PHILIPS

DATA HANDBOOK

PHILIPS ELECTRONIC COMPONENTS AND MATERIALS DIVISION

ELECTRON TUBES

PART 6 AUGUST 1967

Voltage stabilizing- and reference tubes
Counter-, selector- and indicator tubes

Trigger tubes and switching diodes
Thyratrons

Industrial rectifying tubes
Ignitrons

Radiation counter tubes
Miscellaneous nuclear devices

ELECTRON TUBES
PART 6

August, 1967

INTRODUCTION

The Data Handbook ELECTRON TUBES contains data on current types of tubes. It comprises a number of bound parts and a loose-leaf binder: the blue binder.

The bound parts contain both the final and the tentative publishing data which are available at a certain closing date. These parts will be re-issued at regular intervals in order to provide continuously for sufficient information to all those who are professionally engaged in the field of electronics, but for whom it is of secondary importance to have the disposal of the very latest additions.

For those who do need the latest information the loose-leaf binder will be useful, as it contains all data which have become available after the latest issues of the bound part. The binder is kept up-to-date by the regular appearance of supplements.

When a bound part is re-issued, the pertinent contents of the binder are transferred to this part, thus preventing the binder from becoming overcrowded.

The present part 6 of the Handbook ELECTRON TUBES contains data on Voltage stabilizing- and reference tubes, Counter-, selector- and indicator tubes, Trigger tubes and switching diodes, Thyratrons, Industrial rectifying tubes, Ignitrons, Radiation counter tubes, Miscellaneous nuclear devices.

For owners of the loose-leaf binder on tubes it may be advisable to make sure that the data on a particular type in the bound part have not been rendered out of date by a later issue in the binder. This applies especially to tentative data.

Voltage stabilizing and reference tubes

VOLTAGE STABILIZING AND VOLTAGE REFERENCE TUBES APPLICATION DIRECTIONS

1. GENERAL

1.1 A voltage stabilizing tube is a glow discharge tube designed to have a maintaining voltage which is substantially constant over the current operating range.

1.2 A voltage reference tube is a glow discharge tube designed to have a constant maintaining voltage with time at fixed values of current and temperature.

1.3 The limiting values of voltage stabilizing and voltage reference tubes are given in the absolute maximum rating system.

1.4 Dimensions are given in mm.

2. OPERATING CHARACTERISTICS

2.1 Ignition

2.1.1 Ignition voltage (breakdown voltage) symbol V_{ign}

The ignition voltage is the voltage at which breakdown occurs. (See Breakdown)

Normally a tube will ignite at a voltage somewhat lower than the figure quoted, but the latter should always be the minimum available to ensure ignition of all tubes.

2.1.2 Breakdown

Breakdown is a runaway increase in electrode (cathode) current following the moment of highest voltage between the electrodes considered.

At some types the breakdown may occur at a lower voltage than the published maintaining voltage.
See also "Cathode current".

2.1.3 Ignition delay (breakdown delay)

The ignition delay is the time interval between the application of a direct voltage to the anode-cathode gap and the establishment of a self sustaining discharge in that gap.

The ignition delay of certain types is affected by ambient light. In darkness the delay is maximum.

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2.2 Maintaining voltage (Symbol V_m)

The maintaining voltage is the anode voltage with the tube conducting within the current range stated.

It is measured at the conditions stated in the data and will vary with current, temperature and time. In the presence of noise, the average is taken.

2.3 Regulation voltage (Symbol V_r)

The regulation voltage is the difference between the maximum and the minimum maintaining voltages within a specified cathode current range.

This is normally measured over the full current range of the tube at the temperature specified.

2.4 Stability (Symbol ΔV_m)

The change in maintaining voltage during life is a measure of the stability of the tube.

Changes due to variations in tube current and temperature are excluded.

2.5 Temperature coefficient of maintaining voltage (Symbol $\frac{\Delta V_m}{\Delta t_{bulb}}$)

The temperature coefficient of maintaining voltage is the quotient of the change of maintaining voltage by the change of bulb temperature.

The value quoted is normally an average value which applies over the temperature range stated.

2.6 Extinguishing voltage (Symbol V_{ext})

The extinguishing voltage is the anode voltage at which the discharge ceases when the supply voltage is decreasing.

2.7 Noise voltage (Symbol V_n)

2.7.1 Random noise voltage

This particular noise voltage is random in nature and similar to thermal noise. It is normally quoted as the r.m.s. voltage measured over a specified frequency range.

2.7.2 Oscillation noise voltage

An oscillation noise voltage is a voltage which is generated within the tube and which has a major component at one frequency.

It occurs in certain tube types, and then only over a restricted current range.

2.7.3 Vibration noise voltage

The vibration noise voltage is the noise output voltage resulting from sinusoidal vibration of the tube.

Where this information is given it is for guidance only, and it is not recommended that the tube be operated under these conditions for long periods.

2.7.4 Microphonic noise voltage

The microphonic noise voltage is the noise output voltage caused by mechanical excitation due to a single blow.

2.8 Voltage jump (Symbol V_j)

A voltage jump is an abrupt change or discontinuity in maintaining voltage that may occur during operation and is not due to the "incremental resistance".

2.9 Cathode current (Symbol I_k)

2.9.1 Minimum cathode current

The minimum cathode current is the current below which operation will result in deterioration of the performance of the tube.

2.9.2 Maximum cathode current

The maximum cathode current is that instantaneous value which should not be exceeded during normal operation of the tube.
When a tube is switched on, this value may be exceeded. (See starting current.)

2.9.3 Preferred current

The preferred current is that current at which maximum stability may be expected.

2.9.4 Starting current (Symbol I_{ko})

The starting current is the current immediately after ignition.
The maximum permissible value and duration are given in the data.

2.10 Incremental resistance (Symbol r_a)

The incremental resistance is the slope of the V_m/I_k characteristic.
This is measured at a specified current and temperature and voltage jumps are ignored.

2.11 Tube impedance (Symbol z_a)

The tube impedance of the anode-cathode gap for the a.c. component of the cathode current.

This is measured at a specified d.c. cathode current, on which a sinusoidal current of specified amplitude and frequency is superimposed.

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2.12 Bulb temperature (Symbol t_{bulb})

The bulb temperature shall be taken as the temperature of the hottest part of the tube envelope, whether due to internal or external causes. In the interest of stability, the bulb temperature should be kept as close to room temperature as possible.

2.13 Shunt capacitor (Symbol C_p)

In order to avoid relaxation oscillations and to reduce transient current at starting the value of the capacitor should be made as small as possible and should not exceed the specified value.

3. MOUNTING

3.1 Mounting position

If no restrictions are made on the individual published data sheet, the tube may be mounted in any position.

3.2 Tube pins and sockets

Many small glass-base tubes employ semi-rigid pins. It is necessary to ensure that these pins are straight before insertion into the socket.
It is recommended both in wired and in printed circuits that sockets with floating contacts be used. After the socket has been wired or soldered in, the socket contacts should be in the correct position to receive a tube.

3.3 Pins marked i.c.

When a pin is marked i.c., no connection should be made to the corresponding socket tag.

3.4 Flexible leads

Tubes having flexible leads do not normally employ plug-in sockets and it is usually necessary to secure them in position solely by means of the bulb. Any such support should not cause undue stress to be placed on the flexible leads themselves.
Attention should also be given to the effect this mounting may have upon the bulb temperature. Subminiature and smaller types can generally be mounted with the leads only.

3.4.1 Soldering

Where tubes are designed for soldering into the circuit, care must be taken to avoid bending the leads sharply closer than 2 mm to the base. Precautions should be taken during soldering to ensure that the glass temperature at the seal will not rise excessively. One simple method is to clamp a thermal shunt to the wire between the glass and the point being soldered. In any case the wire should not be soldered closer than 5 mm from the seals or as specified in the published data.

7Z2 5083

4. OPERATIONAL NOTES

4.1 Basic circuit

To ensure reliable operation under all operating conditions the following conditions should be observed: (See fig.1).

1. The current I_k should not drop below the published permissible limit I_k min.
2. The published I_k max. should not be exceeded (except at switching on).
3. Ignition must be ensured under the most unfavourable conditions.

In general I_k may be expressed as:

$$I_k = \frac{V_b - V_m}{R_1} - I_L$$

Under the most unfavourable conditions, condition 1 is satisfied if:

$$R_1 < \frac{V_b\,\text{min} - V_m\,\text{max.}}{I_k\,\text{min} + I_L\,\text{max.}} \cdot \frac{1}{1 + p/100}$$

The max. current I_k max. is most likely to be exceeded at the highest value of V_b (= V_b max.), a tube with the lowest maintaining voltage V_m min. and when the load current has the lowest value I_L min.

$$R_1 > \frac{V_b\,\text{max.} - V_m\,\text{min.}}{I_k\,\text{max.} + I_L\,\text{min.}} \cdot \frac{1}{1 - p/100}$$

To ensure ignition:

$$V_b \cdot \frac{R_1}{R_1 + R_L} > V_{ign}\,\text{max.}$$

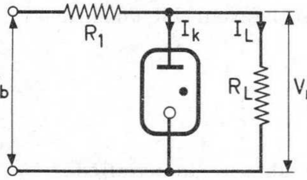
or under the most unfavourable operating conditions

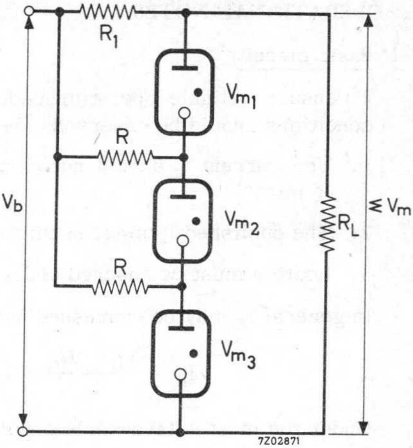
$$R_1 < R_L \left(\frac{V_b\,\text{min.}}{V_{ign}\,\text{max.}} - 1\right) \cdot \frac{1}{1 + p/100}$$

In these formulae the signification of the symbols is the following:

V_b min.	Minimum applied supply voltage
V_b max.	Maximum applied supply voltage
V_m min.	Minimum published maintaining voltage
V_m max.	Maximum published maintaining voltage
I_k min.	Minimum published cathode current
I_k max.	Maximum published cathode current
I_L min.	Minimum load current
I_L max.	Maximum load current
p	Tolerance of resistor R_1 (% in absolute value)
V_{ign} max.	Maximum ignition voltage

7Z2 5084





4.2 Series operation

Series operation of tubes is permitted.
If different types of tubes are connected in series care must be taken to ensure that the current falls within the permitted limits of all tubes.

The minimum supply voltage V_b necessary for ignition of all tubes in the series chain is V_{ign} max. + (n-1) V_m max., provided that a resistor R is connected across one or more of the tubes (See fig.2). These resistors should have a value of the order of 100 kΩ to 1 MΩ.

4.3 Parallel operation

It is not advisable to connect stabilizers in parallel because of the difficulty of ensuring equal current distribution.

7Z2 5085

LIST OF SYMBOLS

Ignition voltage (breakdown voltage)	V_{ign}
Extinguishing voltage	V_{ext}
Maintaining voltage	V_m
Regulation voltage	V_r
Jump voltage	V_j
Noise voltage	V_n
Average cathode current	I_k
Cathode starting current	I_{ko}
Incremental resistance	r_a
Tube impedance	z_a
Bulb or envelope temperature	t_{bulb}
Temperature coefficient of maintaining voltage	$\frac{\Delta V_m}{\Delta t_{bulb}}$
Ambient temperature	t_{amb}
Shunt capacitance	C_p

7Z2 5079

RATING SYSTEM

(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.

7Z2 5065

VOLTAGE STABILIZING TUBE

150 volts gas-filled voltage stabilizing tube with a current range of 5 to 30 mA.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 5 to 30 mA)	V_r	=	2	V
Incremental resistance (I_k = 20 mA)	r_a	=	80	Ω

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C. [1]

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	= max.		180	V
Maintaining voltage at I_k = 17.5 mA	V_m	= 144	to	160	V
Regulation voltage at I_k = 5 to 30 mA	V_r	= max.		6	V

LIMITING VALUES (Absolute maximum rating system)

Cathode current	I_k	= min.	5	mA
		= max.	30	mA
Starting current	I_{k_p}	= max.	75	mA [2]
Negative peak anode voltage	$-V_{a_p}$	= max.	125	V
Ambient temperature	t_{amb}	= min.	-55	°C
		= max.	+90	°C

CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a	= min.	185	V [3]
Shunt capacitor	C_p	= max.	0.1	µF

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

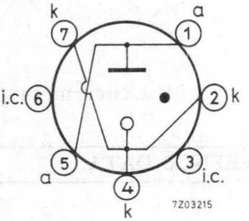
[2]) To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 m after passing this current.

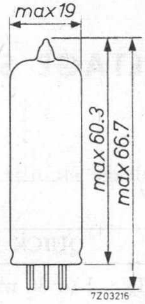
[3]) This value holds good over life.

7Z2 5102

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





7Z2 5103

VOLTAGE STABILIZING TUBE

150 volts gas-filled voltage stabilizing tube with a current range of 5 to 30 mA. The OA2WA is shock and vibration resistant.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 5 to 30 mA)	V_r	=	2	V
Incremental resistance (I_k = 20 mA)	r_a	=	80	Ω

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max. 165	V
Maintaining voltage at I_k = 5 to 30 mA	V_m	=	144 to 153	V
Regulation voltage at I_k = 5 to 30 mA	V_r	=	max. 5	V

Typical limits (initial values)

Incremental resistance at I_k = 20 mA	r_a	=	max. 200	Ω
Jump voltage at I_k = 5 to 30 mA	V_j	=	max. 600	mV
Vibration noise voltage				
I_k = 20 mA, R_a = 10 kΩ, g = 2.5, f = 25 Hz	V_n	=	max. 100	mV
Leakage current				
V = 50 V, R_a = 3 kΩ	I_{isol}	=	max. 5	μA

Life performance

For continuous operation at I_k = 20 mA and at room temperature.

Typical maximum variation in maintaining voltage 0 to 1 hour	ΔV_m	=	max. 2	V

1) Thermal equilibrium is reached within 3 minutes of igniting the tube.

7Z2 5104

Life performance (continued)

For operation at I_k = 20 mA and t_{bulb} = 150 °C

Maintaining voltage at I_k = 5 to 30 mA

0 to 500 hours	V_m	=	142 to 155 V
0 to 1000 hours	V_m	=	140 to 158 V

Typical maximum variation in maintaining voltage at I_k = 20 mA

0 to 500 hours	ΔV_m	=	max. 6 V
0 to 1000 hours	ΔV_m	=	max. 8 V

Typical maximum regulation voltage

0 to 500 hours	V_r	=	max. 6 V
0 to 1000 hours	V_r	=	max. 8 V

SHOCK AND VIBRATION RESISTANCE

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

Shock resistance: 900 g

Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 60 ° in each of 4 different positions of the tube.

Vibration resistance: 2.5 g_{peak}

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

LIMITING VALUES (Absolute max. rating system)

Cathode current	I_k	=	min.	5	mA
		=	max.	30	mA
Starting current	I_{k_p}	=	max.	75	mA [1])
Negative peak anode voltage	$-V_{a_p}$	=	max.	125	V
Temperature during operation	t_{amb}	=	min.	-55	°C
	t_{bulb}	=	max.	150	°C
Altitude	h	=	max.	36	km

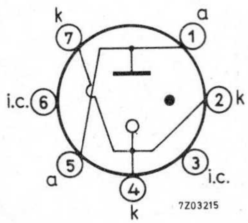
[1]) To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 min. after passing this current. 7Z2 5105

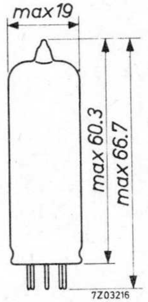
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a	= min. 165 V [1]
Shunt capacitor	C_p	= max. 0.1 μF

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





[1]) This value holds good over life.

7Z2 5106

VOLTAGE STABILIZING TUBE

108 volts gas-filled voltage stabilizing tube with a current range of 5 to 30 mA.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 5 to 30 mA)	V_r	=	2	V
Incremental resistance (I_k = 20 mA)	r_a	=	80	Ω

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C. [1]

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	= max.	127	V
Maintaining voltage at I_k = 17.5 mA	V_m	= 106 to	111	V
Regulation voltage at I_k = 5 to 30 mA	V_r	= max.	3.5	V

Life performance

Typical maximum variation in maintaining voltage.

For continuous operation at I_k = 17.5 mA

0 to 500 hours	ΔV_m	= max.	4	V

LIMITING VALUES (Absolute maximum rating system)

Cathode current	I_k	= min.	5	mA
		= max.	30	mA
Starting current	I_{k_p}	= max.	75	mA [2]
Negative peak anode voltage	$-V_{a_p}$	= max.	75	V
Ambient temperature	t_{amb}	= min.	-55	°C
		= max.	+90	°C

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[1] Thermal equilibrium is reached within 3 minutes of igniting the tube.

[2] To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

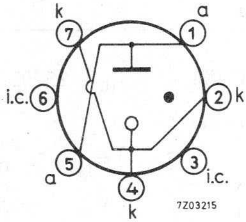
7Z2 5099

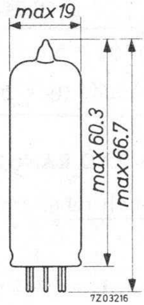
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a = min.	133 V [3]
Shunt capacitor	C_p = max.	0.1 μF

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





[3]) This value holds good over life.

7Z2 5100

VOLTAGE STABILIZING TUBE

108 volts gas-filled voltage stabilizing tube with a current range of 5 to 30 mA. The OB2WA is shock and vibration resistant.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 5 to 30 mA)	V_r	=	2	V
Incremental resistance (I_k = 20 mA)	r_a	=	80	Ω

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max. 130	V
Maintaining voltage at I_k = 5 to 30 mA	V_m	=	105 to 111	V
Regulation voltage at I_k = 5 to 30 mA	V_r	=	max. 2.5	V

Typical limits (initial values)

Incremental resistance at I_k = 20 mA	r_a	=	max. 120	Ω
Jump voltage at I_k = 5 to 30 mA	V_j	=	max. 100	mV
Vibration noise voltage I_k = 20 mA, R_a = 10 kΩ, g = 2.5, f = 25 Hz	V_n	=	max. 100	mV
Leakage current V = 50 V, R_a = 3 kΩ	I_{isol}	=	max. 5	μA

Life performance

For continuous operation at I_k = 20 mA and at room temperature.

Typical maximum variation in maintaining voltage 0 to 1 hour	ΔV_m	=	max. 2	V

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

7Z2 5097

Life performance (continued)

For operation at I_k = 20 mA and t_{bulb} = 150 °C

Maintaining voltage at I_k = 5 to 30 mA

0 to 500 hours	V_m	=	103 to 113	V
0 to 1000 hours	V_m	=	103 to 116	V

Typical maximum variation in maintaining voltage at I_k = 20 mA

0 to 500 hours	ΔV_m	=	max.	4	V
0 to 1000 hours	ΔV_m	=	max.	5	V

Typical maximum regulation voltage

0 to 500 hours	V_r	=	max.	3	V
0 to 1000 hours	V_r	=	max.	4	V

SHOCK AND VIBRATION RESISTANCE

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

Shock resistance: 900 g

Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 60 ° in each of 4 different positions of the tube.

Vibration resistance: 2.5 g_{peak}

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

LIMITING VALUES (Absolute max. rating system)

Cathode current	I_k	=	min.	5	mA
		=	max.	30	mA
Starting current	I_{k_p}	=	max.	75	mA [1]
Negative peak anode voltage	$-V_{a_p}$	=	max.	75	V
Temperature during operation	t_{amb}	=	min.	55	°C
	t_{bulb}	=	max.	150	°C

[1] To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 min. after passing this current.

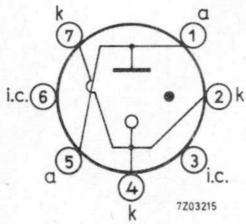
7Z2 5098

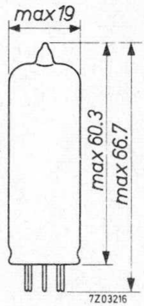
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a	=	min. 130	V [1]
Shunt capacitor	C_p	=	max. 0.1	μF

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





[1] This value holds good over life.

7Z2 5101

VOLTAGE REFERENCE TUBE

81 volts gas-filled voltage reference tube. The ZZ 1000 is shock and vibration resistant.

QUICK REFERENCE DATA				
Preferred cathode current	I_k	=	3.2	mA
Maintaining voltage	V_m	=	81	V
Incremental resistance	r_a	=	200	Ω
Temperature coefficient of maintaining voltage averaged over the range +20 to +125 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	-1.2	mV/°C
averaged over the range −55 to +20 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	-3.2	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 20 to 30 °C. [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	= max.	115	V
Maintaining voltage at I_k = 3.2 mA	V_m	=	80.1 to 82.5	V
Incremental resistance	r_a	= max.	400	Ω

Typical limits (initial values)

Jump voltage at I_k = 2.0 to 4.0 mA	V_j	= max.	100	mV [2])
Ignition delay in darkness at V_b = 115 V		= max.	5	ms
Tube impedance at I_k = 2.7 to 3.7 mA sinusoidal variation with 50 Hz	z_a	= max.	400	Ω

[1]) Thermal equilibrium is reached within 2 minutes of igniting the tube.

[2]) To avoid jump voltages over life, current variations around the preferred current should be limited to 0.3 mA.

7Z2 5226

CHARACTERISTICS AND RANGE VALUES (continued)

Typical limits (initial values) (continued)

Noise voltages

oscillation + random at I_k = 2 to 4 mA frequency band 10 Hz to 10 kHz	V_n	= max.	1	mV
vibration at I_k = 3.2 mA, g = 2.5 g_p f = 10 to 50 Hz , frequency band 1 to 100 Hz	V_n	= max.	100	mV

Temperature coefficient of maintaining voltage at I_k = 3.2 mA

averaged over the range +20 to +125 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	= max.	-2	mV/°C
averaged over the range −55 to +20 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	= max.	-4	mV/°C

Life performance

Typical maximum variation in maintaining voltage

For continuous operation at preferred current

Bulb temperature	t_{bulb}	=	45	°C
0 to 100 hours	ΔV_m	=	0.3	V
0 to 2000 hours	ΔV_m	=	0.7	V

For storage and stand-by

Bulb temperature	t_{bulb}	=	25	°C
0 to 2000 hours	ΔV_m	=	0.3	V

SHOCK AND VIBRATION RESISTANCE

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

Shock resistance: 500 g

Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30° in each of 4 different positions of the tube.

Vibration resistance: 2.5 g_{peak}

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

7Z2 5227

LIMITING VALUES (Absolute maximum rating system)

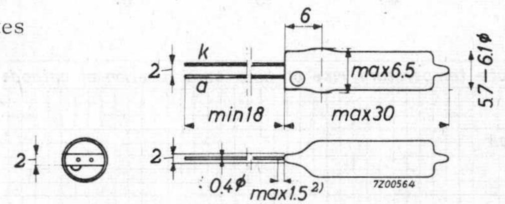
Cathode current	I_k	= max.	4.0	mA [1]
		= min.	2.0	mA
Starting current, $T_{max.}$ = 20 s	I_{k_p}	= max.	20	mA
Negative peak anode voltage	$-V_{a_p}$	= max.	100	V
Bulb temperature				
during operation	t_{bulb}	= min.	-55	°C
		= max.	+125	°C
during storage and stand-by	t_{bulb}	= min.	-55	°C
		= max.	+100	°C

CIRCUIT DESIGN VALUES

Minimum voltage to ensure ignition	V_a	= min.	120	V
Shunt capacitor	C_p	= max.	30	nF

DIMENSIONS AND CONNECTIONS

Glass dot indicates anode lead



MOUNTING

The tube may be soldered directly into the circuit but heat conducted to the glass to metal seal should be kept to a minimum by the use of a thermal shunt.

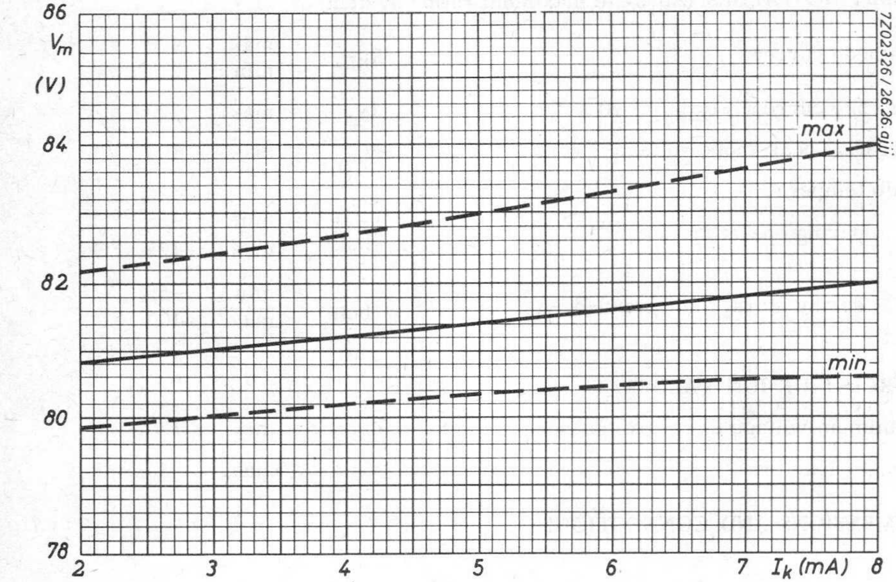
The tube may be dip-soldered at a solder temperature of max. 240 °C for a maximum of 10 seconds up to a point 5 mm from the seal.

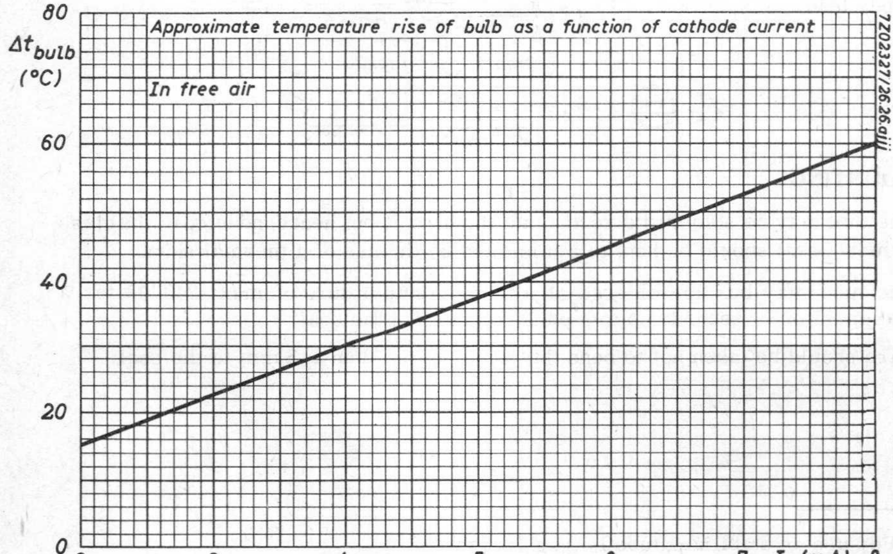
Care should be taken not to bend the leads nearer than 1.5 mm to the seal.

[1])For use as stabilizer tube $I_{k\,max.}$ = 8 mA
At cathode currents between 2 and 8 mA jump voltages of 0.5 V may occur.

[2])Max. 1.5 mm not tinned.

7Z2 5228


86
V_m
(V)
84
82
80
78
max
min
2
3
4
5
6
7
I_k (mA)
8
7Z02326 / 26.26.aiji


Approximate temperature rise of bulb as a function of cathode current
In free air
80
Δt_{bulb}
(°C)
60
40
20
0
2
3
4
5
6
7
I_k (mA)
8
7Z02327/26.26.aiji

VOLTAGE STABILIZING TUBE

78 volts gas-filled voltage stabilizing tube with a current range of 2 to 60 mA.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 2 to 60 mA)	V_r	=	5	V
Incremental resistance	r_a	=	130	Ω
Temperature coefficient of maintaining voltage averaged over the range 25 to 90 °C				
I_k = 30 mA	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	-8.3	mV/°C
I_k = 10 mA	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	-1.8	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max. 115	V
Maintaining voltage at I_k = 30 mA	V_m	=	75 to 81	V
Regulation voltage at I_k = 2 to 60 mA	V_r	=	max. 8	V [2])

Typical limits (initial values)

Incremental resistance at I_k = 10 mA to 60 mA	r_a	=	max. 200	Ω
Jump voltage at I_k = 2 to 20 mA	V_j	=	max. 100	mV
at I_k = 20 to 60 mA	V_j	=	max. 15	mV
Cathode current above which the incremental resistance is positive	I_k	=	max. 7	mA

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

[2]) Following a sudden change in the tube current the regulation voltage may be up to 2.5 V greater than that given until tube thermal equilibrium is re-established.

7Z2 5107

CHARACTERISTICS AND RANGE VALUES (continued)

Life performance

Typical maximum regulation voltage and range of variation in maintaining voltage.

For continuous operation at I_k = 30 mA and t_{bulb} = 60 °C

0 to 1000 hours	ΔV_m	= max.	-0.2 to +0.9	%
0 to 10 000 hours	ΔV_m	= max.	-0.2 to +1.0	%
0 to 30 000 hours	ΔV_m	= max.	-0.2 to +1.2	%
Regulation voltage after 30 000 hours	V_r	= max.	6.5	V

For continuous operation at I_k = 60 mA and t_{bulb} = 90 °C

0 to 1000 hours	ΔV_m	= max.	-0.7 to +1.2	%
0 to 10 000 hours	ΔV_m	= max.	-0.7 to +1.4	%
0 to 30 000 hours	ΔV_m	= max.	-0.7 to +2.0	%
Regulation voltage after 30 000 hours	V_r	= max.	6.5	V

LIMITING VALUES (Absolute max. rating system)

Cathode current	I_k	= min.	2	mA
		= max.	60	mA
Starting current	I_{k_p}	= max.	100	mA [1]
Negative peak anode voltage	$-V_{a_p}$	= max.	50	V
Bulb temperature				
during operation	t_{bulb}	= min.	-55	°C
		= max.	+140	°C [2]
during storage	t_{bulb}	= min.	-55	°C
		= max.	+70	°C

[1] To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

[2] Temperature rise of bulb above ambient approx. 40 °C at I_k = 30 mA and approx. 70 °C at I_k = 60 mA.
The tube will operate satisfactorily at bulb temperature up to 140 °C provided the tube is not used at either extreme of the current range.

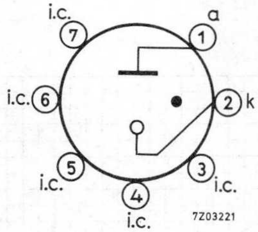
7Z2 5108

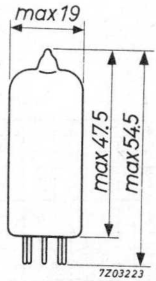
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition V_a = min. 115 V [1]

DIMENSIONS AND CONNECTIONS

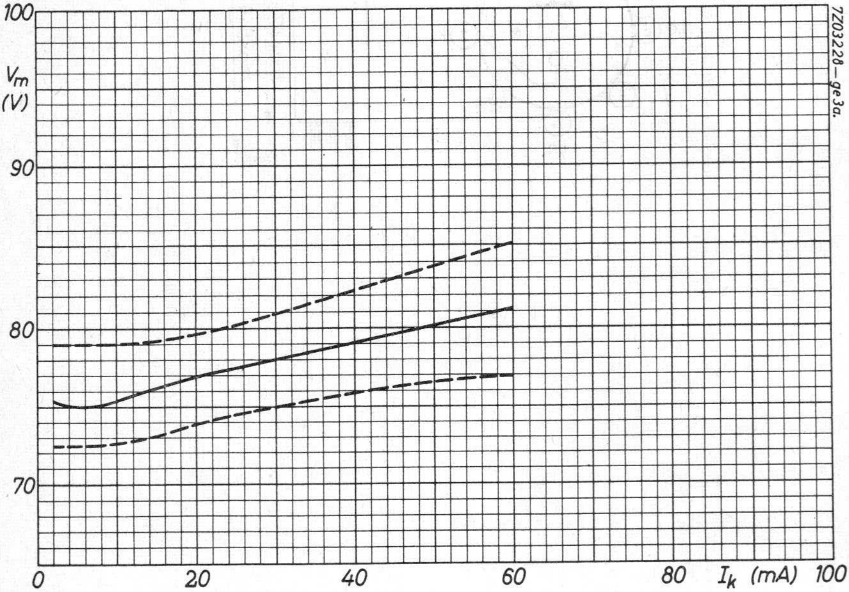
Base: 7 pin miniature





[1]) This value holds good over life.

7Z2 5109



7Z03228-ge3a.
100
V_m
(V)
90
80
70
0
20
40
60
80
I_k (mA)
100

VOLTAGE REFERENCE TUBE

83 volts gas-filled voltage reference tube.

QUICK REFERENCE DATA				
Preferred cathode current	I_k	=	4.5	mA
Maintaining voltage	V_m	=	83.7	V
Incremental resistance	r_a	=	250	Ω
Temperature coefficient of maintaining voltage averaged over the range 25 to 120 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	−2.5	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 20 to 30 °C [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max.	120	V
Maintaining voltage at I_k = 4.5 mA	V_m	=		83.0 to 84.5	V
Incremental resistance	r_a	=	max.	350	Ω

Typical limits (initial values)

Jump voltage at I_k = 3.5 to 6.0 mA	V_j	=	max.	1	mV
Ignition delay in darkness at V_b = 130 V			max.	5	s
Temperature coefficient of maintaining voltage averaged over the range 25 to 120 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	max.	−4	mV/°C

See also sheet A

1) Thermal equilibrium is reached within 1 minute of igniting the tube. 7Z2 5092

CHARACTERISTICS AND RANGE VALUES (continued)

Life performance

Typical maximum variation in maintaining voltage

For continuous operation at preferred current

Bulb temperature		=	25	100	150	°C
0 to 300 hours	ΔV_m	=	+0.4	+0.4	+2.4	%
300 to 2500 hours	ΔV_m	=	+0.25	+0.25	-2.5 to +4.7	%
300 to 10 000 hours	ΔV_m	=	+0.4	+0.4		

For storage and stand-by

Bulb temperature		=	25	100 [1]	°C
0 to 500 hours	ΔV_m	=	negligible	2	%
0 to 3000 hours	ΔV_m	=	negligible	7	%

LIMITING VALUES (Absolute max. rating system)

Cathode current	I_k	=	max.	6.0	mA
		=	min.	3.5	mA
Starting current, $T_{max.}$ = 30 s [2]	I_{k_p}	=	max.	10	mA
Negative peak anode voltage	$-V_{a_p}$	=	max.	50	V
Bulb temperature					
during operation	t_{bulb}	=	min.	-55	°C
		=	max.	150	°C [3]
during storage and stand-by	t_{bulb}	=	min.	-55	°C
		=	max.	100	°C

[1]) Subsequent operation of the tube for approximately 50 hours at I_k = 4.5 mA at not more than 100 °C will restore the maintaining voltage to within 0.2 V of its original value.

[2]) To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

[3]) Temperature rise above ambient approx. 20 °C at I_k = 4.5 mA.

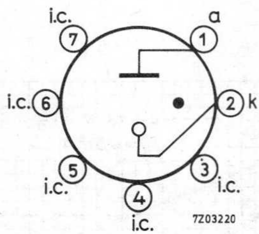
7Z2 5093

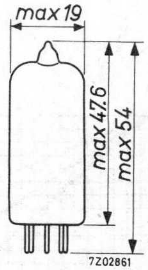
CIRCUIT DESIGN VALUES

Minimum voltage to ensure ignition [1]	V_a	=	min. 130 V
Shunt capacitor	C_p	=	max. 0.1 μF

DIMENSIONS AND CONNECTIONS

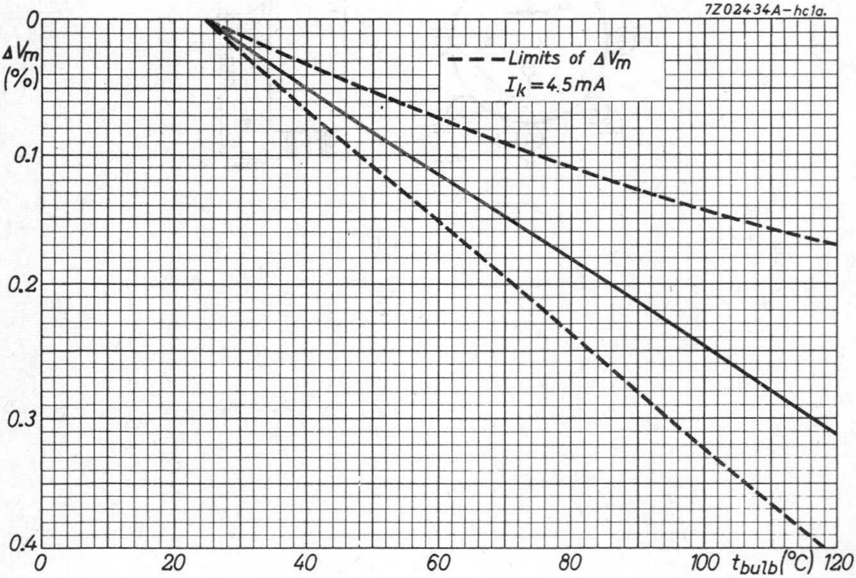
Base: 7 pin miniature





[1]) This value holds good over life, in light and darkness.

7Z2 5094


7Z02434A-hc1a.
0
ΔVm
(%)
0.1
0.2
0.3
0.4
0
20
40
60
80
100
t_{bulb}(°C)
120
– – – Limits of ΔVm
$I_k = 4.5$ mA

VOLTAGE REFERENCE TUBE

85 volts gas-filled voltage reference tube.

QUICK REFERENCE DATA				
Preferred cathode current	I_k	=	5.5	mA
Maintaining voltage	V_m	=	85	V
Incremental resistance	r_a	=	300	Ω
Temperature coefficient of maintaining voltage averaged over the range -55 to +90 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	-2.7	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 20 to 30 °C. [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max. 115	V
Maintaining voltage at I_k = 5.5 mA	V_m	=	83 to 87	V
Incremental resistance	r_a	=	max. 450	Ω

Typical limits (initial values)

Jump voltage at I_k = 4 to 10 mA	V_j	=	max. 50	mV
Temperature coefficient of maintaining voltage averaged over the range -55 to +90 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	max. -4	mV/°C

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

7Z2 5089

CHARACTERISTICS AND RANGE VALUES (continued)

Life performance

Typical maximum variation in maintaining voltage

For continuous operation at preferred current

Bulb temperature		=	35	°C
0 to 300 hours	ΔV_m	=	0.3	%
300 to 1000 hours	ΔV_m	=	0.2	%
Each period of 1000 hours after 1300 hours	ΔV_m	=	0.1	%

For storage and stand-by

Bulb temperature			25	°C
0 to 5000 hours	ΔV_m	=	0.1	%

LIMITING VALUES (Absolute max. rating system)

Cathode current	I_k	= max.	10	mA	
		= min.	1	mA	
Starting current, $T_{max.}$ = 30s 1)	I_{k_p}	= max.	40	mA	
Negative peak anode current	$-V_{a_p}$	= max.	75	V	
Bulb temperature					
during operation	t_{bulb}	= min.	-55	°C	
		= max.	+90	°C	2)
during storage and stand-by	t_{bulb}	= min.	-55	°C	
		= max.	+70	°C	

CIRCUIT DESIGN VALUES

Minimum voltage to ensure ignition 3)	V_a	= min.	120	V
Shunt capacitor	C_p	= max.	0.1	μF

1) To be restricted for long life to approx. 30 s once or twice in each 8 hours use.

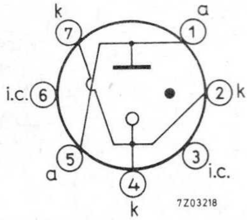
2) Temperature rise of bulb above ambient approx. 15 °C at I_k = 5.5 mA

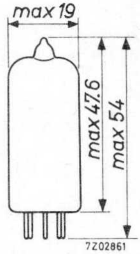
3) This value holds good over life.

7Z2 5090

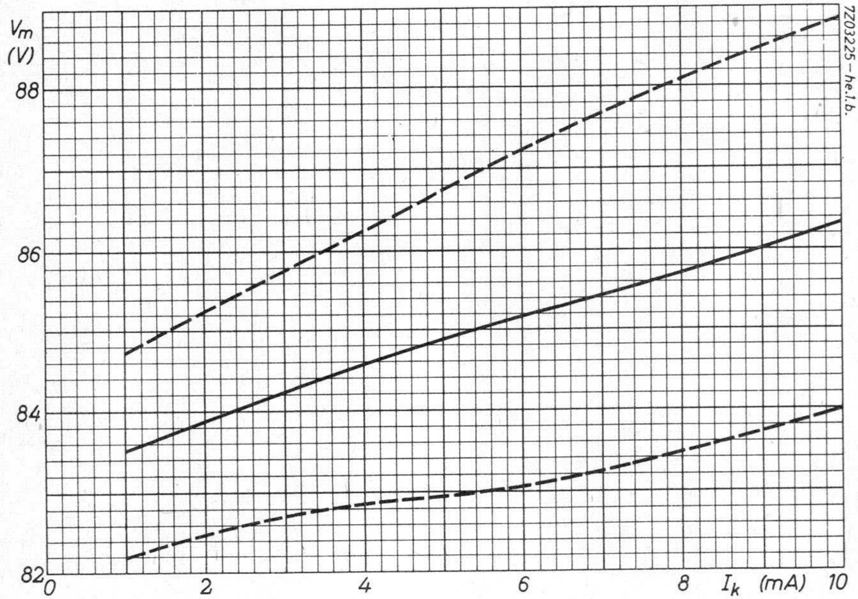
DIMENSIONS AND CONNECTIONS

Base : 7 pin miniature





7Z2 5091



Vm
(V)
88
86
84
82
0
2
4
6
8
Ik (mA)
10
7Z03225-he.1.b.

VOLTAGE STABILIZING TUBE

90 volts gas-filled voltage stabilizing tube with a current range of 1 to 40 mA.

QUICK REFERENCE DATA				
Regulation voltage (I_k = 1 to 40 mA)	V_r	=	12	V
Incremental resistance (I_k = 20 mA)	r_a	=	300	Ω
Temperature coefficient of maintaining voltage averaged over the range −55 to +110 °C I_k = 20 mA	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	−2.7	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	=	max.	115	V
Maintaining voltage at I_k = 20 mA	V_m	=	86 to	94	V
Regulation voltage at I_k = 1 to 40 mA	V_r	=	max.	14	V [2])

Typical limits (initial values)

Incremental resistance at I_k = 20 mA	r_a	=	max.	350	Ω
Jump voltage at I_k = 1 to 40 mA	V_j	=	max.	100	mV

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

[2]) Following a sudden large change in tube current, the regulation voltage may be slightly greater than that given until thermal equilibrium is re-established.

