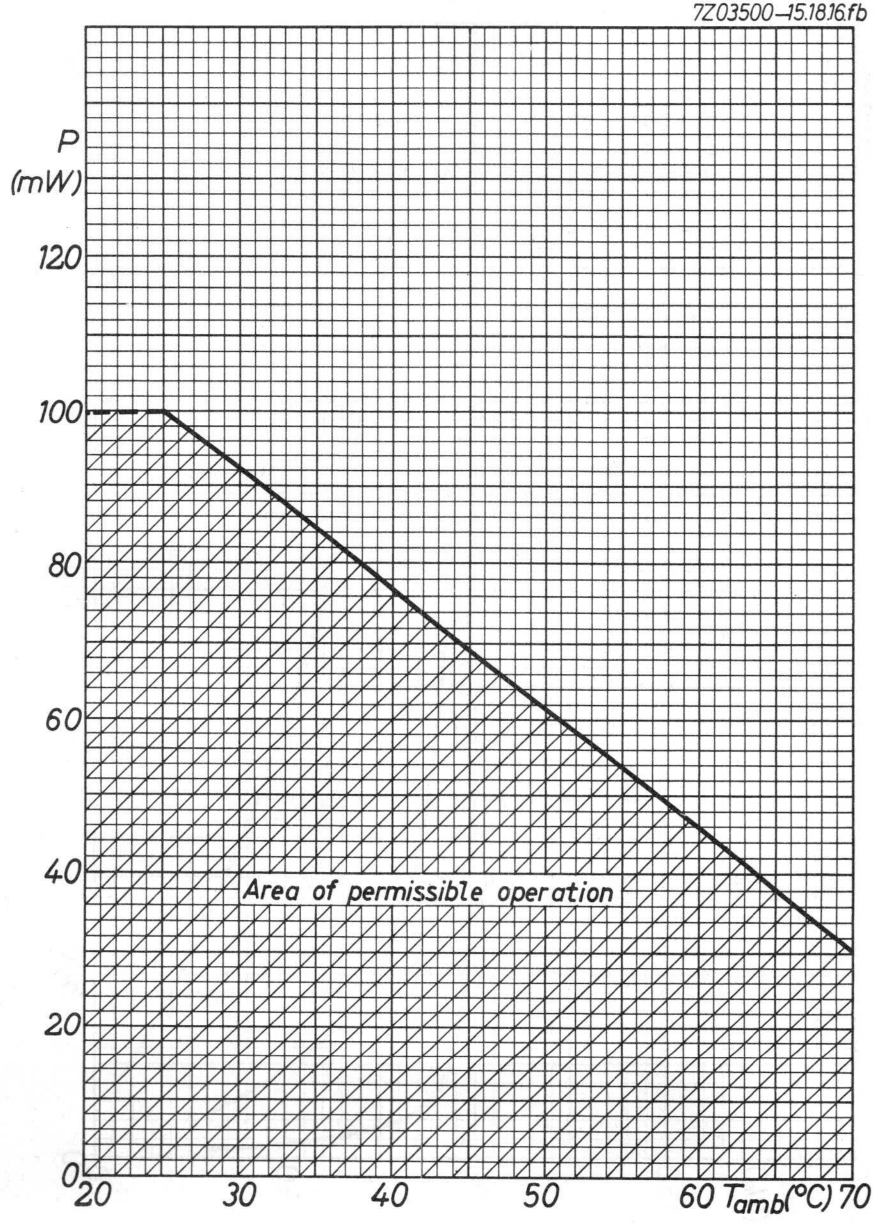
2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

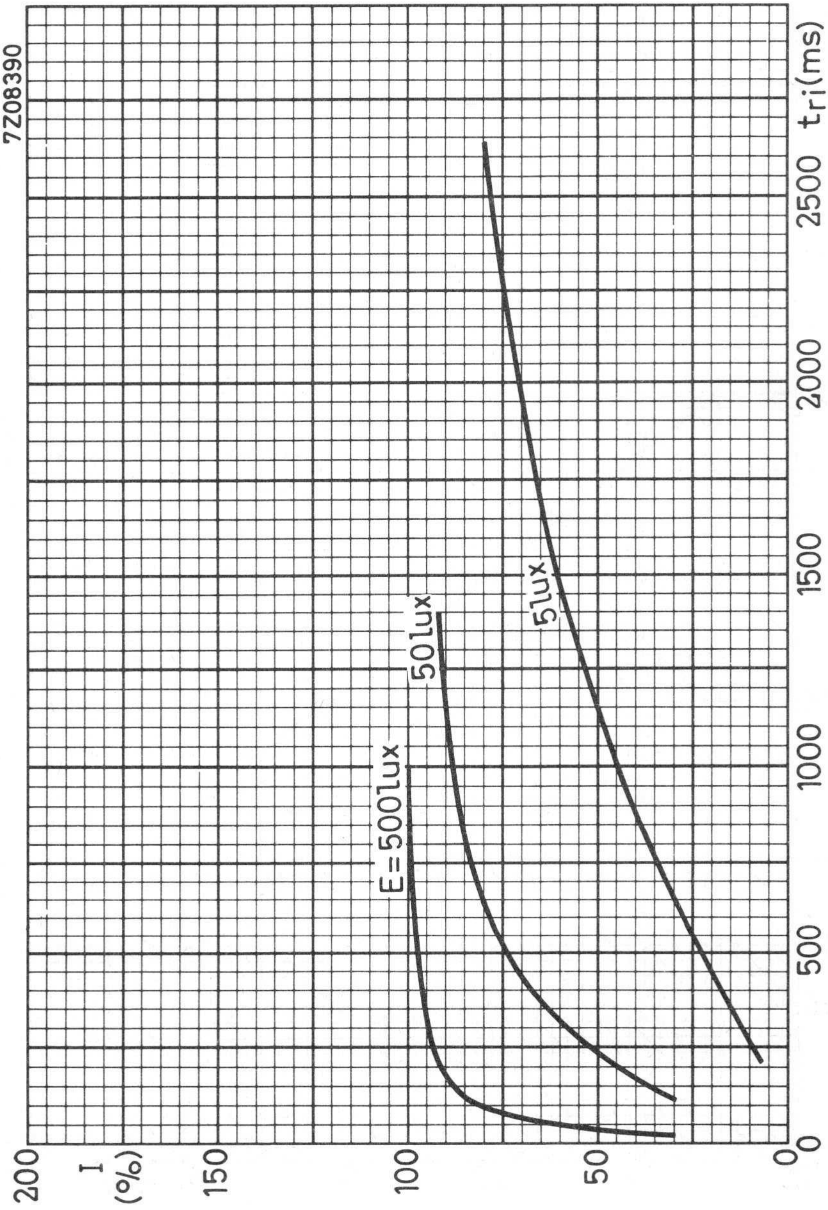
LIMITING VALUES (Absolute max. rating system)

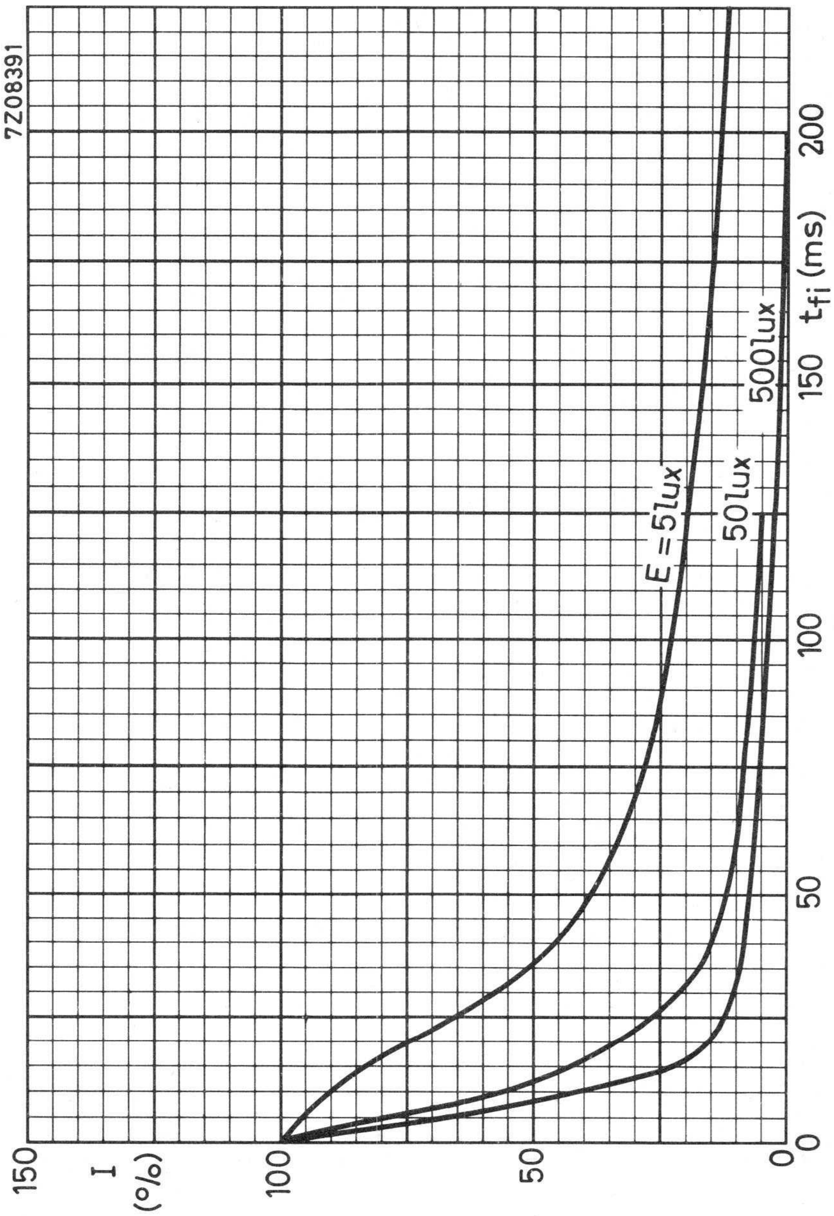
Cell voltage, d.c. and repetitive peak	V	max. 350	V
Cell voltage, pulse, t_{imp} = max. 5 ms p.r.r. max. once per minute	V_p	max. 1000	V
Power dissipation, t_{av} = 2 s	P	see page B	
Power dissipation, pulse	P_p	max. 5 x P	
Temperature CdS tablet, operating	T_{tablet}	max. 85	°C
Ambient temperature, storage and operating	T_{amb}	min. −40	°C
storage	T_{amb}	max. +50	°C 1)
operating	T_{amb}	max. +70	°C

1) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z08389
10^7
r_{lo}
(Ω)
$r_{\ell o}$ initial illumination resistance at 2700 °K colour temperature measured at 30 Vd.c. after 16 h in darkness.
10^6
10^5
10^4
10^3
1
10
10^2
E (lux)
10^3


7Z03500-15.18.16.fb
P
(mW)
120
100
80
60
40
20
0
20
30
40
50
60
T_{amb}(°C)
70
Area of permissible operation


7Z08390
t_{ri}(ms)
0
500
1000
1500
2000
2500
I
(%)
200
150
100
50
0
E=500lux
50lux
5lux


7Z08391
150
I
(%)
100
50
0
0
50
100
150
200
t_{fi} (ms)
E = 5lux
50lux
500lux

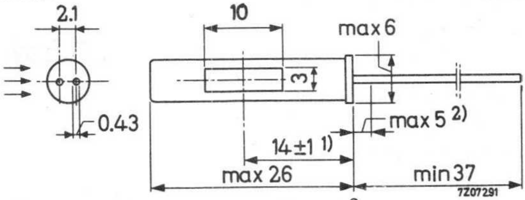
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with side sensitivity.
The cell is tropic proof, shock- and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation	P	max.	75	mW
Cell voltage, d.c. and repetitive peak	V	max.	100	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{lo}		1600	Ω
Spectral response		type D		
Outline dimensions			6 dia. x 26	mm

MECHANICAL DATA

Dimensions in mm



Total area to be illuminated 0.3 cm^2

Sensitive part of this area 0.15 cm^2

Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seal.

1) Centre of sensitive area.

2) Not tin plated.
Care should be taken not to bend the leads nearer than 1.5 mm to the seal.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 ^{o}C, illumination with colour temperature = 2700 ^{o}K and at delivery

	Symbol	min.	typical	max.	unit
Initial dark resistance measured with 100 V d.c. applied via 1 MΩ 20 s after switching off the illumination	r_{do}	9		1)	MΩ
Equilibrium dark resistance measured with 100 V d.c. applied via 1 MΩ, 30 min. after switching off the illumination	r_{de}	250		1)	MΩ
Initial illumination resistance measured at V = 10 V, illumination 50 lux, after 16 hours in darkness 2)	r_{lo}	750	1600	2500	Ω
Equilibrium illumination resistance measured at V = 10 V, illumination 50 lux, after 15 minutes under the measuring conditions	r_{le}	750	1920	3250	Ω
Current rise time Time to reach 90% of its initial illumination current, measured from the instant of starting the illumination of 50 lux, at V = 10 V, after 16 hours in darkness	t_{ri}		1000		ms

1) The spread of the dark resistance is large and values higher than 30 MΩ and 2000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

ELECTRICAL DATA (continued)

	Symbol	min.	typical	max.	unit
Current decay time Time to reach 10% of its initial illumination current, measured from the instant of stopping the illumination of 50 lux, at V = 10 V, after 16 hours in darkness	t_{fi}		75		ms
Sensitivity at 50 lux, with V = 10 V d.c. applied	N		0.15		mA/lux
Negative temperature response of the illumination resistance			0.2	0.5	%/^{o}C
Voltage response $\frac{\text{r at 0.5 V}}{\text{r at 10 V}}$	α		1.5		

DESIGN CONSIDERATIONS

It should be noted that this cell is designed for very high typical sensitivity with respect to its sensitive area, but that it may be expected that a high sensitivity will only be maintained if the dissipation averaged over 2 s is kept below 20 mW at 25 °C. Higher dissipations will accelerate the aging process which lowers sensitivity.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below: More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10000 shocks in one of the three positions of the cell.

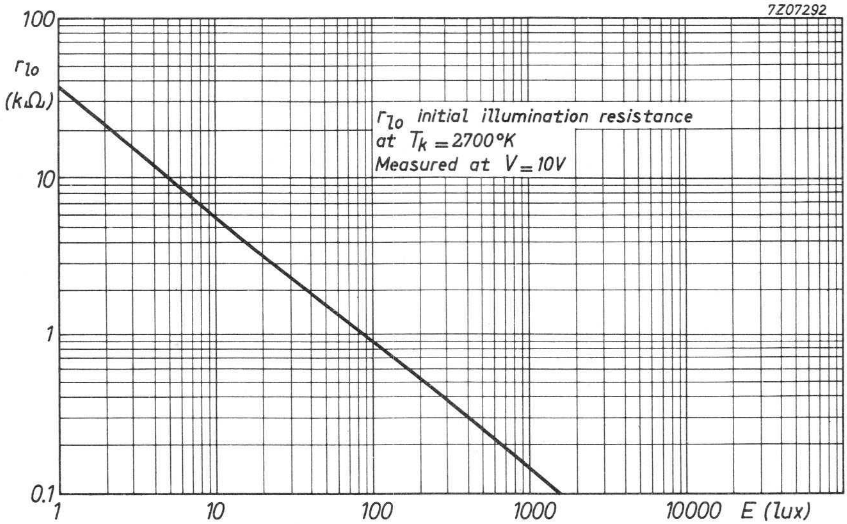
Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

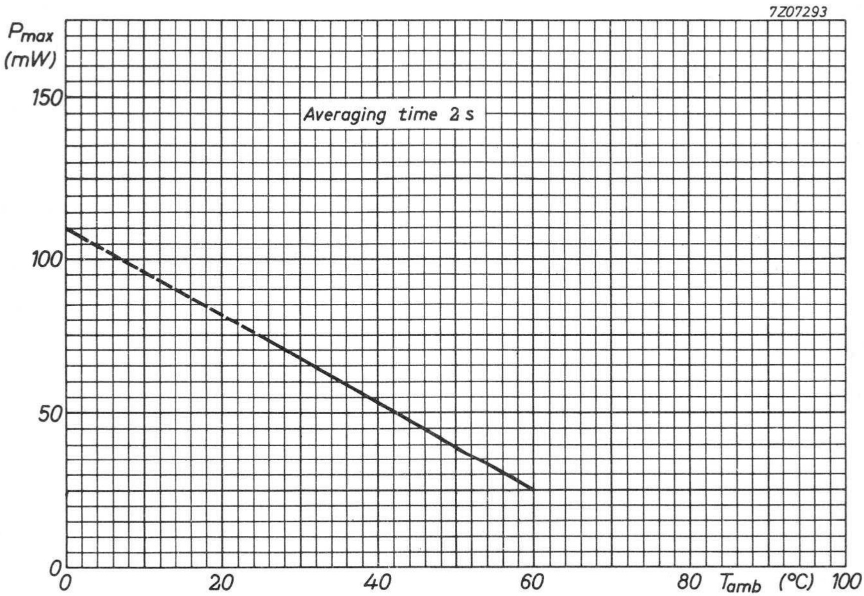
LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak		V	max.	100	V
Power dissipation, t_{av} = 2 s		P	see sheet 5		
Ambient temperature, storage and operating		T_{amb}	min.	-40	°C
	Storage	T_{amb}	max.	+40	°C [1]
	Operating	T_{amb}	max.	+70	°C

[1] Operation of the cell counteracts the deteriorating effect of long periods at the high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.