7Z2 5086

CHARACTERISTICS AND RANGE VALUES (continued)

Life performance

Typical maximum regulation voltage and range of variation in maintaining voltage

For continuous operation at I_k = 20 mA and t_{bulb} = 60 °C

0 to 1000 hours	ΔV_m	= max.	1	%
0 to 10 000 hours	ΔV_m	= max.	3.5	%
Regulation voltage after 1000 hours	V_r	= max.	14	V
Regulation voltage after 10 000 hours	V_r	= max.	15	V

For continuous operation at I_k = 40 mA and t_{bulb} = 70 °C

0 to 1000 hours	ΔV_m	= max.	4	%
0 to 10 000 hours	ΔV_m	= max.	5	%
Regulation voltage after 1000 hours	V_r	= max.	14	V
Regulation voltage after 10 000 hours	V_r	= max.	15	V

For storage at t_{bulb} = 25 °C

0 to 5000 hours	ΔV_m	= max.	0.1	%

LIMITING VALUES (Absolute maximum rating system)

Cathode current	I_k	= min.	1	mA
		= max.	40	mA
Starting current	I_{k_p}	= max.	100	mA [3]
Negative peak anode voltage	$-V_{a_p}$	= max.	75	V
Bulb temperature during operation	t_{bulb}	= min.	-55	°C
		= max.	+110	°C [4]
Bulb temperature during storage	t_{bulb}	= min.	-55	°C
		= max.	+70	°C

[3]) To be restricted for long life to approximately 30s once or twice in each 8 hours use.

[4]) Temperature rise of bulb above ambient approx. 50 °C at I_k = 40 mA. The tube will operate satisfactorily at bulb temperatures up to 110 °C provided the tube is not used at either extreme of the current range.

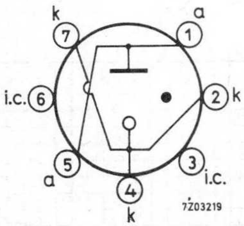
7Z2 5087

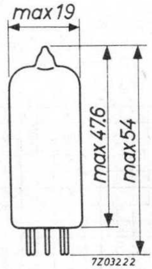
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a	= min.	120	V [1])
Shunt capacitor	C_p	= max.	0.1	μF

DIMENSIONS AND CONNECTIONS

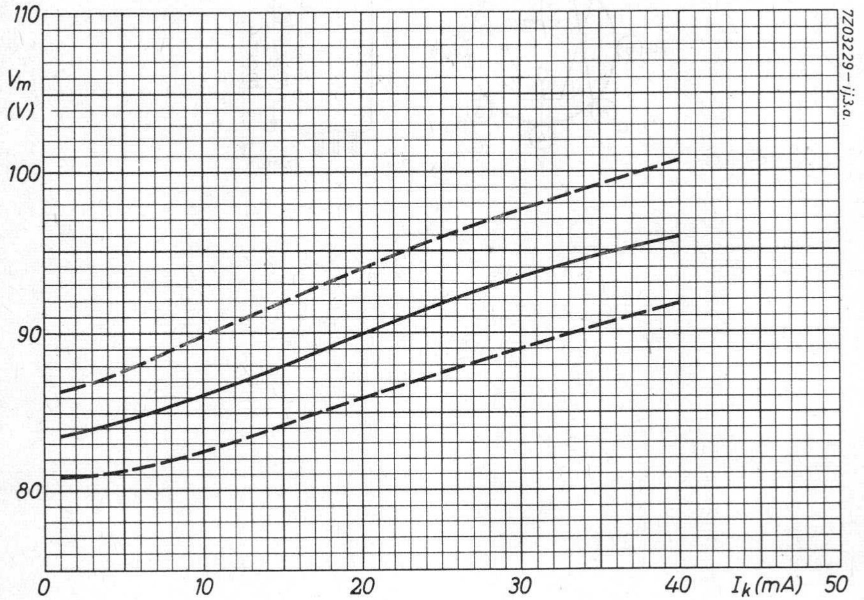
Base 7 pin miniature





1) This value holds good over life

7Z2 5088


110
V_m
(V)
100
90
80
0
10
20
30
40
I_k (mA)
50
7Z03229 - ij3a.

VOLTAGE STABILIZING TUBE

150 volts gas-filled voltage stabilizing tube with a current range of 5 to 15 mA.

QUICK REFERENCE DATA

Regulation voltage (I_k = 5 to 15 mA)	V_r	=	3.5	V
Incremental resistance (I_k = 10 mA)	r_a	=	350	Ω
Temperature coefficient of maintaining voltage averaged over the range −55 to +110 °C I_k = 10 mA	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	10	mV/°C

CHARACTERISTICS AND RANGE VALUES at t_{amb} = 25 °C. [1])

Limits applicable to all tubes (initial values)

Ignition voltage	V_{ign}	= max.	180	V
Maintaining voltage at I_k = 10 mA	V_m	=	146 to 154	V
Regulation voltage at I_k = 5 to 15 mA	V_r	= max.	5	V

Typical limits (initial values)

Incremental resistance at I_k = 10 mA	r_a	= max.	400	Ω
Jump voltage at I_k = 5 to 15 mA	V_j	= max.	200	mV

Life performance

Typical maximum regulation voltage and range of variation in maintaining voltage.

For continuous operation at I_k = 10 mA and t_{bulb} = 60 °C

0 to 1000 hours	ΔV_m	= max.	1.5	%
0 to 10 000 hours	ΔV_m	= max.	2	%
Regulation voltage after 1000 hours	V_r	= max.	5	V
Regulation voltage after 10 000 hours	V_r	= max.	6	V

[1]) Thermal equilibrium is reached within 3 minutes of igniting the tube.

7Z2 5095

CHARACTERISTICS AND RANGE VALUES (continued)

For continuous operation at I_k = 15 mA and t_{bulb} = 70 °C

0 to 1000 hours	ΔV_m	= max.	2	%
Regulation voltage after 1000 hours	V_r	= max.	5	V

For storage at t_{bulb} = 25 °C

0 to 5000 hours	ΔV_m	= max.	0.3	%

LIMITING VALUES (Absolute maximum rating system)

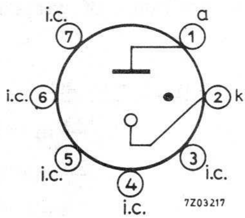
Cathode current	I_k	= min.	5	mA
		= max.	15	mA
Starting current	I_{kp}	= max.	40	mA [1]
Negative peak anode voltage	$-V_{a_p}$	= max.	130	V
Bulb temperature				
during operation	t_{bulb}	= min.	-55	°C
		= max.	+110	°C [2]
during storage	t_{bulb}	= min.	-55	°C
		= max.	+70	°C

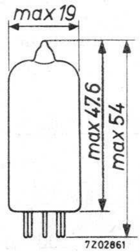
CIRCUIT DESIGN VALUES

Minimum voltage necessary for ignition	V_a	= min.	180	V [3]
Shunt capacitor	C_p	= max.	0.1	μF

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





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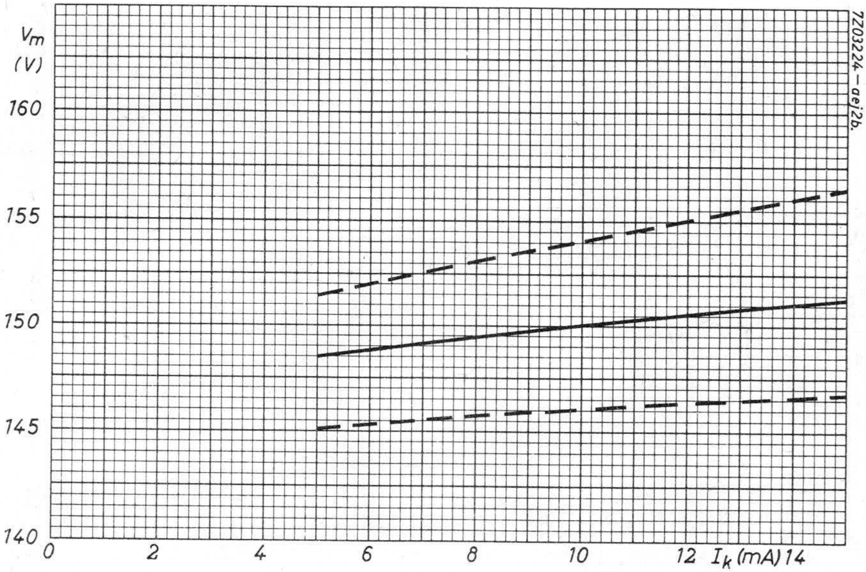
[1] To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

[2] Temperature rise of bulb above ambient approx. 50 °C at I_k = 15 mA

[3] This value holds good over life.

7Z2 5096



V_m (V)
160
155
150
145
140
0
2
4
6
8
10
12
I_k (mA)
14
7Z03224 - aej2b.

Counter-, Selector- and indicator tubes

COUNTER-AND SELECTOR TUBES
APPLICATION DIRECTIONS

CONSTRUCTION

The counter and selector tubes consist of 30 identical rod-shaped cathodes arranged in a circle concentric with the common circular plate anode. The 30 cathodes are devided into three groups of ten and arranged so that every third electrode going around the ring belongs to the same group. The three groups are called main cathodes, guide A cathodes, and guide B cathodes. The order of the electrodes proceeding in a clockwise direction around the tube as seen from the dome is a main cathode, a guide A cathode, guide B cathode, next main cathode etc.

In both the counter tube and the selector tube all the guide A electrodes are connected internally and brought out to a single pin. The guide B electrodes are similarly connected and brought out. In the counter tube the main cathodes 1 to 9 are connected together internally and connected to a single pin. The 0 or tenth main cathode is brought out separately so that the tube can be set to zero and also an electrical output obtained for driving a succeeding tube. In the selector tube all the main cathodes are brought out individually so that an electrical output pulse can be obtained at any point around the tube.

FUNCTION OF THE ELECTRODE GROUPS

Main cathodes

The glow normally rests on a main cathode thus providing indication, and electrical output may also be obtained from this cathode. The position of the discharge may be seen through the dome of the tube as an orange 'cathode glow' at the tip of the cathode concerned. The position of the discharge can be related to the number of input pulse by the use of an external numbered escutcheon aligned so that the numbers coincide with the position of the main cathodes.

Guide cathodes (A and B)

The function of the guide cathodes is to transfer the discharge from one main cathode to the next on the receipt of an input signal.

7Z2 5229

BASIC CIRCUIT

The basic circuit is shown in Figure 1 on the individual data sheets and is essentially the same for both counter and selector tubes. An h.t. voltage, normally 475 V, (which is greater than the anode-cathode ignition voltage) is applied to the circuit and breakdown to one of the main cathodes will, therefore, occur. Breakdown to more than one cathode cannot occur since conduction causes a voltage drop across the anode resistor and reduces the anode voltage across the tube to the maintaining voltage.

THE TRANSFER MECHANISM

The method usually employed to move the discharge around the tube is to convert the input signal into a pair of negative pulses. The first pulse is applied to all guide A cathodes followed immediately by the second pulse applied to all guide B cathodes.

Assume that the discharge is resting on the third main cathode k_3: when the pulse is applied to guides A the voltage between anode and guides A exceeds the ignition voltage and breakdown can therefore occur. Because of the priming from the discharge to the conducting main cathode k_3, breakdown will always occur to the adjacent guide A cathode GA_4. The discharge to k_3 will be extinguished since the anode voltage falls by the magnitude of the applied negative pulse. Similarly breakdown to GB_4 will take place on the arrival of the second pulse and the potential of guides A will return to the bias level. Finally at the end of the second pulse the potential of guides B will also return to the bias level. The anode voltage rises towards a potential equal to the guide bias plus the maintaining voltage. However, when the anode to k_4 voltage exceeds the ignition value the discharge will move to k_4 and the transfer has then been completed. This sequence results in rotation in the clockwise direction. Counting in the anti-clockwise direction can be obtained by applying pulses to guides A and B in the reverse order.

7Z2 5230

OUTPUT PULSE

A resistor is connected in series with k_o (in Figure 1) so that an output pulse can be obtained when the discharge rests on k_o. This resistor must be chosen so that when the glow rests on k_o, the voltage on k_o does not exceed the positive guide bias. It is common practice to take the earthy end of the resistor back to a negative bias supply to obtain a larger pulse. However, the magnitude of the bias should not at any time be more negative than −20 volts.

In the selector tube an output can be obtained by inserting a resistor in series with any of the main cathodes.

The maximum value of the main cathode resistor for either selector or counter is given by

$$R_{k\,max.} = \frac{(V_G + V_k - 10)\, R_a}{(V_{ht} - V_M - V_G + 10)}$$

and the output voltage for any value of R_k is

$$V_{out} = \frac{(V_{ht} - V_M + V_k)\, R_k}{(R_k + R_a)}$$

where V_{ht} is the supply voltage
V_M is the maintaining voltage
V_G is the positive guide bias
V_k is bias to k_o (numerical value only)
R_k is the cathode resistor
R_a is the anode resistor

SET ZERO

The discharge can conveniently be returned to k_o by momentarily disconnecting all cathodes except k_o. An alternative method is to pulse k_o negatively to −120 volts. Care must be taken if this method is adopted that spurious pulses are not fed down the chain of counter tubes at the termination of the pulse.

7Z2 5231

COLD CATHODE INDICATOR TUBES

TERMS AND DEFINITIONS

1. Indicator tube.
An indicator tube is a glow discharge tube designed to give a visual indication of the presence of an electrical signal.

A numerical indicator tube is one in which the indication is given in the form of numerals.

In a point indicator tube the indication is given by the position of the glow.

2. Ignition.

2.1 Ignition voltage (symbol V_{ign})
The ignition voltage is the lowest direct potential, which when applied to a particular anode-cathode gap in the presence of some primary ionisation, will cause a self sustaining discharge to start in that anode-cathode gap.

2.2 Ignition delay.
The ignition delay is the time interval between the application of a direct potential (equal to or exceeding the ignition voltage) to a particular anode-cathode gap and the establishment of a self sustaining discharge in that gap.

The figure quoted applies to a tube which has been inoperative for a time long in comparision with the deionisation time.

3. Maintaining voltage (symbol V_m)
The maintaining voltage is the voltage between an anode and that cathode carrying the main discharge.

4. Extinguishing voltage (symbol V_{ext})
The extinguishing voltage is the voltage between anode and cathode below which the glow discharge extinguishes and is equal to the lowest possible value of the maintaining voltage.

5. "On" cathode.
The "on" cathode is the cathode (numeral) which is required to be displaid and thus carries the main discharge.

6. "Off" cathode.
The "off" cathodes are the cathodes which are not required for display and thus act as probes in the main discharge.

7Z2 5232

7. Cathode selecting voltage (symbol V_{kk})
The cathode selecting voltage is the cathode voltage difference which is used for discrimination between the "off" cathodes and the "on" cathode.

8. Anode selecting voltage (symbol V_{aa})
The anode selecting voltage is the anode voltage difference which is used to select the "on" cathode out of a group of cathodes.

9. Anode to cathode bias voltage (bias voltage) (symbol V_{bias})
The anode to cathode bias voltage is the anode to cathode voltage before any cathode has been ignited. This voltage serves to reduce the required selecting voltage.

10. Shield voltage (symbol V_s)
The shield voltage is the voltage difference between the shield electrode and the "on" cathode and is used to prevent the penetration of the discharge from one compartment into another which is separated from the former by said shield.

11. Cathode current (symbol I_k)
The cathode current is the current flowing to the "on" cathode.

11.1 Minimum cathode current for coverage (symbol $I_{k\,min.}$)
The minimum cathode current is the current necessary to ensure full coverage of the "on" cathode by the glow.

11.2 Maximum cathode current (symbol $I_{k\,max.}$)
The maximum cathode current is the current at which the glow is still restricted to the "on" cathode.
If this current is exceeded the glow may spread to connecting leads or other elements.

12. Probe current (symbol I_{kk})
A probe current is the current flowing to or from an electrode which does not form part of the main discharge gap.
(The magnitude and direction of this current will be dependent on the position of this electrode with respect to the main discharge and on the external circuit conditions).

13. Anode current (symbol I_a)
The anode current is the algebraic sum of cathode current and all probe currents.

14. Life expectancy.
End of life is reached when the characteristics of any one numeral surpass the stated limits.

7Z2 5233

RATING SYSTEM

(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.

7Z2 5065

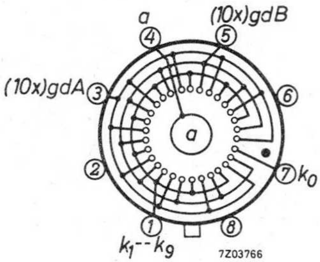
COUNTER TUBE

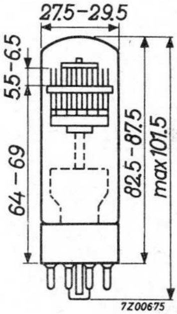
Cold cathode gas-filled bi-directional decade counter tube.
This tube has ten main cathodes, nine of which are brought out together and one separately. The Z303C gives visual indication and operates at speeds up to 4 kHz.

QUICK REFERENCE DATA		
Maximum counting speed	4	kHz
Supply voltage	475	V
Output, current	340	μA
voltage	35	V
Indication	position of glow; end viewing	

DIMENSIONS AND CONNECTIONS

Base: Octal





Mounting position: any

For visual indication the tube is viewed through the dome of the envelope.
k_o is aligned with pin 6 to within $\pm$ 12 ^{o}. The alignment of k_o with pin 6 is defined as the angular tolerance of the tip of the k_o electrode with respect to pin 6 using the vertical axis through the centre of the socket as a reference. This assumes that the tube base sits squarely in the socket.

7Z2 8062

Accessories

Escutcheon type 56063

CHARACTERISTICS

Counting speed (sine or pulse drive)	max.	4	kHz
Time difference between two successive input signals	min.	250	μs
Maintaining voltage at I_k = 300 μA	186 to	196	V
Pulse required for forced resetting to k_o	min.	120	V

OPERATING CONDITIONS

Supply voltage	475	V
Bias voltage on k_o	-12	V
Anode load resistance	820	kΩ
Output cathode load resistance	120	kΩ
Anode current	340	μA
Resultant output pulse	35	V

For double pulse drive

Guide bias	+40	V
Pulse amplitude	100	V
Pulse duration	75	μs

For integrated pulse drive

Guide bias	+40	V
Pulse amplitude	see fig. 1	
Pulse duration	75	μs

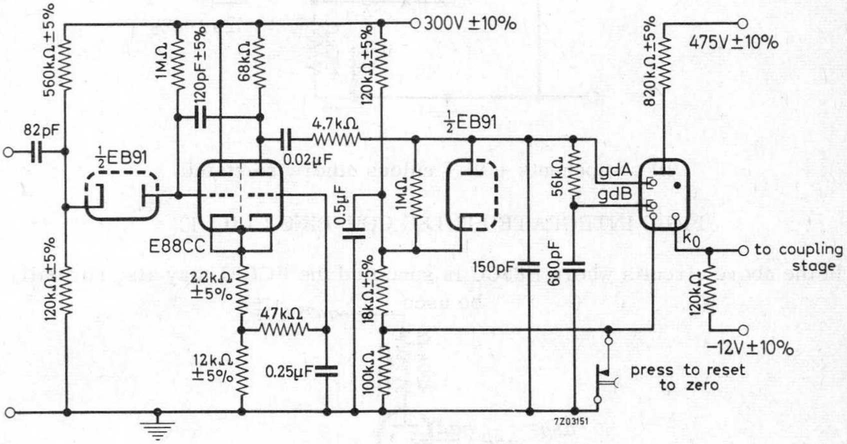
For sine wave drive

Guide bias	+10	V
Sine wave drive voltage (R.M.S.)	40 to 70	V

7Z2 8063

LIMITING VALUES (Absolute max. rating system)

Supply voltage	min. 350	V
Voltage between any two electrodes except anode	max. 140	V
Positive guide bias for pulse drive and integrated pulse drive at 4 kHz	min. +35	V [1]
Negative bias k_o	max. -20	V
Guide pulse duration	min. 65	μs
Main and guide cathode current	max. 550 min. 250	μA μA



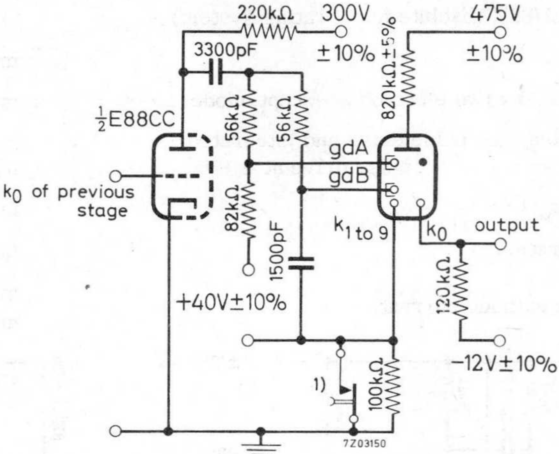
All components ± 10 % unless otherwise stated

FIG.1 INTEGRATED PULSE DRIVE CIRCUIT

Input pulse: Amplitude ≥ 30 V: Rise time $\frac{dV}{dt} \geq 10^8$ V.s

[1]) At lower frequencies a lower value of positive bias can be used down to an absolute minimum of +18 V.

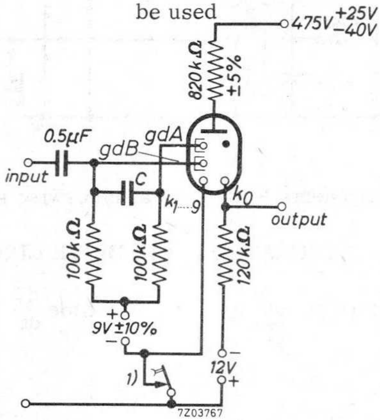
7Z2 8064



All components + 10 % unless otherwise stated

FIG. 2 INTEGRATED PULSE COUPLING CIRCUIT

In the above circuits where E88CC is specified the ECC81 may also normally be used



All components + 10 % unless otherwise stated

Frequency (Hz)	50	100	200	500	1000	2000	4000
Capacitor C (μF)	0.1	0.05	0.02	0.01	0.005	0.002	0.00068

FIG. 3 CIRCUIT FOR SINE WAVE DRIVE

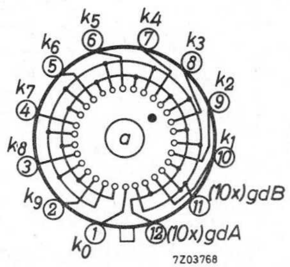
1) Press to reset to zero.

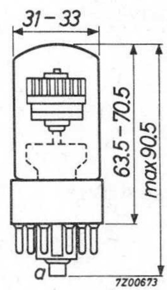
SELECTOR TUBE

Cold cathode gas-filled bi-directional decade selector tube.
This tube has ten main cathodes, all of which are brought out separately.
The Z502S gives visual indication and operates at speeds up to 4 kHz.

QUICK REFERENCE DATA	
Maximum counting speed	4 kHz
Supply voltage	475 V
Output, current	340 μA
voltage	35 V
Indication	position of glow; end viewing

DIMENSIONS AND CONNECTIONS





Mounting position any

For visual indication the tube is viewed through the dome of the envelope. k_1 is aligned with pin 11 to within $\pm 12^o$. The alignment of k_1 with pin 11 is defined as the angular tolerance of the tip of the k_1 electrode with respect to pin 11 using the vertical axis through the centre of the socket as a reference. This assumes that the tube base sits squarely in the socket.

Accessories

Escutcheon type 55064

CHARACTERISTICS

Counting speed (sine or pulse drive)	=	max. 4 kHz
Time difference between two successive input signals	=	min. 250 µs
Maintaining voltage at I_k = 300 µA	=	186 to 196 V
Pulse required for forced resetting to any main cathode	=	min. 120 V

OPERATING CONDITIONS

Supply voltage	=	475 V
Bias voltage on output cathode	=	-12 V
Anode load resistance	=	820 kΩ
Output cathode load resistance	=	120 kΩ
Anode current	=	340 µA
Resultant output pulse	=	35 V

<u>For double pulse drive</u>

Guide bias	=	+40 V
Pulse amplitude	=	100 V
Pulse duration	=	75 µs

<u>For integrated pulse drive</u>

Guide bias	=	+40 V
Pulse amplitude		see fig. 1
Pulse duration	=	75 µs

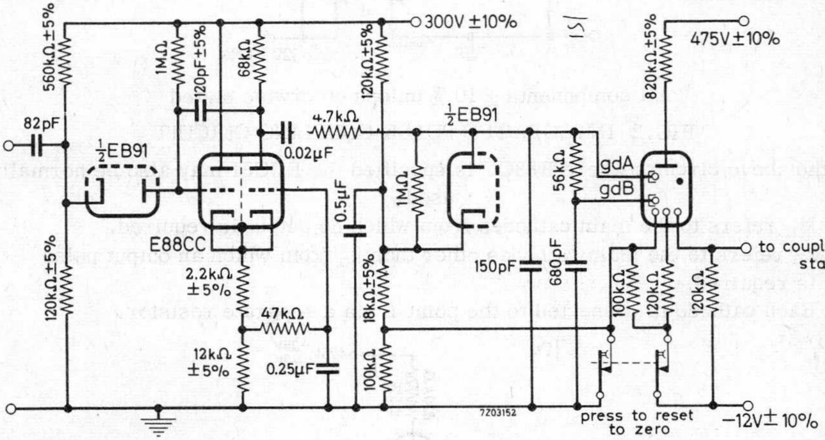
<u>For sine wave drive</u>

Guide bias	=	+10 V
Sine wave drive voltage (R.M.S.)	=	40 to 70 V

7Z2 8067

LIMITING VALUES (Absolute max. rating system)

Supply voltage	= min.	400	V
Voltage between any two electrodes except anode	= max.	140	V
Positive guide bias for pulse drive and integrated pulse drive at 4 kHz	= min.	+35	V [1])
Negative bias to any main cathode	= max.	-20	V
Guide pulse duration	= min.	65	μs
Main and guide cathode current	= max.	550	μA
	= min.	250	μA



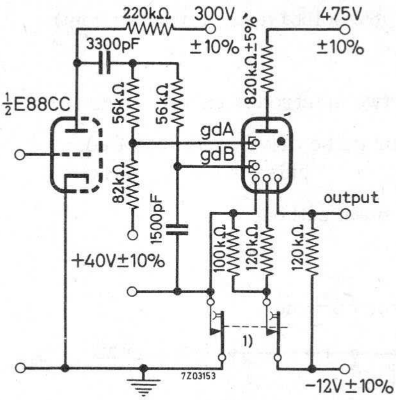
All components + 10 % unless otherwise stated

FIG. 1 INTEGRATED PULSE DRIVE CIRCUIT

Input pulse: Amplitude ≥ 30 V; Rise time $\frac{dV}{dt} \geq 10^8$ V/s

1) At lower frequencies a lower value of positive bias can be used down to an absolute minimum of +18 V.

7Z2 8068



All components ± 10 % unless otherwise stated

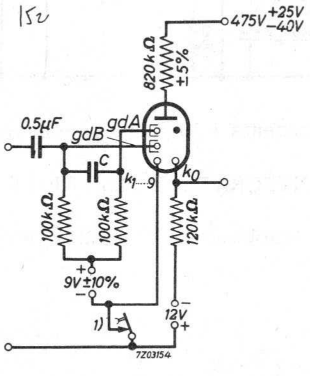
FIG. 2 INTEGRATED PULSE COUPLING CIRCUIT

In the above circuits where E88CC is specified the ECC81 may also be normally used.

k_m refers to the main cathodes from which no output is required.

k_n refers to the main cathodes other than k_o from which an output pulse is required.

Each cathode is connected to the point L via a separate resistor.



All components + 10 % unless otherwise stated

Frequency (Hz)	50	100	200	500	1000	2000	4000
Capacitor C (μF)	0.1	0.05	0.02	0.01	0.005	0.002	0.00068

FIG. 3 CIRCUIT FOR SINE WAVE DRIVE

1) Press to reset to zero

7Z2 8069

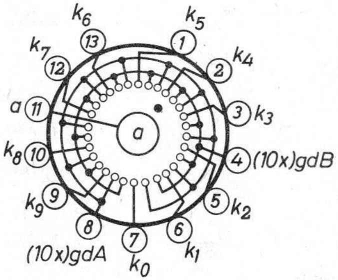
COUNTER AND SELECTOR TUBE

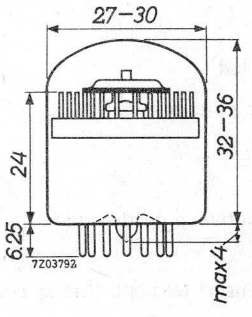
Cold cathode gas-filled bi-directional 10 output selector tube.
The Z504S gives visual indication and operates at speeds up to 5 kHz.

QUICK REFERENCE DATA		
Maximum counting speed		5 kHz
Supply voltage	V_{ba}	475 V
Output, current		340 μA
voltage		35 V
Indication		position of glow; end viewing

DIMENSIONS AND CONNECTIONS

Base: B13B





K_0 is aligned with pin 7 to within $\pm 3^o$

Mounting position: any

This tube has been designed to close tolerances so that no individual adjustment is necessary to align the bulb with the escutcheon.

Accessories

Socket	type B870067
Escutcheon	type 56062

General note

All voltages are referred to the most positive supply potential to which any main cathode (not guide cathode) is returned.

7Z2 7528

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

(initial and during life)

IGNITION REQUIREMENTS

Anode supply voltage	V_{ba}	375 to 1000 V
Time constant rise of anode supply voltage when switching on		
V_{ba} < 550 V		1.0 ms 1)
V_{ba} > 550 V		6.0 ms 1)

DISCHARGE AT REST ON A MAIN CATHODE

Maintaining voltage of anode to main cathode at I_a = 340 μA, V_{gdB} = 25 to 50 V		See also page A
maximum	V_m	max. 205 V
minimum	V_m	min. 185 V
Cathode current		
maximum (except during reset)	I_k	max. 525 μA
minimum	I_k	min. 250 μA
recommended	I_k	340 μA
Guide supply voltage		
maximum	$V_{b_{gd}}$	max. 60 V
minimum	$V_{b_{gd}}$	min. 25 V
Resistance between guides and guide supply	R_{gd}	max. 220 kΩ
Cathode potential (except during reset)		
Non conducting cathode	$-V_k$	max. 14 V
Conducting cathode	V_k max. V_{g_d}	min. 10 V 2)
	$-V_k$	max. 0 V

For notes see page 5 7Z2 7529

STEPPING REQUIREMENTS

See also pages 6 and 7

Discharge dwell time			
main cathode		min.	75 μs
guide A cathode		min.	60 μs
guide B cathode		min.	60 μs
Interval between trailing edge of guide A pulse and leading edge of guide B pulse (double rectangular pulse drive)		max.	3 μs
Negative guide voltage to step the discharge from a main cathode to an adjacent guide cathode		max. 140 V minus V_{g_d} min. 45 V	
Voltage difference required to step the discharge from a guide cathode to the adjacent guide cathode		max. 140 V min. 45 V 3)	
Positive supply voltage to step the discharge from a guide cathode to the adjacent main cathode		max. 50 V min. 25 V	
Main cathode potential			
Non conducting cathodes	$-V_k$	max.	14 V
Conducting cathode	V_k	V_{g_d} minus	10 V 2)
	$-V_k$	max.	0 V

For notes see page 5

7Z2 7530

RESETTING REQUIREMENTS

			Reset to cathodes 7, 8, 9, 0, 1, 2, 3	4, 5, 6	
Main cathode voltage	$-V_k$	max.	240	140	V
pulse duration > 1 ms	$-V_k$	min.	120	120 4)	V
pulse duration ≥ 200 μs	$-V_k$	min.	130	-	V
Pulse duration		min.	200	-	μs
Reset cathode current	I_k	max.	800	650	μA 5)

LIFE AND RELIABILITY

With this tube an average failure rate of less than 0.5%/1000 h has been obtained. When operated continuously this failure rate applies for a period in excess of 25000 h, but the visual read-out may be impaired after the first 15000 h. These figures have been obtained under the following typical conditions:

Anode current	340	μA
Positive guide supply voltage	40	V
Negative guide voltage for transfer	80	V
Output cathode (k_o) voltage		
non conducting	-12	V
conducting	0	V
Guide A dwell time	110	μs
Guide B dwell time	250 to 650	μs
Counting speed	0.2 p.p.h. to 500	p.p.s.
Ambient temperature	20 ± 5	°C

A typical tube can be expected to count correctly with the above conditions after standing on one main cathode for a period up to 4500 h.

For notes see page 5

7Z2 7531

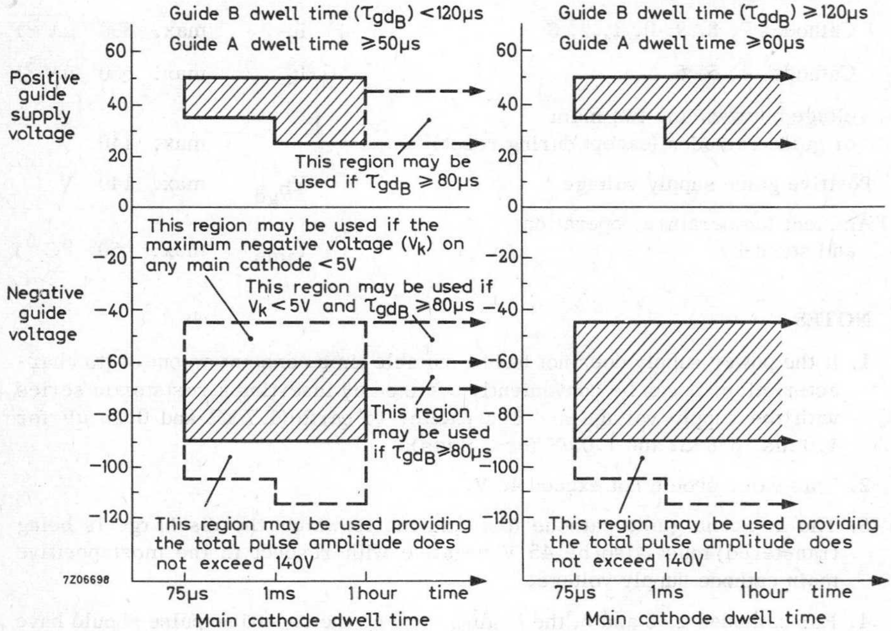
LIMITING VALUES (Absolute maximum rating system)

Continuous main cathode current (except during reset)	I_k	max.	525	μA
Reset cathode current				
Cathodes 7, 8, 9, 0, 1, 2, 3	I_k	max.	800	μA [5])
Cathode 4, 5, 6	I_k	max.	650	μA [5])
Voltage between any two main or guide cathodes (except during reset)		max.	140	V
Positive guide supply voltage	$V_{b_{gd}}$	max.	140	V
Ambient temperature, operation and stand-by	t_{amb}	max.	50	°C [6])

NOTES

1. If the power supply does not have a suitable time constant as one of its characteristics, it can be conveniently obtained by inserting a resistor in series with the supply voltage and a capacitor to earth (4.7 kΩ and 0.25 μF for 1.0 ms, 6.8 kΩ and 1.0 μF for 6.0 ms).
2. This value should not exceed 40 V.
3. The adjacent guide cathode (the cathode to which the discharge is being transfered) must also be 45 V negative with respect to the most positive main cathode supply voltage.
4. For cathodes 4, 5 and 6, the leading edge of the resetting pulse should have a rate of fall not exceeding 140 V per ms. Resetting will occur within 1 ms after the voltage has reached 120 volts.
5. The high current permitted during reset should not be allowed to flow for more than a few seconds.
6. It is preferable to store the tube as near as possible to room temperature.

7Z2 7532

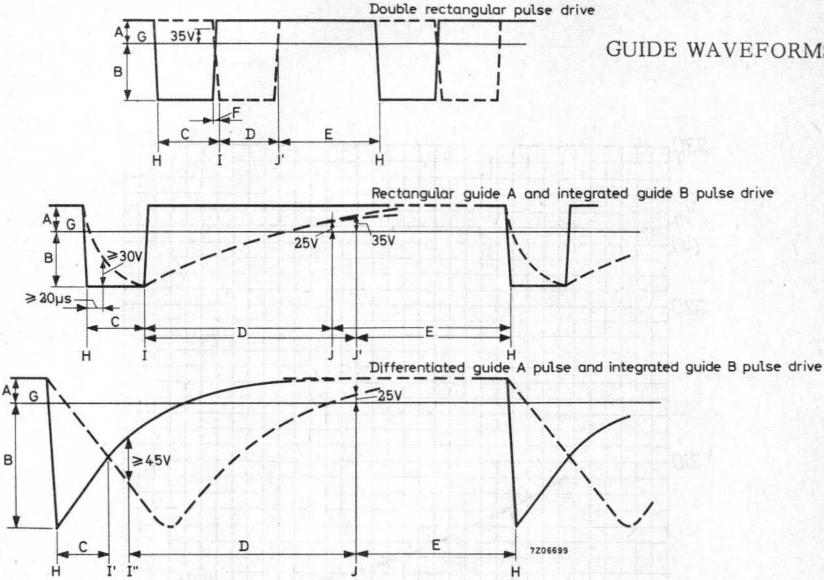


GUIDE OPERATING VOLTAGES

The shaded areas represent regions where the tube may be used without restriction initially and during life

7Z2 7555

GUIDE WAVEFORMS



A Positive guide supply voltage

B Negative guide voltage

C Guide A dwell time

D Guide B dwell time

E Main cathode dwell time

F Interval between trailing edge of guide A pulse and leading edge of guide B pulse

G Potential of most positive main cathode supply voltage

H Discharge transfers from main cathode to guide A cathode

I Discharge transfers from guide A cathode to guide B cathode

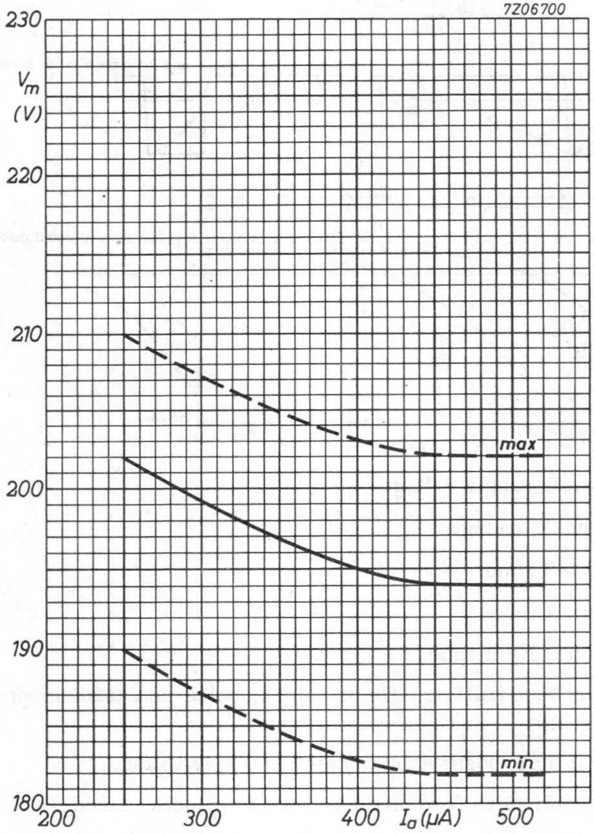
I' Earliest instant for discharge transfer from guide A cathode to guide B cathode

I'' Latest instant for discharge transfer from guide A cathode to guide B cathode

J Latest instant for discharge transfer from guide B cathode to main cathode, for a main cathode dwell time > 1 ms

J' Latest instant for discharge transfer from guide B cathode to main cathode dwell time ≤ 1 ms

7Z2 7533



Anode to main cathode maintaining voltage plotted against anode current

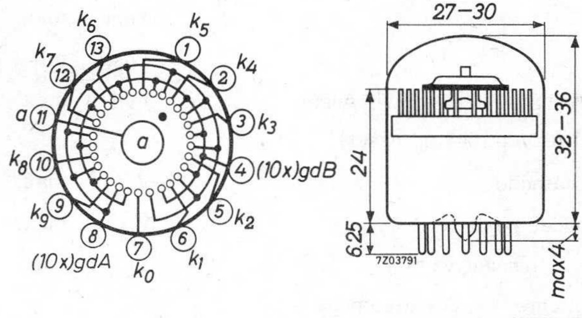
SELECTOR TUBE

Cold cathode gas-filled bi-directional decade selector and counting tube. This tube has ten main cathodes, all of which are brought out separately. The Z505S gives visual indication and operates at speeds up to 50 kHz.

QUICK REFERENCE DATA		
Maximum counting speed		50 kHz
Supply voltage	V_{ba}	500 V
Output, current		800 μA
voltage		24 V
Indication		position of glow; end viewing

DIMENSIONS AND CONNECTIONS

Base: B13B



K_0 is aligned with pin 7 to within $\pm 3^o$

Mounting position: any

This tube has been designed to close tolerances so that no individual adjustment is necessary to align the bulb with the escutcheon.

Accessories

Socket	type 2422 505 00001
Escutcheon	type 55062

General note

All voltages are referred to the most positive supply potential to which any main cathode (not guide cathode) is returned.

7Z2 8421

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN

(initial and during life)

Ignition requirements

Anode supply voltage	V_{ba}		400 to 1000	V
Time constant of rise of anode supply voltage		min.	2	ms [1]

Discharge at rest on a main cathode

Maintaining voltage of anode to main cathode at I_a = 0.8 mA, V_{bgd} = 55 V				
maximum	V_m	max.	275	V
minimum	V_m	min.	240	V
Cathode current,				
recommended	I_k		0.8	mA
maximum	I_k	max.	1.0	mA
minimum	I_k	min.	0.6	mA
Guide supply voltage				
maximum	V_{bgd}	max.	65	V
minimum	V_{bgd}	min.	40	V
Resistance between guides and guide supply	R_{gd}	max.	22	kΩ
Cathode potential (except during reset)				
non conducting cathode	$-V_k$	max.	14	V
conducting cathode, positive	V_k	max.	28	V [2]
negative	$-V_k$	max.	0	V

Stepping requirements See also page 4

Discharge dwell time,				
main cathode		min.	8.0	μs
Guide A		min.	6.0	μs
Guide B		min.	6.0	μs
Interval between trailing edge of guide A pulse and leading edge of guide B pulse (double rectangular pulse drive)		max.	0.3	μs
Guide voltage to step the discharge from a main cathode to an adjacent guide cathode	$-V_{gd}$	max.	80	V
		min.	30	V

[1] [2] See page 5

7Z2 8422

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN (continued)

Voltage difference required between a guide and the adjacent guide in order to step the discharge	$V_{gd\text{-}gd}$	max. min.	140 30	V V 3)
Guide supply voltage to step the discharge from a guide to the next main cathode	V_{bgd}	max. min.	65 40	V V
Cathode potential				
non conducting cathodes	$-V_k$	max.	14	V
conducting cathode, positive	V_k	max.	28	V 2)
negative	$-V_k$	max.	0	V
Resetting requirements 4)				
Cathode voltage	$-V_k$	max. min.	140 100	V V 5)

LIFE

A typical tube can be expected to count correctly with the following conditions after standing on one main cathode for a period of approximately 4500 hours.

Anode current	I_a	0.8	mA
Guide supply voltage	V_{bgd}	60	V
Guide voltage for transfer	V_{gd}	-50	V
Output cathode (k_o) voltage,			
non conducting	V_o	5.0	V
conducting	V_o	-5.0	V
Guide A dwell time		6.0	μs
Guide B dwell time		6.0	μs
Cathode dwell time		8.0	μs
Temperature		20 ± 5	°C

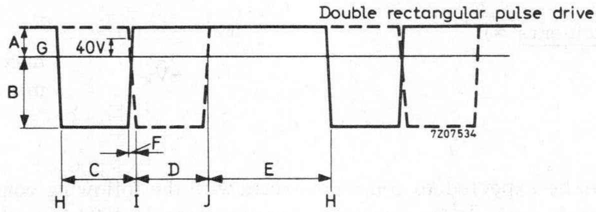
2)3)4)5) See page 5

7Z2 8423

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_{ba}	max.	1000	V
Cathode current (except during reset)	I_k	max.	1.0	mA
Voltage between any two main or guide cathodes (except during reset)		max.	140	V
Guide supply voltage	V_{bgd}	max.	65	V
Reset voltage, negative		max.	140	V
Ambient temperature	t_{amb}	max.	50	°C [1]

GUIDE WAVEFORMS



A Positive guide supply voltage

B Negative guide voltage

C Guide A dwell time

D Guide B dwell time

E Main cathode dwell time

F Interval between trailing edge of guide A pulse and leading edge of guide B pulse

G Potential of most positive main cathode supply voltage

H Discharge transfers from main cathode to guide A

I Discharge transfers from guide A to guide B

J Latest instant for discharge transfer from guide B to main cathode, dwell time $\leq 500\ \mu s$.

[1]) It is preferable to store the tube as near as possible to room temperature.

7Z2 8424

NOTES

1) If the power supply does not have a time constant of 2 ms as one of its characteristics, it can conveniently be obtained by inserting a resistor in series with the anode supply and a capacitor to the negative return.
(4.7 kΩ and 0.5 μF for 2 ms).

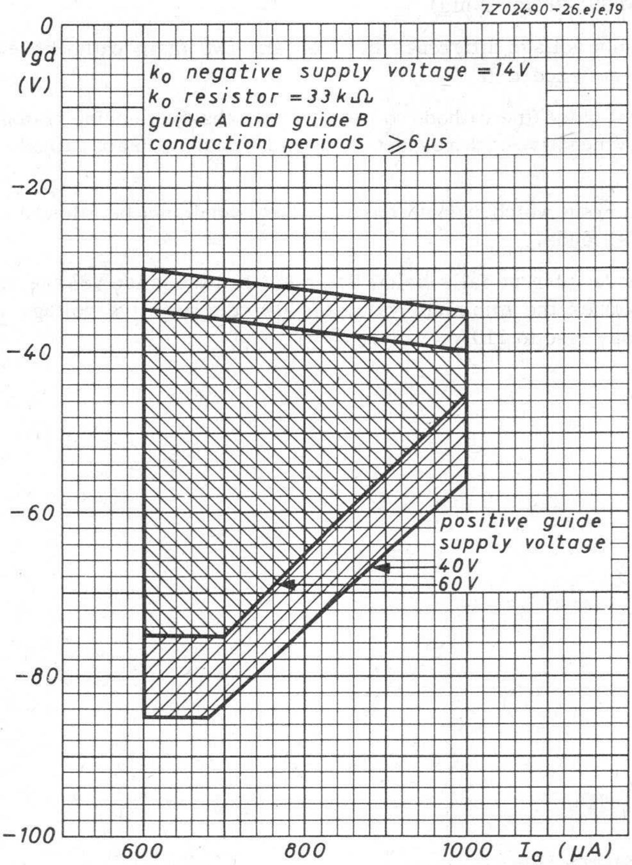
2) The maximum voltage difference between any two main cathodes except during reset must not exceed 28 V.

3) The adjacent guide (the cathode to which the discharge is being transferred) must also be 30 V negative with respect to the most positive main cathode supply voltage.

4) The high current which passes during reset should not be allowed to flow more than a few seconds.

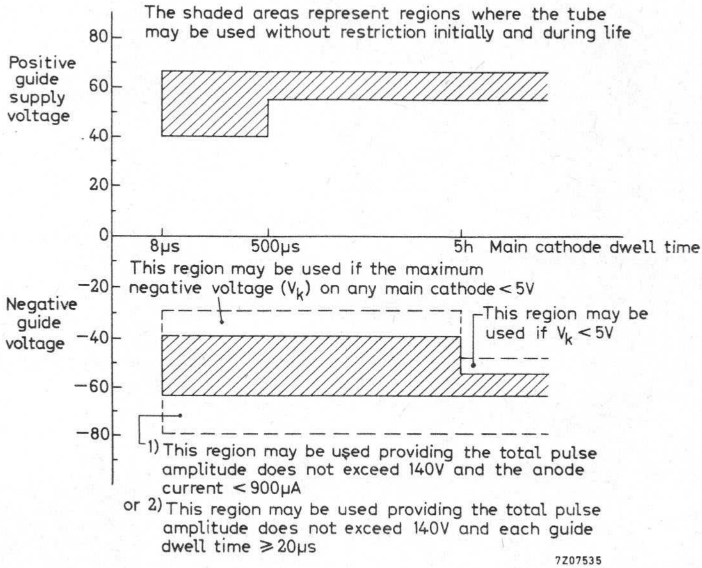
5) If the cathode current falls below 0.7 mA when the guide voltage applied to the tube approaches the minimum value of 40 V the negative voltage required for resetting may rise to 110 V.

7Z2 8425



Guide voltage to ensure stepping.
The area of operation is increased with the use of larger pulse periods

7Z2 5306



Guide operating voltages

7Z2 8427

INDICATOR TUBE

Long life cold cathode ten digit numeral indicator tube for top viewing.

QUICK REFERENCE DATA			
Numeral height		15	mm
Numerals	1 2 3 4 5 6 7 8 9 0		
Supply voltage	min.	170	V
Anode current		2	mA

GENERAL

The numerals are 15 mm high and appear on the same base line allowing in-line read out. The ZM1020 is provided with a red contrast filter.

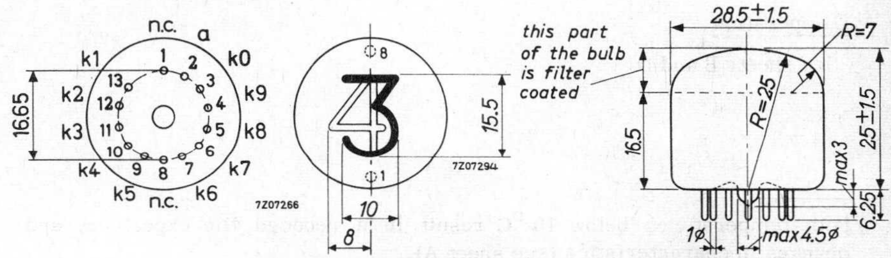
PRINCIPLE OF OPERATION

The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding numeral will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B



7Z2 8033

Mounting position: any

The numerals are viewed through the dome of the envelope. The numerals will appear upright (within 1.5°) when the tube is mounted with the line through pins 1 and 8 vertical, pin 8 being uppermost.

Accessories

Socket	type	2422 505 00001
		or
		2422 505 00002

CHARACTERISTICS AND OPERATING CONDITIONS
(Valid over life and full temperature range)

Ignition voltage	V_{ign}	max.	160	V
Maintaining voltage	V_m	see sheet A		
Anode current for coverage,				
average during any conduction period	I_a	min.	1	mA
Anode current,				
average (T_{av} = max. 20 ms)	I_a	max.	3	mA
peak	I_{kp}	max.	6	mA
Cathode selecting voltage	V_{kk}	see sheet B		
Extinguishing voltage	V_{ext}	min.	118	V

Typical operation [1)]

D.C. operation

See sheets B and C

A.C. operation

See sheets B and D

1) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics (see sheet A).
In designing equipment to be used over a wide temperature range the use of "constant current operation" (high supply voltage with a high anode series resistor) is recommended.

7Z2 8034

LIFE EXPECTANCY AND RELIABILITY (under recommended operating conditions)

Continuous display of one digit	10.000 h
Sequentially changing the display from one digit to the others every 100 h. or less	50.000 h

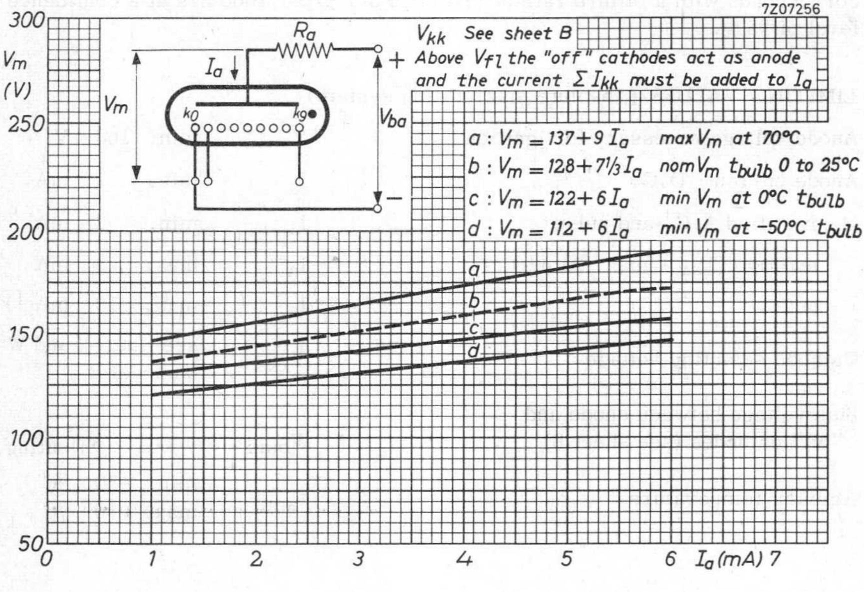
The reliability has been assessed in a life test programme totalling 4.5×10^6 tube hours. The longest test period was 50.000 hrs on 47 tubes. No failures have been found. The Mean Time between Failures is better than 10^6 hrs which corresponds with a failure rate of less than 0.1 % per 1000 hrs at a confidence level of 95 %.

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	160	V
Anode current, D.C.	I_a	min.	1	mA
rectified A.C. and pulse	I_{a_p}	min.	2	mA
average (T_{av} = max. 20 ms)	I_a	max.	3	mA
peak	I_{a_p}	max.	10	mA [1])
Cathode selecting voltage	V_{kk}	see lines N and W on sheet B		
Bias voltage between anode and "off" cathodes (see sheet B)	V_{bias}	max.	$V_{floating}$	
Ambient temperature	t_{amb}	min. -50 max. +70		°C °C

1) Above I_a = 6 mA the connecting wires and eyelets may be covered by the glow.

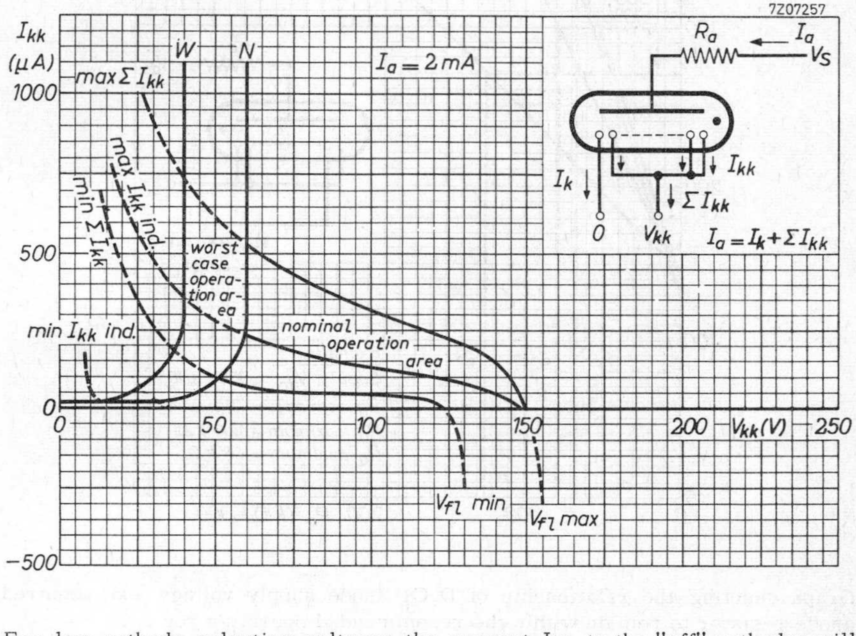
7Z2 8035


7Z07256
V_m (V)
300
250
200
150
100
50
0 1 2 3 4 5 6 I_a(mA) 7
R_a
I_a
V_m
V_{ba}
k0
k9
+
−
V_{kk} See sheet B
Above V_{fl} the "off" cathodes act as anode and the current ΣI_{kk} must be added to I_a
a : $V_m = 137 + 9\,I_a$ max V_m at 70°C
b : $V_m = 128 + 7\frac{1}{3}I_a$ nom V_m t_{bulb} 0 to 25°C
c : $V_m = 122 + 6\,I_a$ min V_m at 0°C t_{bulb}
d : $V_m = 112 + 6\,I_a$ min V_m at −50°C t_{bulb}
a
b
c
d

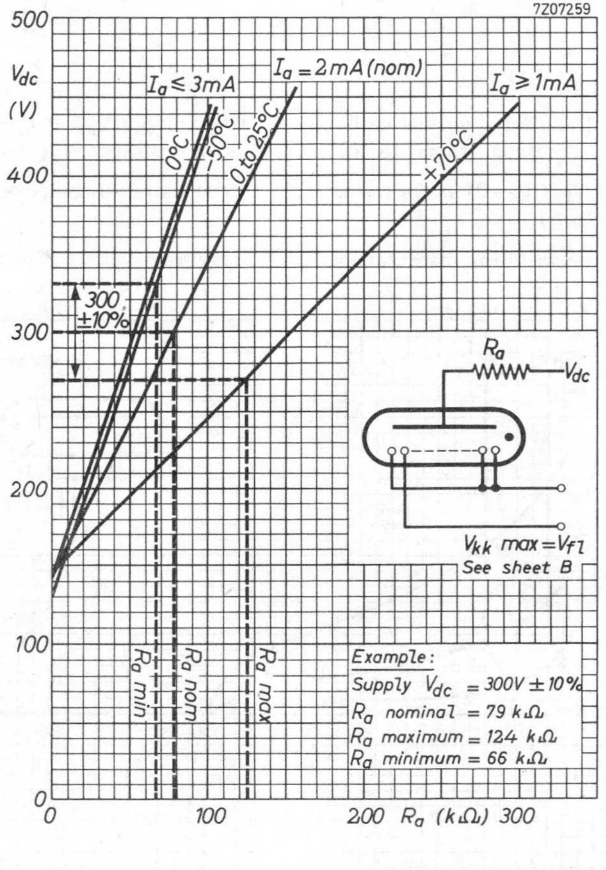
I_{kk} individual and ΣI_{kk} versus cathode selecting voltage V_{kk} at I_a = 2 mA.
I_{kk} and ΣI_{kk} are proportional to anode current in the range V_{kk} = 0 to 100 V.

The range of V_{fl} (I_{kk} = 0) shifts to the right/left at increasing/decreasing anode current (8 V/mA).

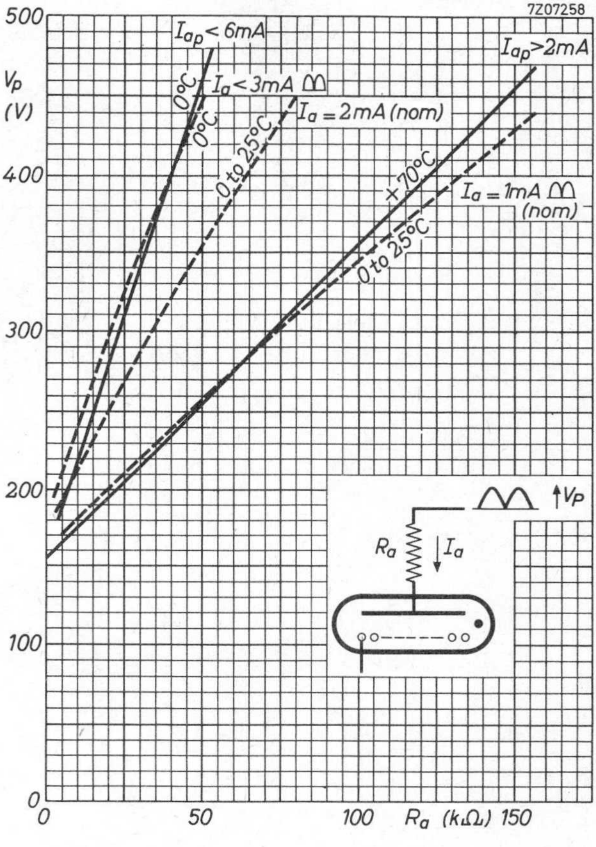
The curves are valid for instantaneous and for average values of anode current.



For low cathode selecting voltages the current I_{kk} to the "off" cathodes will increase and the readability of the "on" cathode will be affected. It is therefore recommended to use a nominal operating point to the right of line N.
Under the worst operating conditions the operating point should never reach the area left of line W.



Graph denoting the relationship of D.C. anode supply voltage and required anode resistor to remain within the recommended operating region.



Graph denoting the relationship of the peak value of full-wave unsmoothed rectified A.C. anode supply voltage and the required anode resistor to remain within the recommended operating area.

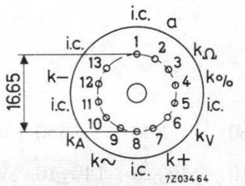
INDICATOR TUBE

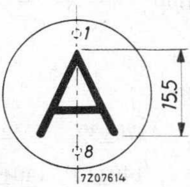
Cold cathode character indicator tube for top viewing.

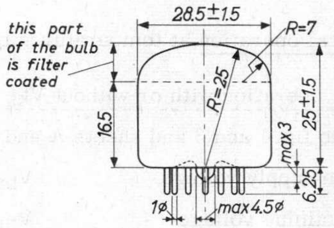
QUICK REFERENCE DATA			
Character height		15	mm
Characters	A, V, Ω, %, ~ ,+, -,		
Supply voltage	min.	170	V
Cathode current		2	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B







Mounting position: any

The characters are viewed through the dome of the envelope. The characters will appear upright (within 1.5°) when the tube is mounted with the line through pins 1 and 8 vertical, pin 8 being uppermost.

Accessories

Socket type 2422 505 00001 or 2422 505 00002

GENERAL

The characters are 15 mm high and appear on the same base line allowing in-line read out. The ZM1021 is provided with a red contrast filter.

7Z2 8052

PRINCIPLE OF OPERATION

The tube contains seven cathodes in the form of seven characters and one common anode.
By applying a suitable voltage between the anode and one of the seven cathodes the corresponding character will be covered by a red neon glow.

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	160	V
Maintaining voltage	V_m	see sheet A		
Cathode current for coverage,				
average during any conduction period	I_k	min.	1	mA
Cathode current,				
average (T_{av} = 20 ms)	I_k	max.	2.5	mA
peak	I_{k_p}	max.	10	mA
Cathode selecting voltage	V_{kk}	see sheets A and B		
Extinguishing voltage	V_{ext}	min.	120	V

Typical operation at temperatures t_{amb} =10 to 50 °C

D.C. operation with or without V_{kk}

(See fig.1 and 3 and sheets A and B)

Anode supply voltage	V_{ba}	170±3%	250	300	350	V
Maintaining voltage	V_m	140±10	140±10	140±10	140±10	V
Anode series resistor	R_a	15	56	86	100	kΩ
Cathode selecting voltage	V_{kk}			min.	60	V 1)

A.C. half-wave rectified operation with or without V_{kk}

(See fig.2 and 4 and sheets A and B)

Secondary transformer voltage	V_{tr}	170	220	250	300	V
Anode series resistor	R_a	10	22	30	47	kΩ
Cathode selecting voltage	V_{kk}			min.	60	V 1)

1) With low cathode selecting voltages the current I_{kk} to the "off" cathodes will increase and the readability of the "on" cathode will be affected.
It is therefore recommended to use a voltage V_{kk} in excess off the stated minimum value.

7Z2 8053

LIFE EXPECTANCY under recommended operating conditions.

Continuous display of one character	5000	h
Sequentially changing the display from one character to the others every 100 hours or less	30 000	h

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	160	V
Cathode current,				
average during any conduction period	I_k	min.	1	mA
average (T_{av} = 20 ms)	I_k	max.	2.5	mA
peak	I_{k_p}	max.	10	mA
Impulse duration of cathode current	T_{imp}	min.	80	μs
Cathode selecting voltage	V_{kk}	min.	60	V [1]
Bias voltage between anode and "off" cathodes	V_{bias}	max.	120	V
Bulb temperature	t_{bulb}	min.	-50	°C [2]
		max.	+70	°C

[1] With low cathode selecting voltages the current I_{kk} to the "off" cathodes will increase and the readability of the "on" cathode will be affected.
It is therefore recommended to use a voltage V_{kk} in excess off the stated minimum value.

[2] Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics (See sheet C)
In designing equipment to be used within a wide temperature range the use of "constant current operation" (high supply voltage with a high anode series resistor) is recommended.

7Z2 8054

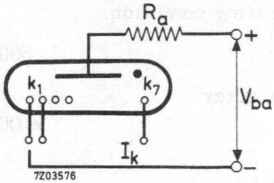


Fig. 1

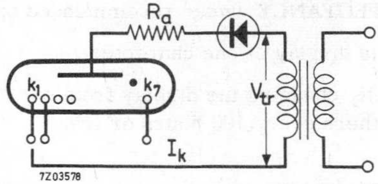


Fig. 2

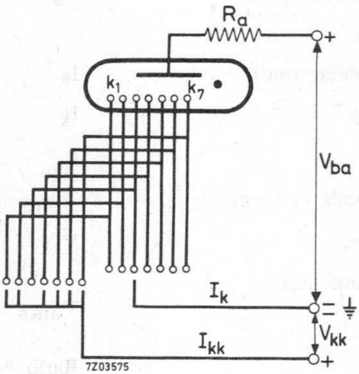


Fig. 3

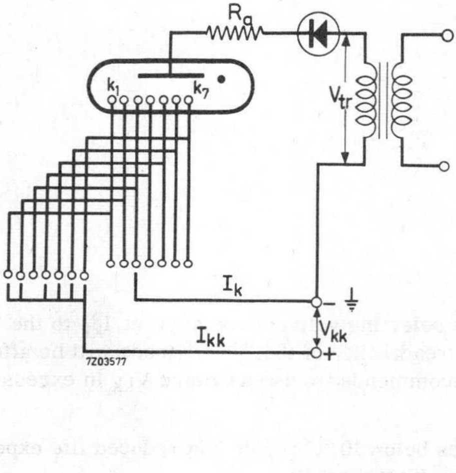
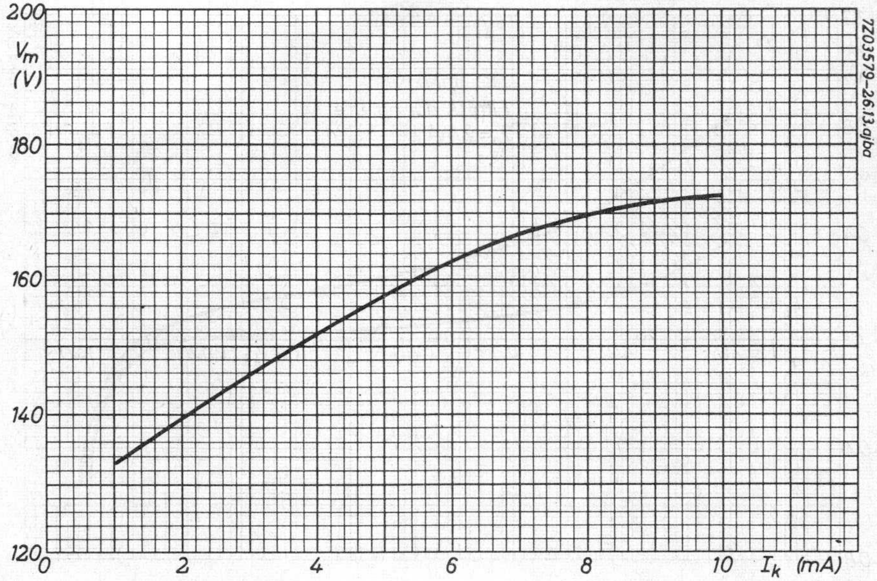
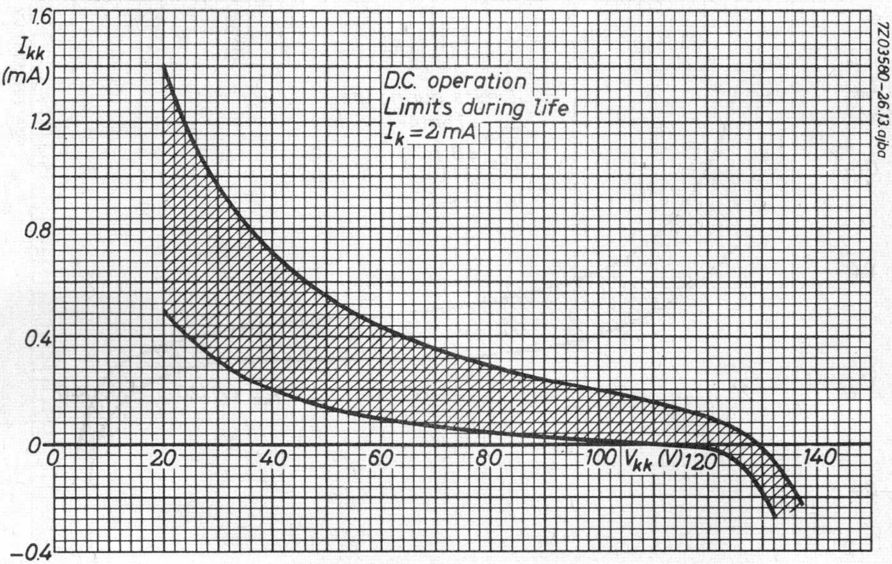
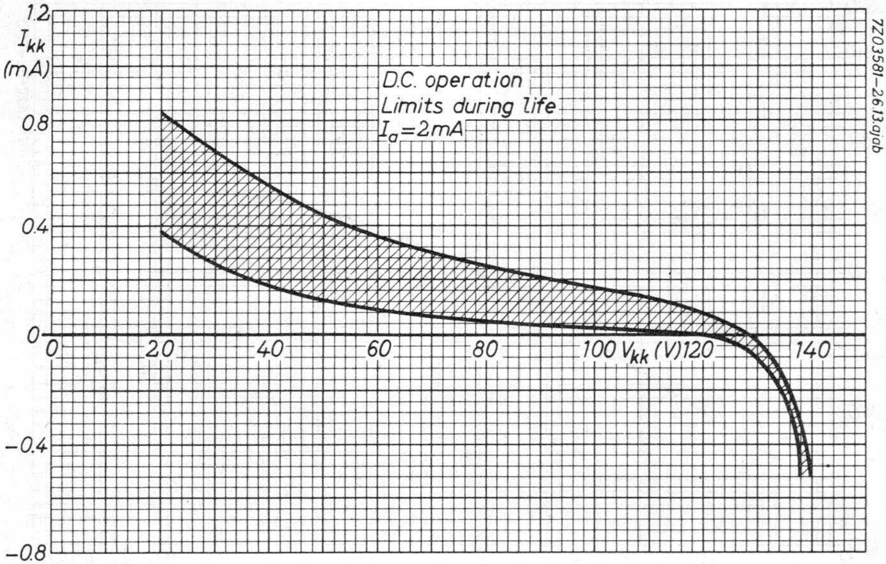


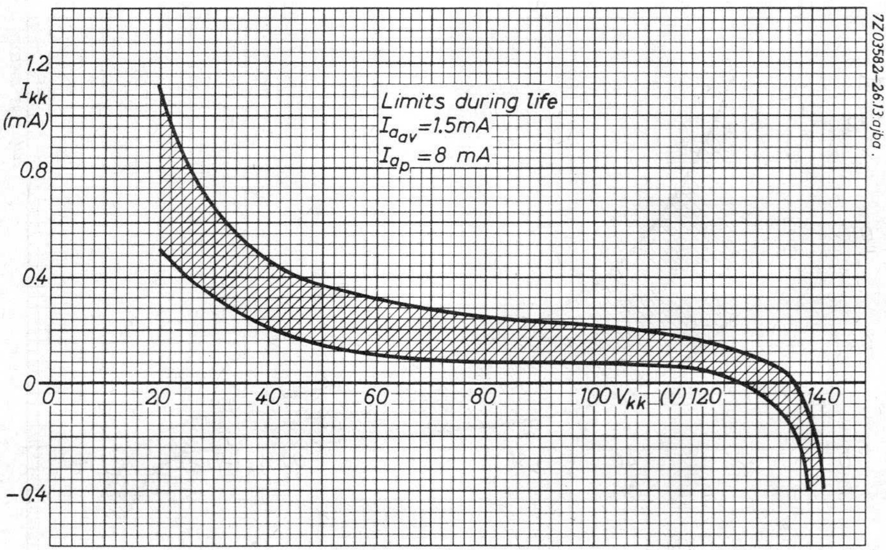
Fig. 4

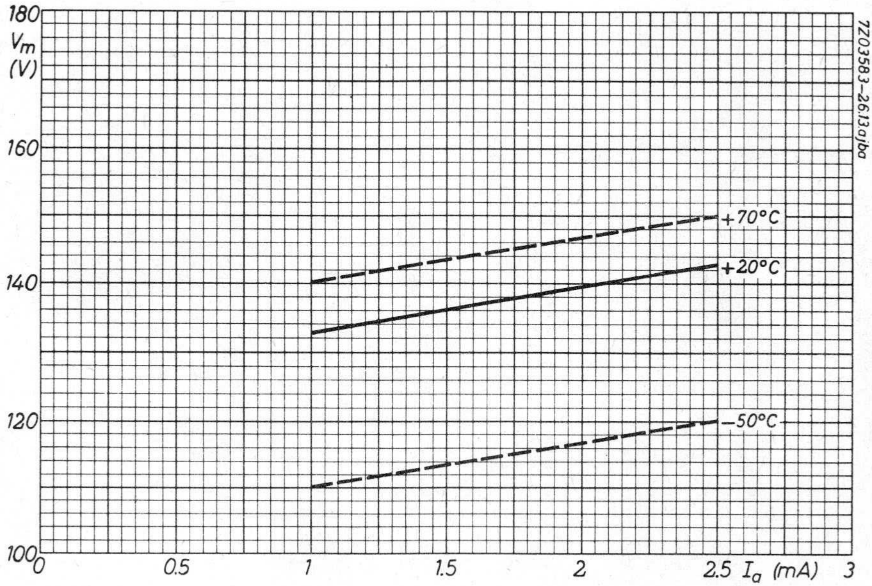
7Z2 5241


200
V_m
(V)
180
160
140
120
0
2
4
6
8
10
I_k (mA)
7Z03579-26.13.ajba


1.6
I_{kk}
(mA)
1.2
0.8
0.4
0
−0.4
D.C. operation
Limits during life
$I_k = 2$ mA
0
20
40
60
80
100
V_{kk} (V)
120
140
7Z03580-26.13.ajba


1.2
I_{kk}
(mA)
D.C. operation
Limits during life
I_a=2mA
0.8
0.4
0
-0.4
-0.8
0
20
40
60
80
100 V_{kk} (V) 120
140
7Z03581-26.13.ajab


1.2
I_{kk}
(mA)
Limits during life
$I_{a_{av}}$=1.5mA
I_{a_p}=8 mA
0.8
0.4
0
-0.4
0
20
40
60
80
100 V_{kk} (V) 120
140
7Z03582-26.13.ajba.

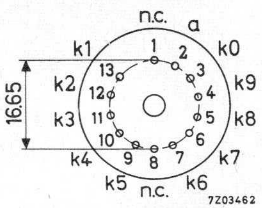

180
V_m
(V)
160
140
120
100
0
0.5
1
1.5
2
2.5
I_a (mA)
3
+70°C
+20°C
−50°C
7Z03583-26.13a/ba

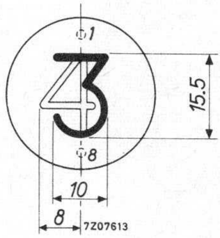
INDICATOR TUBE

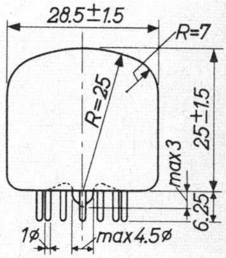
The type ZM1022 is electrically identical with type ZM1020 but has no filter coating.
The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B







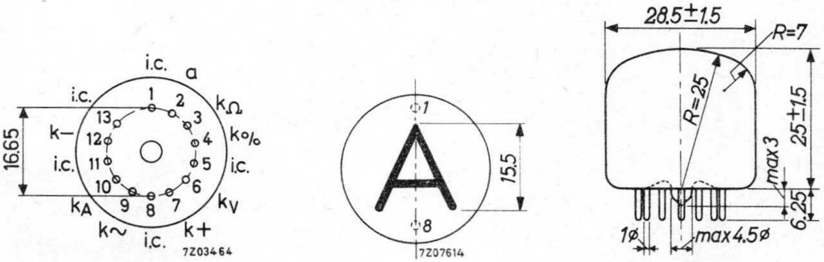
7Z2 8362

INDICATOR TUBE

The type ZM1023 is electrically identical with type ZM1021 but has no filter coating.
The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B



7Z2 8363

INDICATOR TUBE

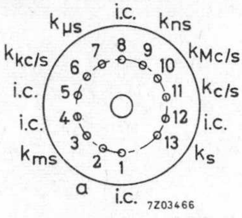
Cold cathode character indicator tube for top viewing

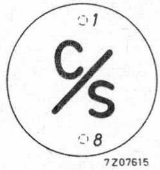
QUICK REFERENCE DATA	
Characters	c/s, Kc/s, Mc/s, μs, ms, ns, s

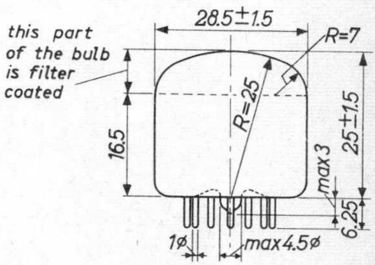
This tube is mechanically compatible with type ZM1020

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B







CHARACTERISTICS , OPERATING CONDITIONS AND LIMITING VALUES

These are essential the same as of type ZM1020.

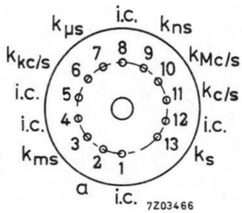
7Z2 5244

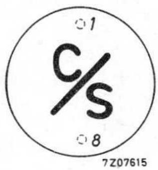
INDICATOR TUBE

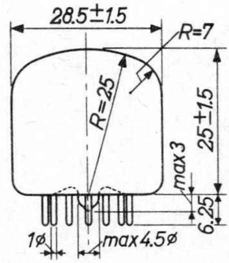
The type ZM1025 is electrically identical with type ZM1024 but has no filter coating.
The use of a separate blue absorbing, e.g. circular polarized, filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B







7Z2 5245

INDICATOR TUBE

Cold cathode gas-filled biquinary numerical indicator tube for side viewing.

QUICK REFERENCE DATA

Numerical height		15.5	mm
Numerals		0 1 2 3 4 5 6 7 8 9	
Supply voltage	V_{ba}	> 170	V
Anode current	I_a	4	mA
Cathode selecting voltage	V_{kk}	50	V
Extinction voltage	V_{ext}	110	V
Screen supply voltage	V_{bs}	50	V
"Off" anode supply voltage	V_{ba} "off"	100	V

GENERAL

The numerals are 15.5 mm high and appear on the same base line allowing in-line read-out. The ZM1030 is provided with a red contrast filter.

PRINCIPLE OF OPERATION

A transparent screen divides the tube into two sections:

- The front section, containing the front- or "odd" anode and the cathode numerals 1-3-5-7-9.
- The rear section, containing the rear- or "even" anode and the cathode numerals 0-2-4-6-8.

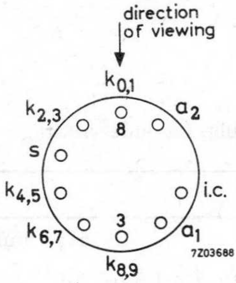
The cathodes are internally connected in pairs: 0-1, 2-3, 4-5, 6-7, 8-9.
By applying a suitable voltage between a cathode pair and the "odd" anode the "odd" cathode of that pair will be covered by a red neon glow.
Switching from one number of a pair to the other of that pair is accomplished by decreasing the voltage on the operating anode and simultaneously increasing the voltage on the other anode. [1])

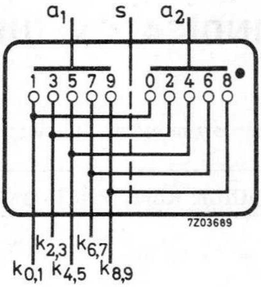
[1]) When mechanical or low speed switching is used, a "make before break" arrangement is preferred. During switching the shield connection and the shield supply should be maintained.

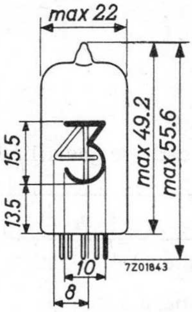
7Z2 5246

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position

When mounted with the base down the viewing direction will coincide with the line from pin 8 throught pin 3 ($\pm 5^o$).

CHARACTERISTICS, RANGE VALUES AND OPERATING CONDITIONS

Reference point for all electrode voltages is the "on" cathode.
During operation no electrode should be left floating. See fig.1

Ignition voltage	V_{ign}	<	170	V
Maintaining voltage	V_m	See page A and B		
Anode current for coverage,				
average during any conduction period	I_a	>	3	mA
Anode current,				
average, T_{av} = 20 ms	I_a	<	5	mA
peak, 50 to 60 pps	I_{ap}	<	12	mA
Cathode selecting voltage [1]	V_{kk}	>	40	V [2]
		<	110	V
"Off" anode supply voltage	V_{ba} "off"	>	85	V
		<	115	V
Screen voltage	V_s	See page D		
Extinction voltage	V_{ext}	>	110	V

[1]) The cathode selecting voltage is the voltage difference V_{kk} used for discrimination between the "off" cathodes and the "on" cathode.

[2]) At low values of V_{kk}, the contrast of the display will be reduced due to glow on adjacent numerals. This will not affect the life of the tube.

7Z2.5247

Operating conditions

D.C. operation	V_{ba} R_a	200 15	220 20	250 27	300 39	V kΩ
A.C. operation half wave rectified 50 to 60 c/s	V_{ba} R_a	170 10	220 18	250 24	300 33	V kΩ
full wave rectified 100 to 120 c/s	V_{ba} R_a	170 15	220 27	250 33	300 47	V kΩ

LIFE EXPECTANCY

Sequentially changing the display from one digit to another every 100 hours or less — 20 000 hours

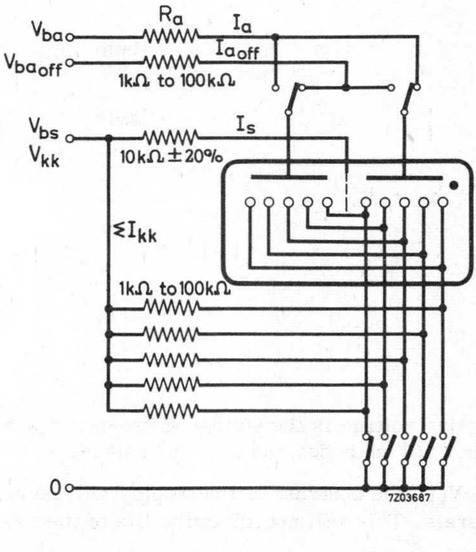


Fig.1

7Z2 5248

LIMITING VALUES (Absolute max. rating system) See fig.1

Anode voltage necessary for ignition	V_a	min. 170	V	[4]
Anode current,				
average during any conduction period	I_a	min. 3	mA	
average T_{av} = max. 20 ms	I_a	max. 5	mA	
peak	I_{ap}	max. 12	mA	
Cathode selecting voltage [1]	V_{kk}	min. 40 max. 110	V V	[2]
"Off" anode supply voltage	V_{ba} "off"	min. 85 max. 115	V V	
Screen voltage	V_s	min. 40 max. 80	V V	
Bulb temperature,				
storage	t_{bulb}	max. +70 min. −55	°C °C	
operation	t_{bulb}	max. +70 min. +15	°C °C	 [3]

REMARK $I_a = I_k + I_{kk} + I_s$

---

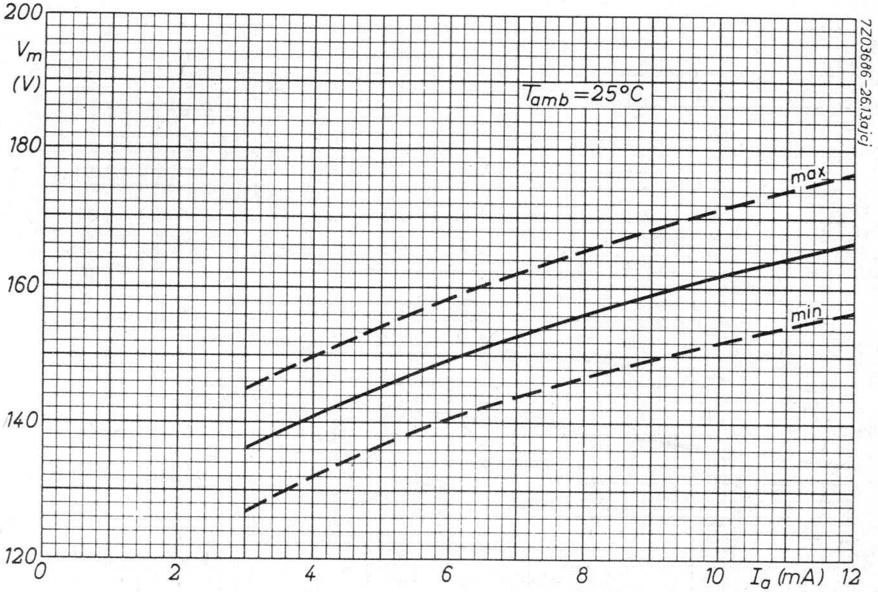
[1] The cathode selecting voltage is the voltage difference V_{kk} used for discrimination between the "off" cathodes and the "on" cathode.

[2] At low values of V_{kk}, the contrast of the display will be reduced due to glow on adjacent numerals. This will not affect the life of the tube.