7Z07292
r_{lo} (kΩ)
100
10
1
0.1
r_{lo} initial illumination resistance
at $T_k = 2700\,°K$
Measured at $V = 10V$
1
10
100
1000
10000
E (lux)



7Z07293
P_{max} (mW)
150
100
50
0
Averaging time 2 s
0
20
40
60
80
T_{amb} (°C)
100

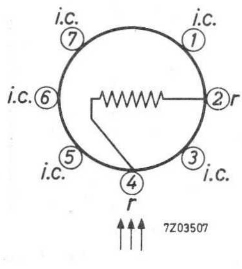
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

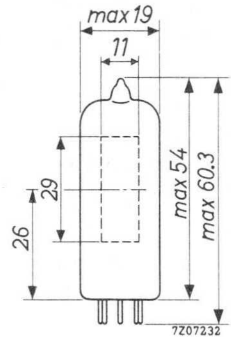
Cadmium sulphide photoconductive cell with side sensitivity intended for use in flame control, smoke detector or industrial on-off switching applications. The cell is shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	1	W
Cell voltage, d.c. and repetitive peak	V	max.	350	V
Cell resistance at 50 lux, 2700 °K colour temperature	r		1000	Ω
Spectral response curve		type D		
Outline dimensions		max. 19 dia. x 60.3		mm

MECHANICAL DATA

Dimensions in mm





Base: 7 p. miniature

Total area to be illuminated 1.1 x 2.9 cm^2

7Z2 7982

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery.

	symbol	min.	typical	max.	unit
Initial dark current measured with 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	I_{do}			70	μA
Equilibrium dark current measured with 300 V d.c. applied via 1 MΩ, 15 minutes after switching off the illumination	I_{do}			2.5	μA
Initial illumination current measured at 10 V d.c. and illumination = 50 lux, after 16 hrs in darkness [1])	I_{lo}	3	10	15	mA
Initial illumination current measured at 10 V d.c., illumination = 50 lux and colour temperature = 1500 °K, after 16 hrs in darkness	I_{lo}	6	20	31	mA
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.2		mA/lux
Current rise time	t_{ri}		see sheet B		
Current decay time	t_{fi}		see sheet B		

[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

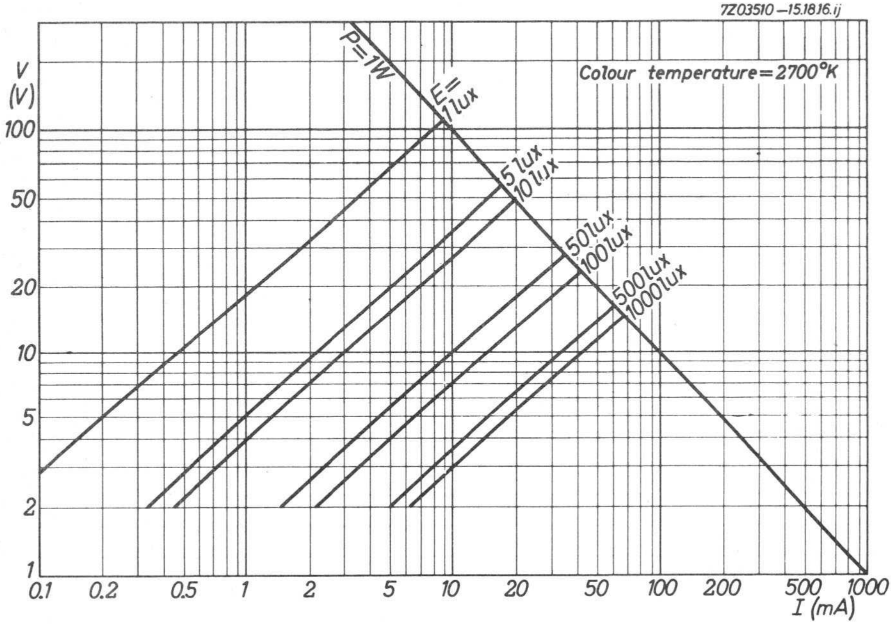
7Z2 5174

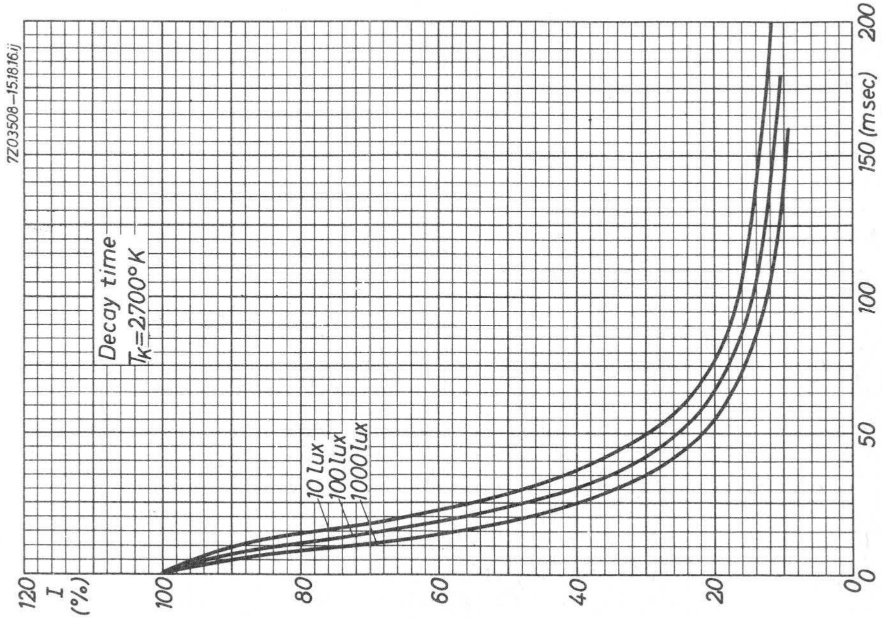
LIMITING VALUES (Absolute max. rating system)

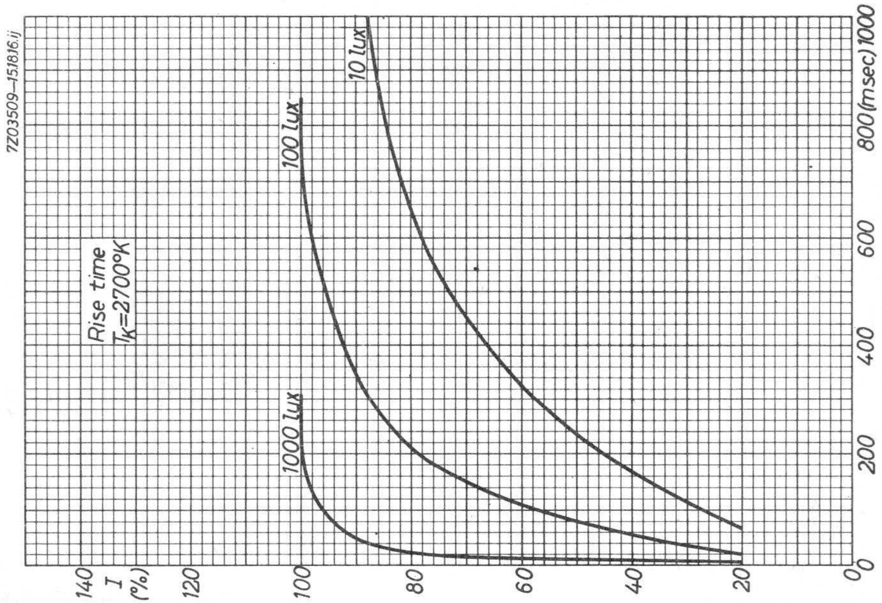
Cell voltage, d.c. and repetitive peak		V	max.	350	V
Power dissipation at T_{amb} = 25 °C	See also	P	max.	1.0	W
Power dissipation at T_{amb} = 70 °C	sheet C	P	max.	0.3	W
Ambient temperature, storage and operating		T_{amb}	min.	−40	°C
storage		T_{amb}	max.	+50	°C [1]
operating		T_{amb}	max.	+70	°C

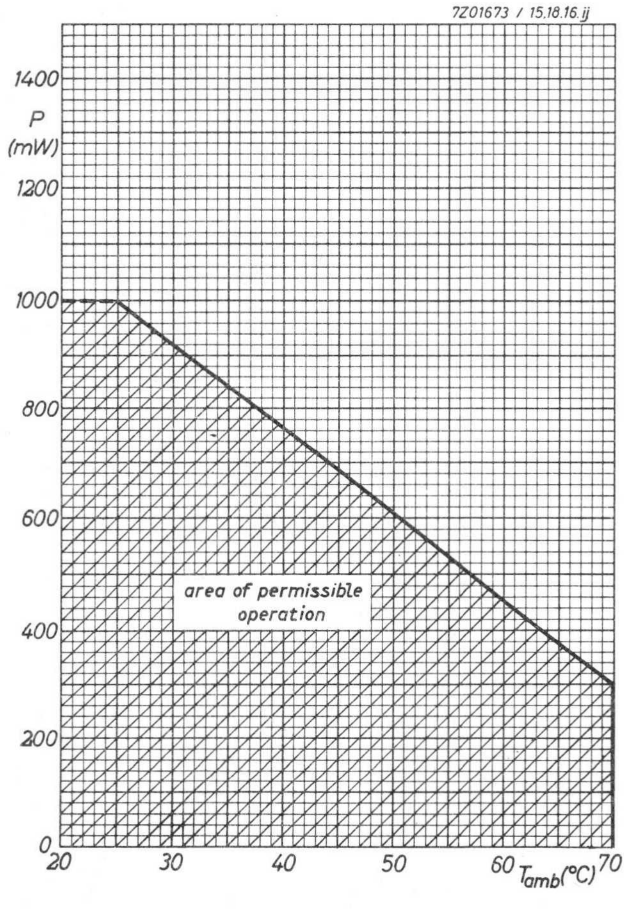
[1] Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

7Z2 5175


7Z03510 –15.18.16.ij
V
(V)
Colour temperature = 2700°K
P = 1W
E = 1 lux
5 lux
10 lux
50 lux
100 lux
500 lux
1000 lux
100
50
20
10
5
2
1
0.1
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
I (mA)


7Z03508-15.18.16.ij
Decay time
$T_K = 2700°K$
10 lux
100 lux
1000 lux
I (%)
120
100
80
60
40
20
0
0
50
100
150 (msec)
200


7Z03509-15.18.16.ij
Rise time
$T_K = 2700°K$
1000 lux
100 lux
10 lux
I (%)
140
120
100
80
60
40
20
0
0
200
400
600
800 (msec) 1000


7Z01673 / 15.18.16.ij
1400
P
(mW)
1200
1000
800
600
area of permissible operation
400
200
0
20
30
40
50
60
T_{amb}(°C)
70

CdS CELLS-LAMP COMBINATION

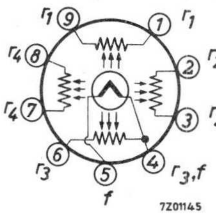
Combination of four cadmium sulphide photoconductive cells and a small incandescent lamp in a Noval envelope for use in relais circuits with low output resistance, control circuits and logic circuits.

QUICK REFERENCE DATA				
Power dissipation, each cell, at T_{amb} = 25 °C	P	max.	150	mW
Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell resistance	r		15	Ω
Outline dimensions		max. 22 dia. x 55.6		mm

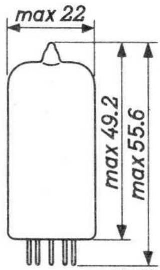
MECHANICAL DATA

Dimensions in mm

Base: Noval



7Z01145



7Z03450

ELECTRICAL DATA

Basic characteristics at T_{amb} = 25 °C, and at delivery

	symbol	min.	typical	max.	unit
Lamp filament voltage	V_f		24		V 2)
Lamp filament current at V_f = 24 V	I_f	54	60	66	mA
Initial dark current measured in the circuit of fig.1	I_{do}			15	μA

Basic characteristics at T_{amb} = 25 °C, and at delivery (continued)

	symbol	min.	typical	max.	unit
Initial illumination resistance measured in the circuit of fig.1 after 16 hrs in darkness [1]	r_{lo}		15	25	Ω
Resistance decay time Time to reach 400 Ω in circuit of fig.2, measured from the instant of starting the illumination after 16 hrs in darkness	t_{fr}		20		ms
Resistance rise time Time to reach 300 kΩ in circuit of fig.2, measured from the instant of stopping the illumination after 5 minutes or longer illumination	t_{rr}			1.7	s
Insulation resistance between two cells or between cell and filament measured at 300 V d.c.	r_{ins}	200			MΩ

CAPACITANCES measured at filament voltage V_f = 0 V

Between the terminals of each cell	C_r		9.5	pF
Between any cell terminal and the filament (except pins 4 and 6)	C_{rf}	max.	1	pF

REMARK

Shock and vibration should be avoided.

LIMITING VALUES (Absolute max. rating system)

Filament voltage (d.c. or r.m.s.)	V_f	max.	25.2	V	[2]
Cell voltage, d.c. and repetitive peak	V	max.	200	V	
Power dissipation of each cell at T_{amb} = 25 °C	P	max.	150	mW	[3]
Power dissipation of each cell at T_{amb} = 55 °C	P	max.	85	mW	[3]
Voltage between any pair of cells	V_{ri}-V_{rj}	max.	350	V	
Ambient temperature, operating	T_{amb}	min.	-40	°C	
		max.	+55	°C	[3]

Measuring circuit for r_{lo} and I_{do}

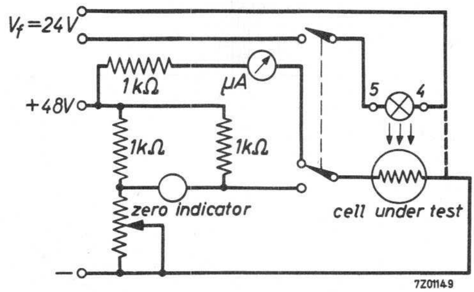


Fig.1

Measuring circuit t_{fr} and t_{rr}

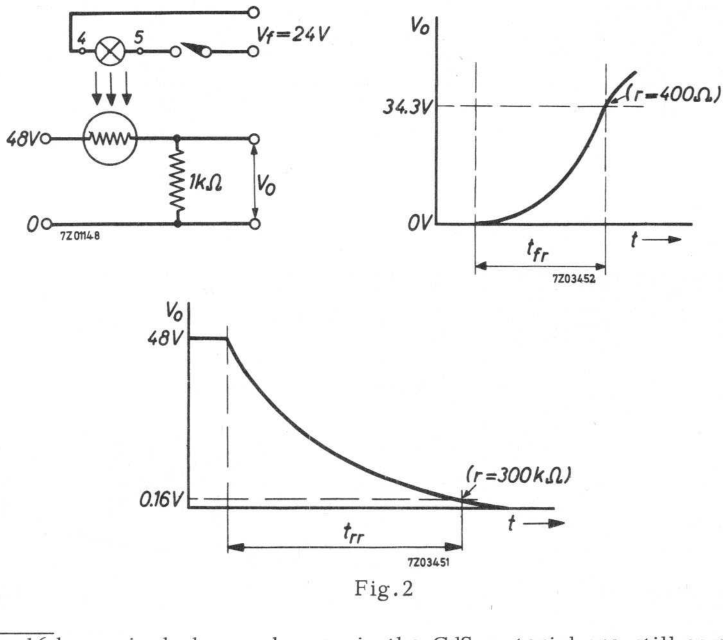
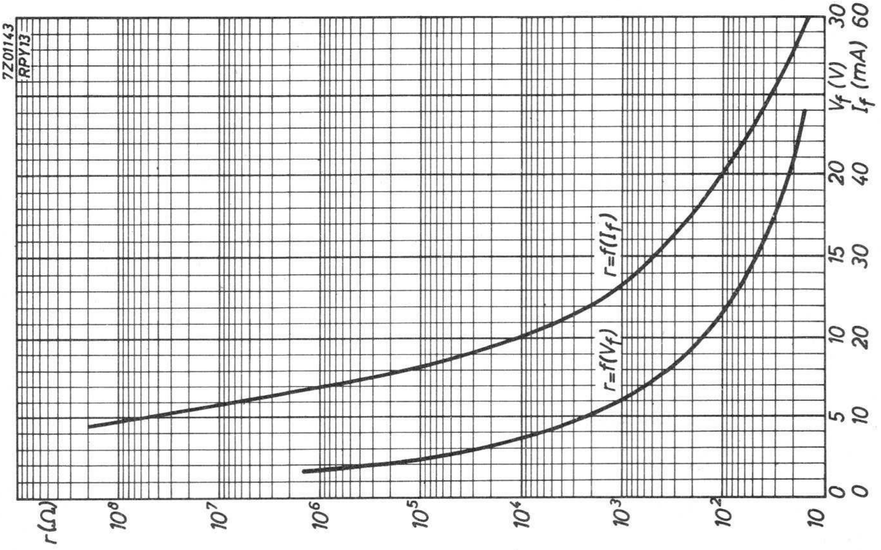