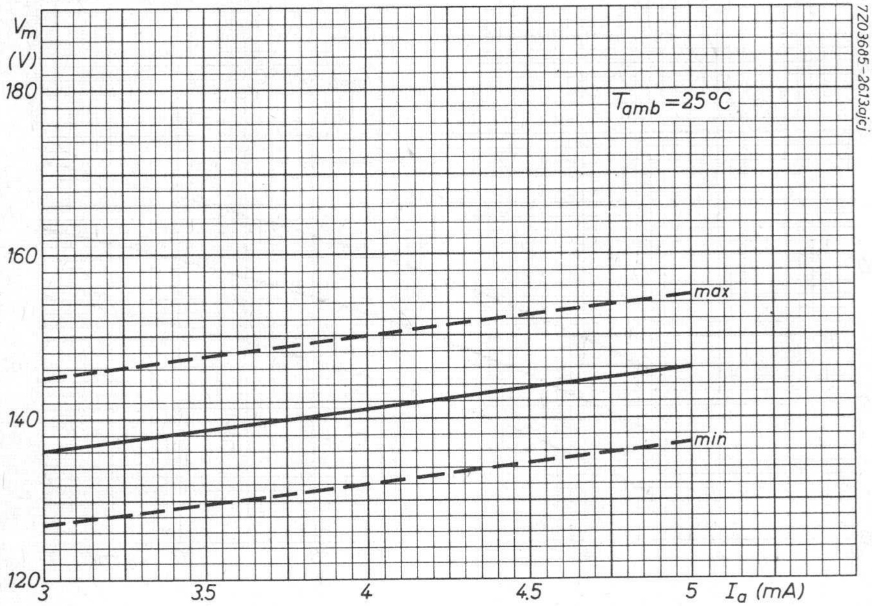
[3] Bulb temperatures below 15 °C result in a reduced life expectancy, larger spread and changes in characteristics. See also note [4].

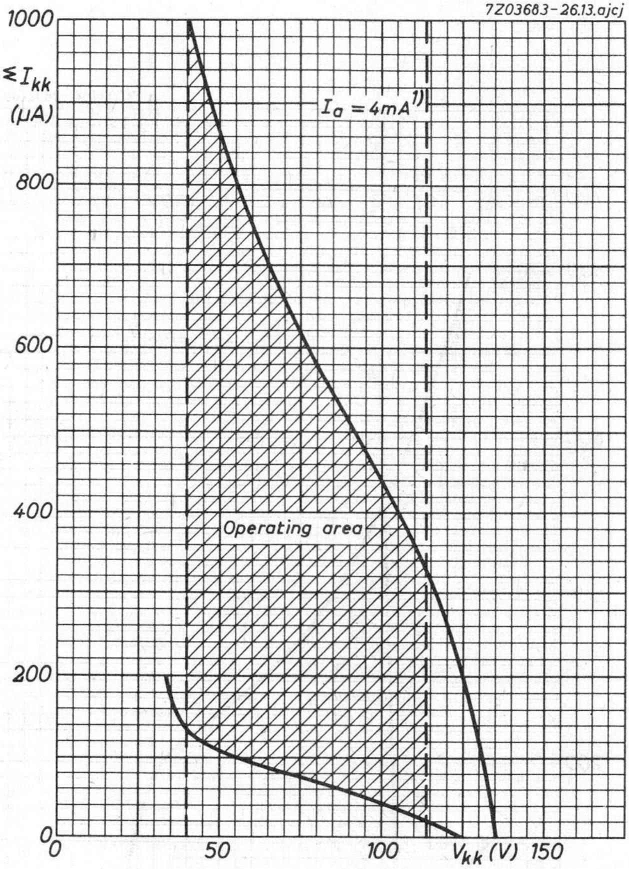
[4] The minimum supply voltage should be as stated. However the use of the highest voltage available with the appropriate series resistor to maintain the anode current within the specified limit is recommended. The use of "constant current operation" (high supply voltage with high resistor) is recommended when designing equipment operation over a wide temperature range.

7Z2 5249



200
V_m
(V)
180
160
140
120
0
2
4
6
8
10
I_a (mA)
12
$T_{amb}=25°C$
max
min
7Z03686-26.13(a)(c)


V_m
(V)
180
160
140
120
3
3.5
4
4.5
5
I_a (mA)
T_{amb} = 25 °C
max
min
7Z03685-26.13a(c)

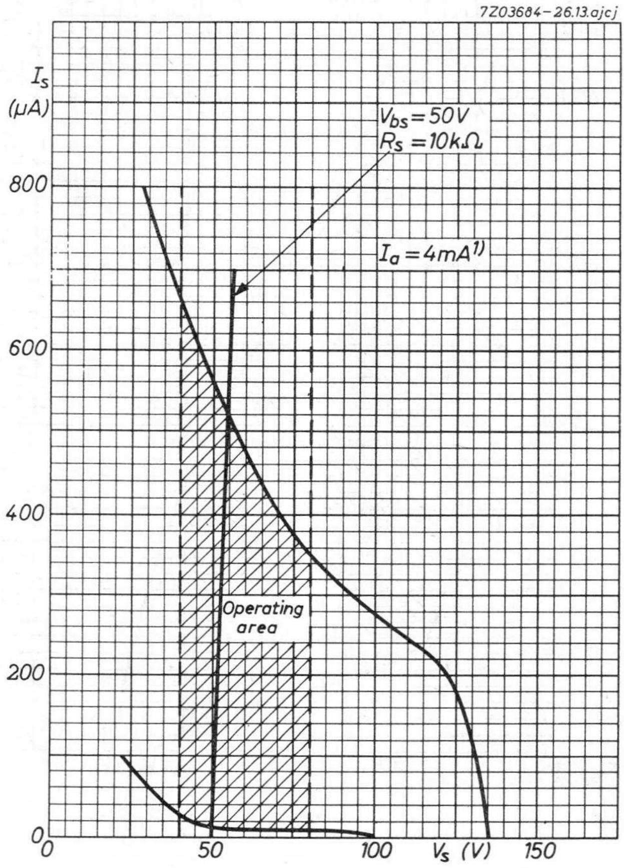


The max. value of I_{kk} to any one pair of numbers will be 55% of I_{kk}.

---

1) The values of I_{kk} varies with anode current. Each mA increase or decrease of I_a results in max. 40% increase or decrease respectively of I_{kk}.

7Z2 5250



[1)] The value of I_S varies with anode current. Each mA increase or decrease of I_a results in max. 30% increase or decrease respectively of I_S.

7Z2 5251

INDICATOR TUBE

Cold cathode sign indicator tube for side viewing.

QUICK REFERENCE DATA				
Sign height			15	mm
Signs			+ − ~	
Supply voltage	V_{ba}	min.	170	V
Cathode current	I_k		4	mA

GENERAL

This tube has the same physical dimensions as the biquinary numerical indicator tube ZM1030. The ZM1031 is provided with a red contrast filter.

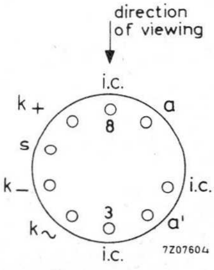
PRINCIPLE OF OPERATION

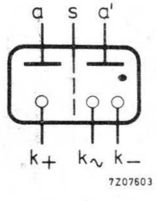
The tube contains two anodes and two cathodes separated by a shield. The rear compartment contains the minus (−) sign and the rear anode, the front compartment contains the plus (+) sign and the front anode.
By applying a suitable voltage between the required sign and the corresponding anode, the sign will be covered by a red neon glow.

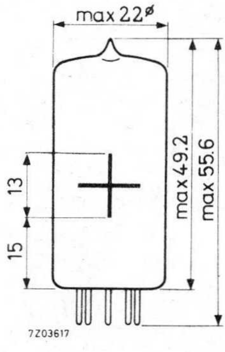
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval







Mounting position: any

The signs are viewed through the side of the envelope.

7Z2 8055

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	<	170	V
Maintaining voltage at I_k = 4 mA	V_m		140	V
Anode current,				
average during any conduction period for coverage	I_a	>	2	mA
average, T_{av} = 20 ms	I_a	<	5	mA
peak	I_{ap}	<	10	mA
Incremental resistance	r_a		4.5	kΩ

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	170	V
Anode current,				
average during any conduction period	I_a	min.	2	mA
average (T_{av} = 20 ms)	I_a	max.	5	mA
peak	I_{ap}	max.	10	mA
Bulb temperature	t_{bulb}	min.	-55	°C [1]
		max.	+70	°C

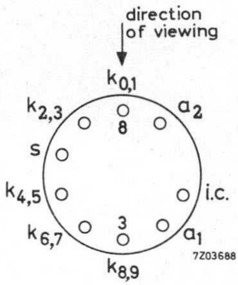
[1]) Below 10 °C the life expectancy is substantially reduced.

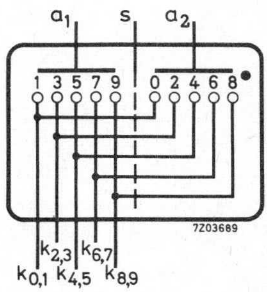
7Z2 8056

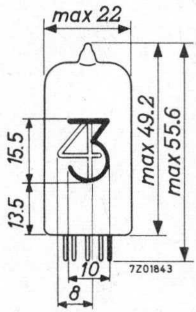
INDICATOR TUBE

The type ZM1032 is electrically identical with type ZM1030 but has no filter coating.
The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm







7Z2 5255

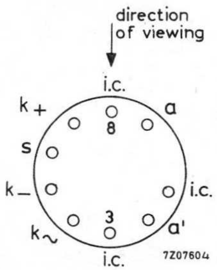
INDICATOR TUBE

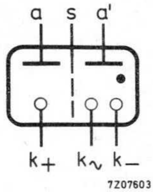
The type ZM1033 is electrically identical with type ZM1031 but has no filter coating. The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

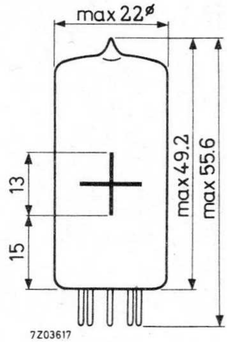
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval







7Z2 8368

INDICATOR TUBE

Cold cathode ten digit numeral indicator tube for side viewing.

QUICK REFERENCE DATA				
Numeral height			30	mm
Numerals	1 2 3 4 5 6 7 8 9 0			
Supply voltage	V_{ba}	min.	170	V
Cathode current	I_k		4.5	mA

GENERAL

The numerals are 30 mm high and appear on the same base line allowing in-line read out. The ZM1040 is provided with a red contrast filter.

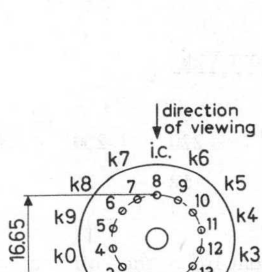
PRINCIPLE OF OPERATION

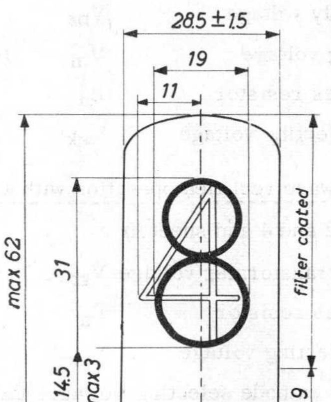
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding numeral will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B





7Z2 5256

Mounting position: any

The numerals are viewed through the side of the envelope. The numerals will appear upright (within 1.5°) when the tube is mounted vertically.

Accessories

Socket	type	2422 505 00001 or 2422 505 00002 or 2422 505 00003

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	160	V
Maintaining voltage	V_m	see sheet A		
Cathode current for coverage,				
average, during any conduction period	I_k	min.	3	mA
Cathode current,				
average (T_{av} = 20 ms)	I_k	max.	6	mA
peak	I_{kp}	max.	20	mA
Cathode selecting voltage	V_{kk}	see sheet B		
Extinguishing voltage	V_{ext}	min.	120	V

Typical operation at temperatures t_{amb} = 10 to 50 °C

D.C. operation with or without V_{kk}

(See fig.1 and 3 and sheets A and B)

Anode supply voltage	V_{ba}	200	250	300	350	V
Maintaining voltage	V_m	140±10	140±10	140±10	140±10	V
Anode series resistor	R_a	15	27	39	47	kΩ
Cathode selecting voltage	V_{kk}			min.	60	V [1])

A.C. half-wave rectified operation with or without V_{kk}

(See fig.2 and 4 and sheet A)

Secondary transformer voltage	V_{tr}	170	220	250	300	V
Anode series resistor	R_a	5.6	12	18	27	kΩ
Cathode selecting voltage	V_{kk}			min.	60	V [1])

[1]) With low cathode selecting voltages the current I_{kk} to the "off" cathodes will increase and the readability of the "on" cathode will be affected. It is therefore recommended to use a voltage V_{kk} in excess off the stated minimum value.

7Z2 8057

LIFE EXPECTANCY under recommended operating conditions

Continuous display of one digit	3000	h
Sequentially changing the display from one digit to the others every 100 hours or less	20 000	h

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	170	V
Cathode current,				
average during any conduction period	I_k	min.	3	mA
average (T_{av} = 20 ms)	I_k	max.	6	mA
peak	I_{k_p}	max.	20	mA
Cathode selection voltage	V_{kk}	min.	60	V
Bias voltage between anode and "off" cathodes	V_{bias}	max.	120	V
Bulb temperature	t_{bulb}	min. max.	0 +70	^{o}C ^{o}C [1]

[1]) Bulb temperatures below 0 ^{o}C result in a reduced life expectancy and changes in characteristics (see sheet C)
In designing equipment to be used over a wide temperature range the use of "constant current operation" (high supply voltage with a high anode series resistor) is recommended.

7Z2 8058

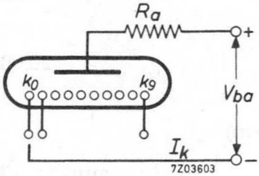


Fig.1

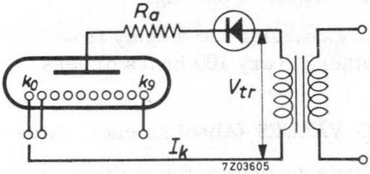


Fig.2

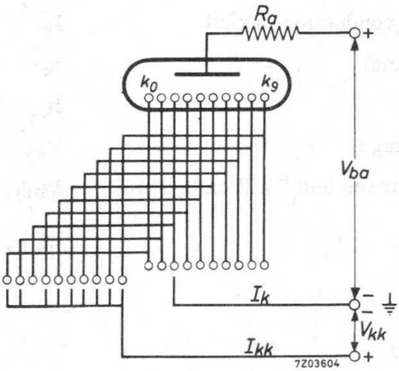


Fig.3

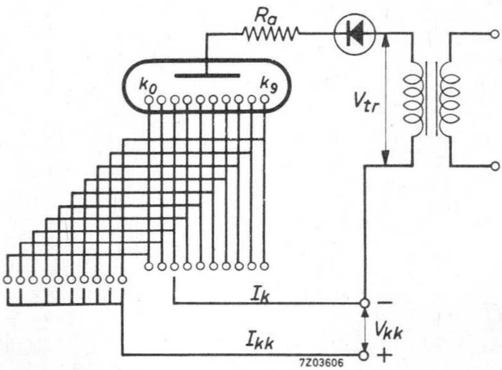
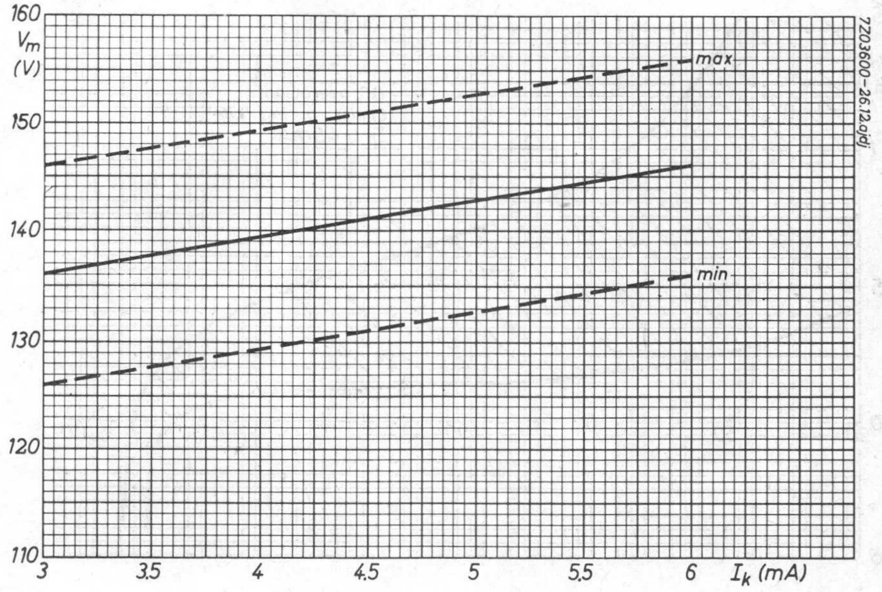
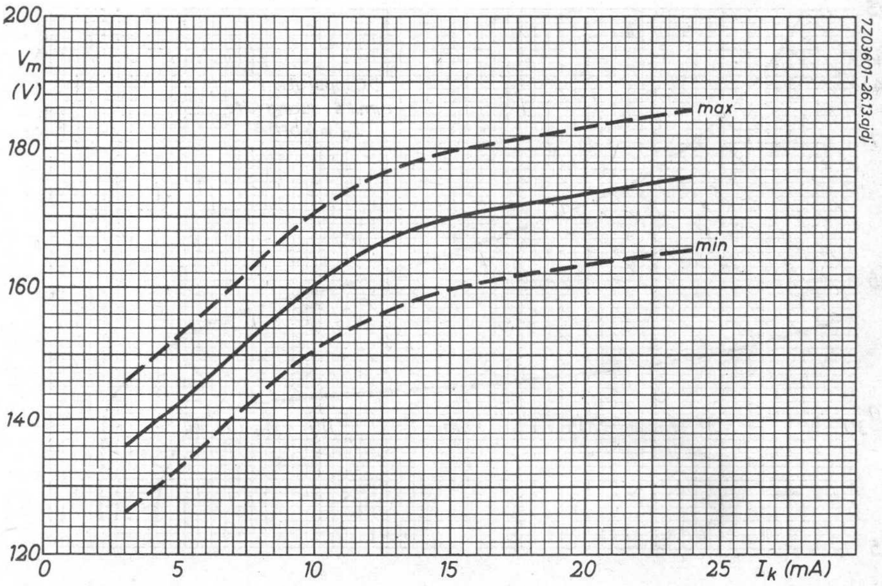
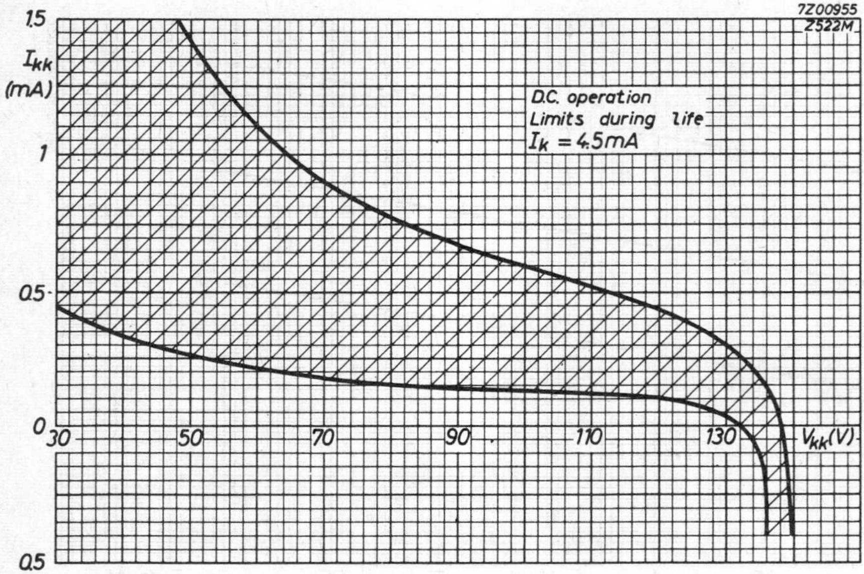


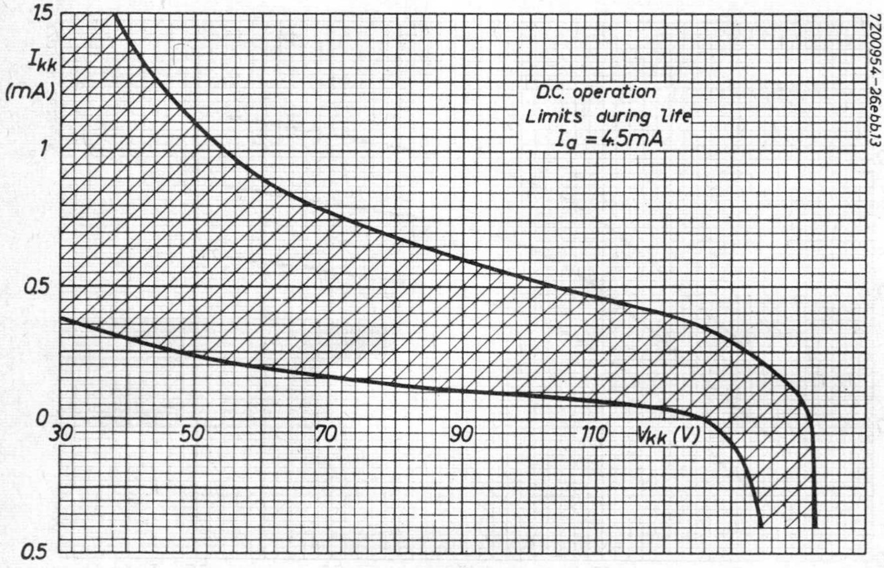
Fig.4

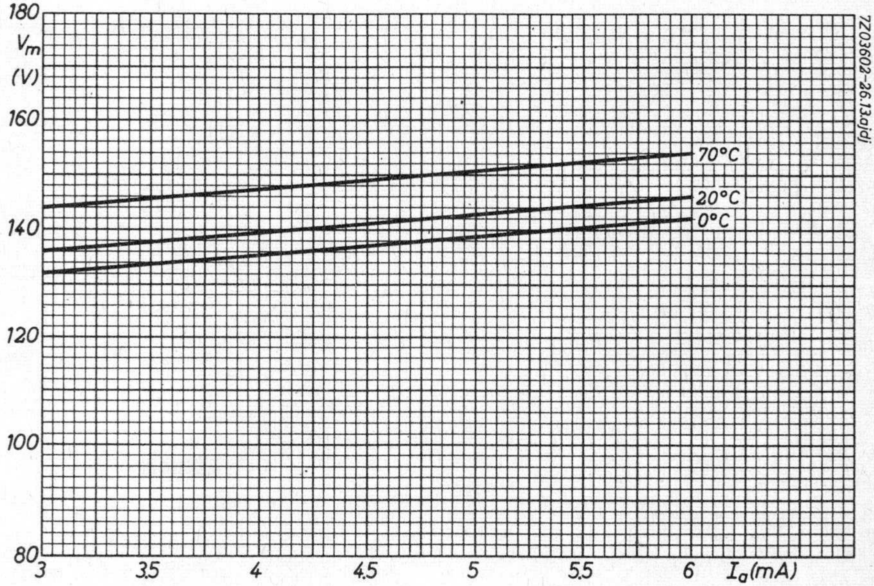
7Z2 5259


160
Vm
(V)
150
140
130
120
110
3
3.5
4
4.5
5
5.5
6
Ik (mA)
max
min
7Z03600-26.12.ajdj


200
Vm
(V)
180
160
140
120
0
5
10
15
20
25
Ik (mA)
max
min
7Z03601-26.13.ajdj


7Z00955
Z522M
1.5
I_{kk} (mA)
1
0.5
0
0.5
30
50
70
90
110
130
V_{kk}(V)
D.C. operation
Limits during life
I_k = 4.5mA


7Z00954-26ebb13
1.5
I_{kk} (mA)
1
0.5
0
0.5
30
50
70
90
110
V_{kk} (V)
D.C. operation
Limits during life
I_a = 4.5mA


180
V_m
(V)
160
140
120
100
80
3
3.5
4
4.5
5
5.5
6
I_a(mA)
70°C
20°C
0°C
7Z03602-26.13a(d)

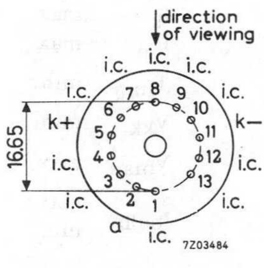
INDICATOR TUBE

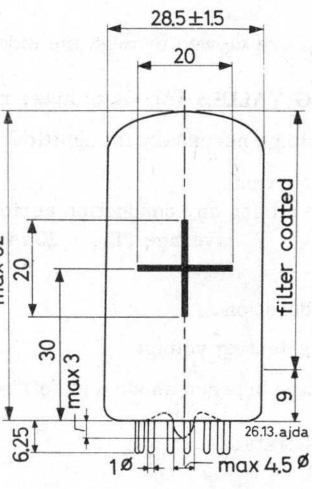
Cold cathode sign indicator tube for side viewing.

QUICK REFERENCE DATA		
Sign height	20	mm
Signs	+ -	
Supply voltage	160	V
Cathode current	4.5	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B





GENERAL

The tube has the same physical dimensions as the ZM1040 numeral indicator tube. The ZM1041 is provided with a red contrast filter.

7Z2 5260

CHARACTERISTICS

Ignition voltage	V_{ign}	max.	160	V
Maintaining voltage	V_m	see sheets A, B		
Extinguishing voltage	V_{ext}	min.	120	V
"Off" cathode probe current characteristic		see sheet B		

PRINCIPLE OF OPERATION

The tube contains two cathodes, in the form of the signs + and -, and a common anode. By applying a suitable voltage between the anode and one of the cathodes the corresponding sign will be covered by a red neon glow.

ACCESSORIES

Socket 2422 505 00001, 2422 505 00002 or 2422 505 00003

MOUNTING POSITION

Any

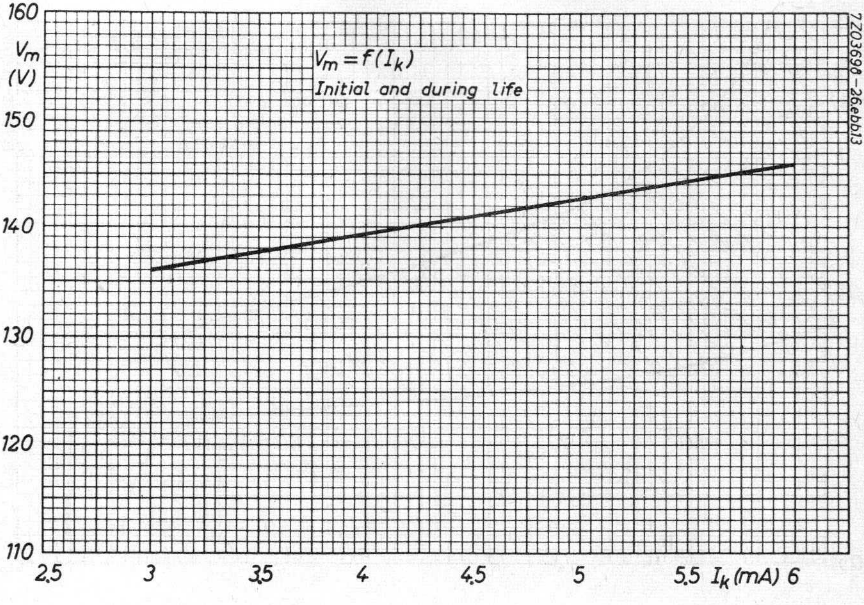
The signs are viewed through the side of the envelope.

LIMITING VALUES (Absolute max. rating system)

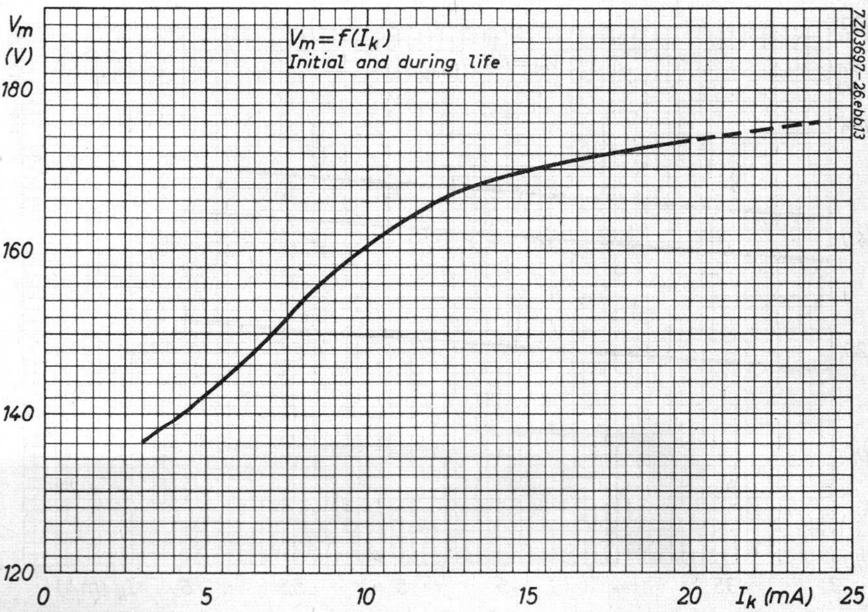
Anode voltage necessary for ignition	V_a	min.	160	V
Cathode current, average during any conduction period	I_k	min.	3	mA
average (T_{av} = 20 ms)	I_k	max.	6	mA
peak	I_{kp}	max.	20	mA
Impulse duration	T_{imp}	min.	80	μs
Cathode selecting voltage	V_{kk}	min.	60	V
Bias voltage between anode and "off" cathode	V_{bias}	max.	120	V
Bulb temperature	t_{bulb}	max.	+70	°C [1]
		min.	-50	°C

[1]) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics (see sheet B).
In designing equipment to be used within a wide temperature range the use of "constant current operation" (high supply voltage with a high anode series resistor) is recommended.

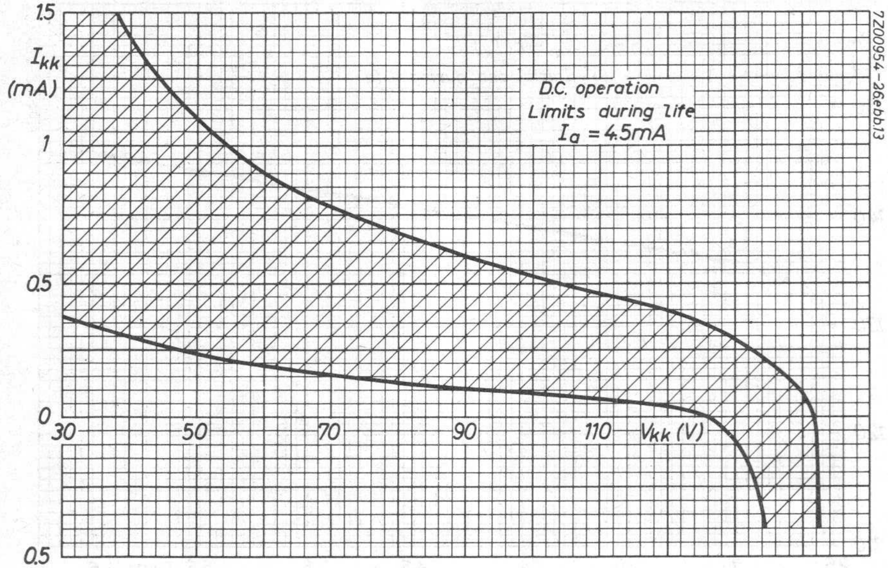
7Z2 8059

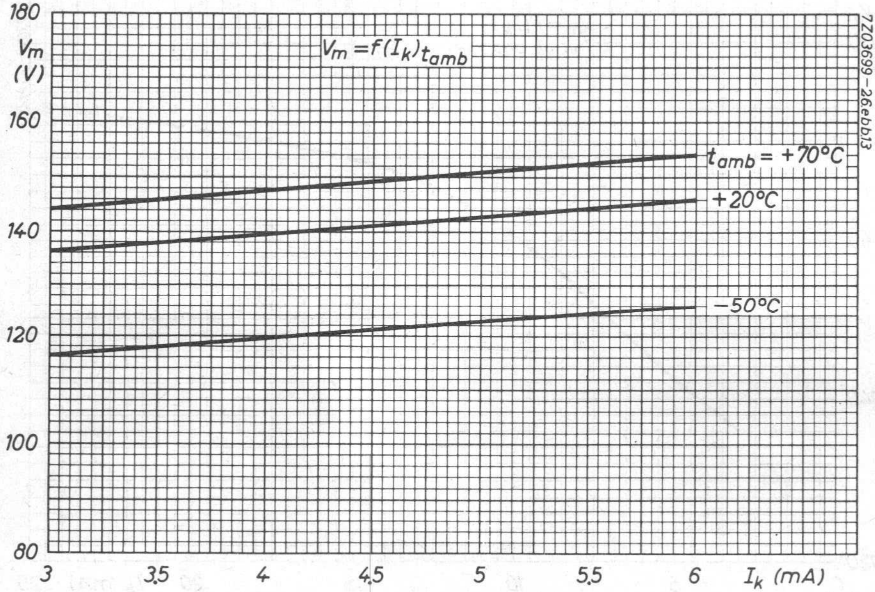


160
Vm
(V)
150
140
130
120
110
Vm = f(Ik)
Initial and during life
7Z03698-26.ebb13
2.5
3
3.5
4
4.5
5
5.5
Ik (mA)
6



Vm
(V)
180
160
140
120
Vm = f(Ik)
Initial and during life
7Z03697-26.ebb13
0
5
10
15
20
Ik (mA)
25


1.5
Ikk
(mA)
1
0.5
0
0.5
30
50
70
90
110
Vkk (V)
D.C. operation
Limits during life
Ia = 4.5mA
7Z00954-26ebb13


180
Vm
(V)
160
140
120
100
80
3
3.5
4
4.5
5
5.5
6
Ik (mA)
Vm = f(Ik)tamb
tamb = +70°C
+20°C
−50°C
7Z03699-26ebb13

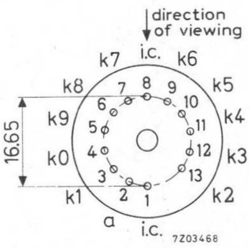
INDICATOR TUBE

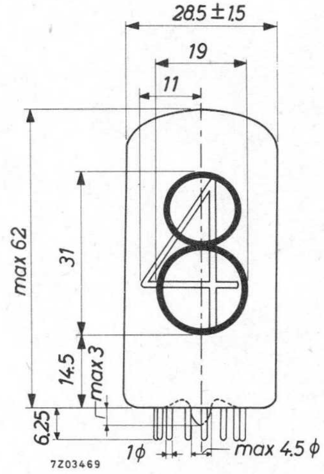
The type ZM1042 is electrically identical with type ZM1040 but has no filter coating.
The use of a separate blue absorbing, e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B





7Z2 5282

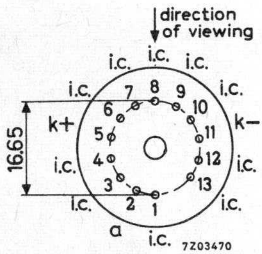
INDICATOR TUBE

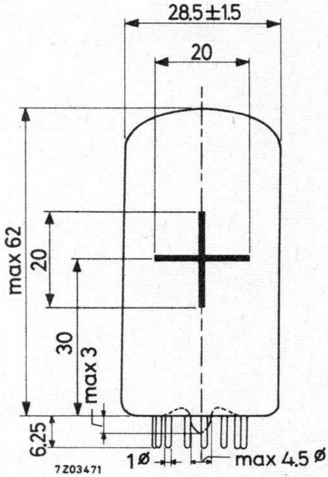
The type ZM1043 is electrically identical with type ZM1041 but has no filter coating.
The use of a separate blue absorbing, e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B





7Z2 5283

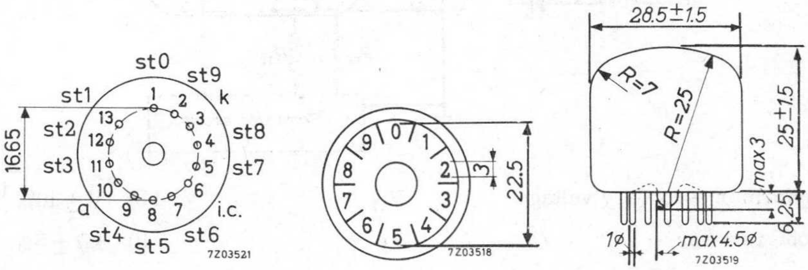
INDICATOR TUBE

Cold cathode numerical indicator tube for top viewing. Formely Z550M

QUICK REFERENCE DATA			
Numeral height		3	mm
Numerals		1 2 3 4 5 6 7 8 9 0	
Supply voltage	V_{ba}	90	Va.c.
Cathode current	I_k	3	mA
Starter selecting voltage		5	V

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B



GENERAL

The 3 mm high numerals are displayed in radial form.
The tube is primarily intended for use in circuits with transistor control.

PRINCIPLE OF OPERATION

The pulsating d.c. supply voltage (preferably half sine waves) causes one of the ten pure molybdenum cathode positions to glow. This position will be determined by the voltage level of corresponding starter being a few volts above the level of the remaining starters. 7Z2 5284

ACCESSORIES

Socket 2422 505 00001, 2422 505 00002 or 2422 505 00003

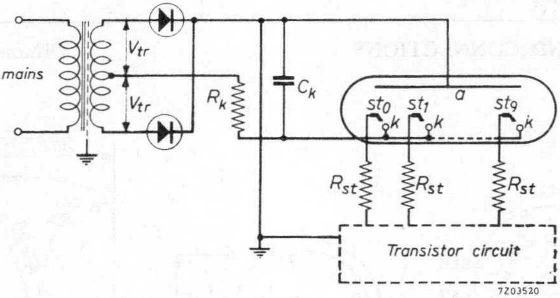
MOUNTING POSITION

Any

The numerals are viewed through the dome of the envelope.
The numerals appear upright when the tube is mounted with the line through pins 1 and 8, vertical pin 1 being uppermost.
Number 0 is aligned with pin 1 to within 3°.

CHARACTERISTICS AND OPERATING CONDITIONS

Recommended circuit



Transformer secondary voltage	V_{tr}	110	V ± 10% [1]
Cathode resistor	R_k	10	kΩ ± 5%
Starter series resistor	R_{st}	330	kΩ [2]
Shunting capacitor	C_k	33	nF [1]
Starter selecting voltage	$V_{st\text{-}st}$	See sheet A and 2) on page 3	
Starter current	I_{st}	50	μA
Maintaining voltage	V_m	84	V
Recommended cathode current	I_k	3	mA

1) The rectified a.c. voltage should be free from spikes.
A shunting capacitor C_k of 33 nF serves this purpose.

2) This resistor should be mounted close to the tube socket. 7Z2 8060

LIFE EXPECTANCY at recommended operating conditions and room temperature

Continuous display of one digit			1000	h	1)
Sequentially changing the display from one digit to the others every 100 h or less		min.	20 000	h	

The criterium for the end of life point is given by the minimum value of starter selecting voltage V_{st-st} shown on sheet A.

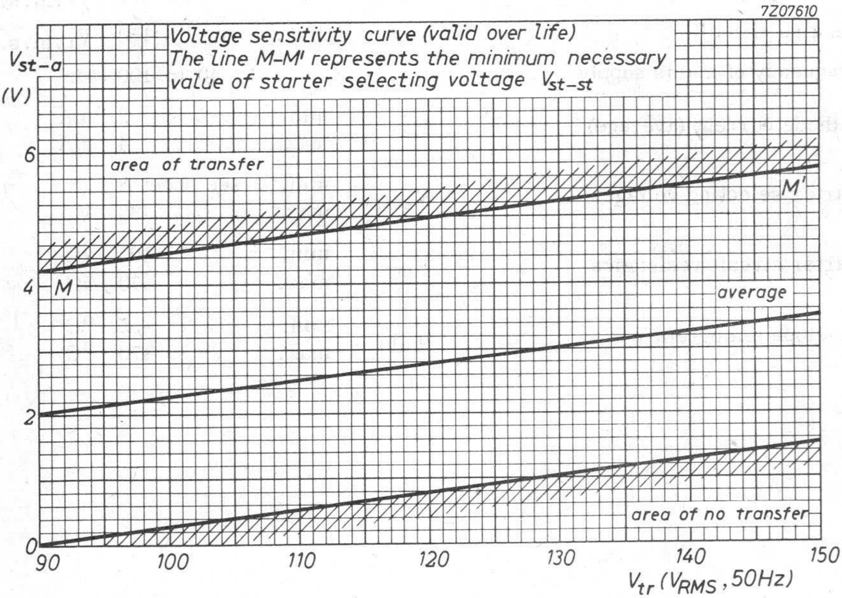
LIMITING VALUES (Absolute max. rating system)

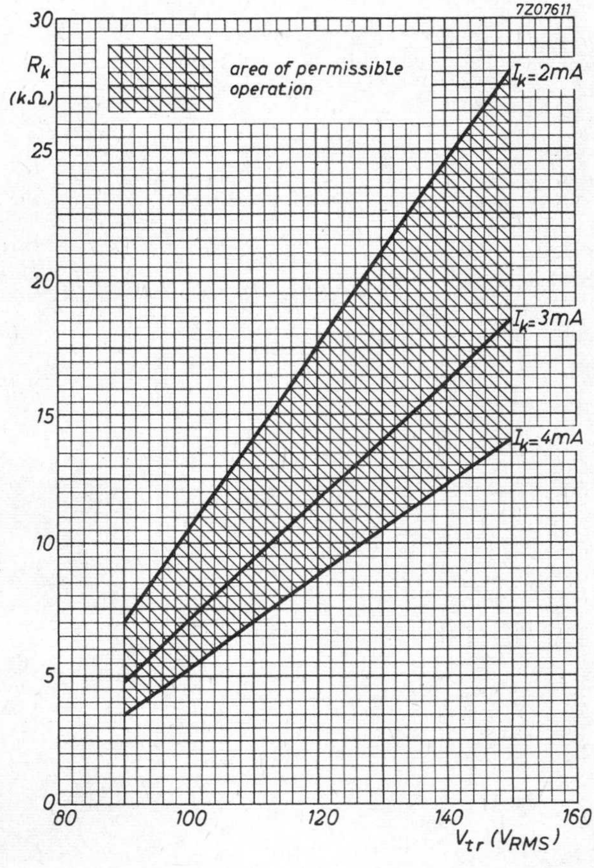
A.C. supply voltage	V_{tr}	min.	90	$V_{r.m.s.}$	
See also sheet B	V_{tr}	max.	150	$V_{r.m.s.}$	
Frequency of mains supply	f		40 to 100	Hz	
Cathode current (average)	I_k	min.	2	mA	
		max.	4	mA	
Starter selecting voltage	V_{st-st}	min.	see sheet A		2)
		max.	30	V	
Starter circuit resistance	R_{st}	min.	100	kΩ	
		max.	470	kΩ	
Envelope temperature	t_{bulb}	min.	-55	^{o}C	
		max.	+70	^{o}C	

1) Under conditions of longer continuous display on one digit it is recommended to apply a starter selecting voltage V_{st-st} greater than the minimum value, as indicated on sheet A.

2) The common starter bias potential may deviate by a maximum of ± 5 V from the anode potential.

7Z2 8061


7Z07610
Voltage sensitivity curve (valid over life)
The line M–M' represents the minimum necessary value of starter selecting voltage V_{st-st}
V_{st-a} (V)
6
4
2
0
area of transfer
M
M'
average
area of no transfer
90
100
110
120
130
140
150
V_{tr} (V_{RMS}, 50Hz)


7Z07611
area of permissible operation
R_k (kΩ)
30
25
20
15
10
5
0
80
100
120
140
160
V_{tr} (V_{RMS})
I_k=2mA
I_k=3mA
I_k=4mA

INDICATOR TUBE

Cold cathode ten digit side viewing numeral indicator tube

QUICK REFERENCE DATA				
Numeral height			13	mm
Numerals	1 2 3 4 5 6 7 8 9 0			
Supply voltage	V_b	min.	170	V
Cathode current	I_k		2	mA
Distance between mounting centres		min.	19	mm

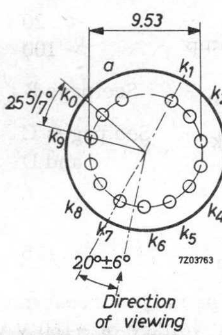
GENERAL

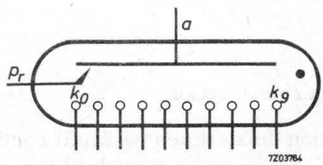
The numerals are 13 mm high and appear on the same base line allowing in-line read out. The ZM1080 is provided with a red contrast filter.

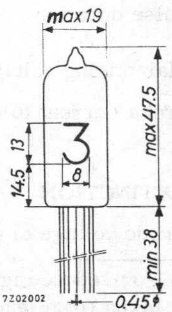
PRINCIPLE OF OPERATION

The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding figure will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS Dimensions in mm







7Z2 5287

Mounting position: any

The numbers are viewed through the side of the envelope. The numbers will appear upright (within ± 3°) when the tube is mounted vertically.
Care should be taken not to bend the leads nearer than 1.5 mm from the seals. The leads are tinned and may be dip soldered to a minimum of 5 mm from the seals at a solder temperature of 240 °C for a maximum of 10 seconds.
The tube may be soldered directly into the circuit but heat conducted to the glass to metal seals should be kept to a minimum by the use of a thermal shunt.

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN

Initially and during life at 20 °C to 50 °C unless otherwise stated.

Ignition			
Anode voltage	V_a	> 170	V
Ignition delay time		See page A [1])	
Conduction			
D.C. operation			
Cathode current [1])	I_k	< 3.5	mA
Cathode current for coverage	I_k	> 1.5	mA
Maintaining voltage at I_k = 2 mA (See also page B)	V_m	140	V
Probe current to individual non-conducting cathodes	I_{kk}	See page C	
Pulse operation			
Cathode current, peak	I_{kp}	< 12	mA
average, T_{av} = 20 ms	I_k	< 2.5	mA
Average cathode current for satisfactorily display	I_k	> 0.8	mA
Pulse duration	T_{imp}	< 20 > 100	ms µs
Maintaining voltage	V_m	See page B	
Probe current to individual non-conducting cathodes	I_{kk}	See pages C and D	

EXTINCTION

Anode voltage to ensure extinction	V_a	< 115	V

[1]) For reduced ignition delay times, a small continuous priming current may be taken from lead 4. This can be obtained from a supply voltage of −180 V with respect to the "on" cathode via a resistor of 18 MΩ.

7Z2 5288

LIFE EXPECTANCY

Under recommended operating conditions and t_{amb} = room

Continuous display of one digit [1]	> 5000	h
Sequentially changing the display from one digit to another every 100 hours or less	> 30 000	h

LIMITING VALUES (Absolute max. rating system)

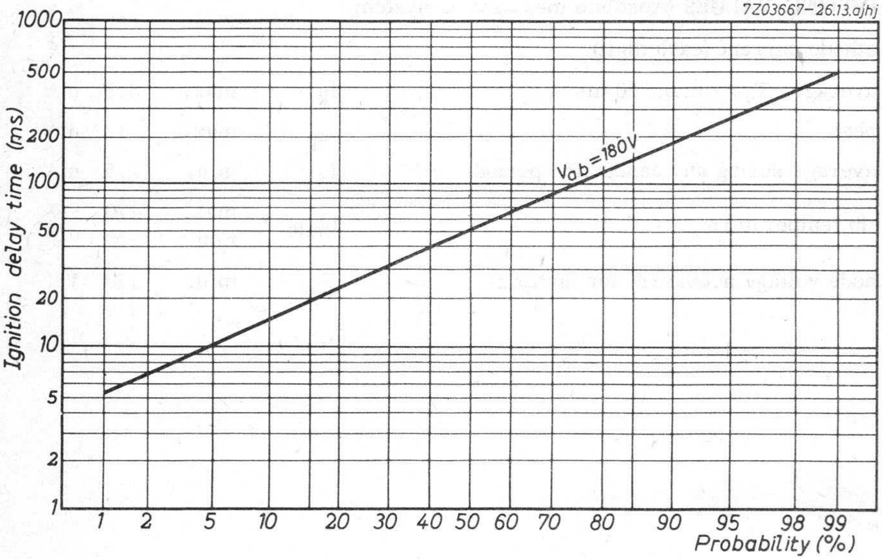
Cathode current (each digit)

average, T_{av} = max. 20 ms	I_k	max.	3.5	mA
peak	I_{kp}	max.	12	mA
average during any conduction period	I_k	min.	1.5	mA
Bulb temperature	t_{bulb}	max.	+70	°C
		min.	-50	°C [2]
Anode voltage necessary for ignition	V_a	min.	170	V

[1]) The life expectancy figures given above relate to operation with d.c. cathode currents between 1.5 mA to 2.5 mA and at all permitted pulsed cathode currents.
When a d.c. cathode current range of 1.5 mA to 3.5 mA is used, the life expectancy exceeds 3000 hours with continuous display of one digit.

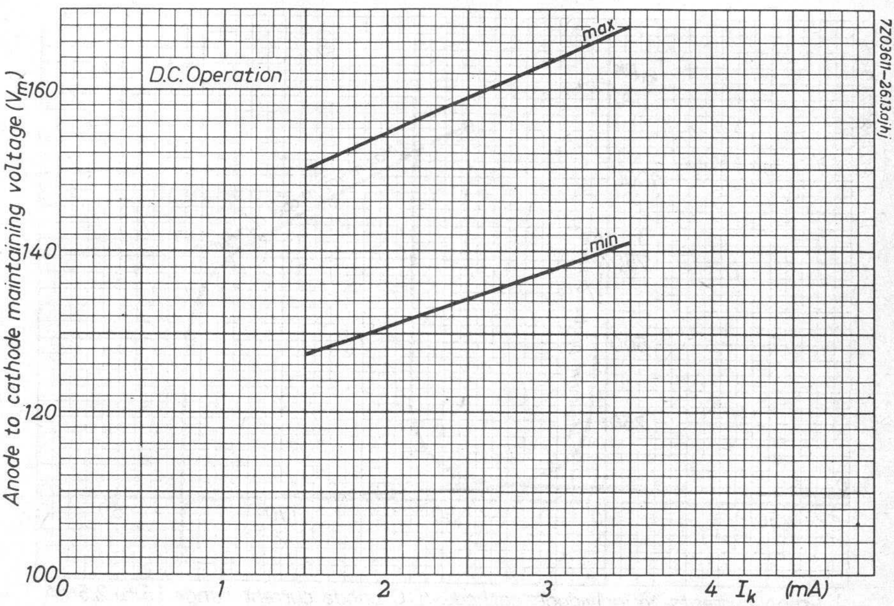
[2]) For bulb temperatures below 0 °C the life expectancy of the tube is substantially reduced.

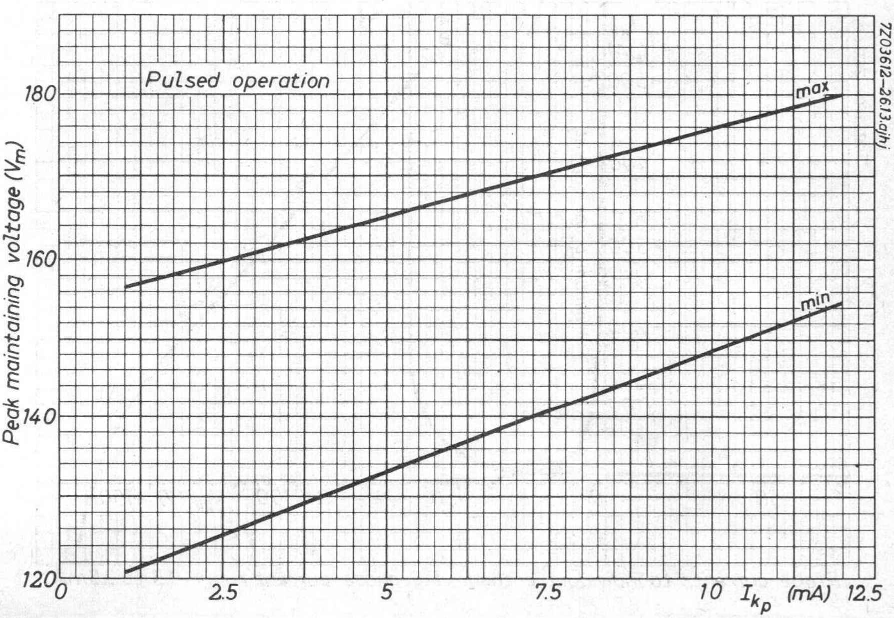
7Z2 5289

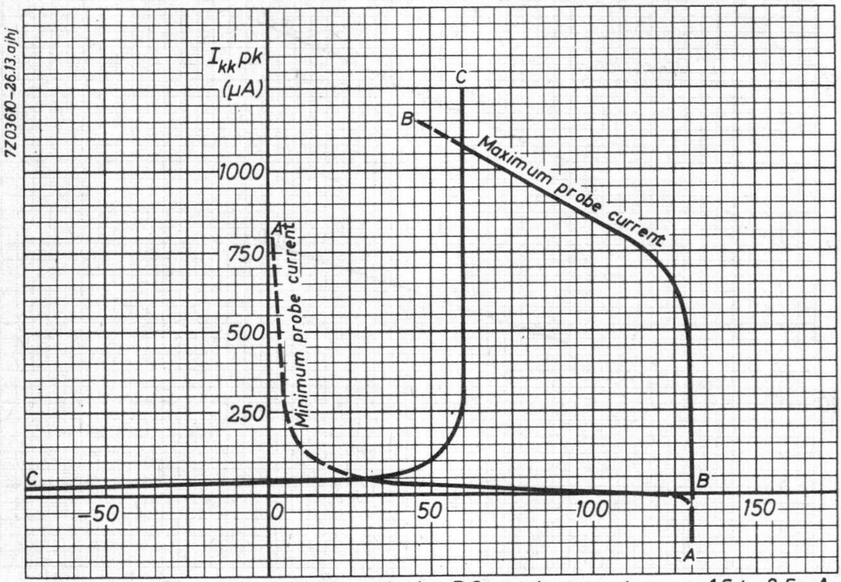


CUMULATIVE DISTRIBUTION OF IGNITION DELAY TIME

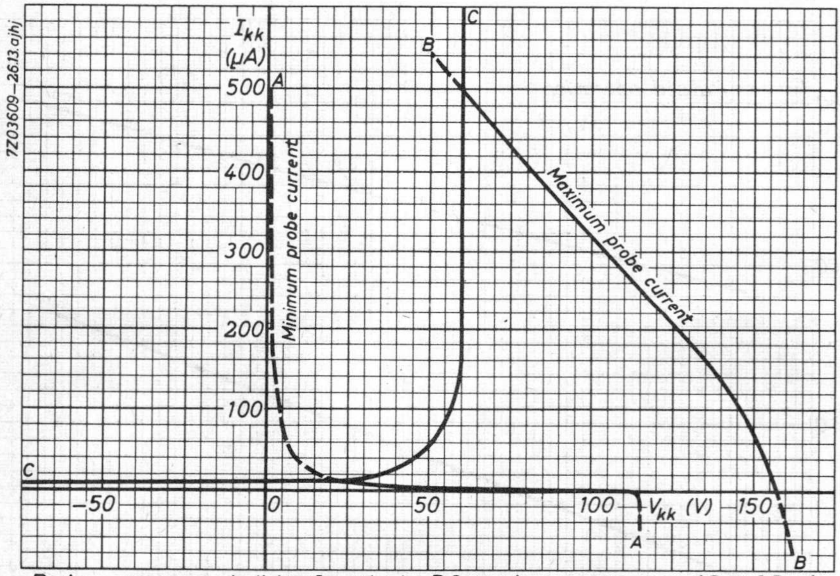
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few seconds. The ignition delay time will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage will reduce the ignition delay time. 7Z2 5290


D.C. Operation
max
min
Anode to cathode maintaining voltage (Vm)
100
120
140
160
0
1
2
3
4
Ik (mA)
7Z03611-26.13.aihj

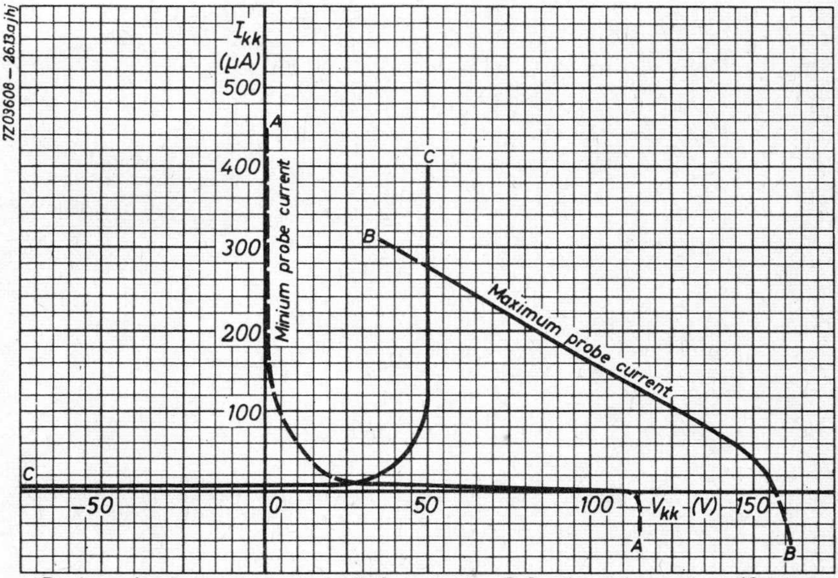

Pulsed operation
max
min
Peak maintaining voltage (Vm)
120
140
160
180
0
2.5
5
7.5
10
Ikp (mA)
12.5
7Z03612-26.13.aihj



Probe currents to individual cathodes. D.C. anode current range 1.5 to 2.5 mA



Probe currents to individual cathodes. D.C. anode current range 1.5 to 3.5 mA



Peak probe currents to individual cathodes. Pulsed anode current 10mA
Duty factor 0.1

PROBE CURRENT CURVES

The boundaries A-A and B-B of the graphs represent, for the shown anode current ranges, the range of probe currents to individual non-conducting cathodes plotted against the voltage difference between the non-conducting cathodes and the conducting cathode.

For optimum display, the probe current to any non-conducting cathode should be as low as possible. In addition, reverse probe current should not be permitted.

These conditions can be satisfied in two ways:

(1) With a low impedance voltage source connected to the non-conducting cathodes. For example, when using a current range of 1.5 to 2.5 mA and a voltage between 50 and 115 V is required.

(2) With a separate high impedance connected to each non-conducting cathode and returned to a voltage source of less than 115 V. In this case the load line of the voltage source must lie to the right of boundary C-C.

7Z2 5291

INDICATOR TUBE

Cold cathode side viewing character indicator tube.

QUICK REFERENCE DATA				
Character height			10.5	mm
Characters			– + ~	
Supply voltage	V_b	min.	170	V
Cathode current	I_k		2	mA

GENERAL

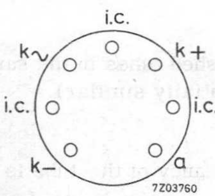
The ZM1081 is provided with a red contrast filter

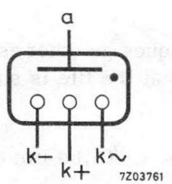
PRINCIPLE OF OPERATION

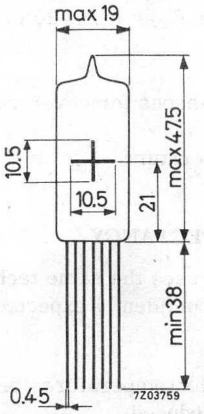
The tube contains 3 cathodes in the form of the characters –, + and ~ and one common anode.
By applying a suitable voltage between the anode and one of the three cathodes the corresponding character will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







7Z2 5292

Mounting position: any

The characters are viewed through the side of the envelope.
The characters will appear upright (within ±2°) when the tube is mounted vertically.

Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

The leads are turned and may be dip soldered to a minimum of 5 mm from the seals at a solder temperature of 240 °C for a maximum of 10 seconds.

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage at I_k = 2 mA	V_m	See page A		
Extinguishing voltage	V_{ext}	min.	115	V

Typical operation

D.C. operation with or without V_{kk}. See fig.1 and 2

Anode supply voltage	V_{ba}	250	300	350	V
Maintaining voltage	V_m	140	140	140	V
Anode series resistor	R_a	56	86	100	kΩ
Cathode selecting voltage	V_{kk}	min.	60		V

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	170	V
Cathode current,				
average T_{av} = max. 20 ms	I_k	max.	3.5	mA
peak	I_{kp}	max.	12	mA
instantaneous for coverage	I_k	min.	1.5	mA
Bulb temperature	t_{bulb}	max.	+70	°C
		min.	-50	°C [1]

LIFE EXPECTANCY

This tube uses the same techniques as other established tubes in the same range and it is confidently expected that the life is substantially similar).

[1] For bulb temperatures below 0 °C the life expectancy of the tube is substantially reduced.

7Z2 5293

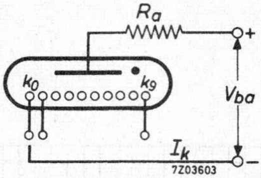


Fig.1

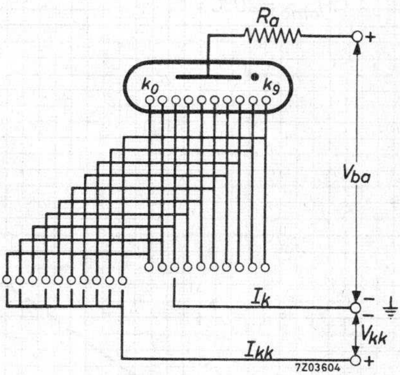
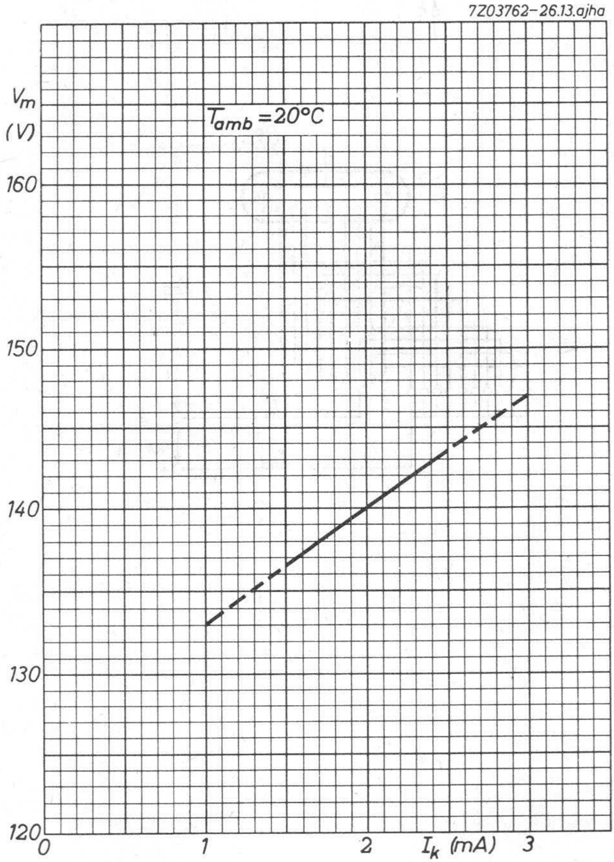


Fig.2

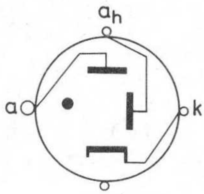
7Z2 5294

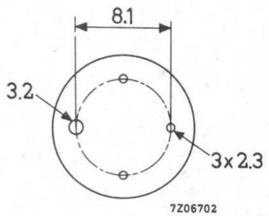

7Z03762–26.13.ajha
V_m
(V)
$T_{amb} = 20°C$
160
150
140
130
120
0
1
2
3
I_k (mA)

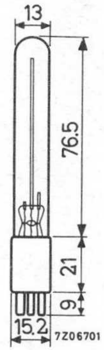
INDICATOR TUBE

DIMENSIONS AND CONNECTIONS

Dimensions in mm







OPERATING CHARACTERISTICS

Ignition voltage of auxiliary anode	V_{ign}	165 to 190	V
Auxiliary anode current	I_{ah}	40 to 50	μA
Maintaining voltage of main anode	V_m	150 to 170	V
Main anode current	I_a	max. 2	mA ←

7Z2 7668

Trigger tubes and switching diodes

RATING SYSTEM
(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.

7Z2 5065

RATINGS SYSTEM

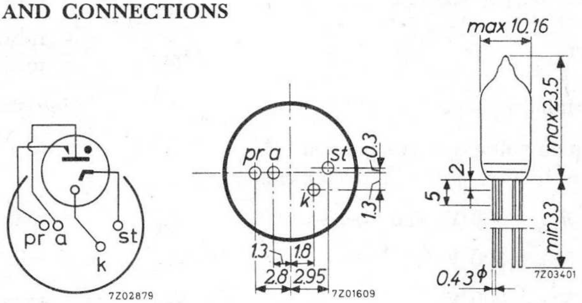
[illegible]

TRIGGER TUBE

Subminiature cold cathode trigger tube with electrical priming. The tube has a molybdenum cathode and is designed for operation with positive voltages on its anode and starter in applications as counters, shift registers, pulse generators, general relay service and timers.
During conduction a red neon glow is visible through the base.

QUICK REFERENCE DATA				
Anode supply voltage	V_{b_a}	=	250	V
Anode to cathode maintaining voltage	V_m	=	116	V
Maximum average cathode current	I_k	=	5	mA
Starter to cathode ignition voltage	$V_{st_{ign}}$	=	145	V
Min. starter capacitance required for transfer	C_{st}	=	100	pF
Max. counting speed in decade counter		=	5	kHz

DIMENSIONS AND CONNECTIONS



MOUNTING

1. Directly soldered connections to the leads must be at least 5 mm from glass and any bending of the leads must be at least 2 mm from the glass.
2. When soldering into the circuit the heat conducted to the glass should be kept to a minimum by the use of a thermal shunt on the leads.
3. The leads may be dip-soldered to minimum 5 mm from the glass at a solder temperature of 240 °C during maximum 10 seconds.

7Z2 8396

MOUNTING (continued)

4. The starter and priming cathode circuit resistors and capacitors should be mounted close to the tube.

5. The tube may ignite spontaneously when mounted in an electric field, the probability of igniting being dependent on the field strength (direction and magnitude) and its rate of change. Touching the envelope by live components should be avoided, and it is recommended to maintain a distance between components or electrostatic shields and any part of the envelope of at least some mm.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN
(over life and full temperature range unless otherwise stated)

All values quoted assume the presence of a priming discharge which should be ensured during stand-by and conduction. This discharge has a typical max. ignition delay of 0.1 sec at V_{ba-pr} = 200 V.

Stand-by (main gap non conducting)

Anode to cathode voltage				
positive ($V_{st} \geq 0$ V, $I_{st} \leq 0.5\ \mu A$) See also sheet D	V_a	= max.	310	V [1])
negative (V_{st} = 0 to 100 V, I_{st} = 0 mA)	$-V_a$	= max.	50	V
Anode to primer supply voltage	V_{ba-pr}	= min.	200	V
Primer current	I_{pr}	= min.	1	μA
		= max.	12	μA
Primer maintaining voltage		See sheet F		
Starter to cathode voltage to ensure non ignition				
positive, at V_{ba} = 300 V, see also sheet A	V_{st}	= max.	135	V [2])
negative, at V_{ba} = 300 V	$-V_{st}$	= max.	30	V [3])
at V_{ba} = 200 V	$-V_{st}$	= max.	50	V [3])
Starter current				
positive		See sheet D		
negative		=	0	μA
Starter to cathode maintaining voltage (I_{st} = 30 μA, I_a = 0 mA, see also sheet D)				
typical minimum	V_{mst}	= min.	105	V

7Z2 8397

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN (continued)

Ignition [4]

Anode to cathode voltage	V_a	= min. 200 V
Primer current	I_{pr}	= min. 1 μA = max. 12 μA

D.C. triggering

Starter to cathode voltage above which all tubes ignite (V_{ba} = 250 V) (See sheet A)		
initially	$V_{st_{ign}}$	= min. 153 V
typical over life	$V_{st_{ign}}$	= min. 155 V [7]
Typical max. change over life	$\Delta V_{st_{ign}}$	= ±3 V [7]
Typical max. temperature coefficient of starter ignition voltage	$\frac{\Delta V_{st_{ign}}}{\Delta t_{bulb}}$	= −25 mV/°C
Starter to cathode capacitance to ensure transfer (See sheet A)	C_{st}	= min. 100 pF [8]
Starter to cathode maintaining voltage (I_{st} = 30 μA, I_a = 0 mA, See also sheet D)		
typical max.	V_{mst}	= max. 128 V
typical min.	V_{mst}	= min. 105 V

Pulse triggering

Starter to cathode pulse + bias voltage above which all tubes ignite (V_{ba} = 250 V, T_{imp} = 20 μs)		
initially	V_{stp}	= min. 172 V [2][3]
typical over life		See sheet G
Typical max. temperature coefficient of starter ignition voltage	$\frac{\Delta V_{st_{ign}}}{\Delta t_{bulb}}$	= −25 mV/°C
Starter coupling capacitance to ensure transfer	C_{st}	= min. 100 pF [9]
Typical anode breakdown delay		= 5 μs [5]

[1][2][3][4][5][7][8][9] See page 5

7Z2 8398

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN (continued)

Main gap conducting

During conduction a neon glow is visible through the base.

Static anode to cathode maintaining voltage

at I_k = 3.5 mA (See also sheet B)	V_m	= min.	111	V [4]
initial max.	V_m	= max.	120	V [4]
typical over life	V_m	= max.	122	V [4]
Min. cathode current during any conduction period	I_k	= min.	2	mA
Max. average cathode current ($T_{av\ max.}$ = 5 s)	I_k	= max.	5	mA
Max. peak cathode current (See also sheet F)	I_{k_p}	= max.	200	mA
Starter current		See sheet E		
positive average ($T_{av\ max.}$ = 5 s)	I_{st}	= max.	3	mA
positive peak	I_{st_p}	= max.	100	mA
negative when d.c. triggering is used	$-I_{st}$	= max.	10	μA [7]
negative when pulse triggering is used	$-I_{st}$	= max.	120	μA [7]
Rise in bulb temperature	Δt_{bulb}	= approx.	8	^{o}C/mA

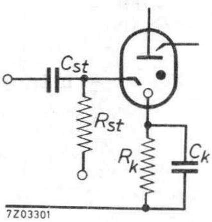
Extinction

Forced extinction

Anode circuit recovery time constant = min. 200 μs [6]

Self extinction

Typical minimum component values to ensure self extinction of the main discharge



C_{st} =	100	pF
R_{st} =	1.2	MΩ
C_k =	330	pF
R_k =	1.8	MΩ

7Z2 8399

LIFE EXPECTANCY 7)

Provided the operating recommendations are observed a life in excess of 30.000 operating hours may be expected with a failure rate of 0.1 % per 1000 h.

1) This value for maximum anode voltage holds for cathode currents up to 6 mA. At cathode currents above 6 mA the maximum anode voltage is reduced with 4 V per additional mA. The normal value of 310 V will be restored within 30 s after cessation of conduction.

2) At anode supply voltages higher than 270 V, spurious ignitions may occur if a large amplitude pulse (higher than 100 V) with a steep leading edge which is not intended to ignite the tube reaches the starter.

3) In some circuits differentiation may give rise to negative pulses on the starter. Care must be taken not to exceed the limiting value for $-V_{st}$.

4) Immediately after ignition a voltage considerably lower than the published maintaining voltage may occur across the tube. Thus the output pulse may be higher than the difference between the supply voltage and the static maintaining voltage. Care should be taken to sustain the priming discharge.

5) The anode breakdown delay is given under the following conditions: Starter overvoltage 50 V, R_{st} = 1.2 MΩ, C_{st} = 100 pF, V_{ba} = 200 to 300 V.

6) The anode recovery time is the time required after interruption of the anode current for the starter to regain control. The figure quoted is the minimum required value of the time constant RC determining the rate of rise of the anode voltage.

7) To achieve the maximum stability over life the following operating notes should be observed:

a) Repetitive ignition via the starter to cathode gap is recommended. The frequency of these ignitions should preferably be higher than once per minute.

b) Negative starter current should be kept to a minimum.

c) Periods during which negative starter current is drawn shall be kept as short as possible.

d) It is recommended that peak currents should be allowed to flow immediately after ignition. This can be done by the use of by-pass capacitors.

e) In general pulsed cathode currents are preferable to d.c.

8) It is recommended to use higher values of C_{st} at low anode supply voltages e.g. 1 nF at V_{ba} = 200 V.

9) Where possible (at low frequencies) a larger starter capacitor than the specified minimum should be used.

10) Adequate cooling should be provided. Envelope temperature rise above ambient at I_k = 20 mA is abt. 160 °C.

7Z2 5277

LIMITING VALUES (Absolute max. rating system)

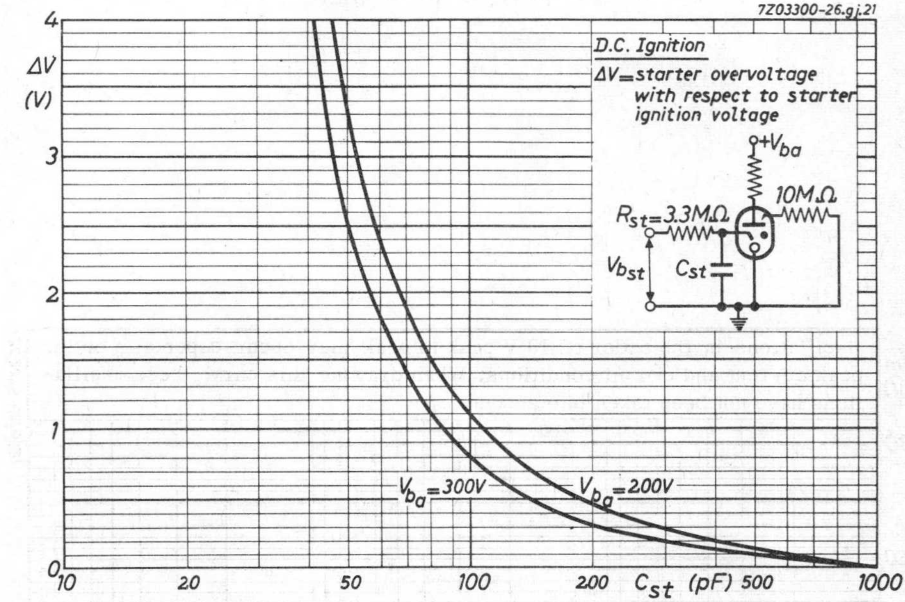
Anode voltage				
negative (V_{st} = −50 to +100 V, I_{st} = 0 μA)	$-V_a$	= max.	50	V
(I_{st} > 0 μA)	$-V_a$	= max.	0	V
Starter voltage				
negative at V_{ba} = 300 V	$-V_{st}$	= max.	30	V
at V_{ba} = 200 V	$-V_{st}$	= max.	50	V
Cathode current, average during conduction period	I_k	= min.	2	mA
average ($T_{av\ max.}$ = 5 s)	I_k	= max.	5	mA
peak (See also sheet F)	I_{kp}	= max.	200	mA
Starter current				
positive average ($T_{av\ max.}$ = 5 s)	I_{st}	= max.	3	mA
peak	I_{st_p}	= max.	100	mA
negative, main gap conducting				
when d.c. triggering is used	$-I_{st}$	= max.	10	μA
when pulse triggering is used	$-I_{st}$	= max.	120	μA
main gap non conducting	$-I_{st}$	= max.	0	μA
Primer current	I_{pr}	= max.	12	μA
Envelope temperature				
tube conducting	t_{bulb}	= max.	100	°C
		= min.	−55	°C
storage and stand-by	t_{bulb}	= max.	70	°C
		= min.	−55	°C

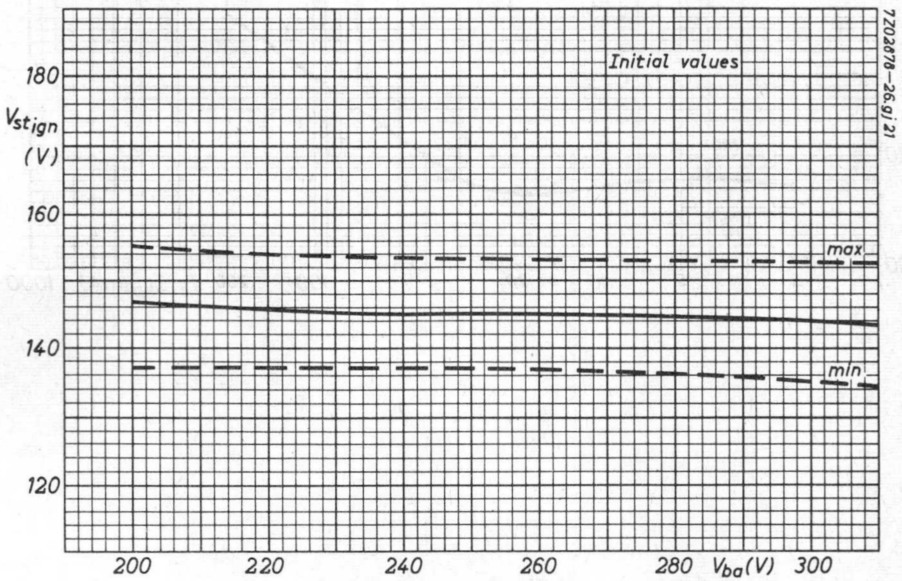
LIMITING VALUES (Absolute max. rating system) <u>for reduced life expectancy</u> (4000 operating hours)

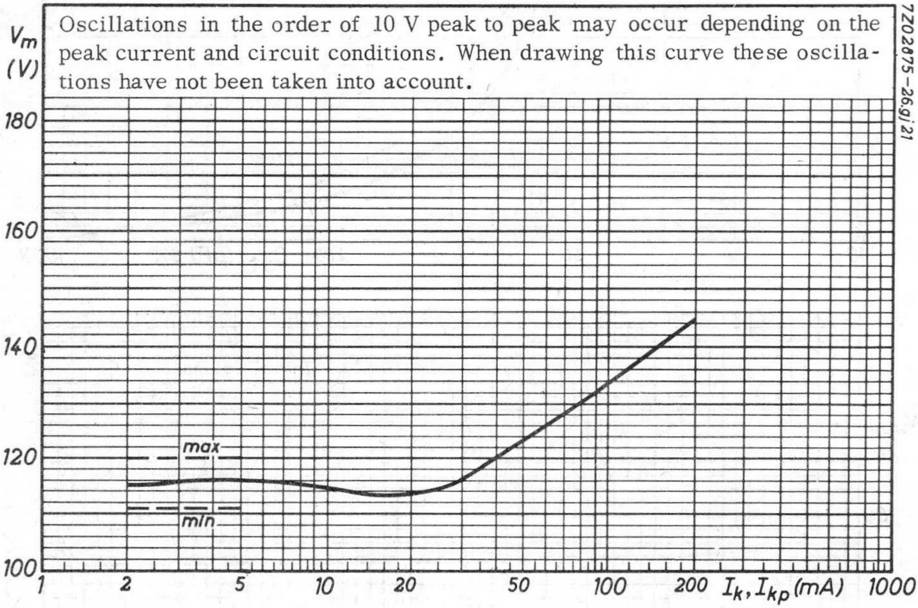
If reduced life expectancy can be tolerated the following limiting values apply:

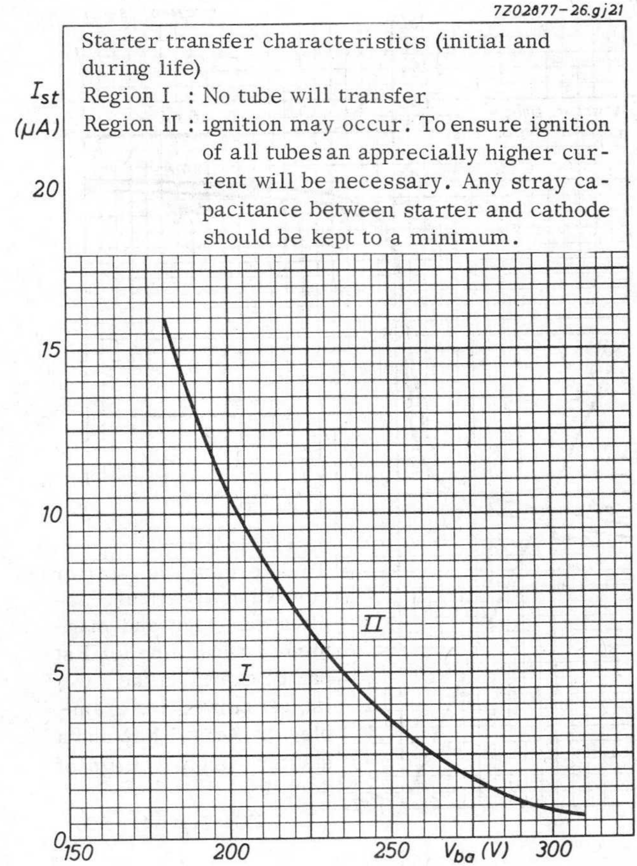
Cathode current				
d.c.	I_k	= max.	20	mA
half-wave rectified a.c., average	I_k	= max.	8	mA
peak ($T_{max.}$ = 20 ms)	I_{kp}	= max.	32	mA
Envelope temperature	t_{bulb}	= max.	200	°C 10)

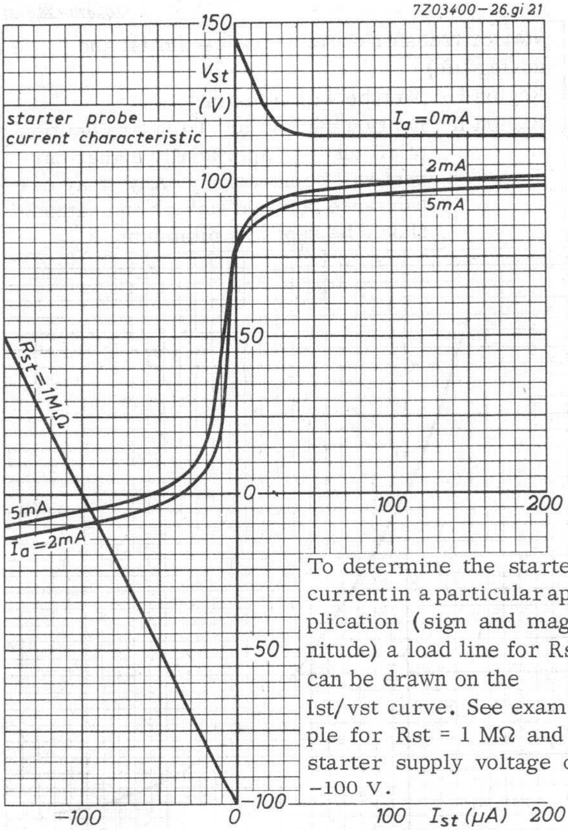
7Z2 8400


7Z03300-26.gj.21
D.C. Ignition
ΔV=starter overvoltage with respect to starter ignition voltage
+Vba
10MΩ
Rst=3.3MΩ
Vbst
Cst
ΔV (V)
Vba=300V
Vba=200V
Cst (pF)
10
20
50
100
200
500
1000
0
1
2
3
4

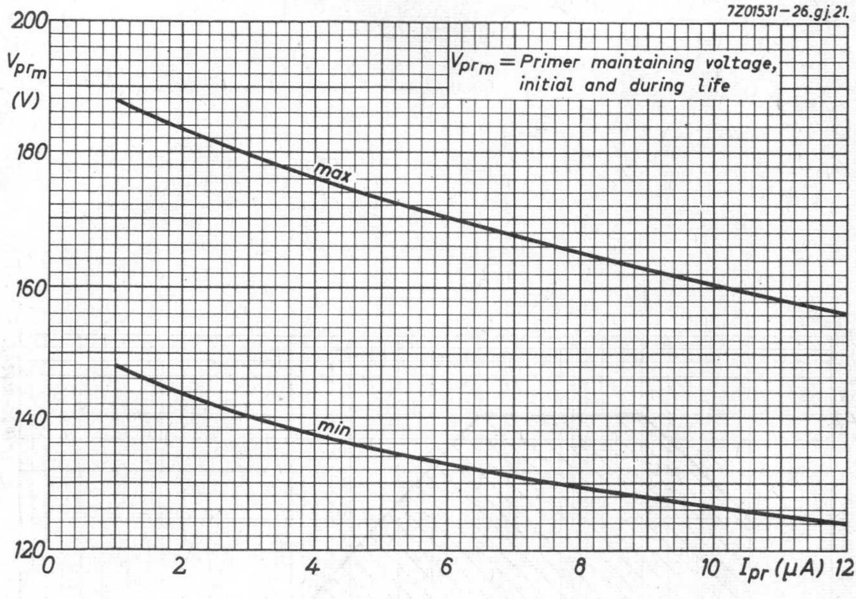

7Z02678-26.gj 21
Initial values
Vstign (V)
max
min
120
140
160
180
200
220
240
260
280
Vba(V)
300

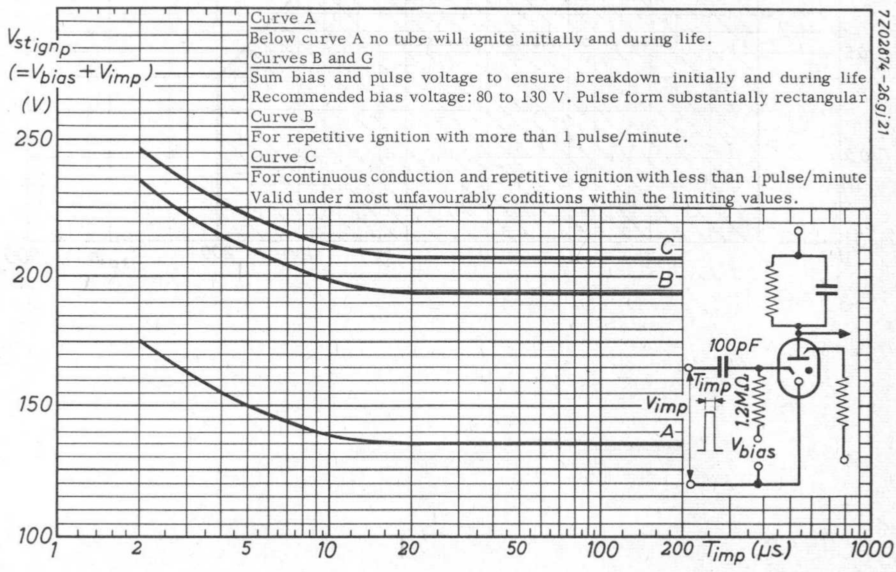

Oscillations in the order of 10 V peak to peak may occur depending on the peak current and circuit conditions. When drawing this curve these oscillations have not been taken into account.
V_m (V)
180
160
140
120
100
max
min
1
2
5
10
20
50
100
200
I_k, I_{kp} (mA)
1000
7Z02875-26.gj 21

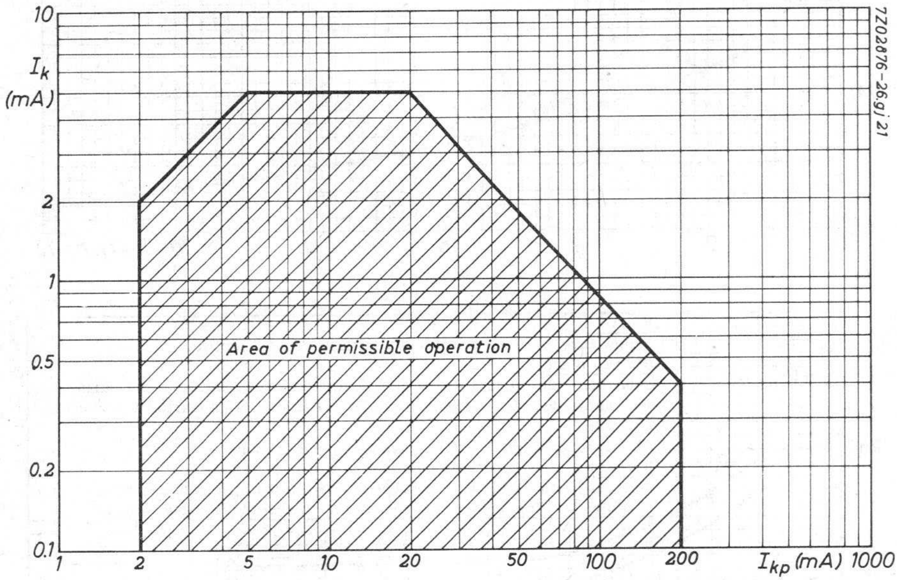

7Z02877-26.gj21
Starter transfer characteristics (initial and during life)
Region I : No tube will transfer
Region II : ignition may occur. To ensure ignition of all tubes an apprecially higher current will be necessary. Any stray capacitance between starter and cathode should be kept to a minimum.
I_{st} (μA)
20
15
10
5
0
150
200
250
V_{ba} (V)
300
I
II



To determine the starter current in a particular application (sign and magnitude) a load line for Rst can be drawn on the Ist/vst curve. See example for Rst = 1 MΩ and a starter supply voltage of -100 V.