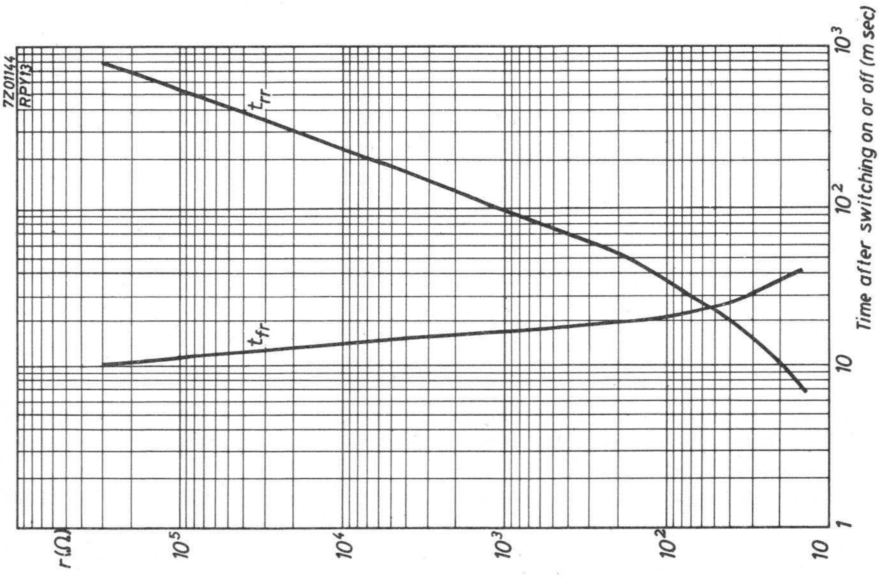
Fig.2

1) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

2) The life expectancy is considerably longer with lower values of V_f. In this respect it is recommended to apply a voltage not higher than 20 V.

3) For V_f = 24 V.


7Z01143
RPY13
r(Ω)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
r=f(If)
r=f(Vf)
0 5 10 15 20 30
0 10 20 30 40 60
Vf (V)
If (mA)


7Z01144
RPY13
r(Ω)
10^5
10^4
10^3
10^2
10
trr
tfr
1 10 10^2 10^3
Time after switching on or off (m sec)

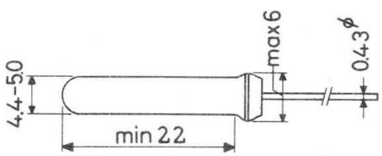
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

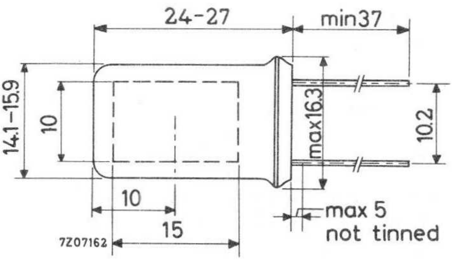
Cadmium sulphide photoconductive cell with side sensitivity intended for use in general control circuits. The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 ^{o}C	P	max.	0.5	W
Power dissipation, with a heatsink with K = 5 ^{o}C/W and T_{amb} = 25 ^{o}C	P	max.	2	W
Cell voltage, d.c. and repetitive peak	V	max.	100	V
Cell resistance at 5000 lux, 2700 ^{o}K colour temperature	r		25	Ω
Spectral response curve		type D		
Outline dimensions		max.	27 x 16.3 x 6	mm

MECHANICAL DATA

Dimensions in mm





The centre distance of the leads is compatible with the IEC standard raster for printed wiring (0.1 inch).

7Z2 7963

Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery.

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 100 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	5.6		[1]	MΩ
Equilibrium dark resistance measured with 100 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	50		[1]	MΩ
Initial illumination resistance (1) measured at 10 V d.c., illumination = 50 lux, after 16 hrs in darkness. [2]	r_{lo} (1)	235	400	1200	Ω
Initial illumination resistance (2) measured at 1 V d.c., illumination = 5000 lux, after 16 hrs in darkness [2][3]	r_{l_o} (2)		25	35	Ω

[1] The spread of the dark resistance is large and values higher than 15 MΩ and 2000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

[2] After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

[3] Maximum during life 40 Ω.

7Z2 7964

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery. (continued)

	symbol	min.	typical	max.	unit
Equilibrium illumination resistance (1) measured at 10 V d.c., illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le} (1)	235	480	1560	Ω
Equilibrium illumination resistance (2) measured at 1 V d.c., illumination = 5000 lux, after 15 minutes under the measuring conditions. [2]	r_{le} (2)			35	Ω
Resistance decay time Time to reach 50 Ω, measured from the instant of starting the illumination of 5000 lux, after 16 hrs in darkness. [1]	t_{fr}		5	25	ms
Resistance rise time Time to reach 2 kΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination of 5000 lux	t_{rr}		40	200	ms
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.5		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.1		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max. +85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K	120	°C/W
Thermal resistance from CdS tablet to heatsink (temperature of heatsink measured near the centre of the cell), when the cell is properly clamped on a heatsink as described on sheet 5	K	25	°C/W

[1]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

[2]) Maximum during life 40 Ω.

7Z2 7965

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from -30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

Vibration

2,5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

N.B. These conditions are used solely to assess the mechanical quality of the cell. It is not advisable to subject the cell to such conditions.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max.	100	V
Cell voltage, pulse, t_{imp} = max. 5 ms prr = max. once per minute	V_p	max.	250	V
Power dissipation, t_{av} = 2 s	P	see sheet C		
Power dissipation, pulse	P_p	max.	5 x P	
Cell current, d.c. and repetitive peak	I	max.	250	mA
Illumination	E	max.	50000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	^{o}C [1]
Ambient temperature, storage and operating	T_{amb}	min.	-40	^{o}C
storage	T_{amb}	max.	+50	^{o}C [2]
operating	T_{amb}	max.	+70	^{o}C

[1] If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83 ^{o}C when the CdS tablet temperature is 85 ^{o}C. This temperature can be determined e.g. with a thermocouple fastened on the envelope.

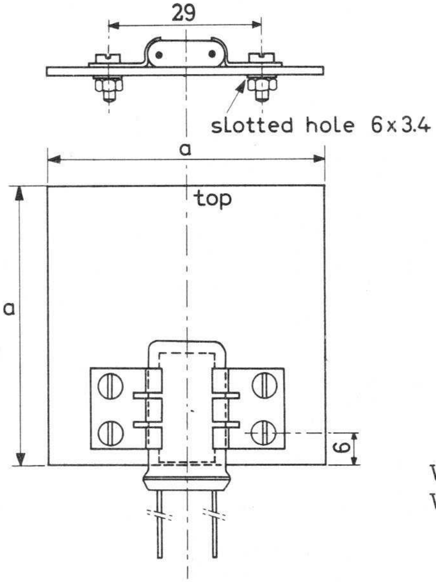
[2] Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

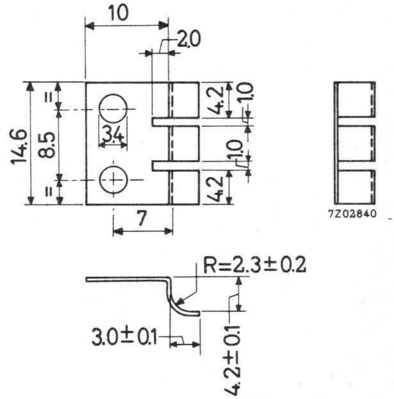
7Z2 7966

MECHANICAL DATA (continued)

Dimensions in mm

RPY18 MOUNTED ON HEATSINK





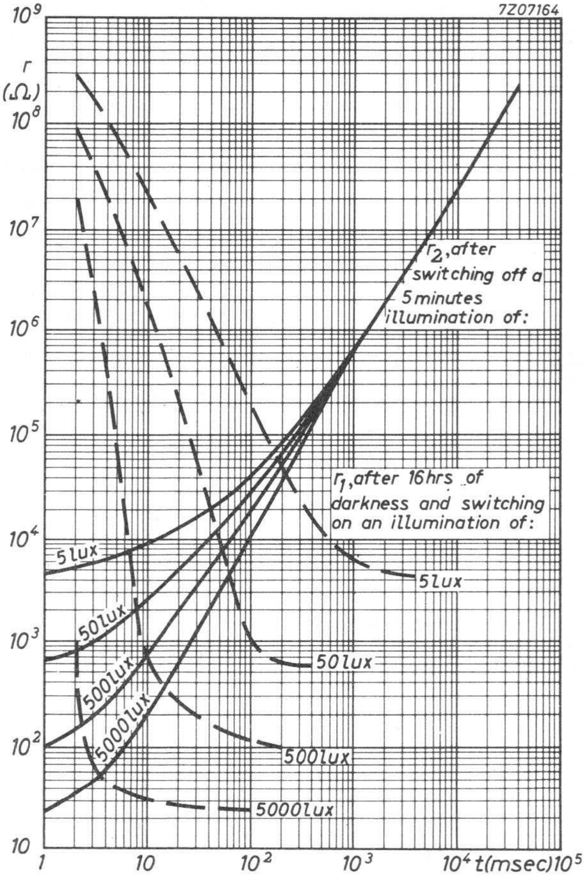
Detail: Clamping strip
tombac 0.3 mm

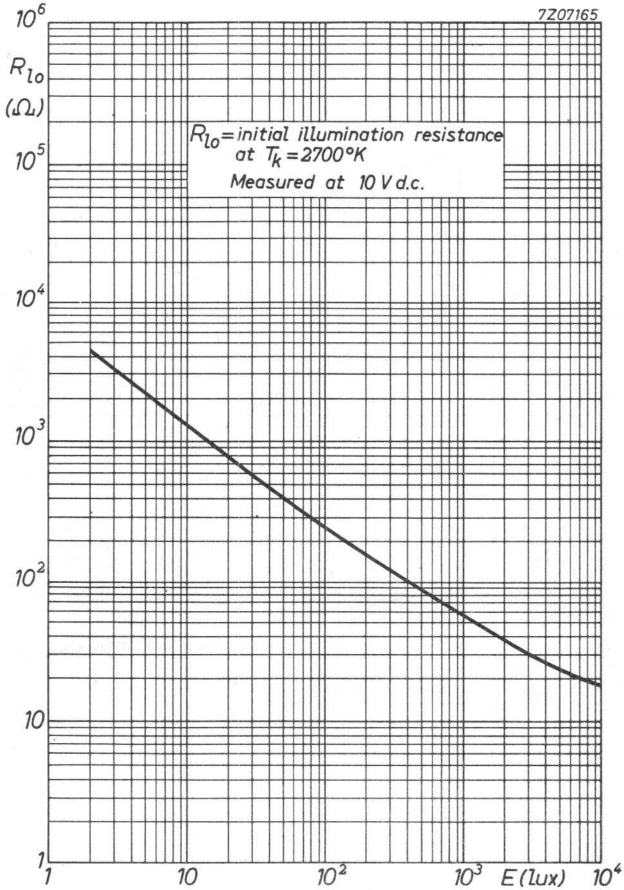
With a	=	50	mm	K	=	19 °C/W
With a	=	100	mm	K	=	7.5 °C/W

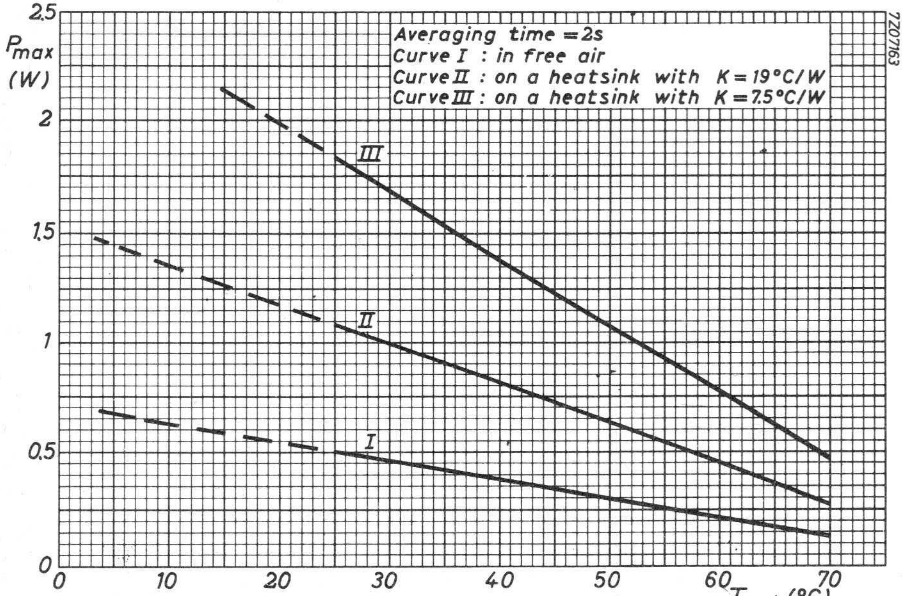
Mounting instructions

1. Mount one clamp on the heatsink, using the side with round holes.
2. Push the RPY18 under than clamp.
3. Press the second clamp firmly against the RPY18, using the slot holes.

7Z2 6277


7Z07164
r
(Ω)
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4 t(msec)10^5
r2, after switching off a 5 minutes illumination of:
r1, after 16 hrs of darkness and switching on an illumination of:
5 lux
50 lux
500 lux
5000 lux
5 lux
50 lux
500 lux
5000 lux


7Z07165
10^6
R_{lo}
(Ω)
10^5
10^4
10^3
10^2
10
1
R_{lo} = initial illumination resistance at $T_k = 2700\,°K$
Measured at 10 V d.c.
1
10
10^2
10^3
E (lux)
10^4


2,5
P_{max}
(W)
2
1,5
1
0,5
0
0
10
20
30
40
50
60
70
T_{amb} (°C)
Averaging time = 2s
Curve I : in free air
Curve II : on a heatsink with K = 19°C/W
Curve III : on a heatsink with K = 7.5°C/W
III
II
I
7Z07163

CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

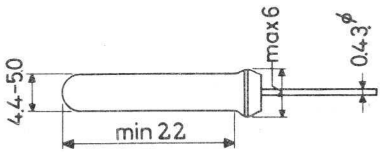
Cadmium sulphide photoconductive cell with side sensitivity intended for use in general control circuits.
The cell is tropic proof, shock and vibration resistant.