7Z01531-26.gj.21.
V_{pr_m} = Primer maintaining voltage, initial and during life
V_{pr_m} (V)
200
180
160
140
120
max
min
0
2
4
6
8
10
I_{pr} (μA)
12

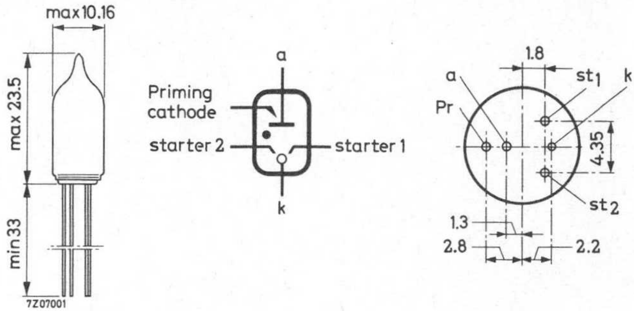

7Z02874-26.gj.21
Curve A
Below curve A no tube will ignite initially and during life.
Curves B and G
Sum bias and pulse voltage to ensure breakdown initially and during life
Recommended bias voltage: 80 to 130 V. Pulse form substantially rectangular
Curve B
For repetitive ignition with more than 1 pulse/minute.
Curve C
For continuous conduction and repetitive ignition with less than 1 pulse/minute
Valid under most unfavourably conditions within the limiting values.
V_{stign_p}
$(=V_{bias}+V_{imp})$
(V)
250
200
150
100
C
B
A
100pF
T_{imp}
V_{imp}
1.2MΩ
V_{bias}
1
2
5
10
20
50
100
200
T_{imp} (μs)
1000


10
I_k
(mA)
2
1
0.5
0.2
0.1
1
2
5
10
20
50
100
200
I_{kp} (mA) 1000
Area of permissible operation
7Z02876-26.gj 21

TRIGGER TUBE

The type Z70W is electrically identical with type Z70U but has two independent starter electrodes

DIMENSIONS AND CONNECTIONS Dimensions in mm



MOUNTING

1. Directly soldered connections to the leads must be at least 5 mm from the glass and any bending of the leads must be at least 2 mm from the glass.
2. When soldering into the circuit the heat conducted to the glass should be kept to a minimum by the use of a thermal shunt on the leads.
3. The leads may be dip-soldered to minimum 5 mm from the glass at a solder temperature of 240 °C during maximum 10 seconds.

For electrical data please refer to type Z70U

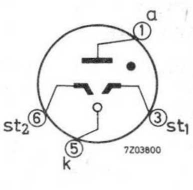
7Z2 7911

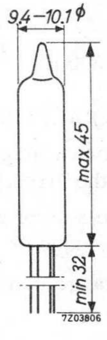
TRIGGER TUBE

Cold cathode trigger tube with two starters designed for operation with positive voltages on anode and starters. The tube is intended for use in counting circuits, switching circuits and speech passing circuits in telephone exchanges. When conducting, the tube has a low noise level and a low impedance to speech frequencies.

QUICK REFERENCE DATA			
Anode supply voltage	V_{ba}	150	V
Maintaining voltage	V_m	60	V
Cathode current,			
continuous	I_k	7	mA
intermittent	I_k	9	mA
Starter ignition voltage (either starter)	$V_{st\ ign}$	80	V
Starter transfer current (either starter)	I_{st}	40	μA

DIMENSIONS AND CONNECTIONS Dimensions in mm





MOUNTING

The tube may be soldered directly into the circuit but heat conducted to the glass should be kept to a minimum by the use of a thermal shunt.
The leads may be dip-soldered to minimum 5 mm from the glass to metal seals at a solder temperature of 240 °C during max. 10 seconds.
Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

7Z2 5318

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN

These values apply only when the tube is exposed to some light (10 lux, 1 foot-candle). Direct exposure to bright sunlight may affect the anode hold-off and should be avoided.

Starter ignition voltage	$V_{st\,ign}$	<	90	V [1])
at V_a = 130 V, see fig. 1 page A	$V_{st\,ign}$	>	73	V
Starter transfer current at V_a = 130 V	I_{st}		30	μA
see fig. 2 page A	I_{st}	<	100	μA
Starter maintaining voltage	$V_{m_{st}}$	see fig. 4 page A		
Anode supply voltage range	V_{ba}		120 to 165	V
Anode ignition voltage with starter connected to cathode. see page B	V_{ign}		200	V
	V_{ign}	>	175	V
Anode maintaining voltage	V_m		58	V
at I_k = 5 mA. see fig. 3 page A	V_m	<	66	V
	V_m	>	55	V
Preferred current range	I_k		3 to 7	mA
Preferred current range in counting circuits	I_k		1.5 to 7	mA
Preferred current range for use as speech passing device (intermittent service)	I_k		7 to 9	mA
Impedance at I_k = 8 mA d.c. + 1 $mA_{r.m.s.}$,	z		400	Ω
frequency 300 Hz to 3.300 Hz	z	<	800	Ω

TYPICAL DYNAMIC CHARACTERISTICS

The dynamic starter ignition voltage depends on the pulse shape and the circuit components		see page C	
Recommended value of the sum of pulse and bias voltage (circuit see page 4)		120	V
Anode voltage operating range in a pulsed circuit	V_a	110 to 165	V
Anode delay time (circuit see page 4)		5	μs
Max. frequency in a counter (circuit see page 4)		see page D	
Typical components in a self-quenching pulse forming circuit		see page 4)	

7Z2 8401

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	I_k < 9 mA	V_{ba}	max.	165	V
	I_k < 5 mA	V_{ba}	max.	170	V
Cathode current,					
average, continuous		I_k	max.	7	mA
average, intermittent		I_k	max.	9	mA
peak T = max. 1 s		I_{k_p}	max.	12	mA
Starter current, negative					
tube conducting		$-I_{st}$	max.	200	μA
tube non-conducting		$-I_{st}$	max.	0	μA
Bulb temperature		t_{bulb}	max.	+70	°C
			min.	-50	°C
Starter pulse voltage (20 μs) (circuit see fig. 6)			max.	80	V
Starter circuit resistance		R_{st}	max.	1	MΩ [2]

LIFE EXPECTANCY

at I_k = 9 mA	2000	hours
at I_k = 5 mA	10 000	hours

REMARK

The starter resistors and capacitors should be mounted close to the tube.

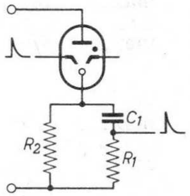
---

[1]) In capacitive starter circuits the starter-to-cathode capacitor shall have a value of 1 nF to 10 nF the higher value to be used at the lower anode voltage.

[2]) Higher values of R_{st} are permitted but a value of the starter pre-strike current during life of max. 5 μA has to be taken into account. The starter pre-strike current causes a virtual increase of the starter ignition voltage.

7Z2 5320

TYPICAL SELF EXTINGUISHING PULSE FORMING CIRCUIT

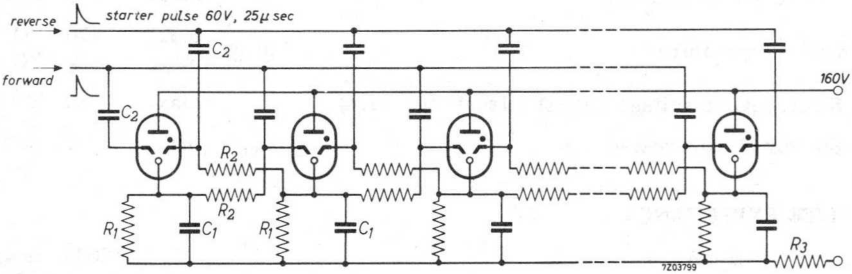


R_1 = 5.6 kΩ C_1 = 10 nF

R_2 = 470 kΩ (> 350 kΩ)

In this type of circuit the required starter voltage is > 100 V

TYPICAL DECADE COUNTER CIRCUIT See also page D



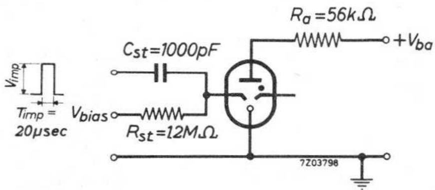
R_1 = 10 kΩ to 33 kΩ with C_1 = 56 nF to 6.8 nF

R_2 = 0.2 MΩ to 1.2 MΩ with C_2 = 2 nF to 220 pF

R_3 = 6.8 kΩ to 22 kΩ

$R_1.C_1$ > 200 μs

STARTER CIRCUIT



7Z2 8402

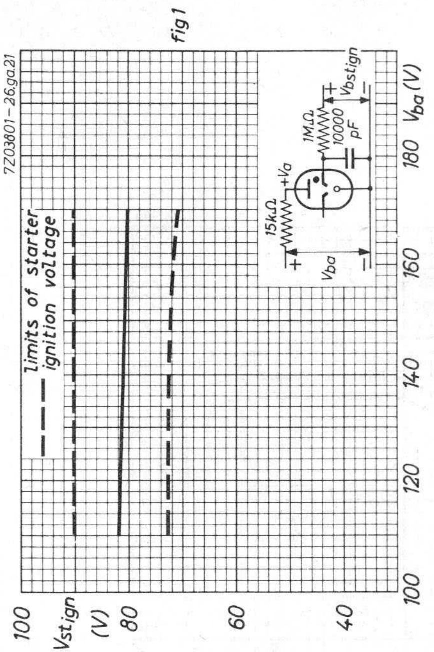


fig 1

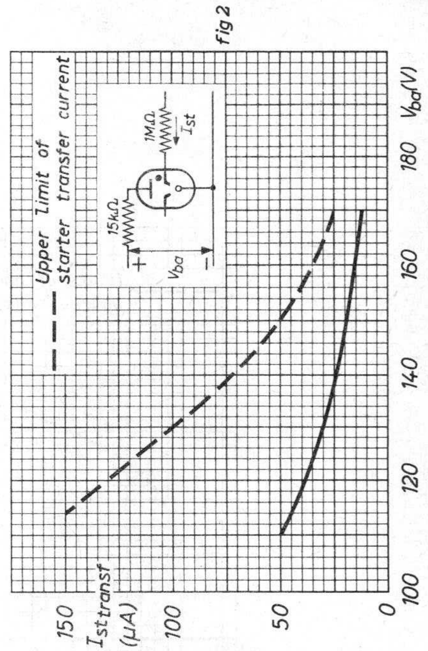


fig 2

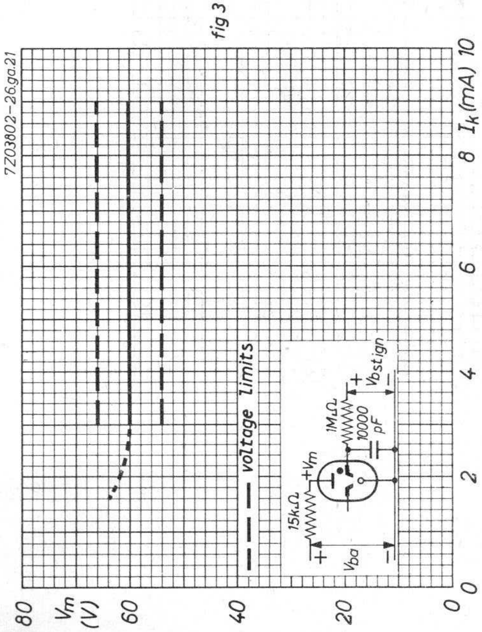


fig 3

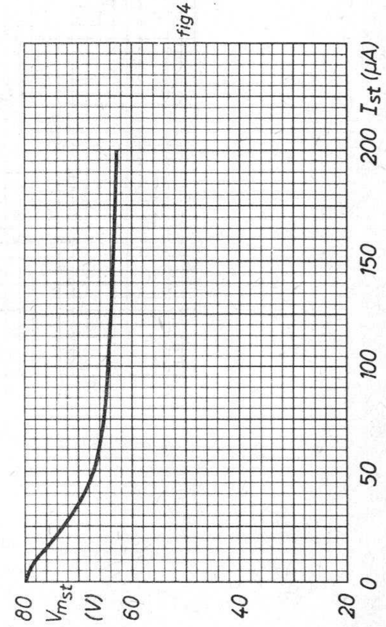
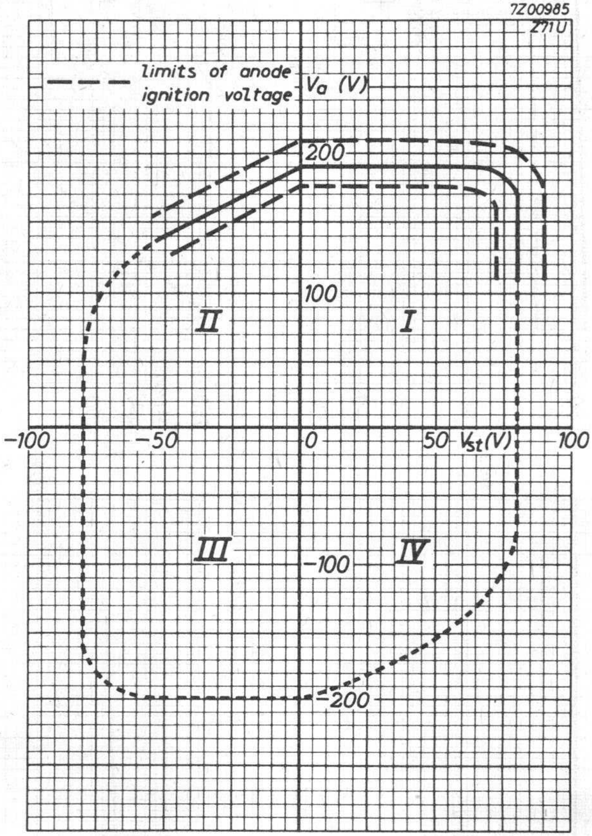
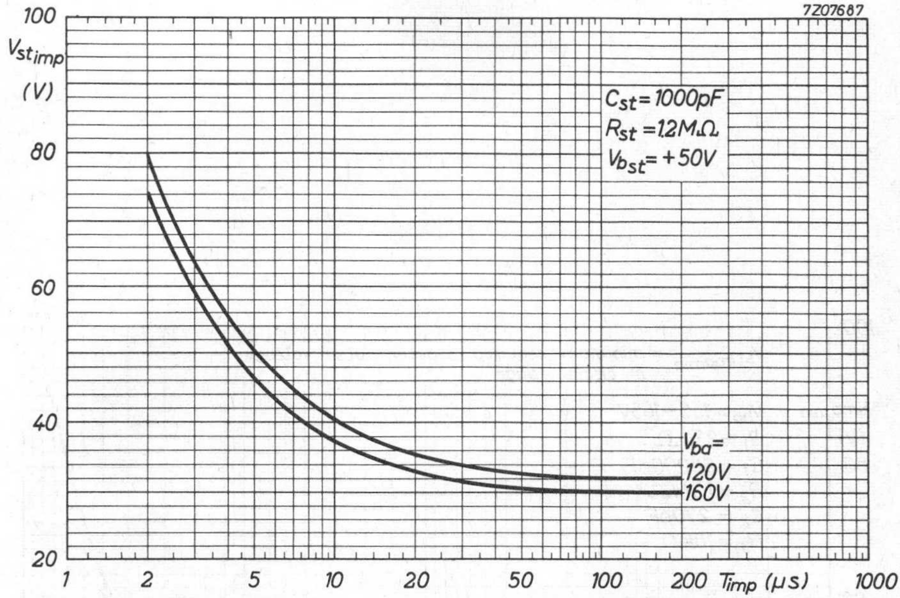
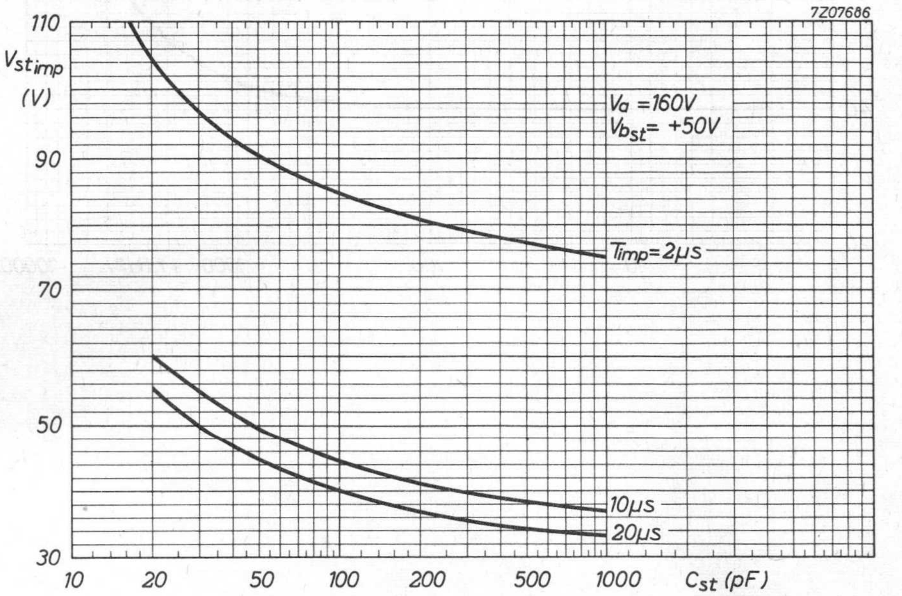
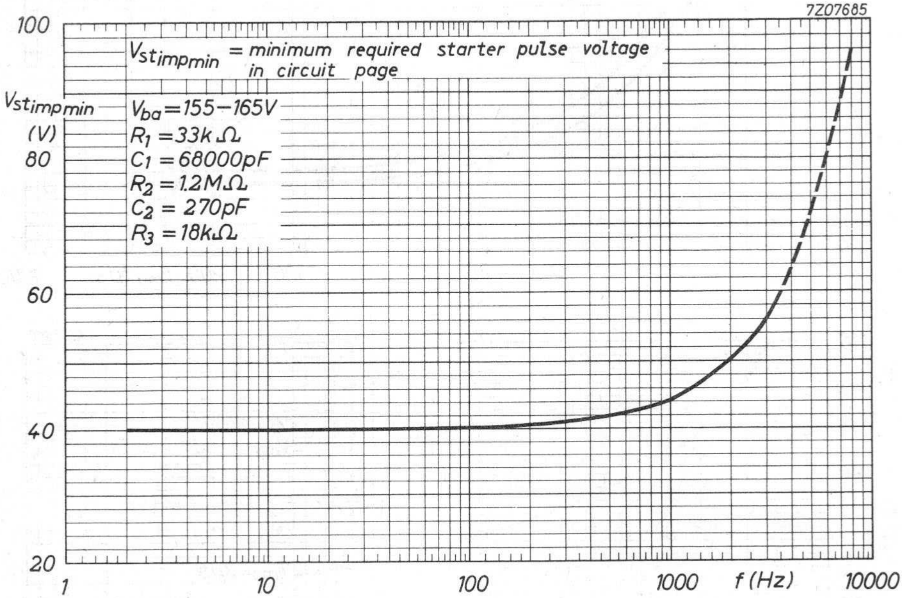


fig 4


7Z00985
Z71U
limits of anode
ignition voltage
V_a (V)
200
100
-100
-200
-100
-50
0
50
V_{st}(V)
100
I
II
III
IV


7Z07687
100
$V_{st\,imp}$
(V)
80
60
40
20
1
2
5
10
20
50
100
200
1000
T_{imp} (μs)
C_{st} = 1000pF
R_{st} = 1.2MΩ
V_{bst} = +50V
V_{ba} =
120V
160V


7Z07686
110
$V_{st\,imp}$
(V)
90
70
50
30
10
20
50
100
200
500
1000
C_{st} (pF)
V_a = 160V
V_{bst} = +50V
T_{imp} = 2μs
10μs
20μs


7Z07685
$V_{stimpmin}$ = minimum required starter pulse voltage in circuit page
$V_{stimpmin}$ (V)
V_{ba}=155−165V
R_1 =33kΩ
C_1 =68000pF
R_2 =1.2MΩ
C_2 = 270pF
R_3 =18kΩ
100
80
60
40
20
1
10
100
1000
f (Hz)
10000

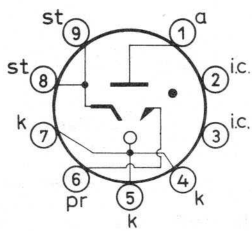
TRIGGER TUBE

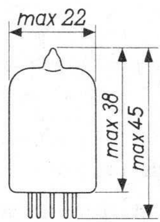
Gas-filled cold cathode trigger tube with electrical priming, and stable ignition characteristics, designed to be ignited only with positive voltages on the anode and starter intended for voltage control, sensitive relay applications, timers.

QUICK REFERENCE DATA

Anode supply voltage	V_{ba}	240	V
Anode maintaining voltage	V_m	105	V
Max. average cathode current	I_k	40	mA
Starter to cathode ignition voltage	$V_{st\ ign}$	132	V
Starter transfer requirements			
capacitance	C_{st}	500	pF
current	I_{st}	45	μA

DIMENSIONS AND CONNECTIONS Dimensions in mm





CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN
(Initial and during life)

All values stated assume the presence of a priming discharge unless otherwise stated. This priming discharge can be established as follows:

Primer supply voltage	7)	V_{bpr}	max. 290 min. 150	V V
Recommended primer resistor	8)	R_{pr}	10	MΩ
Primer to cathode maintaining voltage		V_{mpr}	100	V
Primer current		I_{pr}	2 to 25	μA

7)8) See page 5.

7Z2 5322

A. STAND-BY (Main gap non-conducting)

Anode voltage, [1]

positive at I_{kav} < 25 mA, I_{kp} < 100 mA [2]	V_a	max.	290	V
at I_k > 25 mA and/or I_{kp} > 100 mA [3]	V_a	max.	250	V
negative	$-V_a$	max.	90	V

Starter to cathode voltage,

positive	V_{st}	max.	125	V
negative	$-V_{st}$	max.	75	V

Anode to starter voltage,

positive	$V_{a\ st}$	max.	290	V
negative	$-V_{a\ st}$	max.	140	V

Starter pre-ignition current, [6]

at I_{pr} = 2 to 25 μA	I_{st}		4×10^{-8}	A
at I_{pr} = 0 μA	I_{st}		5×10^{-10}	A

B. IGNITION

Anode voltage	V_a	min.	170	V
Starter to cathode ignition voltage (V_a = 280 V)				
Initial [5]	$V_{st\ ign}$	max. min.	137 128	V V
Max. variation during life	$\Delta V_{st\ ign}$	max.	± 2	%
Max. decrease of starter-to-cathode ignition voltage (V_a changed from 170 to 290 V)	$\Delta V_{st\ ign}$	max.	1.5	V
Starter to cathode maintaining voltage	$V_{st\ m}$		95	V
Starter series resistance (I_{pr} = 2 to 25 μA)	R_{st}	max.	100	MΩ
(I_{pr} = 0 μA)	R_{st}	max.	1000	MΩ

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

7Z2 5323

B. IGNITION (continued)

Transfer requirements

Starter-to-cathode capacitance for transfer (limiting resistor = 0 to 2.2 kΩ) [9]

V_a = 170 V	C_{st}	min.	2700	pF
V_a = 200 V	C_{st}	min.	1000	pF
V_a = 240 V	C_{st}	min.	500	pF

Starter limiting resistor [9]

C_{st} < 4700 pF	R_{st}	min.	0	Ω
C_{st} = 4700 to 15000 pF	R_{st}	min.	2.2	kΩ
C_{st} > 15000 pF	R_{st}	min.	5.6	kΩ

Starter current required for transfer

V_a = 240 V	I_{st}	min.	25	μA
V_a = 170 V	I_{st}	min.	500	μA

Ignition delay (I_{pr} = 2 to 25 μA; V_{st} = $V_{st\ ign}$ + 0.5 V) (see curve)	2	ms
(I_{pr} = 0 μA; V_{st} = $V_{st\ ign}$ + 4 V)	5	s

C. MAIN GAP CONDUCTING

Anode maintaining voltage (I_k = 10 mA) [4] and page B	V_m		105	V
Cathode current,				
average (T_{av} = 15 s)	I_k	max.	25	mA
(T_{av} = 20 ms)	I_k	max.	40	mA
peak (50 Hz duty or repetitive operation)	I_{kp}	max.	200	mA
(max. duration = 1 ms)	I_{kp}	max.	1	A
average during any conduction period	I_k	min.	8	mA
Starter-to-cathode maintaining voltage	$V_{m\ st}$		95	V
Starter current,				
positive peak	I_{st_p}		8	mA
negative [10]	I_{st}		0	mA

[4][9][10] See page 5.

7Z2 8403

D. EXTINCTION

Components for self-extinguishing circuits (V_{ba} = 290 V)

C_{a-k} = min. 2700 pF (R_{lim} = 1 kΩ)

C_{st-k} = min. 500 pF

R_a = min. 1 MΩ

R_{st} = min. 1 MΩ

Recovery time (at I_{kp} = 8 to 20 mA)	3.5	ms
(at I_{kp} = 20 to 100 mA)	12	ms

LIMITING VALUES (Absolute max. rating system)

Anode voltage,				
positive	V_a	max.	290	V
negative (I_{st} = 0 mA)	$-V_a$	max.	90	V
Cathode current,				
average (T_{av} = max. 15 s)	I_k	max.	25	mA
(T_{av} = max. 20 ms)	I_k	max.	40	mA
peak (50 Hz duty or repetitive operation)	I_{kp}	max.	200	mA
(max. duration = 1 ms)	I_{kp}	max.	1	A
Average cathode current during any conduction period	I_k	min.	8	mA
Negative starter-to-cathode voltage				
(I_k = I_{st} = 0 mA)	$-V_{st}$	max.	75	V
Peak starter current,				
positive	I_{stp}	max.	8	mA
negative (I_k = 0 mA [10])	$-I_{stp}$	max.	0	mA
Anode-to-starter voltage, (I_k = 0 mA)				
anode positive	V_{a-st}	max.	290	V
anode negative	$-V_{a-st}$	max.	140	V

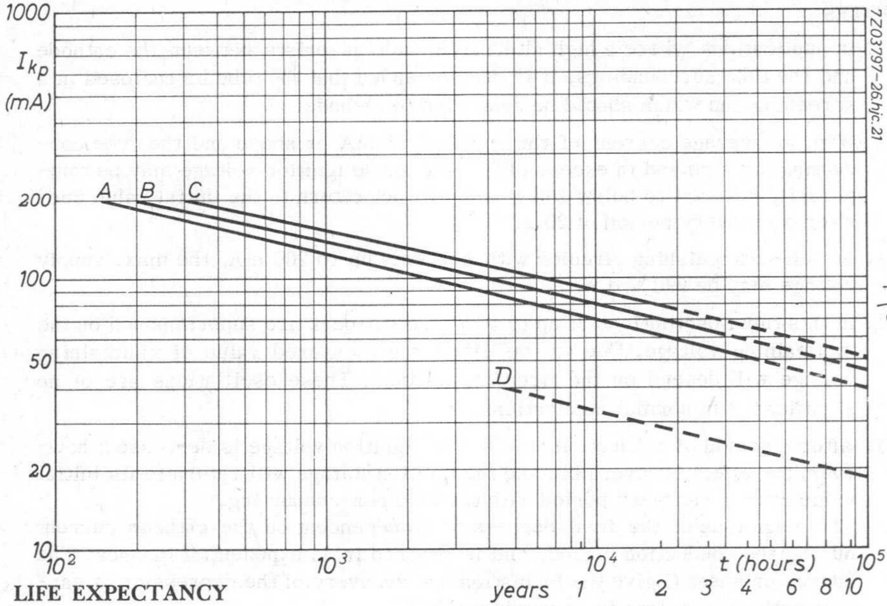
[10]) See page 5.

7Z2 8404

NOTES

1. In applications where a high alternating voltage exists between the cathode and the tube surroundings, it is recommended that the tube be enclosed in a screening can which should be connected to cathode.
2. With an average current of the order of 15 mA or above and the tube conducting for a period in excess of 5 s, the anode ignition voltage may be temporarily reduced to below 290 V and will not return to the initial value until after a recovery period of 20 s.
3. In self-extinguishing circuits with currents up to 200 mA, the max. supply voltage may be 290 V d.c.
4. In this tube, oscillations of up to 10 V peak-to-peak are superimposed on the maintaining voltage. Due to this effect the measured value of maintaining voltage will depend on the circuit conditions. These oscillations are of no significance in normal applications.
5. After a period of conduction, the starter ignition voltage is depressed: however, the effect is reversible and the ignition voltage will return to its initial value after a recovery period with the tube non-conducting.
   The magnitude of the final depression is dependent on the cathode current during the conduction period, and is reached in an exponential manner. The curves on sheet C give the formation and recovery of the depression at various cathode currents for a nominal tube.
   In a repetitive circuit where the non-conducting period is short compared with the recovery time constant (e.g. 50 Hz operation), the depression can be obtained from the curve by using a direct current equal to the mean current passing through the tube.
6. In applications where pre-ignition current 4×10^{-8} A is required the primer should be left disconnected. In this case, the starter-to-cathode gap ionisation time may be of the order of seconds.
7. A period of the order of several seconds may elapse between the application of supply voltage to the primer and the establishment of a priming discharge.
8. The resistor between the primer and the supply voltage must be soldered directly to pin 6 of the tube socket. Stray circuit capacitance at the primer must be kept to less than 4 pF.
9. This is the sum of any resistors in the capacitance discharge circuit and may include a cathode resistor.
10. Negative starter current will flow during anode-to-cathode conduction in any circuit in which the starter is returned via a resistor to a potential with respect to cathode which is less than the starter-to-cathode maintaining voltage. It is preferable that the circuit should be designed to avoid this condition by keeping the starter supply voltage greater than the starter maintaining voltage. In those applications where this cannot be achieved, the maximum anode supply voltage must be reduced from 290 to 250 V and the magnitude of the negative starter current must be less than 1% of the cathode current.

7Z2 8405



LIFE EXPECTANCY

The curves show the life expectancy when the tube is run continuously at room temperature.

During periods of non-operation at room temperature the characteristics of the tube remain substantially constant. The total life expectancy in any given application is the sum of the non-operating periods and the operating life obtained from the curve.

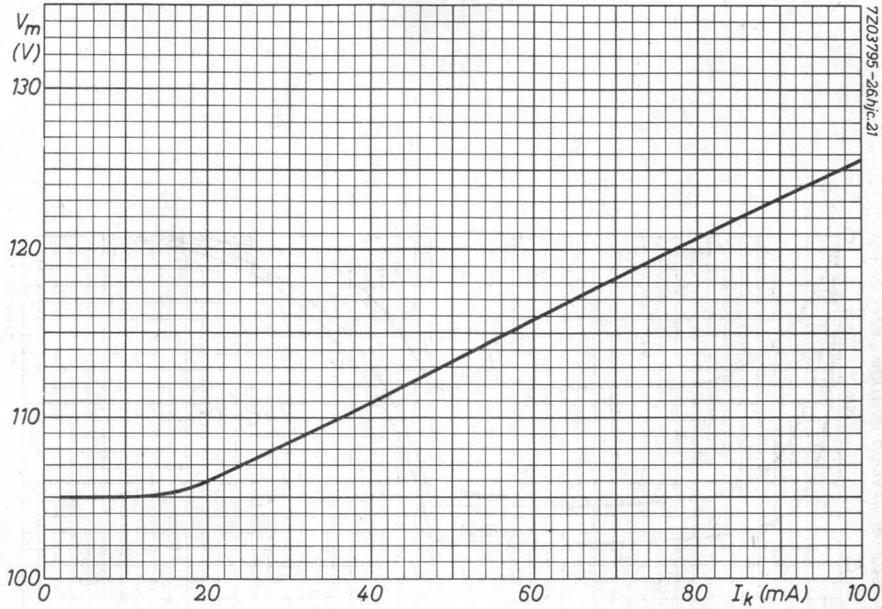
For a given value of cathode current, it is estimated that 80% of all tubes will remain within the end points concerned for longer than the time shown.

The time during which the starter ignition voltage will remain within $\pm 2\%$ of its original value, when the tube is operating continuously at room temperature from a half-wave rectified supply, is dependent on the peak cathode current passed. Curve A shows the relationship between the peak current and the expected time for which the starter ignition voltage will remain within these limits. After this time the starter ignition voltage will fall steadily and the times at which it can be expected to have fallen by 4 and 8% are shown by lines B and C respectively.

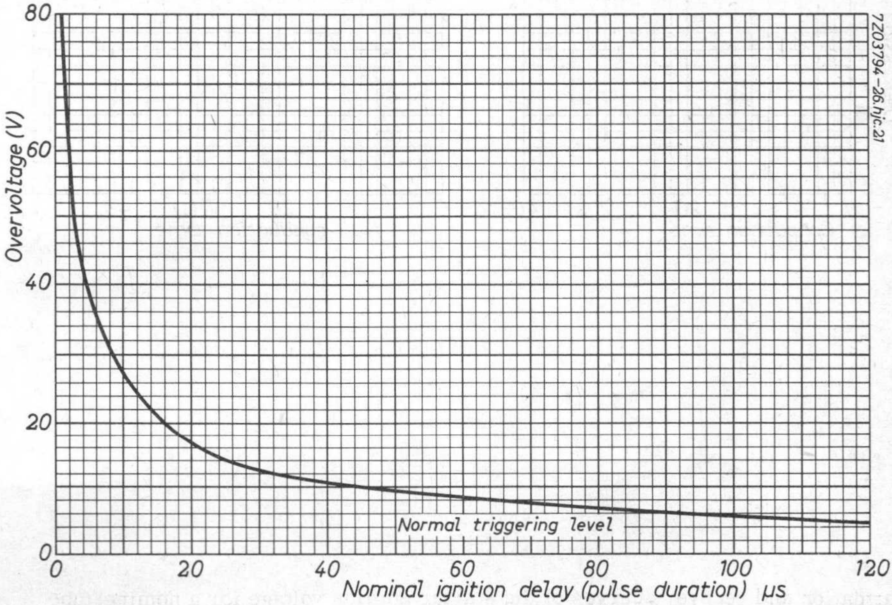
Curve B shows the estimated length of time for which the change of starter ignition voltage can be expected to remain within $\pm 2\%$ when passing direct current at room temperature.

In self-extinguishing circuits with $I_{kp} < 200$ mA and $I_k < 0.8$ mA, the change of starter ignition voltage can be expected to remain within $\pm 2\%$ for more than 30 000 hours.

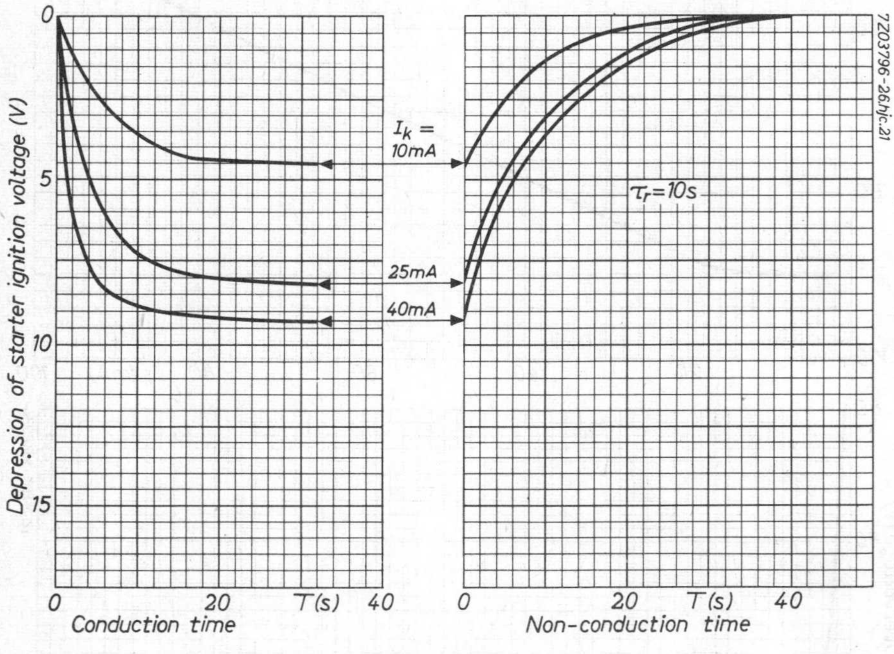
7Z2 8406



V_m (V)
130
120
110
100
0
20
40
60
80
I_k (mA)
100
7Z03795-26.hjc.21



Overvoltage (V)
80
60
40
20
0
Normal triggering level
0
20
40
60
80
100
120
Nominal ignition delay (pulse duration) μs
7Z03794-26.hjc.21



Formation and recovery curves of the starter ignition voltage for a nominal tube

7Z2 5328

SWITCHING DIODE

Cold cathode gas-filled subminiature switching diode with a constant difference between ignition- and maintaining voltage intended for use as relaxation oscillator tube e.g. in electronic musical instruments.
This tube is shock and vibration resistant.

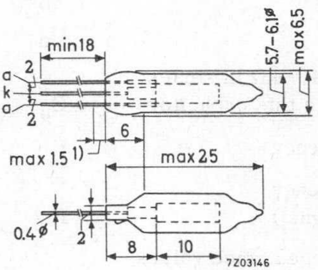
QUICK REFERENCE DATA				
Ignition voltage	V_{ign}	=	128	V
Difference between ignition and maintaining voltage		=	35	V

OPERATING PRINCIPLE

The tube contains two electrodes : a rod shaped cathode and a concentric anode. In a suitable circuit with a series resistor and a parallel capacitor a sawtooth voltage becomes available.

DIMENSIONS AND CONNECTIONS

Colour code type indication on pinch : brown dot



[1]) This part of the leads is not tinned.

MOUNTING

The tube may be soldered directly into the circuit but heat conducted to the glass to metal seals should be kept to a minimum by the use of a thermal shunt. The leads may be dip-soldered to a minimum of 5 mm from the seals at a solder temperature of 240 °C during max. 10 s.
Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

7Z2 5280

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN t_{amb} = room

Typical limits (initial values)

Ignition voltage, static conditions	V_{ign}	=	120 to 135	V
Ignition voltage, dynamic conditions			see sheet A	
Maintaining voltage at I_k = 1.5 mA	V_m	=	91 to 95	V
Maintaining voltage, dynamic conditions			see sheet B	
Insulation resistance	r_{ins}	=	min. 300	MΩ
Temperature coefficient of ignition voltage averaged over the range −55 to +70 °C	$\frac{\Delta V_{ign}}{\Delta t_{bulb}}$	=	+6	mV/°C
Temperature coefficient of maintaining voltage averaged over the range −55 to +70 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	=	−7	mV/°C

Life performance

Variation of the difference between ignition- and maintaining voltage (in a relaxation oscillator)

0 to 5000 hours	=	max. 6	V

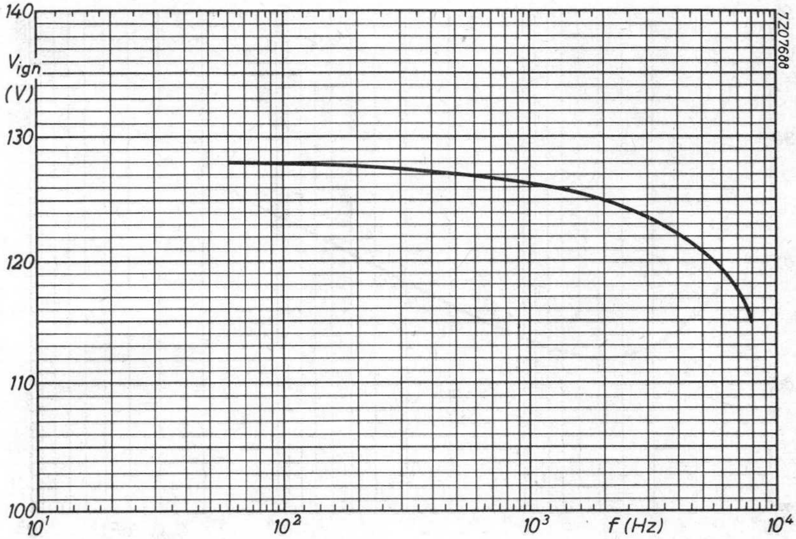
CIRCUIT DESIGN VALUES

Anode supply voltage	V_b	=	min. 140	V
Shunt capacitor	C_p	=	max. 6.8	nF
Shunt capacitor with min. 4.7 kΩ in series with this capacitor	C_p	=	max. 30	nF
Relaxation oscillator frequency	f	=	min. 65	Hz
Relaxation oscillator frequency (without sync signal)	f	=	max. 5	kHz
Minimum resistance and capacitance values for self extinguishing circuits			see sheet C	

LIMITING VALUES (Absolute max. rating system)

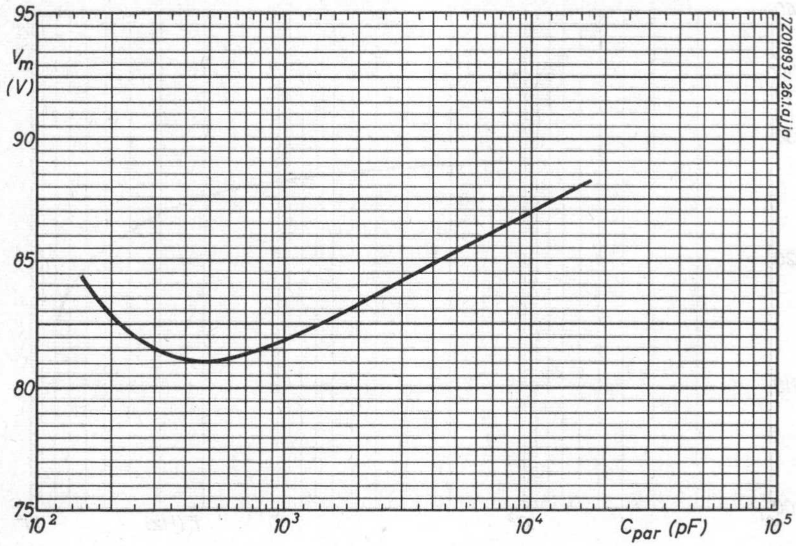
Negative anode peak voltage	$-V_{a_p}$	=	max. 100	V
Bulb temperature	t_{bulb}	=	min. −55	°C
		=	max. +70	°C

7Z2 8436



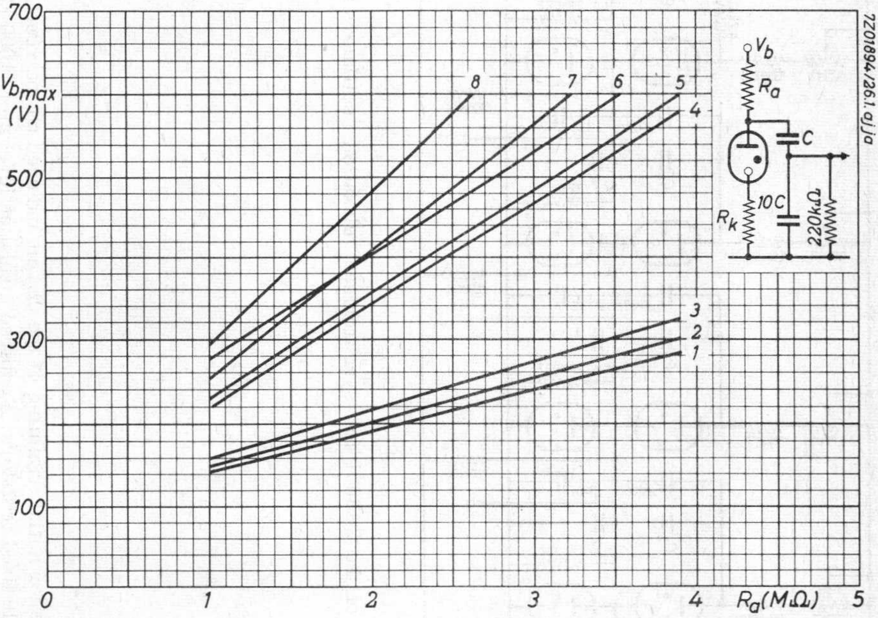
Ignition voltage under dynamic conditions

7Z2 8437



Maintaining voltage under dynamic conditions
C_{par} = Capacitance in parallel with tube.

7Z2 8438

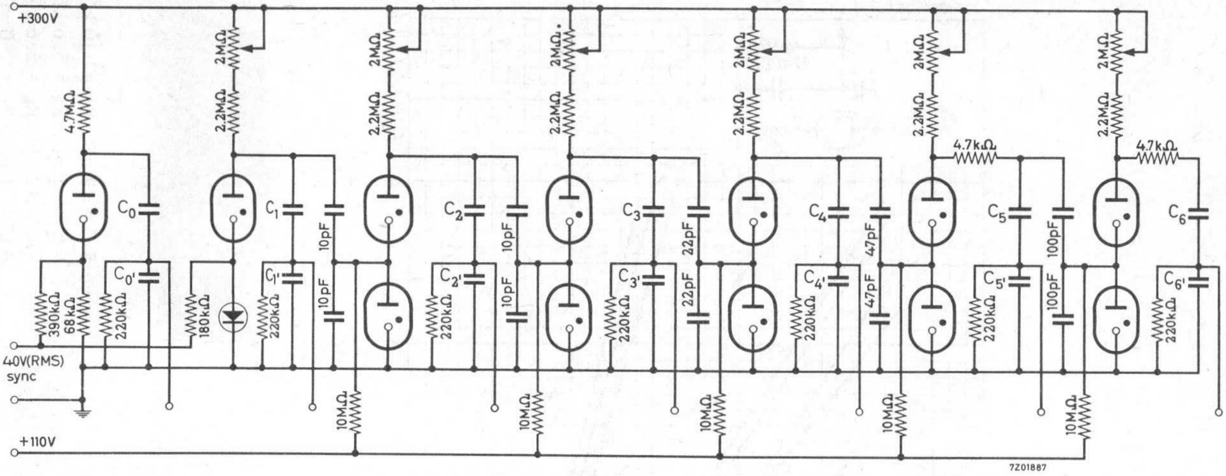


Max. anode supply voltage for self ext. circuits.

Curve 1 C = 220 pF, R_k = 10 kΩ
2 C = 220 pF, R_k = 5.6 kΩ
3 C = 220 pF, R_k = 0 Ω
4 C = 1 nF, R_k = 10 kΩ

Curve 5 C = 12 nF, R_k = 10 kΩ
6 C = 1 nF, R_k = 5.6 kΩ
7 C = 12 nF, R_k = 5.6 kΩ
8 C = 1 nF, R_k = 0 Ω

7Z2 8439



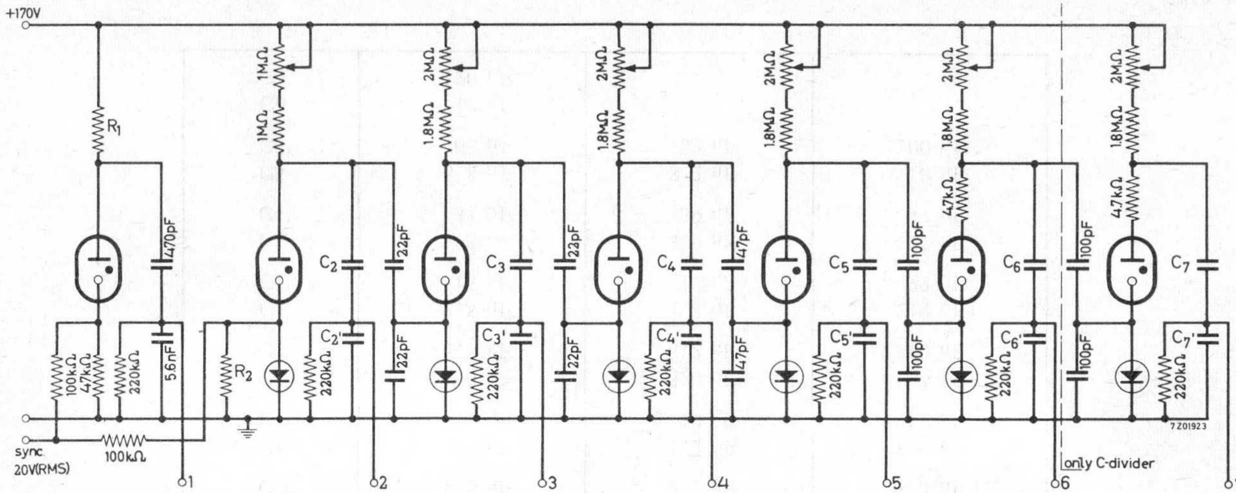
Typical example of the application of the ZA1001 for synchronised relaxation oscillators in a frequency dividing chain.

The 2 MΩ potentiometers only serve for initial trimming of the circuit and need not be reset during life. Therefore they also may be replaced by suitable fixed resistors. Required insulation level min. 1000 MΩ. 7Z2 8440

COMPONENT VALUES FOR CIRCUIT SHEET D

	group a, ais, b, c c : 4186 } 3850 Hz a : 3520 }	group f, fis g, gis gis: 3322 } 3050 Hz f : 2794 }	group cis, d dis, e cis: 2217 } 2420 Hz e : 2637 }
CO	220 pF	330 pF	390 pF
CO'	1.8 nF	2.7 nF	3.3 nF
C1	1 nF	1.2 nF	1.5 nF
C1'	8.2 nF	10 nF	12 nF
C2	680 pF	820 pF	1 nF
C2'	6.8 nF	8.2 nF	10 nF
C3	1.5 nF	1.8 nF	2.2 nF
C3'	15 nF	18 nF	22 nF
C4	3.3 nF	3.9 nF	4.7 nF
C4'	33 nF	39 nF	47 nF
C5	6.8 nF	8.2 nF	10 nF
C5'	68 nF	82 nF	100 nF
C6	12 nF		
C6'	120 nF		

7Z2 8444



The potentiometers only serve for initial trimming of the circuit and need not be reset during life. Therefore they also may be replaced by suitable fixed resistors. Required insulation level min. 50 MΩ.
The semiconductor diodes should have a leakage resistance of min. 10 MΩ at −10 V.

7Z2 8441

COMPONENT VALUES FOR CIRCUIT SHEET F

	cis d dis e	f fis g gis	a ais b c
R1	1.5 MΩ	1.2 MΩ	1 MΩ
C2	1 nF	0.82 nF	0.68 nF
C3	1 nF	0.82 nF	0.68 nF
C4	2.2 nF	1.8 nF	1.5 nF
C5	5.7 nF	3.9 nF	2.7 nF
C6	10 nF	8.2 nF	6.8 nF
C7			12 nF
R2	68 kΩ	56 kΩ	47 kΩ
C2'	10 nF	8.2 nF	6.8 nF
C3'	18 nF	12 nF	8.2 nF
C4'	68 nF	47 nF	33 nF
C5'	150 nF	150 nF	100 nF
C6'	180 nF	180 nF	180 nF
C7'			180 nF

7Z2 5330

SWITCHING AND LIGHT DIODE

Cold cathode neon filled subminiature switching and light diode with a large and stable difference between ignition and maintaining voltage intended for low speed switching and counting e.g. in combination with CdS photo sensitive devices. The tube is shock and vibration resistant.

QUICK REFERENCE DATA			
Ignition voltage	V_{ign}	170	V
Maintaining voltage	V_m	109	V
Cathode current	I_k	3.5	mA

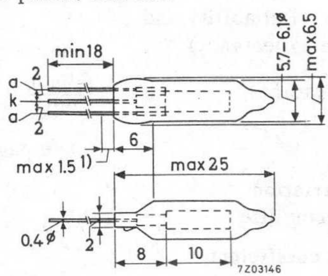
OPERATING PRINCIPLE

The diode contains a rod shaped molybdenum cathode and a concentric gauze anode. By applying a suitable voltage between the electrodes, a glow discharge occurs and its red light is available outside the tube.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Colour type indication on pinch: red dot.



MOUNTING

The tube may be soldered directly into the circuit but heat conducted to the glass to metal seals should be kept to a minimum by the use of a thermal shunt. The leads may be dip-soldered to a minimum of 5 mm from the seals at a solder temperature of 240 °C during max. 10 s. Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

1) This part of the leads is not tinned.

7Z2 6477

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

(Valid over the first 15000 hours operation within the preferred current range and at t_{amb} = room. The electrical characteristics are independent of ambient illumination)

Non conduction

Anode voltage below which ignition will not occur in any tube	$V_{ign\ min}$		163	V
Insulation resistance	r_{isol}	>	300	MΩ

Ignition

Anode voltage to ensure ignition	$V_{ign\ max}$		178	V
Ignition delay	See page A and B			
Typical max. individual variation of ignition voltage during life	ΔV_{ign}	<	5	V
Typical temperature coefficient of ignition voltage, averaged over the range -55 °C to +70 °C	$\frac{\Delta V_{ign}}{\Delta t_{bulb}}$	<	±15	mV/°C

Conduction

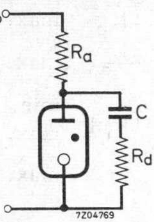
Cathode current, average during any conduction period	I_k	>	2.2	mA
average (T_{av} = max. 1 s)	I_k	<	4.5	mA
peak (See "Reliability and life expectancy)	I_{kp}	<	50	mA
Typical rise in bulb temperature	$\frac{\Delta t_{bulb}}{\Delta I_k}$		10	°C/mA
Maintaining voltage	See page A			
Typical max. individual variation of maintaining voltage during life	ΔV_m	<	+2 -4	V
Typical max. temperature coefficient of maintaining voltage, averaged over the range -55 °C to +70 °C	$\frac{\Delta V_m}{\Delta t_{bulb}}$	<	±15	mV/°C
Light intensity [1][2]	E	>	20	lux/mA
Typical variation of light intensity	ΔE	<	-3	%/1000 h

[1][2] See page 3

7Z2 8407

Extinction

Typical min. RC components to ensure self extinction at V_b = 250 V for different values of current limiting resistance R_d.



R_d	0	1	10	47	100	kΩ
R_a	1	1	1.5	2	3	MΩ
C	5	22	22	22	22	nF

RELIABILITY AND LIFE EXPECTANCY

Reliability has been assessed in a life test programme totalling 5.10^6 tube hours on 400 tubes. The longest test periode being 15000 hours on 100 tubes. A total of 7 failures result in a failure rate of better than 0.15% per 1000 h. This failure rate is not expected to increase over the next period of 15000 h.

Life expectancy: 30000 operating hours within the preferred current range
or
$2.4x10^6$ ignitions discharging a capacitor of max. 16 μF with suitable series impedance to limit the peak current to max. 50 mA.

1) Light intensity measured over an angle of 70° at a distance of 3.6 mm from the tube axis opposite the anode cylinder.

2) Measured with a Standard Weston Cell adopted to eye sensitivity.
Because the light emission of the neon discharge is mainly contained in the red region, the illumination resistance of a CdS cell will be 1.5 to 2 times lower than in case of irradiation by a 2700 °K incandescent light source. The exact conversion factor depends on the type of CdS cell used. 7Z2 6479

LIMITING VALUES (Absolute max. rating system)

Cathode current, average for continuous conduction		I_k	min.	2.2	mA [1]
	average (T_{av} = max. 1 s)	I_k	max.	4.5	mA [1]
	peak	I_{kp}	max.	50	mA
Anode voltage, negative peak		$-V_{ap}$	max.	200	V
Bulb temperature		t_{bulb}	min.	-55	°C
			max.	+70	°C
Altitude		h	max.	24	km

SHOCK AND VIBRATION RESISTANCE

These conditions are solely used to assess the mechanical quality of the tube. The tube must not be continuously operated under these conditions.

Shock resistance 500 g

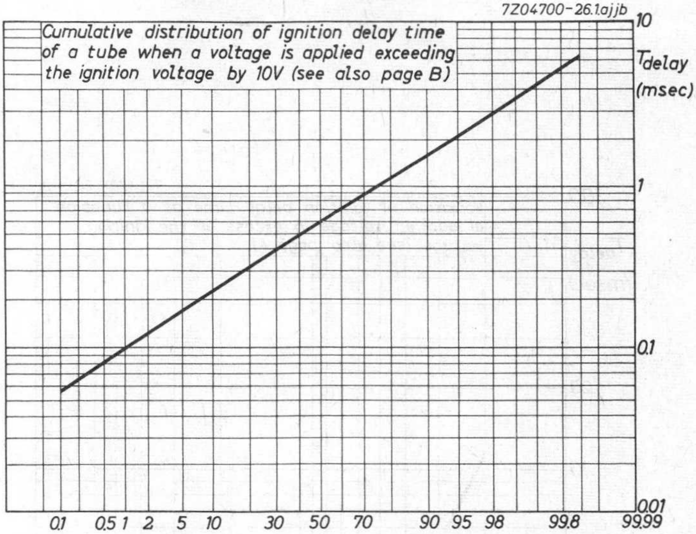
Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30° in each of 4 positions of the tube.

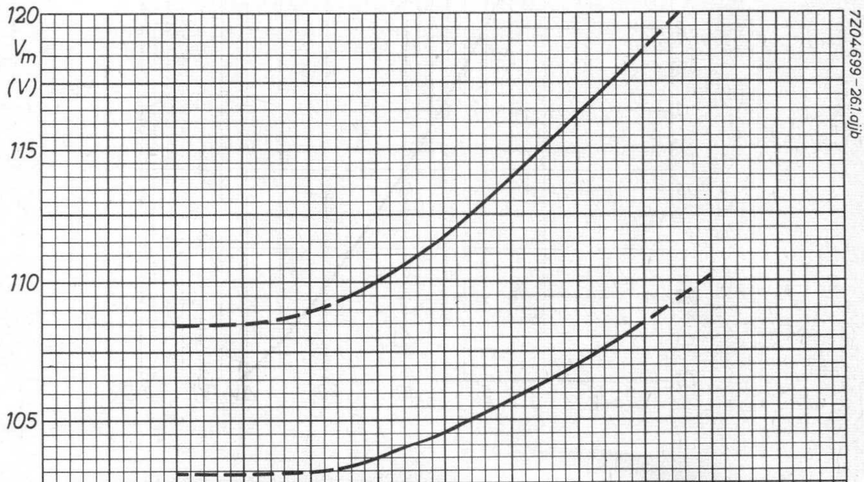
Vibration resistance 2.5 $g_{(peak)}$

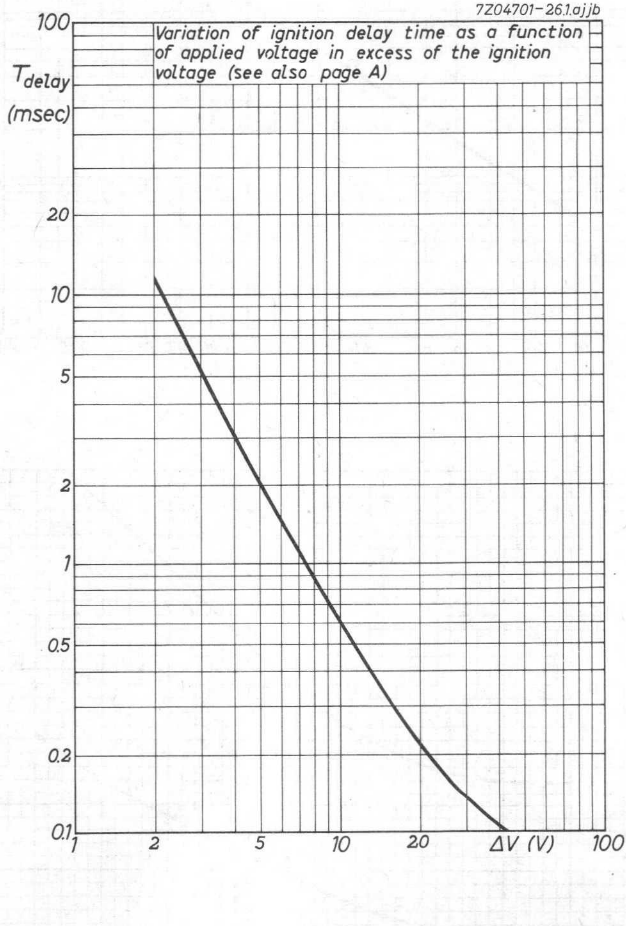
Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions.

[1]) Current excursions down to 1 mA and up to 5 mA are permitted under conditions of e.g. extreme supply voltage variations. The excursion times should preferably be as short as possible but never exceed 24 hours.

7Z2 8442


7Z04700-26.1.ajjb
Cumulative distribution of ignition delay time of a tube when a voltage is applied exceeding the ignition voltage by 10V (see also page B)
T_{delay} (msec)
10
1
0.1
0.01
0.1
0.5
1
2
5
10
30
50
70
90
95
98
99.8
99.99


V_m (V)
120
115
110
105
100
0
1
2
3
4
5
6
I_k (mA)
7Z04699-26.1.ajjb


7Z04701-26.1.ajjb
Variation of ignition delay time as a function of applied voltage in excess of the ignition voltage (see also page A)
100
T_{delay}
(msec)
20
10
5
2
1
0.5
0.2
0.1
1
2
5
10
20
ΔV (V)
100

GAS FILLED INDICATOR DIODE

Shock and vibration resistant cold-cathode gas-filled subminiature diode with visible glow-discharge for read-out purposes.
The tube contains two electrodes, a rod shaped molybdenum cathode and a concentric gauze anode.

APPLICATION

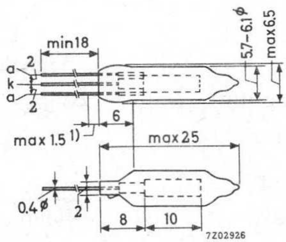
Indicator in low voltage transistor circuits. The diode can be used in combination with CdS photoconductive cells and it can be controlled by voltage signals down to 3 V.

QUICK REFERENCE DATA				
Ignition voltage	V_{ign}	=	90	V
Extinction voltage	V_{ext}	>	83.5	V
Cathode current	I_k	=	1	mA
Light intensity at I_k = 1 mA	E	=	60	lux

MECHANICAL DATA

Dimensions in mm

Type indication on pinch: yellow dot.



MOUNTING

The tube may be soldered directly into the circuit, but heat conducted to the glass-to-metall seals should be kept to a minimum by the use of a thermal shunt.
The leads may be dip-soldered to a minimum of 5 mm from the glass-to-metal seals at a solder temperature of 240 °C during max. 10 seconds.
If the tube is held in its position by the leads only, the connection of both anode leads is recommended.
Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

[1]) Not tinned

7Z2 5307

SHOCK AND VIBRATION RESISTANCE

These conditions are solely used to assess the mechanical quality of the tube. The tube must not be continuously operated under these conditions.

Shock resistance 500 g

Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30° in each of 4 positions of the tube.

Vibration resistance 2.5 g (peak)

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions.

CHARACTERISTICS

Valid over 15 000 operating hours within the preferred current range and at room temperature unless otherwise stated.
The electrical characteristics are independent of ambient illumination.

Non conduction

Anode voltage below which ignition will not occur in any tube	$V_{ign\,min.}$	=	88	V	
Insulation resistance	r_{isol}	>	300	MΩ	

Ignition

Ignition voltage,					
upper limit	$V_{ign\,max.}$	=	93	V	1)
individual variation during life	ΔV_{ign}	<	2.5	V	
Ignition delay at V_{ba} = 93 V	T_{delay}	=	0.05	s	2)
Temperature coefficient of ignition voltage	$\frac{\Delta V_{ign}}{\Delta t_{bulb}}$	<	-15	mV/°C	3)
Reignition voltage in case of full wave rectified a.c. supply	V_{reign}	<	101	V	4)
		>	96.5	V	4)

1) The ignition and extinction voltage depression (hysteresis) is max. 0.75 V per mA prior current measured 50 ms after cessation of conduction.

2) Due to the statistical nature of ignition delay values of delay time > 1 s may occasionally occur.

3) Characteristic range value for equipment design.

4) These values apply to 220 V (+10 %, −15 %), 50 Hz to 60 Hz full-wave rectified unsmoothed supply and assume conduction in the course of the preceeding half cycle, so that residual ionization eliminates delay of the following ignition.

7Z2 8408

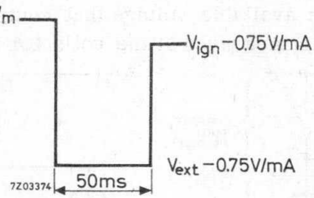
CHARACTERISTICS (continued)

Conduction

Cathode current,					
preferred range	I_k	=	0.4 to 2	mA	5)
peak	I_{kp}	=	3	mA	
Maintaining voltage	V_m	<	86 V + 4.25	V/mA	6)
		>	83 V + 2.5	V/mA	7)
Individual variation during life	ΔV_m	<	1.5	V	
Temperature coefficient of maintaining voltage	$\frac{\Delta V_m}{\Delta t_{bulb}}$	<	-15	mV/°C	3)
Rise in bulb temperature	$\frac{\Delta t_{bulb}}{\Delta I_k}$	=	10	°C/mA	
Light intensity,	E	>	30	lux/mA	8)9)
individual minimum, measured over an angle of 70° averaged over the full circumference of the tube	E_{av}	>	60	lux/mA	8)9)

Extinction

Extinction voltage	V_{ext}	>	83.5	V	1)



See note 1) page 2

5) Current excursions during ignition and extinction are not taken into account.
6) Valid within the range 0.1 mA to 3 mA.
7) Valid within the range 0.2 mA to 3 mA. Between 0.05 mA and 0.2 mA $V_{m\,min.} = V_{ext} = 83.5$ V.
8) Light intensity at a distance of 3.6 mm from the tube axis opposite the anode cylinder, measured with a standard Weston cell adopted to eye sensitivity. Because the emission of the neon discharge is mainly contained in the red region the illumination resistance of a CdS cell will be 1.5 to 2 times lower than in case of irradiation by a 2700 °K incandescent light source. The exact conversion factor depends on the type of CdS cell used.
9) At least 90% of the tubes will meet the figure stated.

7Z2 5309

RELIABILITY AND LIFE EXPECTANCY

The electrical characteristics have been assessed in a life test programme, totalling 3.0×10^6 tube hours with no failures, denoting a failure rate of better than 0.1 % per 1000 hours. The maximum test period was 19000 hours on 22 tubes. This failure rate is not expected to increase over the first 25000 hours of continuous operation within the preferred current range.

LIMITING VALUES (Absolute maximum rating system)

Cathode current, averaging time = 5 s	I_k	= max.	2.5	mA	
Cathode current during conduction	I_k	= min.	0.1	mA	[1]
Cathode current, peak	I_{kp}	= max.	3	mA	
Anode voltage, negative peak	$-V_{ap}$	= max.	70	V	
Bulb temperature	t_{bulb}	= min.	-55	^oC	
		= max.	70 ^oC + 10	$^oC/mA$	
Altitude	h	= max.	24	km	

READ-OUT CIRCUIT BISTABLE MULTIVIBRATORS

Principle of operation

The figures 1 and 2 show equivalent circuits for bistable multivibrators, equipped with p-n-p- and n-p-n transistors respectively, to which a read-out circuit has been added. The transistors are replaced by ideal switches, the voltage source V_T represents the available voltage that controls the diodes 2) and R_T is the output resistance as measured at the collector of the cut-off transistor.

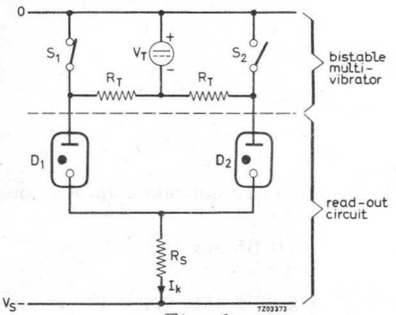


Fig. 1

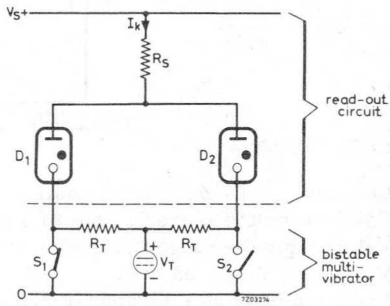


Fig. 2

[1]) Current excursions down to 50 μA with a duration < 1 s are permitted.

[2]) $V_T = V_{c.o.} - V_{sat}$ (V) in which

$V_{c.o.}$ = voltage between collector of the cut-off transistor and the common terminal (absolute value).

V_{sat} = voltage across the bottomed transistor (absolute value).

7Z2 5310

READ-OUT CIRCUIT BISTABLE MULTIVIBRATORS (continued)

Correct read-out is obtained when only the diode corresponding to the bottomed transistor conducts. For this the following conditions must be met: [1])

(I) Ignition of the correct diode, corresponding to the bottomed transistor, when the other diode is conducting.

Thus: $V_{m\,min.} + I_k R_T + V_T > V_{ign\,max}$,

resulting in $I_k > \dfrac{10 - V_T}{R_T + 2.5} \quad \dfrac{(V)}{(k\Omega)}$ for $I_k > 0.2$ mA

(II) Extinction of the diode corresponding to the cut-off transistor, when the correct diode is conducting.

Thus: $V_{m\,max.} - V_T < V_{ext\,min}$,

resulting in $I_k < \dfrac{V_T - 2.5}{5} \quad \dfrac{(V)}{(k\Omega)}$ for $I_k > 0.1$ mA

(III) Non-ignition of the diode corresponding to the cut-off transistor when the correct diode is conducting.

Thus: $V_{m\,max.} - V_T < V_{ign\,min}$,

resulting in $I_k < \dfrac{V_T + 2}{5} \quad \dfrac{(V)}{(k\Omega)}$ for $I_k > 0.1$ mA

These conditions are shown graphically on page A below.

Condensed instructions for designing the read-out circuit. [2])

The following directives are based on the requirement that correct read-out shall be ensured under worst case conditions, after the instant that the bistable circuit has reached its final stationary state. It is irrelevant whether the read-out diodes follow the changes of state of the multivibrator during its dynamic operation or not.

A choice can be made between the following modes of operating the diodes, namely by means of:

(A) a constant direct current

(B) a constant direct current on which a pulse is superimposed prior to reading-out. Three kinds of pulses are possible:
- a) a positive going pulse;
- b) a negative going pulse;
- c) a positive going pulse followed by a negative going one

(C) an unsmoothed current supplied by a full wave rectifier.

---

[1]) It is assumed that the supply voltage V_S exceeds the ignition voltage of the gas diodes, so that ignition of at least one diode is ensured; the most adverse situation being that only the wrong diode conducts.

[2]) For a detailed analysis of the design procedure please apply to the manufacturer.

7Z2 8409

READ-OUT CIRCUIT BISTABLE MULTIVIBRATORS (continued)

In fig. 3, schematically representing these waveforms, the required minimum duration of the superimposed pulses is indicated; t_s denotes the instant at which the bistable circuit reaches its final state.

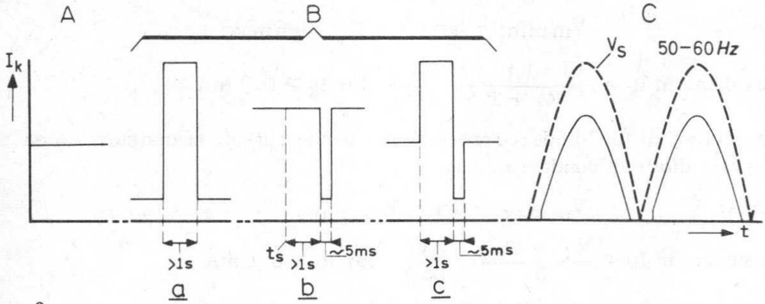


Fig. 3

The conditions to be obeyed by the current I_k are specified in the table below:

Mode of operation		Values of I_k lower limit	Values of I_k upper limit	V_T
(A) constant direct current		(I)	(II)	> 5 V
(B) direct current with superimposed:				
(a) positive going pulses	steady state current	–	(II)	> 4.5 V
	pulse current	(I)	–	
(b) negative going pulses	steady state current	(I)	(III)	> 3 V
	pulse current	–	(II)	
(c) positive and negative going pulses	steady state current	–	(III)	> 3 V
	positive going pulse	(I)	–	
	negative going pulse	–	(II)	
(C) rectified alternating current, peak value of I_k		(I)	(III)	> 4.5 V [1]

This table should be read in conjunction with the specified recommended operating conditions and limiting values.

[1]) Since both diodes are extinguished at the end of each half cycle of the supply voltage, condition (II) is not required, and is replaced by the condition that only the correct diode will reignite. The lower limit is thus given by the spread of the reignition voltage (e.i. 4.5 V).

7Z2 8443

READ-OUT CIRCUIT BISTABLE MULTIVIBRATORS (continued)

The minimum available value of V_T being known, the points of intersection with the curves I, II and III on page B, and hence the limits of I_k (I_{kI}, I_{kII} and I_{kIII}) can be determined. This having been done, the required values of $V_{S\,min}$ and R_S can be evaluated from the following expressions: [1])

$$\frac{V_{S\,min} - V_{ign\,max}}{R_{S\,max}} = I_{kI} \qquad (1)$$

$$\frac{V_{S\,max} - V_{ext\,min} - V_T}{R_{S\,min}} = I_{kII} \qquad (2)$$

$$\frac{V_{S\,max} - V_{ign\,min} - V_T}{R_{S\,min}} = I_{kIII} \qquad (3)$$

In these expressions the suffices min and max denote the worst case limits of the quantities concerned.

For mode of operation (C) the peak value of the supply voltage must be substituted for V_S in the above expressions.

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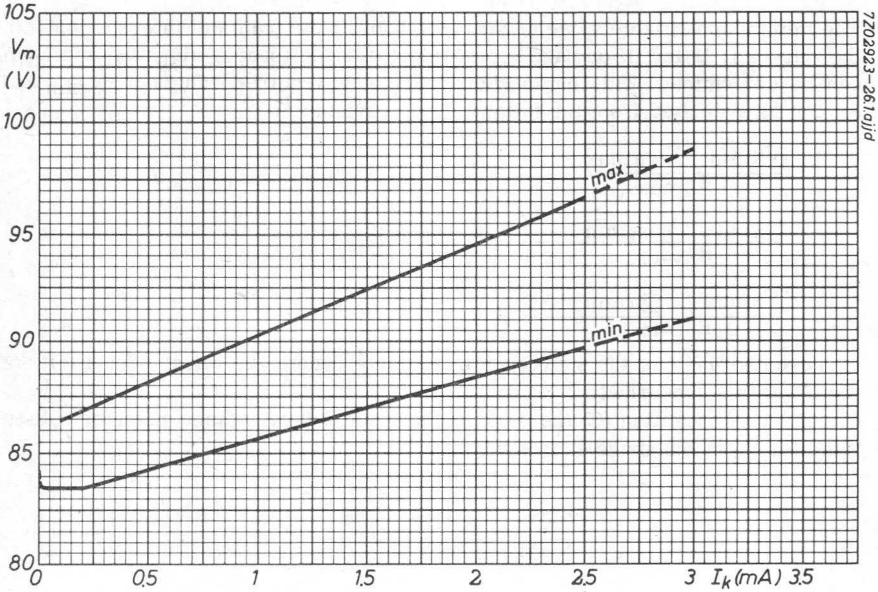
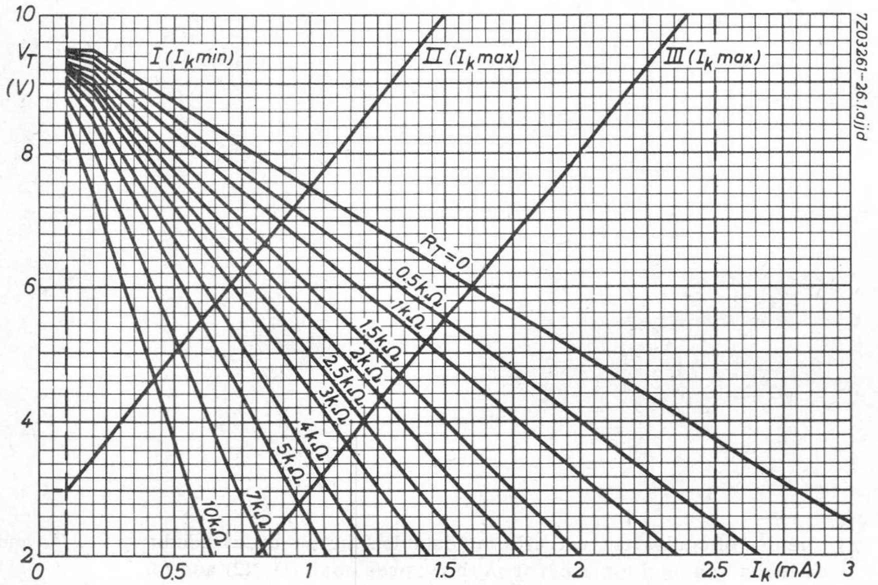
[1]) The use of equivalent circuits for establishing the exact conditions I, II, and III leads to a negligible error in the expressions (1), (2) and (3).

7Z2 5313


105
V_m
(V)
100
95
90
85
80
0
0.5
1
1.5
2
2.5
3
I_k (mA)
3.5
max
min
7Z02923-26.1.ajd


10
V_T
(V)
8
6
4
2
0
0.5
1
1.5
2
2.5
I_k (mA)
3
I (I_k min)
II (I_k max)
III (I_k max)
$R_T = 0$
0.5kΩ
1kΩ
1.5kΩ
2kΩ
2.5kΩ
3kΩ
4kΩ
5kΩ
7kΩ
10kΩ
7Z03261-26.1.ajd

SWITCHING DIODE

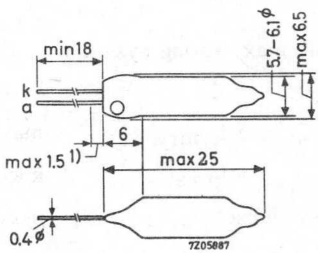
Cold cathode gas-filled subminiature diode with pure molybdenum electrodes designed for firing of silicon controlled rectifiers.

QUICK REFERENCE DATA		
Circuit see fig. 2		
Ignition voltage, forward	125	V
Peak current, forward	170	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Type number indication on pinch: green dot

Glass dot on pinch indicates anode lead



MOUNTING

The tube may be soldered directly into the circuit, but heat conducted to the glass-to-metal seals should be kept to a minimum by the use of a thermal shunt. The leads may be dip-soldered to a minimum of 5 mm from the glass-to-metal seals at a solder temperature of 240 °C during max. 10 seconds. Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

Touching the envelope by live components should be avoided, and it is recommended to maintain a distance between components or electrostatic shields and any part of the envelope of at least some mm.

---

1) Not tinned.

7Z2 6816

CHARACTERISTIC RANGE VALUES Valid over life

See Fig. 1a, 1b, 1c. The characteristics are independent of ambient illumination.

Insulation resistance	r_{ins}	max.	300	MΩ
Ignition voltage,				
forward	$V_{ign\ forw}$	max.	138	V [1]
		min.	108	V [1]
reverse	$V_{ign\ rev}$	max.	114	V [1]
		min.	94	V [1]
Dynamic maintaining voltage,				
forward	$V_{mdyn\ forw}$	max.	86	V
		min.	70	V
reverse	$V_{mdyn\ rev}$	max.	98	V
		min.	88	V
Peak current,				
forward	$I_{p\ forw}$	max.	250	mA
		min.	50	mA
reverse	$I_{p\ rev}$	max.	15	mA

LIMITING VALUES (Absolute max. rating system)

Peak current,				
forward	$I_{p\ forw}$	max.	300	mA
reverse	$I_{p\ rev}$	max.	25	mA
Average current, forward + reverse (T_{av} max. 20 ms)	I_{av}	max.	5	mA [2]
reverse	I_{rev}	max.	2.5	mA
Bulb temperature	t_{bulb}	min.	-55	°C
	t_{bulb}	max.	70 °C + 10	°C/mA

[1]) When the diode is used with an alternating supply voltage (50 or 60 Hz mains frequency) - either not rectified or full-wave rectified - so that reignition occurs with a frequency of min. 100 p.p.s. the residual ionization after the the first ignition is sufficient to eliminate ignition delay for the following ignition.

[2]) Sum of absolute values of currents.

7Z2 6817

SHOCK AND VIBRATION RESISTANCE

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

Shock resistance 500 g

Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30^o in each of 4 different positions of the tube.

Vibration resistance 2.5 g_{peak}

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

LIFE EXPECTANCY

The life expectancy under recommended 50 or 60 Hz conditions (Fig. 2) is min. 4000 operating hours at maximum average reverse current.