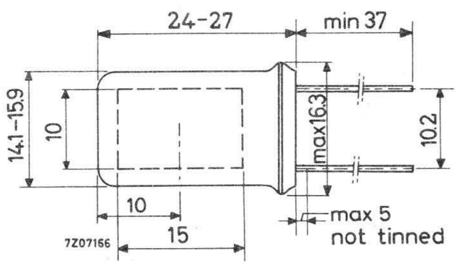
QUICK REFERENCE DATA

Power dissipation at T_{amb} = 25 °C	P	max.	0.5	W
Power dissipation, with a heatsink with K = 5 °C/W and T_{amb} = 25 °C	P	max.	2	W
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell resistance at 50 lux, 2700 °K colour temperature	r		3000	Ω
Spectral response curve		type D		
Outline dimensions		max. 27 x 16.3 x 6		mm

MECHANICAL DATA

Dimensions in mm





Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

7Z2 7967

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	10		[1]	MΩ
Equilibrium dark resistance measured with 300 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	200		[1]	MΩ
Initial illumination resistance measured at 10 V d.c. illumination = 50 lux, after 16 hrs in darkness [2]	r_{lo}	1400	3000	6600	Ω
Equilibrium illumination resistance measured at 10 V d.c. illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}	1400	3800	9000	Ω
Resistance decay time Time to reach 20 kΩ, measured from the instant of starting the illumination of 50 lux, at 10 V d.c. after 16 hours in darkness	t_{fr}			0.2	s

[1]) The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

[2]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

7Z2 7968

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery (continued)

	symbol	min.	typical	max.	unit
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination of 50 lux, at 10 V d.c.	t_{rr}		0.6	1.25	s
Sensitivity	N		0.07		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.1		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max. +85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K	120	°C/W
Thermal resistance from CdS tablet to heatsink (temperature of heatsink measured near the centre of the cell), when the cell is properly clamped on a heatsink as described on sheet 5	K	25	°C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from −30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

7Z2 7969

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

LIMITING VALUES (Absolute max. rating system)

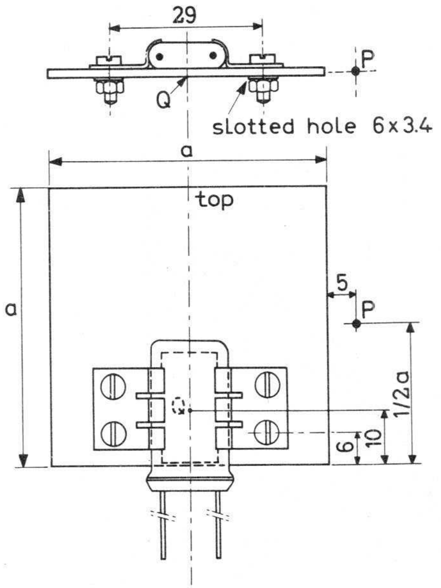
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell voltage, pulse, T_{imp} = max. 5 ms p_{rr} = max. once per minute	V_p	max.	1000	V
Power dissipation, t_{av} = 1 s	P	See sheet C		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	250	mA
Illumination	E	max.	50000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	°C 1)
Ambient temperature, storage and operating	T_{amb}	min.	−40	°C
storage	T_{amb}	max.	+50	°C 2)
operating	T_{amb}	max.	+70	°C

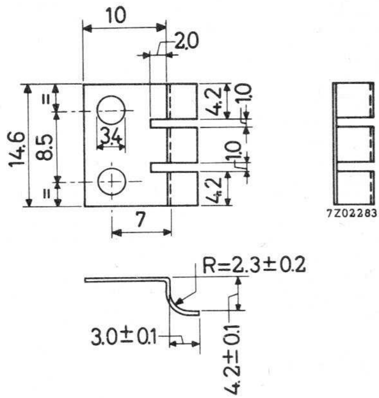
1) If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83 °C when the CdS tablet temperature is 85 °C. This temperature can be determined e.g. with a thermocouple fastened on the envelope.

2) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

7Z2 7970

RPY19 MOUNTED ON HEATSINK





Detail: Clamping strip
tombac 0.3 mm

The heat resistance K of the heatsink is defined as the temperature difference between the point Q at the backside of the heatsink, and ambient at point P, per Watt dissipation in the device, the heatsink being placed in an enclosure as given below.

Enclosure: cubical with internal edges 5 x a mm.
Place : point Q in the centre of the cubic, plane of heatsink vertical, top upside.

Determined according to the above rules a heatsink as given in the drawing has a heat resistance K = 19 ^{o}C/W when a = 50 mm and a K = 7.5 ^{o}C/W when a = 100 mm.

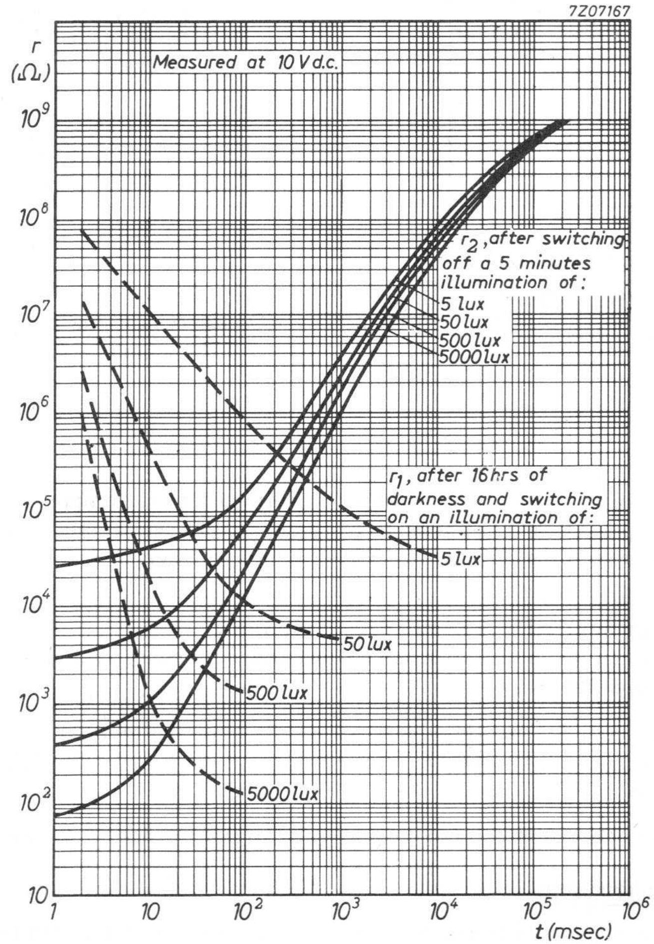
With smaller enclosure dimensions a higher value for K may be expected.

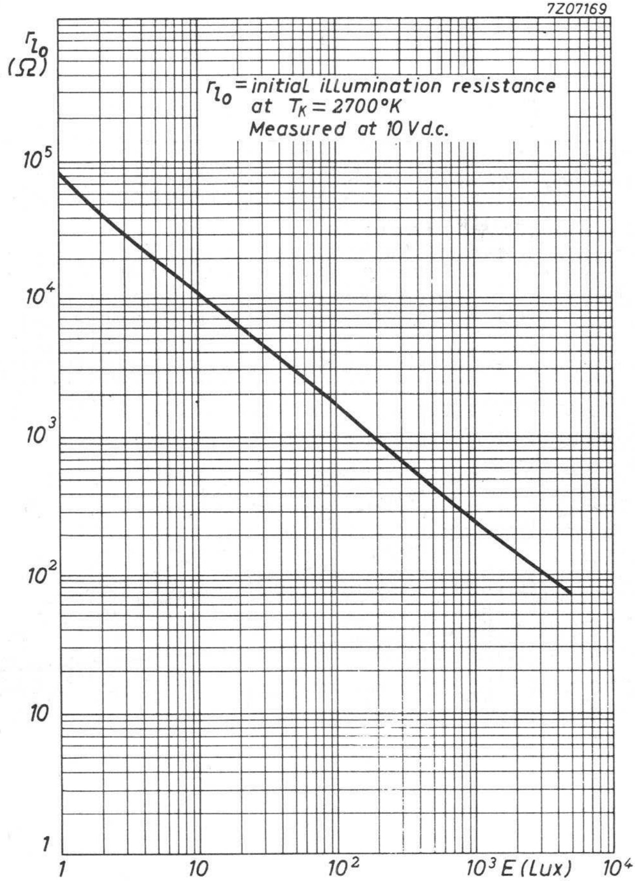
Mounting instructions

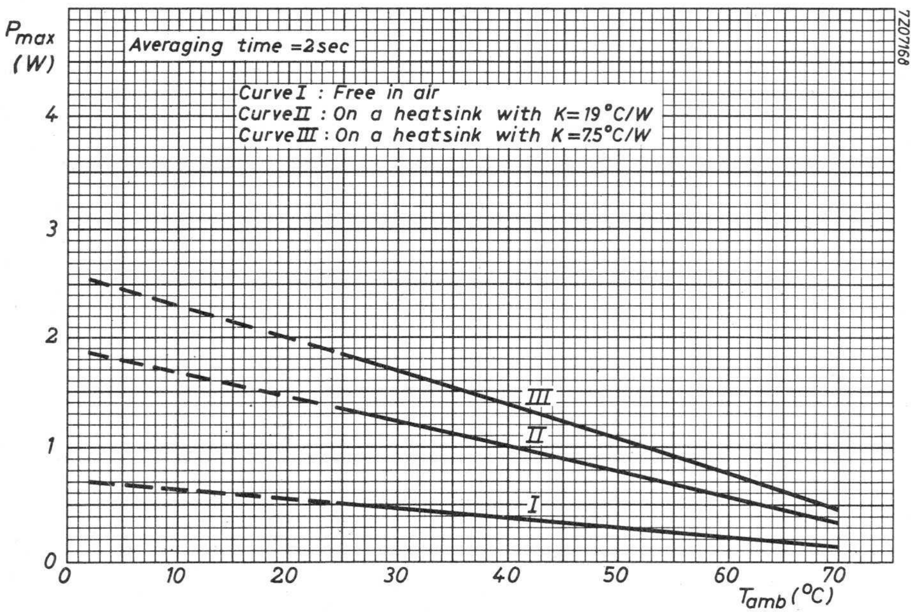
To reach the above mentioned K values it is essential that the RPY19 be installed in the following manner:

1. Mount one clamp on the heatsink, using the side with round holes.
2. Push the RPY19 under that clamp.
3. Press the second clamp firmly against the RPY19, using the slot holes.

7Z2 5188


7Z07167
r
(Ω)
Measured at 10 V d.c.
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
r2, after switching off a 5 minutes illumination of:
5 lux
50 lux
500 lux
5000 lux
r1, after 16 hrs of darkness and switching on an illumination of:
5 lux
50 lux
500 lux
5000 lux
1
10
10^2
10^3
10^4
10^5
10^6
t (msec)


7Z07169
r_{l_0} (Ω)
r_{l_0} = initial illumination resistance at $T_K = 2700°K$ Measured at 10 V d.c.
10^5
10^4
10^3
10^2
10
1
1
10
10^2
10^3 E (Lux)
10^4



7Z07168
Pmax (W)
Averaging time = 2sec
Curve I : Free in air
Curve II : On a heatsink with K = 19 °C/W
Curve III : On a heatsink with K = 7.5 °C/W
III
II
I
0
1
2
3
4
0
10
20
30
40
50
60
70
Tamb (°C)

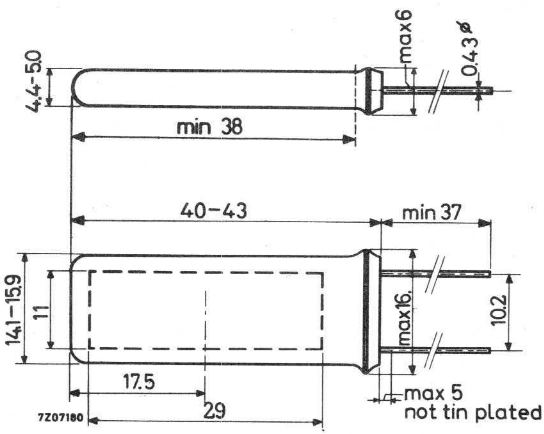
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with side sensitivity intended for use in general control circuits such as twilight switches and flame failure equipment. The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	1	W
Power dissipation, with a heatsink with K = 5 °C/W and T_{amb} = 25 °C	P	max.	3	W
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell resistance at 50 lux, 2700 °K colour temperature	r		1500	Ω
Spectral response curve		type D		
Outline dimensions		max. 43 x 16.3 x 6		mm

MECHANICAL DATA

Dimensions in mm



The centre distance of the leads is compatible with the standard raster for printed wiring (0.1 inch)

Soldering

The cell may be soldered directly into the circuit but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 ^{o}C for a maximum of 10 s up to a point 5 mm from the seals.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 ^{o}C, illumination with colour temperature of 2700 ^{o}K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	6.5		1)	MΩ
Equilibrium dark resistance measured with 300 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	120		1)	MΩ
Initial illumination resistance measured at 10 V, d.c. illumination = 50 lux, after 16 hrs in darkness 2)	r_{lo}	700	1500	3300	Ω
Equilibrium illumination resistance measured at 10 V, d.c. illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}	700	1900	4500	Ω

1) The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

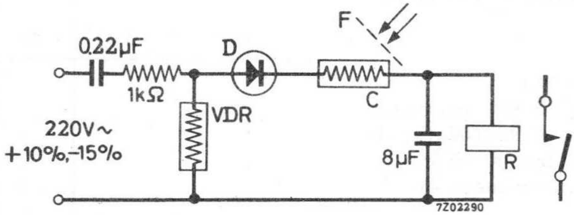
Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery (continued)

	symbol	min.	typical	max.	unit
Resistance decay time Time to reach 10 kΩ, measured from the instant of starting the illumination of 50 lux, at 10 V d.c. after 16 hours in darkness 2)	t_{fr}			0.2	s
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination of 50 lux, at 10 V d.c.	t_{rr}		0.9	1.5	s
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.15		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.05		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max.	+85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K		60	°C/W
Thermal resistance from CdS tablet to heatsink (temperature of heatsink measured near the centre of the cell), when the cell is properly clamped on a heatsink as described on sheet 6.	K		15	°C/W

OPERATING CONDITIONS in a typical twilight switching circuit.



C = CdS cell RPY20

R = D.C. Relay 20 kΩ with I_e < 2.7 e.g. energizing current I_e of 2 mA and release current I_r of 0.8 mA.

VDR = voltage dependent resistor 10 mA at 180 V, 2 W e.g. type E299DG/P248

F = Absorption filter to be used to correct spread of the circuit and to adjust the switching level (10 to 70 lux).
Light transmission 5 to 20 %.

D = Diode V_{inv_p} > 500 V

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from −30 % to +70 % do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95 % of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

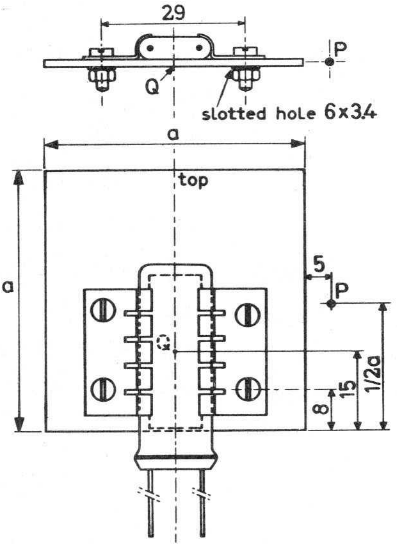
LIMITING VALUES (Absolute max. rating system)

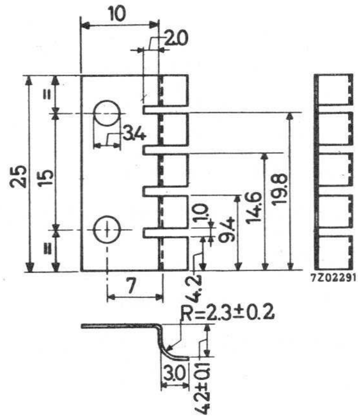
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell voltage, pulse, t_{imp} = max. 5 ms; p_{rr} = max. once per minute	V_p	max.	1000	V
Power dissipation, t_{av} = 2 s	P	See sheet 8		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	500	mA
Illumination	E	max.	50 000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	^oC 1)
Ambient temperature, storage and operating	T_{amb}	min.	-40	^oC
storage	T_{amb}	max.	+50	^oC 2)
operating	T_{amb}	max.	+70	^oC

1) If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83 ^oC when the CdS tablet temperature is 85 ^oC. This temperature can be determined e.g. with a thermocouple fastened on the envelope.

2) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

RPY20 MOUNTED ON HEATSINK





Detail: clamping strip
tombac 0.3 mm

The heat resistance K of the heatsink is defined as the temperature difference between the point Q at the backside of the heatsink, and ambient at point P, per Watt dissipation in the device, the heatsink being placed in an enclosure as given below.

Enclosure: cubical with internal edges 5 x a mm
Place : point Q in the centre of the enclosure, plane of heatsink vertical, "top" up

Determined according to the above rules a heatsink as given in the drawing has a heat resistance K = 19 ^{o}C/W when a = 50 mm and K = 7.5 ^{o}C/W when a = 100 mm.

With smaller enclosure dimensions a higher value for K may be expected.

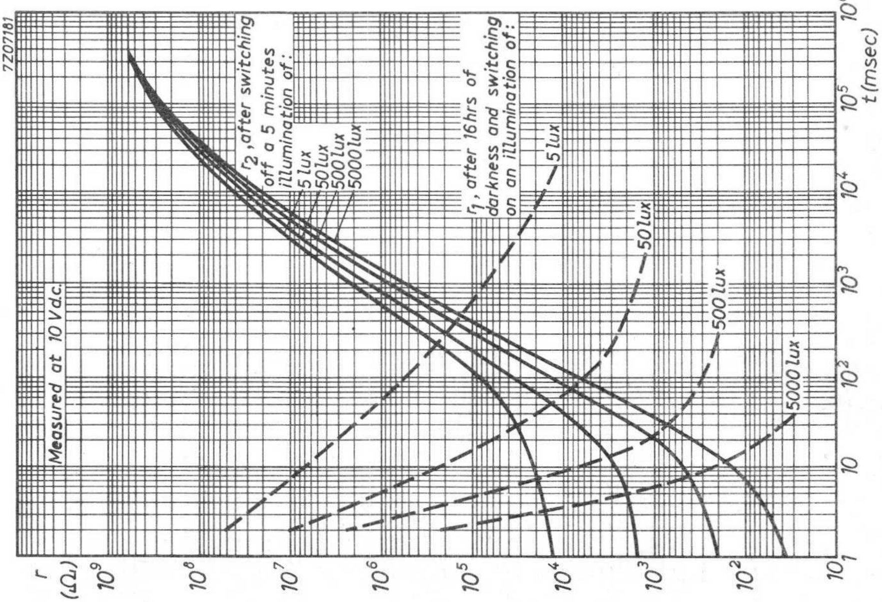
Mounting instructions

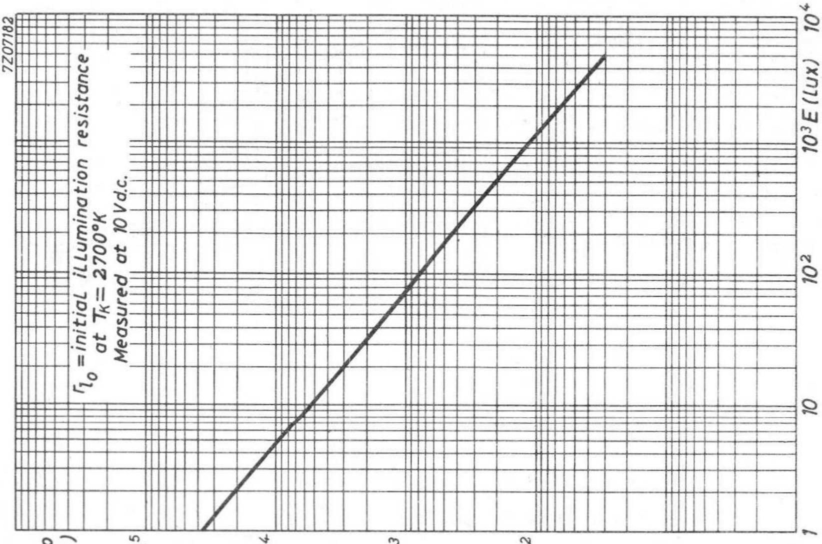
To reach the above mentioned K values it is essential that the RPY20 be installed in the following manner:

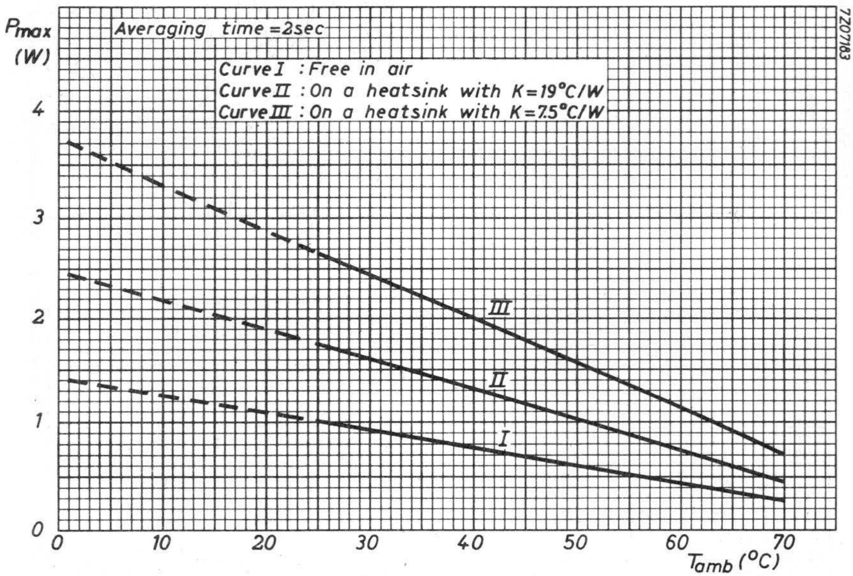
1. Mount one clamp on the heatsink, using the side with round holes.

2. Push the RPY20 under that clamp.

3. Press the second clamp firmly against the RPY20, using the slot holes.


7Z07181
Measured at 10 V d.c.
r2, after switching off a 5 minutes illumination of:
5 lux
50 lux
500 lux
5000 lux
r1, after 16 hrs of darkness and switching on an illumination of:
5 lux
50 lux
500 lux
5000 lux
r (Ω)
t (msec)


7Z07182
rlo = initial illumination resistance at TK = 2700°K
Measured at 10 V d.c.
rlo (Ω)
E (lux)



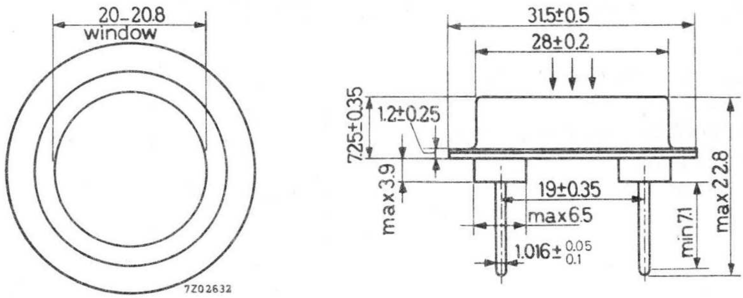
Pmax (W)
Averaging time = 2sec
Curve I : Free in air
Curve II : On a heatsink with K=19°C/W
Curve III : On a heatsink with K=7.5°C/W
7Z07183
0
1
2
3
4
0
10
20
30
40
50
60
70
Tamb (°C)
I
II
III

CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with top sensitivity intended for use in general control circuits such as twilight switches and flame failure equipment. The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	1	W
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell resistance at 50 lux, 2700 °K colour temperature	r		650	Ω
Spectral response curve		type D		
Outline dimensions		max. 31.5 dia. x 7.25		mm

MECHANICAL DATA



Accessories

Contact springs type 55561

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 400 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	6.0		1)	MΩ
Equilibrium dark resistance measured with 400 V d.c. applied via 1 MΩ, 30 minutes after switching of the illumination	r_{de}	100		1)	MΩ
Initial illumination resistance measured at 10 V d.c. after 16 hrs in darkness 2) illumination 50 lux	r_{lo}	380	650	1900	Ω
Equilibrium illumination resistance measured at 10 V d.c. after 15 minutes under the measuring conditions illumination 50 lux	r_{le}	380	820	2600	Ω

1) The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery (continued)

	symbol	min.	typical	max.	unit
Resistance decay time Time to reach 10 kΩ, measured from the instant of starting the illumination of 50 lux, at 10 V d.c. after 16 hours in darkness [2])	t_{fr}			0.2	s
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination with 50 lux, at 10 V d.c.	t_{rr}		1.0	1.5	s
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.3		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.05		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max.	+85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K		60	°C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from −30 % to +70 % do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95 % of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

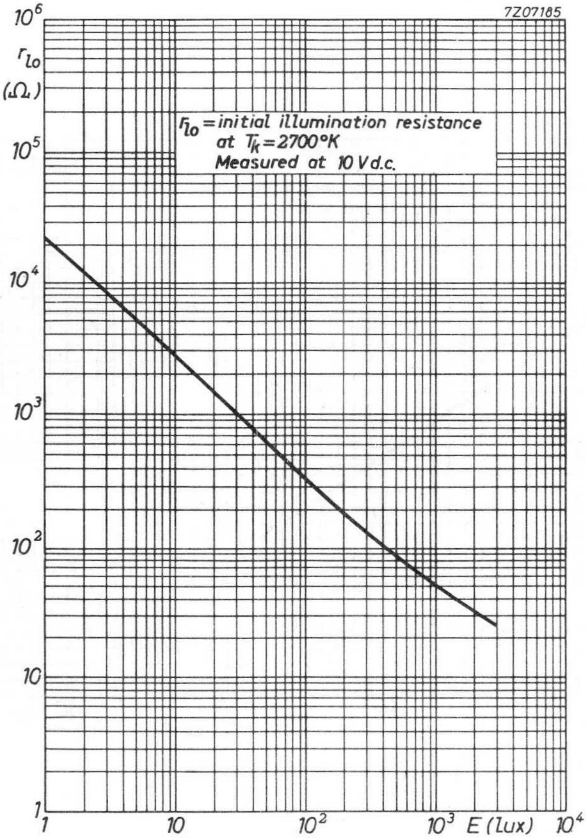
Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

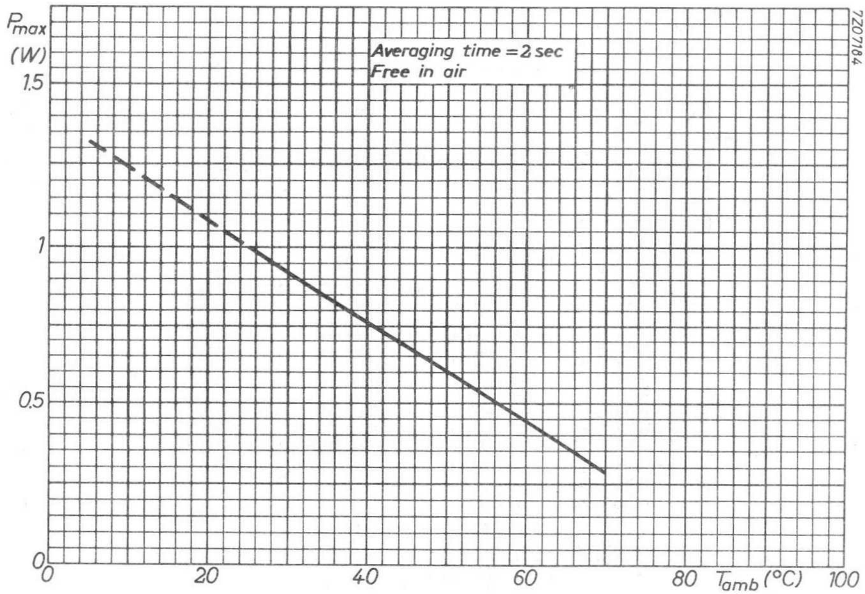
LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell voltage, pulse, t_{imp} = max. 5 ms p_{rr} = max. once per minute	V_p	max.	1000	V
Power dissipation, t_{av} = 2 s	P	See sheet 6		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	250	mA
Illumination	E	max.	50 000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	^oC
Ambient temperature, storage and operating	T_{amb}	min.	−40	^oC
storage	T_{amb}	max.	+50	^oC [1])
operating	T_{amb}	max.	+70	^oC

[1]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.



7Z07185
r_{lo} (Ω)
r_{lo} = initial illumination resistance at T_k = 2700°K
Measured at 10 V d.c.
10^6
10^5
10^4
10^3
10^2
10
1
1
10
10^2
10^3
E (lux)
10^4



P_{max} (W)
1.5
1
0.5
0
Averaging time = 2 sec
Free in air
7Z07184
0
20
40
60
80
T_{amb} (°C)
100

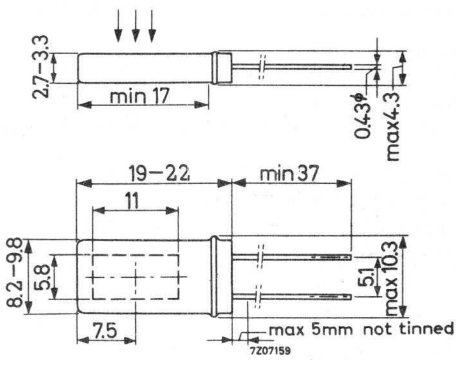
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with side sensitivity intended for use in general control circuits.
The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 ^{o}C	P	max.	225	mW
Cell voltage, d.c. and repetitive peak	V	max.	100	V
Cell resistance at 50 lux, 2700 ^{o}K colour temperature	r_{lo}		1.6	kΩ
Spectral response curve		type D		
Outline dimensions		max. 22x9.8x4.3		mm

MECHANICAL DATA

Dimensions in mm



Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 ^{o}C for a maximum of 10 s up to a point 5 mm from the seals.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 100 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	9		1)	MΩ
Equilibrium dark resistance measured with 100 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	100		1)	MΩ
Initial illumination resistance measured at V = 10 V d.c., illumination 50 lux, after 16 hours in darkness 2)	r_{lo}	950	1600	4800	Ω
Equilibrium illumination resistance measured at V = 10 V d.c., illumination 50 lux, after 15 minutes under the measuring conditions	r_{le}	950	1900	6200	Ω
Resistance decay time Time to reach 20 kΩ at V = 10 V d.c. measured from the instant of starting the illumination of 50 lux, after 16 hours in darkness. 2)	t_{fr}			0.2	s
Resistance rise time Time to reach 1 MΩ at V = 10 V d.c. measured after 5 minutes or longer illumination of 50 lux	t_{rr}		1.0	1.5	s
Sensitivity, at V = 10 V d.c. and 50 lux	N		0.12		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.1		

1)2) See page 4

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	+85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K	265	°C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the CdS cells during life from −30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10000 shocks in one of the three positions of the cell.

Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

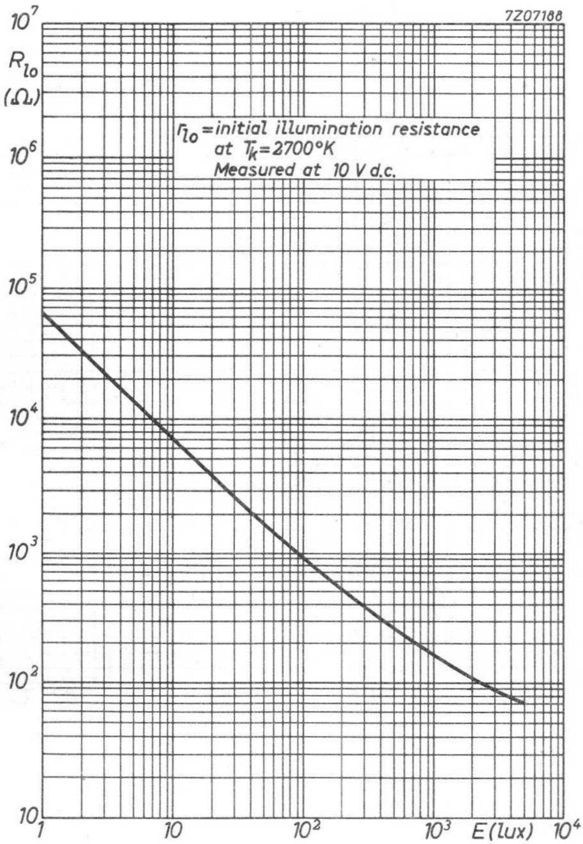
LIMITING VALUES (Absolute max. rating system)

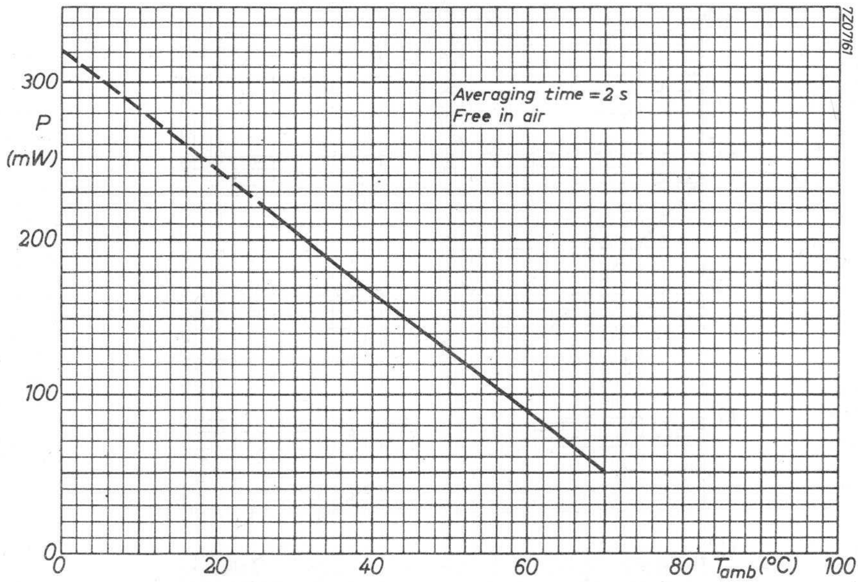
Cell voltage, d.c. and repetitive peak	V	max.	100	V
Cell voltage, pulse, T_{imp} = max. 5 ms, P_{rr} = max. once per minute	V_p	max.	250	V
Power dissipation, t_{av} = 2 s	P	See sheet 6		
Power dissipation, pulse	P_p	max.	5 x P	W
Cell current, d.c. and repetitive peak	I	max.	100	mA
Illumination	E	max.	50000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	°C [3]
Ambient temperature, storage and operating	T_{amb}	min.	−40	°C
storage	T_{amb}	max.	+50	°C [4]
operating	T_{amb}	max.	+70	°C

[3] [4] See page 4.

NOTES

1. The spread of the dark resistance is large and values higher than 30 MΩ and 2000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.
2. After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.
3. If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83 °C when the CdS tablet temperature is 85 °C. This temperature can be determined e.g. with a thermocouple fastened on the envelope.
4. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z07188
10^7
R_{lo}
(Ω)
r_{lo} = initial illumination resistance
at T_k = 2700°K
Measured at 10 V d.c.
10^6
10^5
10^4
10^3
10^2
10
1
10
10^2
10^3
E (lux)
10^4


7Z07161
Averaging time = 2 s
Free in air
300
P
(mW)
200
100
0
0
20
40
60
80
T_{amb} (°C)
100

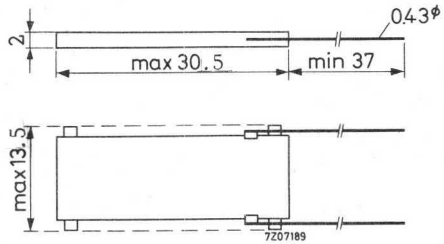
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with side sensitivity.
The device satisfies Test C: Damp heat test (long term exposure), severity IV (56 days exposure) of Publication 68-2 of the International Electrotechnical Commission (IEC).

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 ^{o}C	P	max.	0.75	W
Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell resistance at 50 lux, 2700 ^{o}K colour temperature	r		1500	Ω
Spectral response curve		type D		
Outline dimensions		max. 30.5x13.5x2		mm

MECHANICAL DATA

Dimensions in mm



Soldering

The cell may be soldered directly into the circuit but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 ^{o}C for a maximum of 10 s up to a point 5 mm from the seal.

Mounting

The cell is not insulated electrically and should be mounted accordingly.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 300 V d.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	10		[1]	MΩ
Equilibrium dark resistance measured with 400 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	200		[1]	MΩ
Initial illumination resistance measured at 10 V d.c. illumination = 50 lux, after 16 hrs in darkness [2]	r_{lo}	700	1500	3300	Ω
Equilibrium illumination resistance measured at 10 V d.c. illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}	700	1900	4500	Ω

[1] The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the intial dark resistance and the equilibrium dark resistance respectively.

[2] After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery (continued)

	symbol	min.	typical	max.	unit
Resistance decay time Time to reach 10 kΩ, measured from the instant of starting the illumination of 50 lux at 10 V d.c. after 16 hrs in darkness [2]	t_{fr}			0.2	s
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination of 50 lux, at 10 V d.c.	t_{rr}		0.9	1.5	s
Sensitivity at 50 lux, with 10 V d.c. applied	N		0.15		mA/lux
Negative temperature response of illumination resistance			0.2	0.5	%/°C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.05		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	+85	°C

CLIMATIC DATA

The device satisfies test C: Damp heat test (long term exposure), severity IV (56 days at 40 ± 2 °C, 90 to 95% humidity) of Publication 68-2 of the International Electrotechnical Commission (IEC).

2) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

LIMITING VALUES (Absolute maximum rating system)

Cell voltage, d.c. and repetitive peak	V	max.	400	V
Cell voltage, pulse, t_{imp} = max. 5 ms p_{rr} = max. once per minute	V_p	max.	1000	V
Power dissipation, t_{av} = 2 s	P	see sheet 6		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	500	mA
Illumination	E	max.	50 000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	°C
Ambient temperature, storage and operating	T_{amb}	min.	-40	°C
storage	T_{amb}	max.	+50	°C [1])
operating	T_{amb}	max.	+70	°C

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from -30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

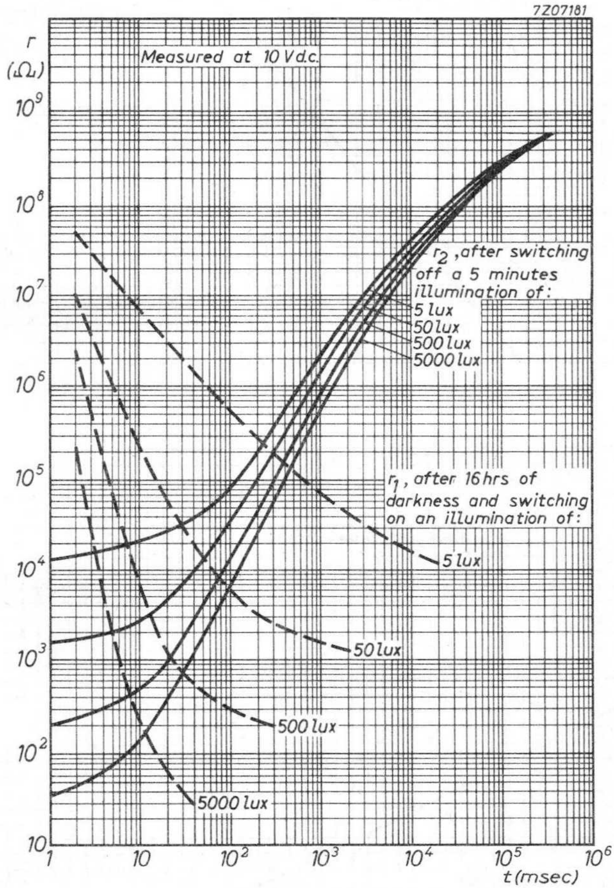
25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

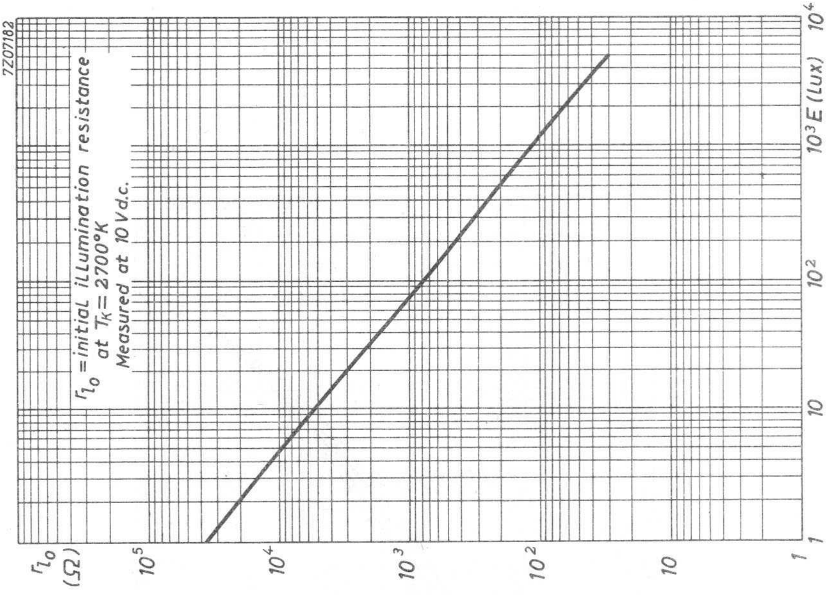
Vibration

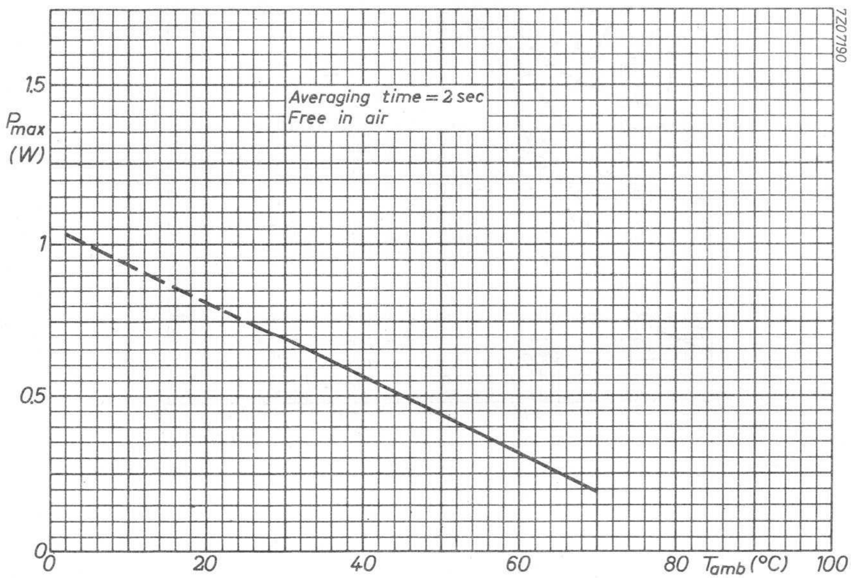
2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

---

1) Operating of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature


7Z07181
r
(Ω)
Measured at 10 V d.c.
r2 , after switching off a 5 minutes illumination of:
5 lux
50 lux
500 lux
5000 lux
r1 , after 16 hrs of darkness and switching on an illumination of:
5 lux
50 lux
500 lux
5000 lux
10
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸
10⁹
1
10
10²
10³
10⁴
10⁵
10⁶
t (msec)


7Z07182
r_lo = initial illumination resistance
at T_K = 2700°K
Measured at 10 V d.c.
E (Lux)
1
10
10^2
10^3
10^4
r_lo (Ω)
10^5
10^4
10^3
10^2
10
1


7Z07190
Averaging time = 2 sec
Free in air
P_max (W)
1.5
1
0.5
0
0
20
40
60
80
T_amb (°C)
100

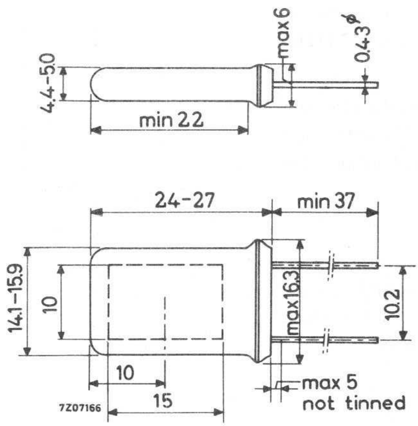
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with side sensitivity intended for use in industrial on-off applications such as flame failure circuits.
The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	0.5	W
Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell resistance at 50 lux, 2700 °K colour temperature	r_{lo}		1500	Ω
Spectral response curve		type D		
Outline dimensions		max. 27 x 16.3 x 6		mm

MECHANICAL DATA

Dimensions in mm



Soldering

The cell may be soldered directly into the circuit but heat conducted to the seal should be kept to a minimum by the use of a thermal shunt. The cell may be dip-soldered at a solder temperature of 240 °C for a maximum of 10 s up to a point 5 mm from the seals.

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination, colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 ^{o}C, illumination with colour temperature of 2700 ^{o}K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 200 V d.c. applied via 1 mΩ, 20 s after switching off the illumination	r_{do}	6.5		[1]	MΩ
Equilibrium dark resistance measured with 200 V d.c. applied via 1 MΩ, 30 minutes after switching off the illumination	r_{de}	120		[1]	MΩ
Initial illumination resistance measured at 10 V d.c., illumination = 50 lux, after 16 hours in darkness [2]	r_{lo}	700	1500	3300	Ω
Equilibrium illumination resistance measured at 10 V d.c., illumination = 50 lux, after 15 minutes under the measuring conditions	r_{le}	700	1900	4500	Ω
Resistance decay time Time to reach 10 kΩ, measured from the instant of starting the illumination of 50 lux, at 10 V d.c. after 16 hours in darkness	t_{fr}			0.2	s

[1]) The spread of the dark resistance is large and values higher than 100 MΩ and 10 000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

[2]) After 16 hours in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

Basic characteristics at T_{amb} = 25 ^{o}C, illumination with colour temperature of 2700 ^{o}K and at delivery (continued)

	symbol	min.	typical	max.	unit
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination after 5 minutes or longer illumination of 50 lux, at 10 V d.c.	t_{rr}		0.9	1.5	s
Sensitivity at 50 lux with 10 V d.c. applied	N		0.15		mA/lux
Negative temperature response of illumination resistance	$\Delta r_l/\Delta T$		0.2	0.5	%/^{o}C
Voltage response $\frac{\text{r at 0.5 V d.c.}}{\text{r at 10 V d.c.}}$	α		1.1		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max. +85	^{o}C
Thermal resistance from CdS tablet to ambient, device free in air	K	120	^{o}C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from -30% to +70% do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests mentioned below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10 000 shocks in one of the three positions of the cell.

Vibration

2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

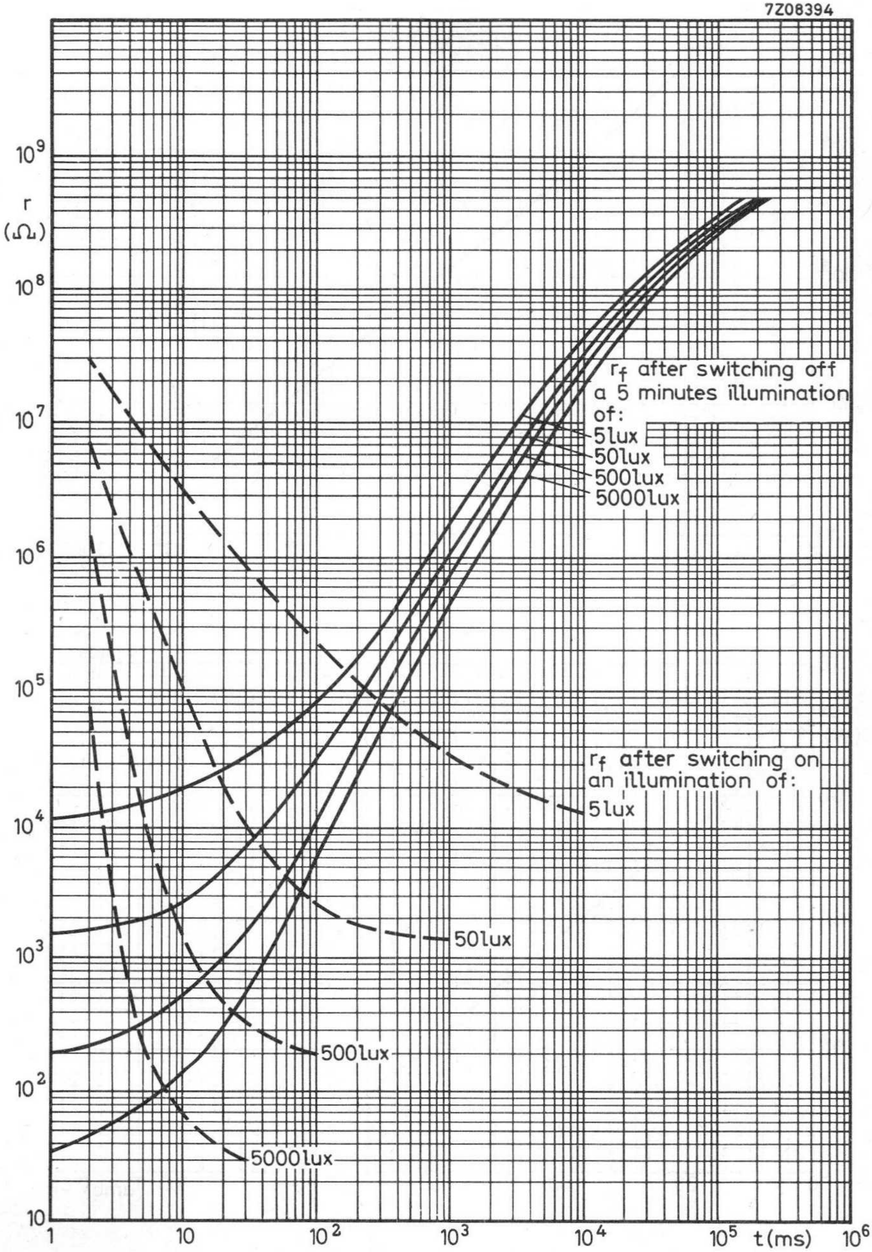
LIMITING VALUES (Absolute max. rating system)

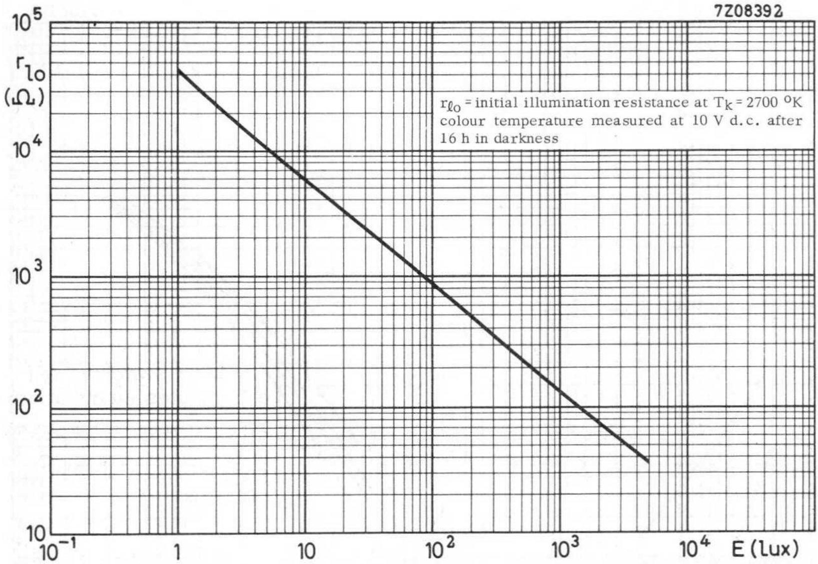
Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell voltage, pulse, timp = max. 5 ms p.r.r. = max. once per minute	V_p	max.	500	V
Power dissipation, t_{av} = 2 s	P	See sheet 6		
Power dissipation, pulse	P_p	max.	5xP	
Cell current, d.c. and repetitive peak	I	max.	250	mA
Illumination	E	max.	50 000	lux
Temperature CdS tablet, operating	T_{tablet}	max.	+85	°C [1])
Ambient temperature, storage and operating	T_{amb}	min.	-40	°C
storage	T_{amb}	max.	+50	°C [2])
operating	T_{amb}	max.	+70	°C

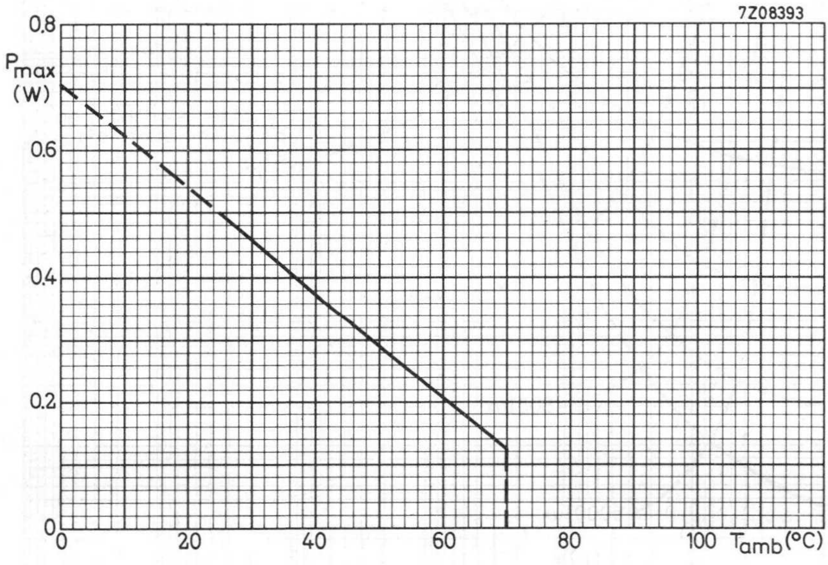
---

[1]) If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83 °C when the CdS tablet temperature is 85 °C. This temperature can be determined e.g. with a thermocouple fastened on the envelope.

[2]) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z08394
r
(Ω)
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
1
10
10^2
10^3
10^4
10^5
t (ms)
10^6
r_f after switching off a 5 minutes illumination of:
5lux
50lux
500lux
5000lux
r_f after switching on an illumination of:
5lux
50lux
500lux
5000lux


7Z08392
10^5
r_{lo}
(Ω)
$r_{\ell o}$ = initial illumination resistance at T_K = 2700 °K colour temperature measured at 10 V d.c. after 16 h in darkness
10^4
10^3
10^2
10
10^{-1}
1
10
10^2
10^3
10^4
E (lux)


7Z08393
0.8
P_{max}
(W)
0.6
0.4
0.2
0
0
20
40
60
80
100
T_{amb} (°C)

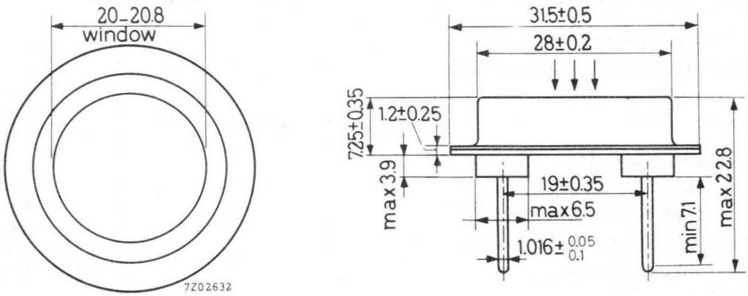
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELL

Cadmium sulphide photoconductive cell with top sensitivity intended for use in general control circuits such as twilight switches and flame failure equipment.
The cell is tropic proof, shock and vibration resistant.

QUICK REFERENCE DATA				
Power dissipation at T_{amb} = 25 °C	P	max.	1	W
Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell resistance at 50 lux, 2700 °K c.t.	r_{lo}		420	Ω
Spectral response curve			type D	
Outline dimensions		max.	32 dia x 7.6	mm

MECHANICAL DATA

Dimensions in mm



Accessories

Contact springs type 55561

ELECTRICAL DATA

General

The electrical properties of CdS cells are dependent on many factors such as illumination colour temperature of the light source, voltage, current, temperature, total time of operation in the circuit and time of operation during the last 24 hours prior to the measurement. The following basic characteristics are therefore only checkpoints of the electrical properties of these devices measured with defined values of the various conditions and at delivery.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery

	symbol	min.	typical	max.	unit
Initial dark resistance measured with 200 Vd.c. applied via 1 MΩ, 20 s after switching off the illumination	r_{do}	3		1)	MΩ
Equilibrium dark resistance measured with 200 Vd.c. applied via 1 MΩ, 30 min. after switching off the illumination	r_{de}	50		1)	MΩ
Initial illumination resistance measured at 10 Vd.c., illumination 50 lux, after 16 h in darkness 2)	r_{lo}	250	420	1250	Ω
Wquilibrium illumination resistance measured at 10 Vd.c., illumination 50 lux, after 15 min. under the measuring conditions	r_{le}	250	530	1700	Ω
Resistance decay time Time to reach 5 kΩ, measured from the instant of starting the illumination of 50 lux, at 10 Vd.c. after 16 h in darkness 2)	t_{fr}			0.3	s

1) the spread of the dark resistance is large and values higher than 50 MΩ and 5000 MΩ are possible for the initial dark resistance and the equilibrium dark resistance respectively.

2) After 16 h in darkness changes in the CdS material are still occurring, but have only insignificant effect on the illumination resistance and on the resistance decay time.

Basic characteristics at T_{amb} = 25 °C, illumination with colour temperature of 2700 °K and at delivery.

	symbol	min.	typical	max.	unit
Resistance rise time Time to reach 1 MΩ, measured from the instant of stopping the illumination, after 5 min. or longer illumination of 50 lux at 10 Vd.c.	t_{rr}			2	s
Sensitivity at 50 lux, with 10 Vd.c. applied	N		0.5		mA/lux
Negative temperature response of illumination resistance	$\Delta r_l/\Delta T$		0.2	0.5	% / °C
Voltage response $\frac{r \text{ at } 0.5 \text{ V}}{r \text{ at } 10 \text{ V}}$			1.05		

THERMAL DATA

Continuous temperature of CdS tablet	T_{tablet}	max.	+ 85	°C
Thermal resistance from CdS tablet to ambient, device free in air	K		60	°C/W

DESIGN CONSIDERATIONS

Apparatus with CdS cells should be designed so that changes in resistance values of the cells during life from - 30 % to + 70 % do not impair the circuit performance. Direct sunlight irradiation should be avoided.

SHOCK AND VIBRATION

An indication for the ruggedness of the cell is the following:
Samples taken from normal production are submitted to shock and vibration tests More than 95 % of the devices pass these tests without perceptible damage.

Shock

25 g_{peak}, 10000 shocks in one of the three positions of the cell.

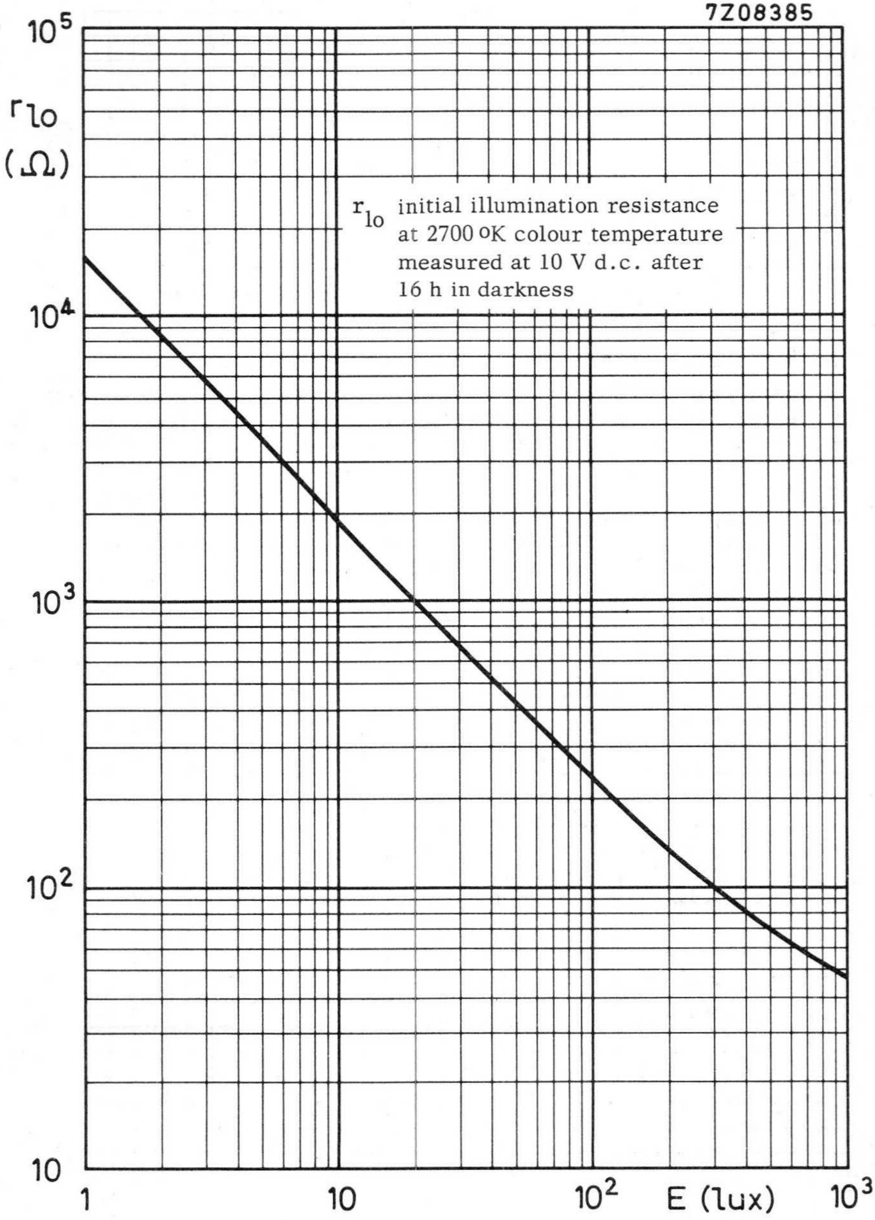
Vibration

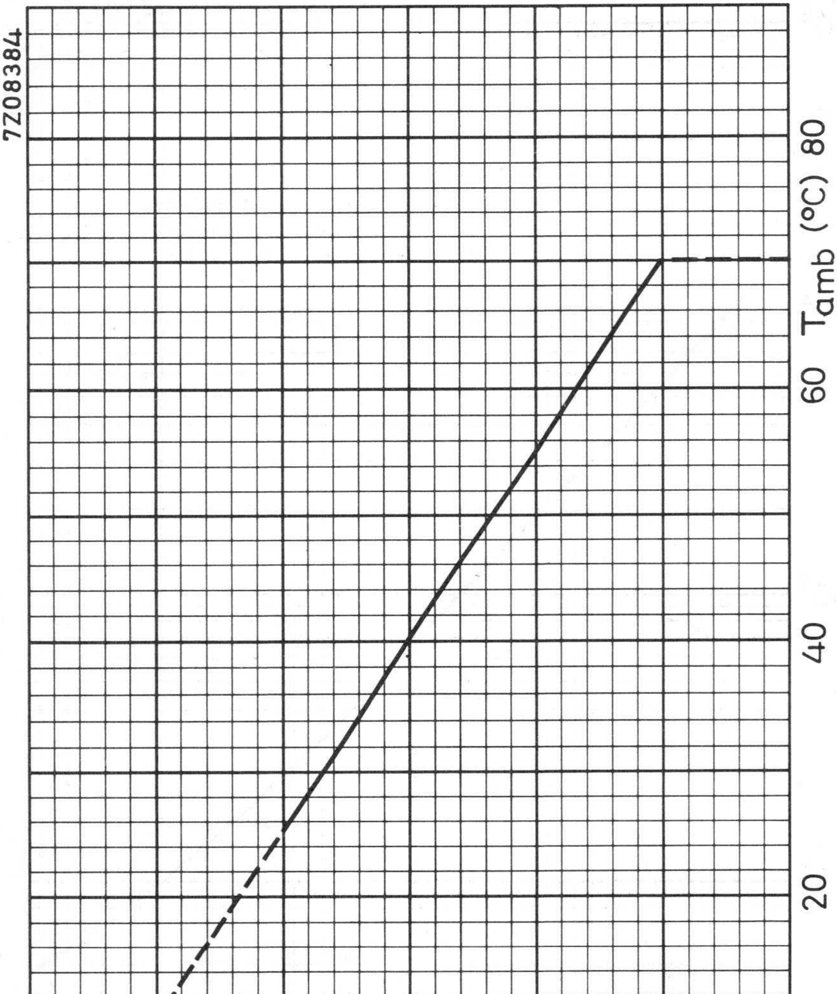
2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the cell.

LIMITING VALUES (Absolute max. rating system)

Cell voltage, d.c. and repetitive peak	V	max.	200	V
Cell voltage, pulse, t_{imp}=max. 5 ms p.r.r. = max. once per minute	V_P	max.	500	V
Power dissipation, t_{av} = 2 s	P	See	page	B
Power dissipation, pulse	P_p	max.	5 x	P
Cell current, d.c. and repetitive peak	I	max.	250	mA
Illumination	E	max.	50000	lux
Temperature Cds tablet, operating	T_{tablet}	max.	85	^oC
Ambient temperature, storage and operating	T_{amb}	min.	- 40	^oC
storage	T_{amb}	max.	+ 50	^oC 1)
operating	T_{amb}	max.	+ 70	^oC

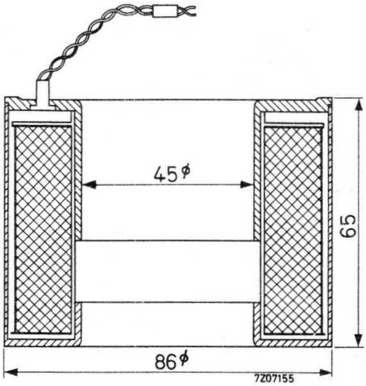
1) Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.


7Z08385
r_{lo} (Ω)
10^5
10^4
10^3
10^2
10
r_{lo} initial illumination resistance at 2700 °K colour temperature measured at 10 V d.c. after 16 h in darkness
1
10
10^2
E (lux)
10^3


7Z08384
P_{max}
(W)
1.5
1
0.5
0
0
20
40
60
80
T_{amb} (°C)

Associated accessories

FOCUSING COIL

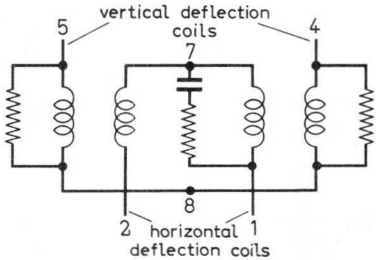


Number of turns	26500
D.C. Resistance	6000 Ω

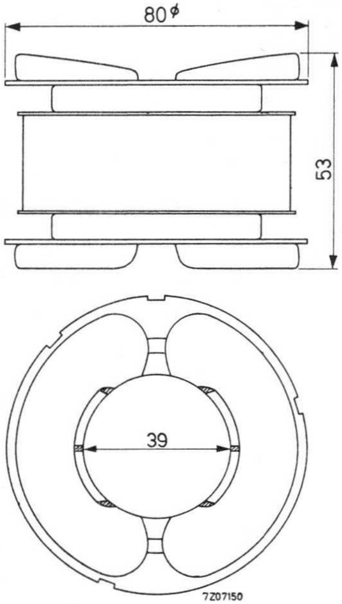
When the MC13-16 is operated at $V_{g_2(\ell)}$ = 25 kV, the current through the focusing coil should be adjusted at approx. 33 mA.

The distance between air-gap centre and the screen surface of the MC13-16 should be 217 mm.

DEFLECTION COIL UNIT



When the MC13-16 is operated at $V_{g_2(\ell)} =$ 25 kV and raster dimensions 60×80 mm^2, the horizontal and vertical deflection coils should be connected in series.



Horizontal deflection coils

Inductance	6	mH
Resistance	5.6	Ω
Current, peak to peak	700	mA
Connections (red, grey)	1 and 2	

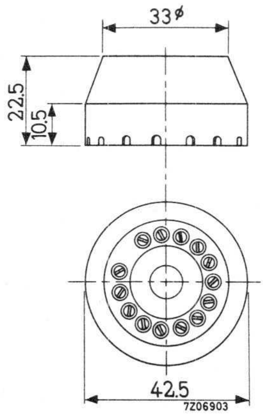
Vertical deflection coils

Inductance	8	mH
Resistance	9.6	Ω
Current, peak to peak	540	mA
Connections (yellow, black)	4 and 5	

Operating temperature max. 85 ^{o}C

TUBE SOCKET

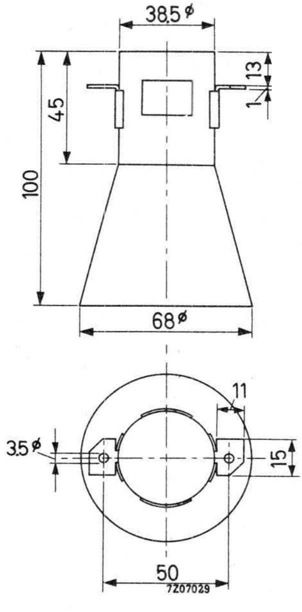
FOR 14-PIN ALL GLASS BASES



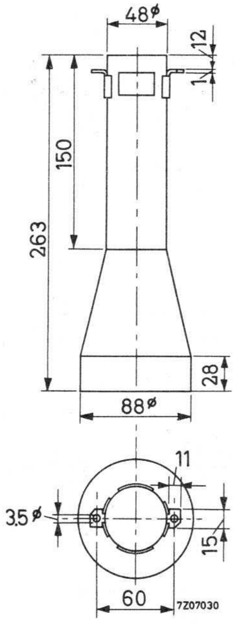
Material: Synthetic resin insulating material

14 silver plated fork-shaped contacts

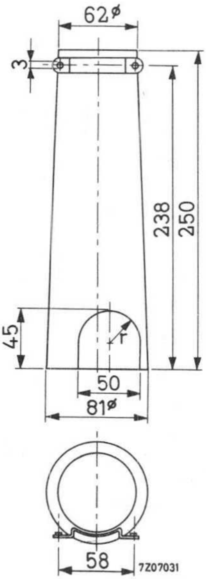
MU-METAL SCREEN



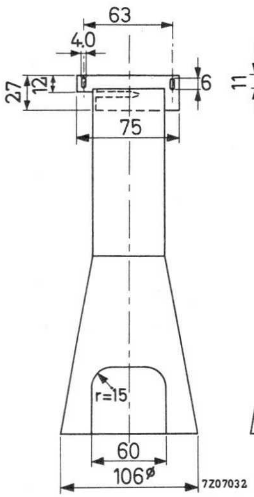
MU-METAL SCREEN



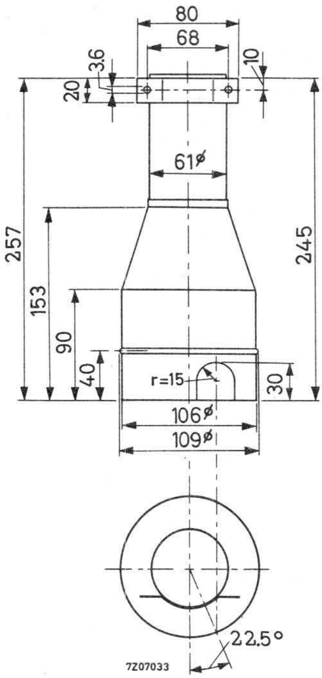
MU-METAL SCREEN



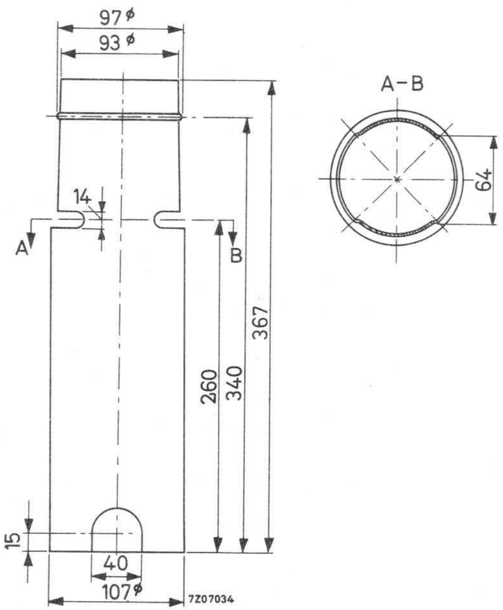
MU-METAL SCREEN



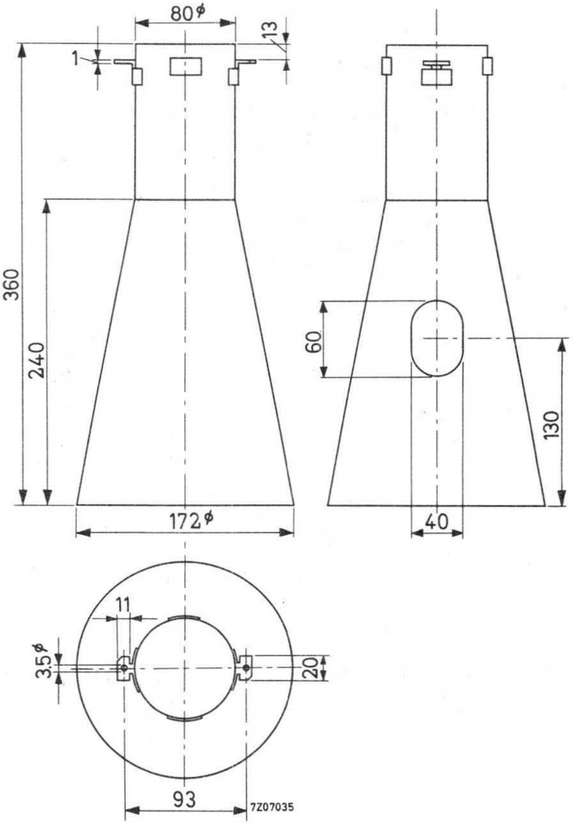
MU-METAL SCREEN



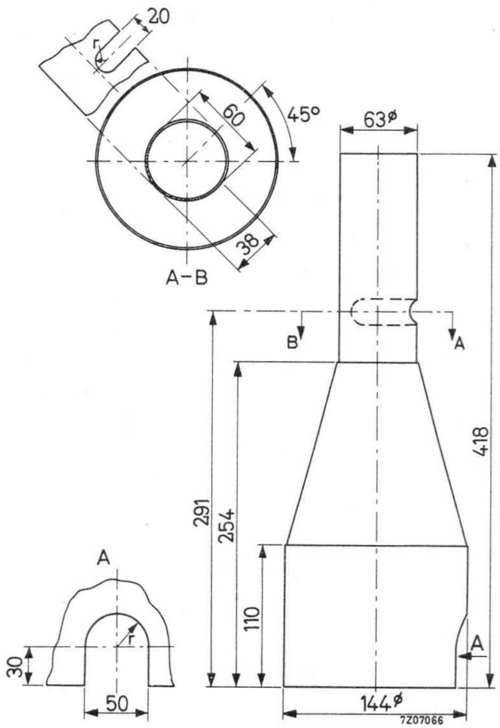
MU-METAL SCREEN



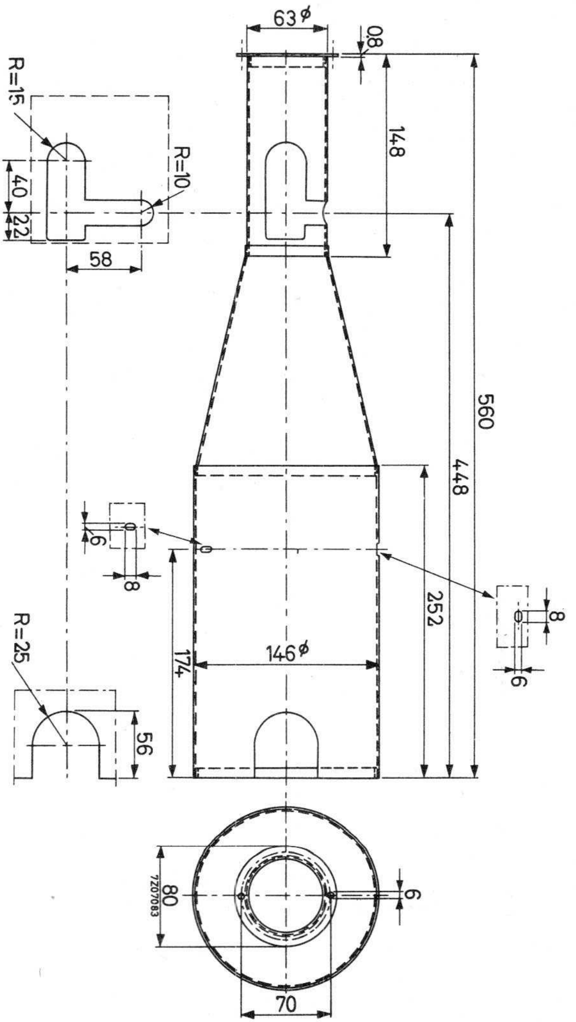
MU-METAL SCREEN



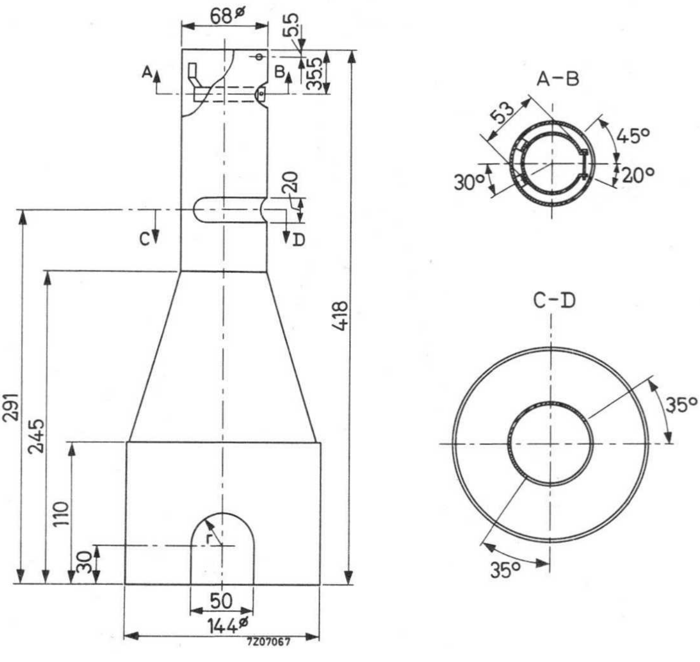
MU-METAL SCREEN



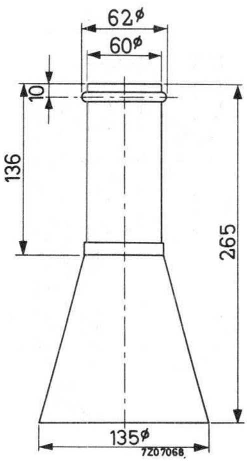
MU-METAL SCREEN



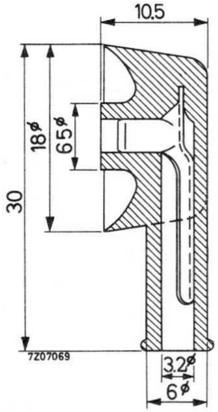
MU-METAL SCREEN



MU-METAL SCREEN

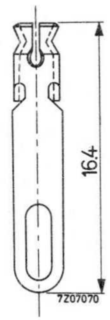


FINAL ACCELERATOR CONTACT CONNECTOR

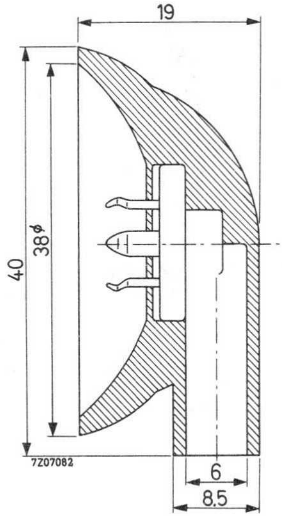


Material: cadmium plated spring contact
rubber insulating material

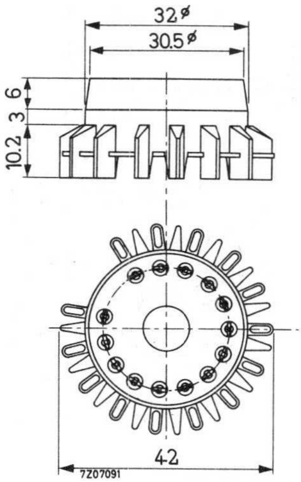
SIDE CONTACT CONNECTOR



FINAL ACCELERATOR CONTACT CONNECTOR



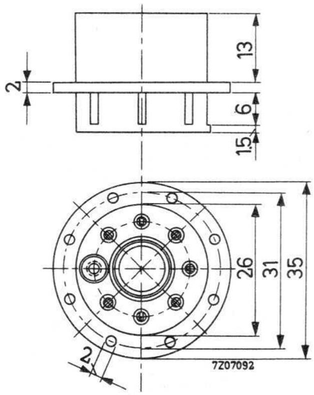
TUBE SOCKET FOR 14-PIN BASES



Material: synthetic resin insulating material

14 gold plated fork shaped contacts

TUBE SOCKET FOR 7-PIN BASES



Material: synthetic resin insulating material

7 contacts, guiding hole and central hole

INDEX OF TYPENUMBERS

Type No.	Section	Type No.	Section	Type No.	Section
AT1997	Acc.	M21-11W	CRT	150AV	PT
AT5010	Acc.	M21-12W	CRT	150CV	PT
D7-190..	CRT	M28-12W	CRT	150UV	PT
D10-11..	CRT	M36-11W	CRT	155UG	PT
D10-12..	CRT	M36-13W	CRT	40467	Acc.
D10-160..	CRT	M.13-16	CRT	55530	Acc.
D10-170..	CRT	MG/U/Y13-38	CRT	55531	Acc.
D13-15..	CRT	MW13-38	CRT	55532	Acc.
D13-16..	CRT	ORP11	PcD	55540	Acc.
D13-16../01	CRT	ORP30	PcD	55541	Acc.
D13-19..	CRT	ORP50	PcD	55545	Acc.
D13-21..	CRT	ORP52	PcD	55550	Acc.
D13-23..	CRT	ORP60	PcD	55551	Acc.
D13-24..	CRT	ORP61	PcD	55554	Acc.
D13-26..	CRT	ORP62	PcD	55555	Acc.
D13-26../01	CRT	ORP63	PcD	55557	Acc.
D13-27..	CRT	ORP90	PcD	55560	Acc.
D13-480..	CRT	RPY13	PcD	55561	Acc.
D14-120..	CRT	RPY18	PcD	55563	Acc.
D.3-91	CRT	RPY19	PcD	55566	Acc.
D.7-5	CRT	RPY20	PcD	55850	CT
D.7-6	CRT	RPY27	PcD	55850AM	CT
D.7-11	CRT	RPY41	PcD	55851	CT
D.7-31	CRT	RPY43	PcD	55852	CT
D.7-32	CRT	RPY54	PcD	55875, R, G, B	CT
D.7-36	CRT	RPY55	PcD	55876	CT
D.7-78	CRT	XQ1040	CT	56020	Acc.
D.10-6	CRT	XQ1050	CT		
D.10-74	CRT	58CG	PT		
D.10-78	CRT	58CV	PT		
D.13-2	CRT	90AV	PT		
D.13-32	CRT	90CG	PT		
D.13-34	CRT	90CV	PT		
E10-12..	CRT	92AG	PT		
E10-130..	CRT	92AV	PT		

Acc = Accessories
CRT = Cathode-ray tubes
CT = Camera tubes
PcD = Photoconductive devices
PT = Photo tubes

Printed in Holland

9399 241 00601