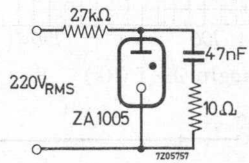


Fig. 1a
Measuring circuit

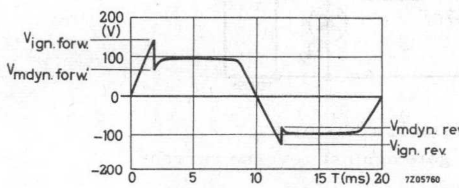


Fig. 1b
Typical voltage across ZA1005

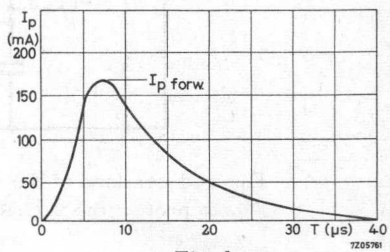
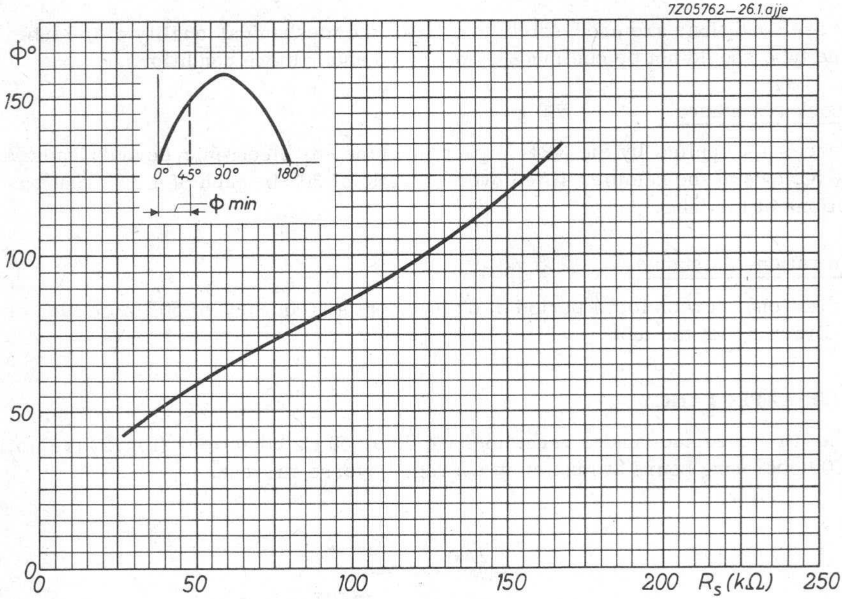


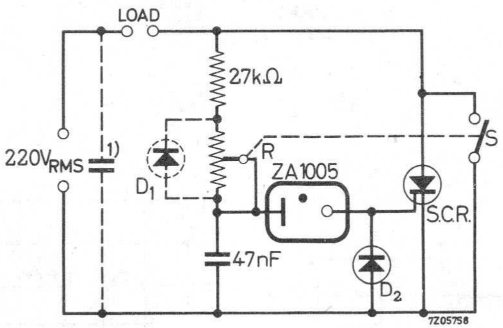
Fig. 1c
Typical forward peak current through 10 Ω resistor

7Z2 6818

Fig. 2 Half-wave control



Conduction angle ϕ = f (Rs) R_S = 27 kΩ + R



Close for full power

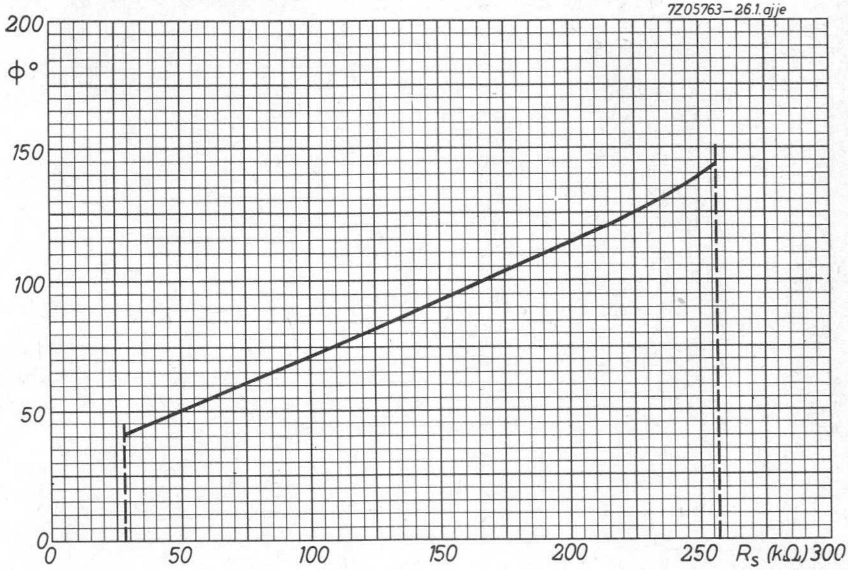
D_1. reduces load of the variable résistor R_S

D_2. to protect the S.C.R. gate against reverse current

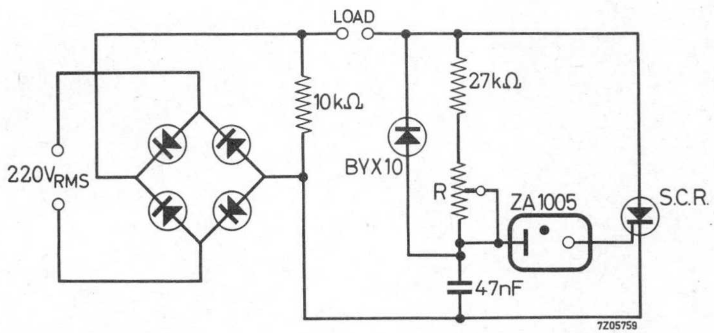
1) Application note:

When a load is shunted by an anti interference capacitor it is necessary that this capacitor be connected over load and control circuit to avoid self extinction of the S.C.R. 7Z2 6819

Fig. 3 Full-wave control



Conduction angle ϕ = f (Rs) R_S = 27 kΩ + R



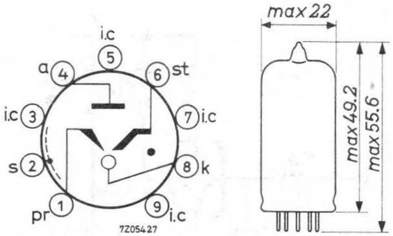
TRIGGER TUBE

Gas filled cold cathode trigger tube with molybdenum cathode and electrical priming. The tube has been designed to be ignited with positive voltages on starter and anode only and can be fed from a.c. or d.c. anode voltages.

QUICK REFERENCE DATA				
Anode supply voltage	a.c.	V_{ba}	220	V
	d.c.	V_{ba}	300	V
Anode maintaining voltage		V_m	112	V
Cathode current, max.		$I_{k\ max.}$	40	mA
Starter to cathode ignition voltage		V_{st-ign}	130	V
Transfer requirements:	capacitance	C_{st}	330	pF
	current	I_{st}	200	μA

DIMENSIONS AND CONNECTIONS

Base: Noval



MOUNTING

Mounting position: any

Starter and primer resistances should be mounted directly on the corresponding socket soldering tag to avoid stray capacitances.

7Z2 6774

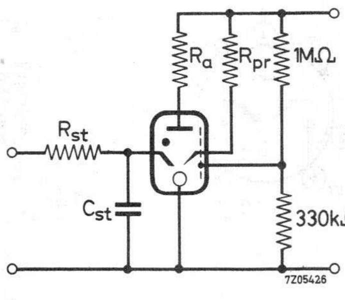
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

The electrical characteristics assume the presence of a priming discharge. This priming discharge can be established by connecting the primer via a 10 MΩ resistor to the anode supply voltage.

A.C. OPERATION

(Anode and starter voltage in phase. When the tube is fed from an alternating supply voltage, the internal shield (s) shall be connected to a voltage divider across the anode supply voltage so that the voltage at s is 25% of the anode voltage. See fig. 1)

Anode voltage	V_a	min.	180	V_{RMS}
		max.	250	V_{RMS}
Starter ignition voltage	$V_{st\text{-}ign}$	min.	85	V_{RMS}
		max.	100	V_{RMS}
Transfer requirements				
current	I_{st}	min.	200	μA
capacitance	C_{st}	min.	200	pF
		max.	500	pF
Cathode current				
average (T_{av} max. 15 s)	I_k	max.	25	mA
average (T_{av} max. 20 ms)	I_k	max.	40	mA
average during any conduction period	I_k	min.	10	mA



7Z2 6775

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

(continued)

D.C. OPERATION

Anode voltage	V_a	min.	250	V
		max.	350	V
Starter ignition voltage	$V_{st\text{-}ign}$	min.	120	V
		max.	140	V
Transfer requirements				
current	I_{st}	min.	200	μA
capacitance	C_{st}	min.	200	pF
Cathode current				
average (T_{av} max. 15 s)	I_k	max.	25	mA
average during conduction	I_k	min.	15	mA
Maintaining voltage (at I_a = 20 mA)	V_m	min.	106	V
		max.	115	V

LIMITING VALUES (Absolute max. rating system)

A.C. OPERATION (Anode and starter voltage in phase)

Anode voltage	V_a	max.	250	V_{RMS}
Cathode current				
average (T_{av} max. 15 s)	I_k	max.	25	mA
average (T_{av} max. 20 ms)	I_k	max.	40	mA
peak (f max. 60 Hz)	I_{k_p}	max.	200	mA
average during any conduction period	I_k	min.	10	mA
Negative starter current	$-I_{st}$	max.	200	μA
Voltage at internal shield (in phase with anode voltage)	V_s	min.	45	V_{RMS}
	V_s	max.	75	V_{RMS}
Temperature	t_{bulb}	min.	-55	^oC
	t_{bulb}	max.	+70	$^oC + 2\ ^oC/mA$

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LIMITING VALUES (Absolute max. rating system) (continued)

D.C. OPERATION

Anode voltage				
positive	V_a	max.	350	V
negative	$-V_a$	max.	100	V
Cathode current				
average (T_{av} max. 15 s)	I_k	max.	25	mA
average during conduction	I_k	min.	15	mA
peak	I_{kp}	max.	200	mA
surge ($T_{max.}$ 1 ms)	I_{surge}	max.	1	A
Starter to cathode capacitor	C_{st}	max.	10	nF [1]
Negative starter voltage	$-V_{st}$	max.	0	V
Temperature	t_{bulb}	min.	-55	^oC
	t_{bulb}	max.	+70	$^oC + 2\ ^oC/mA$

[1]) Higher values of starter capacitor are permitted, provided a current limiting resistor of 1 kΩ to 10 kΩ is used in series with the starter.

7Z2 6777

Thyratrons

APPLICATION DIRECTIONS
THYRATRONS

The following instructions and recommendations apply in general to all types of thyratrons. If there are deviations for any type of tube they will be indicated on the published data sheets of the type in question.

MOUNTING

Normally the tubes must be mounted vertically with the base or filament strips at the lower end. They must be mounted so that air can circulate freely around them. Where additional cooling is necessary forced air should assist the natural convection. (This is of great importance in the case of mercury-vapour filled tubes, in order to condense the mercury in the lower part of the tube). The clearance between the tubes and other components of the circuit and between the tubes and cabinet walls should be at least half the maximum tube diameter.

When 2 or more tubes are used the minimum clearance between them should be 3/4 the maximum tube diameter. When the tube is mounted in a closed cabinet the heat dissipated by the tube and other components should be taken into account. While the tube is working it must not touch any other part of the installation or be exposed to falling drops of liquid.

The tubes should be mounted in such a way that they are not subjected to dangerous shock or vibration. In general, if shock or vibration exceeds 0.5 g a shock absorbing device should be used.

The electrode connections, except for those of the tube holder, must be flexible. The nuts (e.g. of the anode connections) should be well tightened but care must be taken to ensure that no undue forces are exerted on the tube. The contacts must be checked at regular intervals and their surfaces kept clean in order to avoid excessive heating of the glass-metal seals. The cross section of the conductors and leads should be sufficient to carry the r.m.s. value of the current. (It should be noted that in grid controlled rectifier circuits the r.m.s. value of the anode current may reach 2.5 x the average d.c. value and even more).

FILAMENT SUPPLY

In order to obtain the maximum life of a directly heated tube, a filament transformer with centre-tap and a phase shift of $90^o \pm 30^o$ between V_a and V_f is recommended.

7Z2 7658

If, in the published data, limits are given for the filament voltage, steps should be taken to prevent the filament voltage exceeding these limits owing to the spread of the transformer, fluctuations of the mains voltage, etc. The filament voltage at nominal mains voltage is measured at the terminals of the tube. If no limits for the filament voltage are given, deviations with a maximum of 2.5% from the published value, can be accepted.

It is therefore recommended to have tappings on the filament transformer. The mains fluctuations should, in general, not exceed 5%. During short intervals fluctuations of 10% are admissible.

In calculating the ratings of the filament transformer a variation in the filament current of plus and minus 10% from tube to tube should be taken into account, whilst for directly heated tubes the d.c. current flowing through the filament winding should also be considered.

TEMPERATURE

1. For tubes filled with mercury vapour or with a mixture of mercury vapour and inert gas.

   For these tubes temperature limits for the condensed mercury are given in the published data. Care should be taken to ensure that the temperature during operation is between these limits. Too low temperature gives low gas pressure which results in a low current capability, high arc drop and consequently shortening of life. Too high a temperature gives high gas pressure which results in a reduction of the "arc-back" voltage, and with it the permissible peak inverse and forward voltages. The condensed mercury temperature can be measured with a thermo-element placed against the envelope. The measurement should be made at the coldest part of the bulb where the mercury condenses; in general this will be just above the base or the lower connections.
   Good technique and instruments are necessary for accurate thermocouple measurements. In addition to the temperature limits for the condensed mercury sometimes limits for the ambient temperature are given.
   The latter are only intended as a guide, as the difference between the ambient and the condensed mercury temperature largely depends on mounting and cooling.

   The mercury condensed temperature is decisive in all cases.

   The ambient temperature can be measured with a thermometer which has been screened against direct heat radiation. The measurement should be carried out at various points around the lower part of the tube.

2. Tubes with inert gas-filling

   For these tubes only the limits of the ambient temperature are given. These limits are in general minimum −55 °C and maxima +75 °C.

7Z2 7659

SWITCHING ON

1. Tubes filled with mercury vapour or with a mixture of mercury vapour and inert gas

   It is necessary to allow some time for the cathode to reach its operating temperature before drawing cathode current. Therefore the minimum cathode heating time is given on the published data sheets.
   After the cathode heating time the tube may be switched on provided the temperature of the condensed mercury is not too low.
   Switching on (not after transport) may be done at a condensed mercury temperature which lies 5 to 10 °C below the minimum temperature published (minimum waiting time required).
   However, it is good practice to switch on after the temperature having passed its minimum published value (recommended waiting time)
   The switching on times, the minimum required and the recommended one can be read from the curve representing the condensed mercury temperature as a function of time with only the filament voltage applied to the tube.
   The minimum required switching on time can directly be read from the curve representing this time as a function of the ambient temperature.
   Switching on after transport or after a considerable interruption of operation should be done according to the instructions for use which are packed with the tube.
   In order to avoid long preheating times it is recommended to leave the filament supply on during stand-by periods (e.g. overnight) at 60-80% of the nominal voltage.

2. Tubes with inert gas-filling

   It is necessary to allow the cathode to reach operating temperature before drawing cathode current.
   Therefore the minimum cathode heating time is published after which the anode voltage may be applied provided that the ambient temperature is not below the minimum published value.

LIMITING VALUES

In general these values are given as absolute maxima; i.e. maxima which should not be exceeded under any conditions (so they may not be exceeded owing to mains voltage fluctuations, load variations, tolerances on components, overvoltages etc.)

For each rating of maximum average current a maximum averaging time is quoted. This is to ensure that an anode current greater than the maximum continuously permissible average value is not drawn for such a length of time as would give rise to an excessive temperature within the tube.

The maximum peak anode current is determined by the available safe cathode emission whereas the average current is limited by its heating effects.

7Z2 7660

Under no circumstances may the peak current exceed its maximum published value. For the determination of the actual value of the peak inverse voltage and the peak anode current, the measured values with an oscilloscope or otherwise are decisive.

TYPICAL CHARACTERISTICS

1. Arc voltage

   The value published for V_{arc} applies to average operating conditions; under high peak current conditions, e.g. 6 phase rectification, V_{arc} will be higher. The spread which is dependent on the circuit can be expected to be plus and minus 1 V.

   During life and increase of approximately 2 V must be taken into account.

2. Frequency

   Unless otherwise stated the maximum frequency at which the tubes may run under full load is 150 Hz.

   Under special conditions higher frequencies may be used, details should be obtained from the manufacturer.

OPERATING CHARACTERISTICS

The data under this heading are based on normal practical conditions.

SHORT CIRCUIT PROTECTION

In order to prevent the tube from being damaged by passing too high a peak current a value for the surge current is given. The figure given for the maximum surge current is intended as a guide to equipment designers. It indicates the maximum value of a transient current resulting from a sudden overload or short circuit which the thyratron can pass for a period not exceeding 0.1 second without resulting in its immediate destruction. Several overloads of this nature will, however, considerably reduce the life of the tube.

The equipment designer has to take into account this maximum surge current rating when calculating the short-circuit impedance of the equipment.

This surge current value is not intended as a peak current that may occur on switching or during operation.

A simple method to limit the surge current to the max. rating is to incorporate a series resistance in the anode circuit.

SCREENING AND INTERFERENCE

In order to prevent unwanted ionisation of the gas filling (and consequent flash over) due to strong R.F. fields, it may be necessary to enclose the thyratron in a separate earthed screening box.

7Z2 7661

In circuits with gas-filled tubes oscillation in the transformer windings and other circuit components may occur, resulting in excessive peak inverse voltages and arc back. Damping of these oscillations is necessary especially at higher voltages. Parallel RC-circuits are recommended for this purpose.

SMOOTHING CIRCUITS

In order to limit the peak anode current in a rectifier it is necessary that a choke should precede the first smoothing condenser.

To ensure good voltage regulation on fluctuating loads the inductance value of the choke should be large enough to give uninterrupted current at minimum load.

The choke and capacitor must not resonate at the supply or ripple frequency. In grid controlled rectifier circuits under phased-back conditions the harmonic content of the d.c. output will be large unless the inductance is adequate.

PARALLEL OPERATION OF GAS-FILLED TUBES

As individual gas-filled thyratrons may have slightly different characteristics two or more tubes must not be connected directly in parallel. An alternative expedient must be adopted if a higher current output is required. Information on suitable methods will be supplied on request.

EFFECTS OF POSITIVE ION CURRENT

When a thyratron is conducting, a positive ion current of a magnitude proportional to the cathode current is generated. This current will, in general, flow to that electrode which is at the most negative potential during conduction (e.g. the grid). In order to prevent damage to the tube it is necessary to ensure that the voltage of this electrode is more positive then -10 V during this phase. This precaution will prevent an increase in grid emission due to excessive grid dissipation, sputtering of grid material, changes in the control characteristics caused by shifts in contact potential and, in the case of inert-gas-filled tubes, a rapid gas clean up.

In circuits where the control grid is held negative during anode conduction, a suitable choice of resistor in series with the grid will maintain an effective grid bias more positive than -10 V. The minimum allowable value of the grid resistor is 0.1 x the recommended one.

In circuits where the anode potential changes from a positive to a negative value and the control grid is at a positive potential, thereby drawing cathode current, a small positive ion current flows to the anode. At high negative anode voltages it is therefore essential to limit the magnitude of the positive ion current by severely restricting the current flowing from cathode to grid. This may be effected by using the maximum permitted series resistor, or preferably by using fixed negative grid bias and a narrow positive firing pulse.

7Z2 7662

In those circuits where the anode potential changes very rapidly from a positive to a high negative value, such as with inductive loads fed from polyphase supplies, there will be residual positive ions within the tube which will be drawn towards the anode with considerable energy. In the case of an inert-gas filled tube this would result in excessive gas clean-up and it is therefore necessary to observe the limitations imposed by the commutation factor.

CONTROL CHARACTERISTICS

In most cases the control characteristic given on the data sheets is shown by upper and lower boundary curves within which all tubes may be expected to remain at all temperatures of the published range and during life.

In multitube circuits where the tubes are operating under the same conditions the spread will in general be smaller. The published boundaries are therefore to be considered as extreme limits. This should be taken into consideration when designing grid excitation circuits.

GRID EXCITATION CIRCUITS

To keep the instant of ignition as constant as possible a large value of excitation voltage is recommended.

The use of a negative grid bias (20 to 50 V for a d.c. output voltage of 200 to 600 V) and a sharp positive grid pulse is recommended.

The magnitude of the grid should be 70 to 100 V with a grid series resistor of 20 kΩ and a maximum impedance of the peaking transformer of 30 kΩ. If a sinusoidal grid voltage is used the following r.m.s. values are recommended. With inductive or resistive load without a back E.M.F. this excitation voltage should be of the order of 8 x the spread of the control characteristic (30 to 50 V_{rms}).

If a back E.M.F. is present the value of excitation voltage should be 15 x the spread of the control characteristic (50 to 100 V_{rms}).

7Z2 7663

RATING SYSTEM

(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.

7Z2 5065

RATING SYSTEM

(in accordance with IEC publication 134)

Absolute maximum rating system

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

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

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

THYRATRON

Thyratron, inert gas filled tetrode for relay service, electronic timers, stabilized rectifiers, stabilization of A.C. output, in grid circuits of power thyratrons.

QUICK REFERENCE DATA				
Peak anode voltage	V_{a_p}	=	650	V
Cathode current, peak	I_{k_p}	=	0.5	A
average	I_k	=	0.1	A

HEATING: indirect by A.C. or D.C.

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	600	mA
Waiting time	T_w	=	20	s [1]

CAPACITANCES

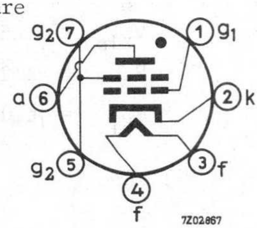
Grid No.1 to all other elements	C_{g_1}	=	2.4	pF
Anode to all other elements	C_a	=	1.6	pF
Anode to grid No.1	C_{ag_1}	=	26	mpF

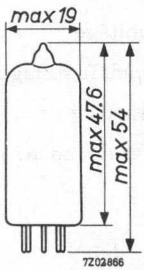
MECHANICAL DATA

Dimensions in mm

Base: 7 pin miniature

Net weight: 10 g





Mounting position: any

---

[1]) If urgently wanted T_w may be decreased to min. 10 s.

7Z2 5116

TYPICAL CHARACTERISTICS

Ionization time at $V_{a=}$ = 100 V, grid No.1 over- voltage = 50 V (substantial square pulse) Anode peak current during conduction = 0.5 A	T_{ion}	=	0.5	µs
Deionization time at $V_{a=}$ = 125 V, V_{g_1} = −100 V, R_{g_1} = 1000 Ω, I_a = 0.1 A	T_{dion}	=	35	µs
Deionization time at $V_{a=}$ = 125 V, V_{g_1} = −10 V, R_{g_1} = 1000 Ω, I_a = 0.1 A	T_{dion}	=	75	µs
Critical grid No.1 current at $V_{a\sim}$ = 125 V_{RMS}, I_a = 0.1 A	I_{g_1}	=	0.5	µA
Maintaining voltage	V_{arc}	=	8	V
Control ratio grid No.1 at striking point R_{g_1} = 0 Ω, V_{g_2} = 0 V	$\frac{V_a}{V_{g_1}}$	=	250	
Control ratio grid No.2 at striking point V_{g_1} = 0 V, R_{g_1} = 0 Ω, R_{g_2} = 0 Ω	$\frac{V_a}{V_{g_2}}$	=	1000	

OPERATING CONDITIONS for relay service

Anode voltage	$V_{a\sim}$	=	117	400	V_{RMS}
Grid No.2 voltage	V_{g_2}	=	0	0	V
Grid No.1 (bias) voltage	$V_{g_1\sim}$	=	5	-	V_{RMS} [1]
Grid No.1 (bias) voltage	V_{g_1}	=	-	-6	V
Grid No.1 peak (signal) voltage	$V_{g_{1p}}$	=	5	6	V
Anode circuit resistance	R_a	=	1.2	2.0	kΩ
Grid No.1 circuit resistance	R_{g_1}	=	1.0	1.0	MΩ

[1]) Phase difference between V_a and V_{g_1} approx. 180°.

7Z2 5117

LIMITING VALUES for relay- and grid controlled service
(Absolute max. rating system)

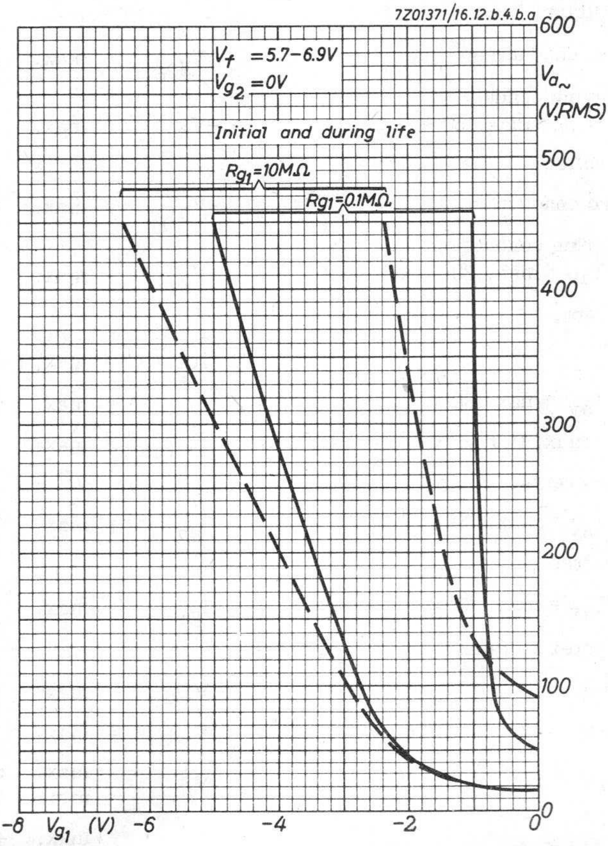
Anode voltage,				
forward peak	V_{a_p}	= max.	650	V
inverse peak	$V_{a\,inv_p}$	= max.	1300	V
Grid No.2 voltage,				
peak before conduction	$-V_{g_{2p}}$	= max.	100	V
average during conduction T_{av} = max. 30 s	$-V_{g_2}$	= max.	10	V
Grid. No.1 voltage,				
peak before conduction	$-V_{g_{1p}}$	= max.	100	V
average during conduction T_{av} = max. 30 s	$-V_{g_1}$	= max.	10	V
Cathode current,				
peak	I_{k_p}	= max.	0.5	A
average, T_{av} = max. 30 s	I_k	= max.	0.1	A
surge, T = max. 0.1 s	I_{surge}	= max.	10	A
Grid No.2 current				
average, T_{av} = max. 30 s	I_{g_2}	= max.	10	mA [1]
Grid No.1 current,				
average, T_{av} = max. 30 s	I_{g_1}	= max.	10	mA
Cathode to heater voltage,				
k pos., peak	V_{+kf-}	= max.	100	V
k neg., peak	V_{-kf+}	= max.	25	V
Heater voltage	V_f	= max.	6.9	V
		= min.	5.7	V
Ambient temperature	t_{amb}	= max.	+90	°C
		= min.	-75	°C

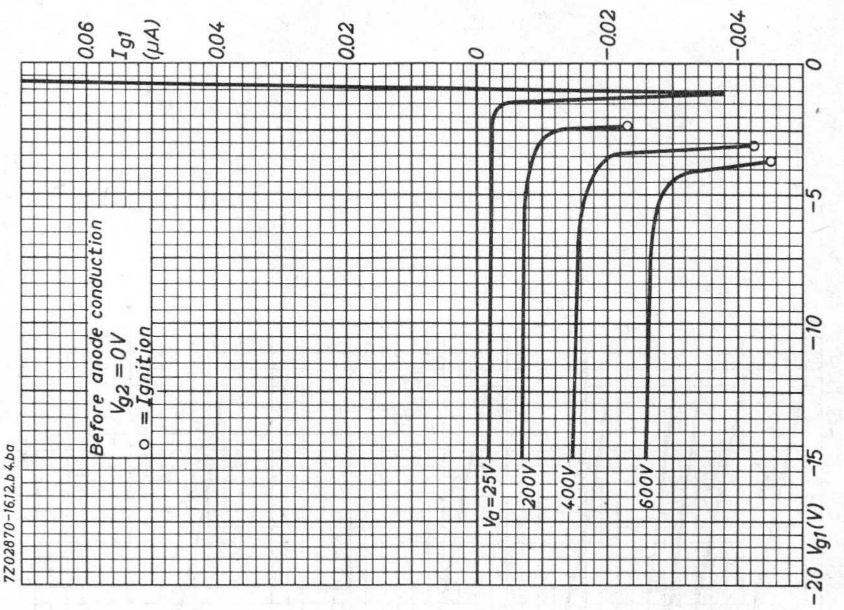
CIRCUIT DESIGN VALUES

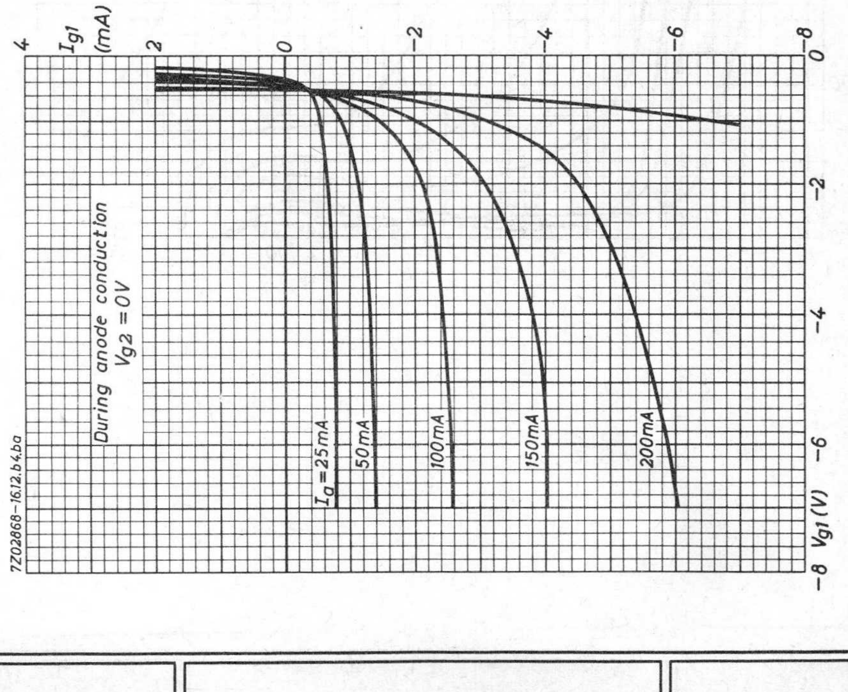
Grid No.1 circuit resistance	R_{g_1}	= max.	10	MΩ
recommended value	R_{g_1}	=	1	MΩ

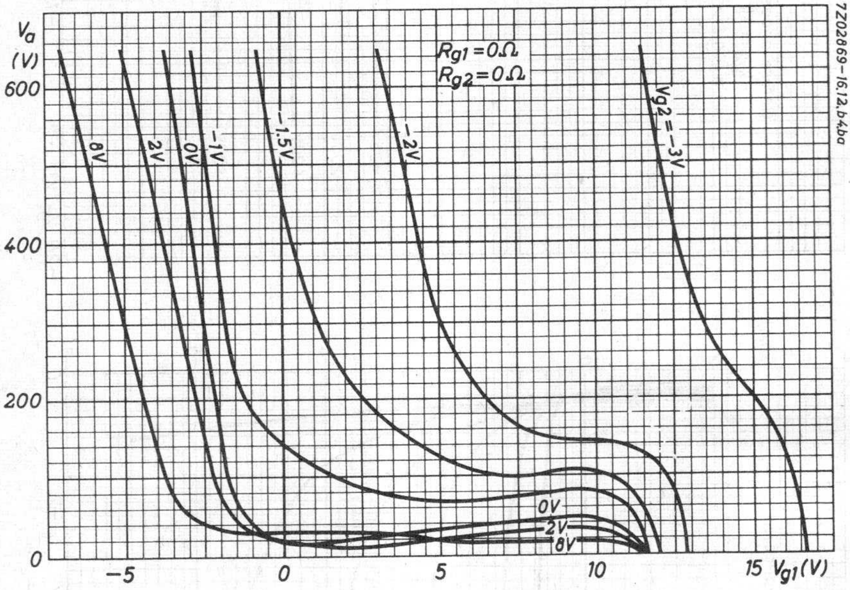
[1]) In order not to exceed this maximum value it is recommended to insert a resistor of 1000 Ω in the grid No.2 lead.

7Z2 5118


7Z01371/16.12.b.4.b.a
V_f =5.7−6.9V
V_{g_2} =0V
Initial and during life
R_{g_1}=10MΩ
R_{g1}=0.1MΩ
$V_{a\sim}$
(V,RMS)
600
500
400
300
200
100
0
−8
V_{g_1} (V)
−6
−4
−2
0


7Z02870-16.12.b4.ba
Before anode conduction
Vg2 = 0V
o = Ignition
Ig1 (μA)
0.06
0.04
0.02
0
-0.02
-0.04
Va=25V
200V
400V
600V
0
-5
-10
-15
-20 Vg1(V)


7Z02868-16.12.b4.ba
During anode conduction
Vg2 = 0V
Ig1 (mA)
4
2
0
-2
-4
-6
-8
Ia=25mA
50mA
100mA
150mA
200mA
0
-2
-4
-6
-8 Vg1 (V)


7Z02869-16.12.b4.ba
V_a (V)
600
400
200
0
−5
0
5
10
15 V_{g1}(V)
R_{g1} = 0 Ω
R_{g2} = 0 Ω
8V
2V
0V
−1V
−1.5V
−2V
V_{g2} = −3V
0V
2V
8V

TRIODE THYRATRONS

Mercury vapour and inert gas filled triode thyratron with negative control characteristic

QUICK REFERENCE DATA					
Peak forward anode voltage	V_{ap}	=	max.	1500	V
Peak inverse anode voltage	$V_{a\,invp}$	=	max.	1500	V
Average cathode current	I_k	=	max.	1.6	A
Peak cathode current	I_{kp}	=	max.	6.4	A
Average grid current	I_g	=	max.	10	mA
Peak grid current	I_{gp}	=	max.	50	mA

HEATING: direct

Filament voltage	V_f	=		2.5	V
Filament current	I_f	=		7	A
Waiting time	T_w	=	min.	15	sec [1])

CAPACITANCE

Capacitance between anode and grid	C_{ag}	=	2	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	=	10	V
Ionisation time	T_{ion}	=	10	μsec
Deionisation time	T_{dion}	=	1000	μsec

1) Recommended waiting time 30 sec.

2) Page 2. The ambient temperature is defined as the temperature of the surrounding air and shall be measured under the following conditions:

a. normal atmospheric pressure,
b. the tube shall be adjusted to the worst probable operating conditions,
c. the temperature shall be measured when thermal equilibrium is reached,
d. the distance of the thermometer shall be 52 mm from the outside of the envelope (measured in a plane perpendicular to the main axis of the tube at the height of the condensed mercury boundary),
e. the thermometer shall be shielded to avoid direct heat radiation.

7Z2 3128

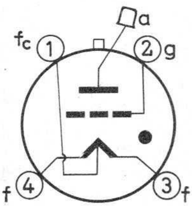
MECHANICAL DATA Dimensions in mm

Base : Medium 4p with bayonet

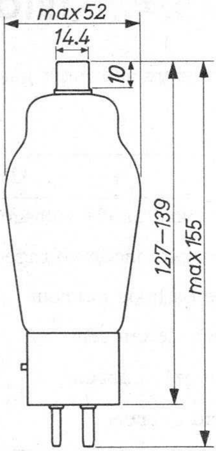
Socket : 2422 511 90003

Cap : 40619

Net weight: 90 g



PL3C23A



Mounting position: Vertical with base down

LIMITING VALUES (Absolute limits)

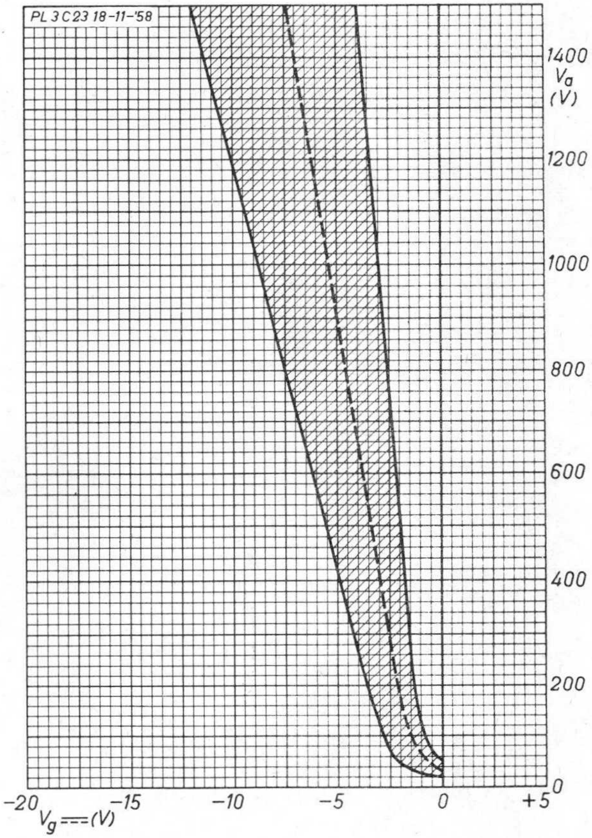
Peak forward anode voltage	V_{a_p}	=	max. 1500	V	
Peak inverse anode voltage	$V_{a\,inv_p}$	=	max. 1500	V	
Negative grid voltage before conduction	$-V_g$	=	max. 500	V	
Negative grid voltage during conduction	$-V_g$	=	max. 10	V	
Average grid current, anode positive	I_g	=	max. 10	mA	
(Averaging time	T_{av}	=	5	sec)	
Peak grid current	I_{g_p}	=	max. 50	mA	
Grid circuit resistance	R_g	=	5 to 100	kΩ	[1]
Average cathode current	I_k	=	max. 1.6	A	
(Averaging time	T_{av}	=	5	sec)	
Peak cathode current	I_{k_p}	=	max. 6.4	A	
Surge cathode current	I_{surge}	=	max. 120	A	
(Duration	T	=	max. 0.1	sec)	
Ambient temperature	t_{amb}	=	−40 to +50	°C	[2][3]
Condensed mercury temperature	t_{Hg}	=	−40 to +80	°C	

[1] Recommended value 50 kΩ

[2] See page 1

[3] Recommended temperature approximately 25 °C

7Z2 8502


PL 3 C23 18-11-'58
1400
V_a
(V)
1200
1000
800
600
400
200
0
-20
-15
-10
-5
0
+5
V_g === (V)

THYRATRON

Gas filled triode with insulated grid intended for use in pulse and relay circuits.

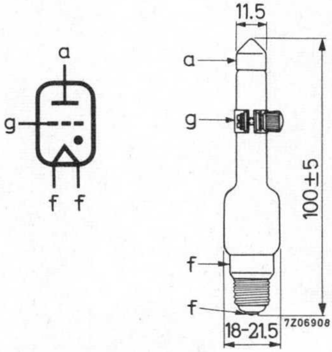
QUICK REFERENCE DATA			
Anode voltage, peak forward	V_{a_p}	max. 400	V
peak inverse	$V_{a_{invp}}$	max. 400	V
Anode current, average (T_{av} max. 10 s)	I_a	max. 100	mA
peak	I_{a_p}	max. 4	A

HEATING: direct

Filament voltage	V_f	1.85	V
Filament current	I_f	3.4	A
Waiting time	T_w	0	s

MECHANICAL DATA Dimensions in mm

Base: Mignon



Accessories

Socket	type No.	88168/01
Top cap connector		S80 37 00

7Z2 7645

TYPICAL CHARACTERISTICS

Arc voltage at I_a 0.1 A to 0.4 A	V_{arc}	20 to 35 V

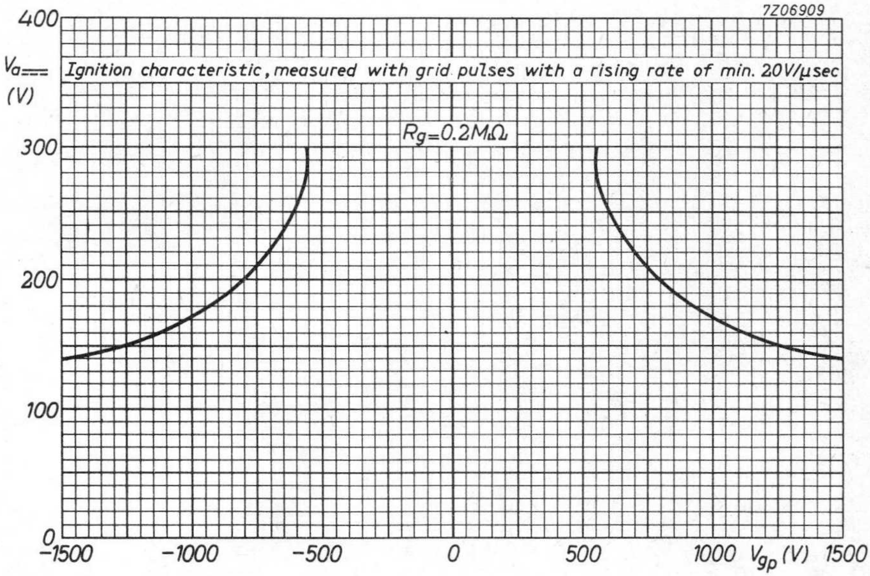
LIMITING VALUES (Absolute max. rating system)

Frequency	f	max.	100	Hz
Anode voltage, peak forward	V_{ap}	max.	400	V
peak inverse	$V_{a_{inv_p}}$	max.	400	V
Anode current, average (T_{av} = 10 s)	I_a	max.	100	mA
peak	I_{a_p}	max.	4	A
Grid voltage, peak	V_{g_p}	max.	1800	V
	$-V_{g_p}$	max.	1800	V
Grid resistor	R_g	max.	10	MΩ
Ambient temperature	t_{amb}	min.	-75	^oC
		max.	+90	^oC

REMARK

Thanks to the special grid construction which prevents striking at normal anode voltage during short circuit between anode and grid, a high safety is obtained.

7Z2 7646


7Z06909
Ignition characteristic, measured with grid pulses with a rising rate of min. 20V/µsec
V_a (V)
R_g=0.2MΩ
400
300
200
100
0
-1500
-1000
-500
0
500
1000
V_{gp} (V)
1500

THYRATRON

Mercury vapour filled tetrode thyratron intended for the following applications:

D.C. : for use as rectifier with variable or stabilized output voltage and for electronic D.C. motor speed control.

A.C. : for use as electronic switch and control of ignition circuits; control of electric furnances, incandescent lamps and discharge lamps; for resistance welding up to 27 kVA.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	2500	V
peak inverse	V_{inv_p}	max.	2500	V
Anode current, average (T_{av} = max. 15 s)	I_a	max.	6.4	A
peak (f ≥ 25 Hz)	I_{ap}	max.	40	A

HEATING: indirect

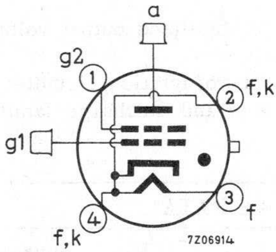
Heater voltage	V_f		5.0	V ± 5%
Heater current	I_f		10	A
Waiting time	T_w	min.	5	min.

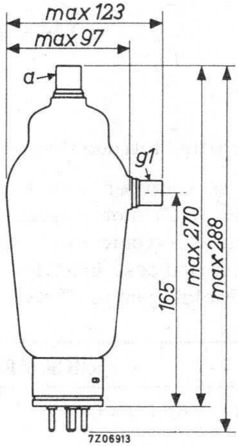
See curves on page C. During long periods of interrupted service (e.g. during night hours) it is recommended to reduce V_f to 60% to 80% of its nominal value instead of switching off the heater voltage. In this way the value of T_w can be decreased according to the dotted curve.

7Z2 7647

MECHANICAL DATA Dimensions in mm

Base: Super Jumbo with bayonet





Pins 2 and 3 heater, pin 4 cathode return

Mounting position: vertical, base down

Net weight: 510 g

ACCESSORIES

Socket	type No.	40403/00
Cap connector		40620

CAPACITANCES

Anode to grid No. 1	C_{ag_1}	1.8	pF
Grid No. 1 to cathode	C_{g_1k}	5.0	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Recovery time (Reionization time)	T_{dion}	1000	μs
Frequency	f	max. 150	Hz

7Z2 7648

Intermittent service

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{a_p}	max.	750	V
peak inverse	V_{inv_p}	max.	750	V
Grid No. 2 voltage	$-V_{g_2}$	max.	500	V
tube conducting	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage	$-V_{g_1}$	max.	1000	V
tube conducting	$-V_{g_1}$	max.	10	V
Anode current, peak ($f < 25$ Hz)	I_{a_p}	max.	5.0	A
($f \geq 25$ Hz)	I_{a_p}	max.	77	A
average (T_{av} = max. 5 s)	I_a	max.	2.5	A
Surge current (T = max. 0.1 s)	I_{surge}	max.	400	A
Grid No. 2 current, peak	$I_{g_{2p}}$	max.	2.0	A
average (T_{av} = max. 5 s)	I_{g_2}	max.	0.5	A
Grid No. 1 current, peak	$I_{g_{1p}}$	max.	1.0	A
average (T_{av} = max. 5 s)	I_{g_1}	max.	0.25	A
Grid No. 2 resistor	R_{g_2}	max.	10	kΩ
recommended value	R_{g_2}		10	kΩ
Grid No. 1 resistor	R_{g_1}	max.	100	kΩ
recommended value	R_{g_1}		10	kΩ
Mercury temperature	t_{Hg}		40 to 80	°C
recommended value	t_{Hg}		60	°C

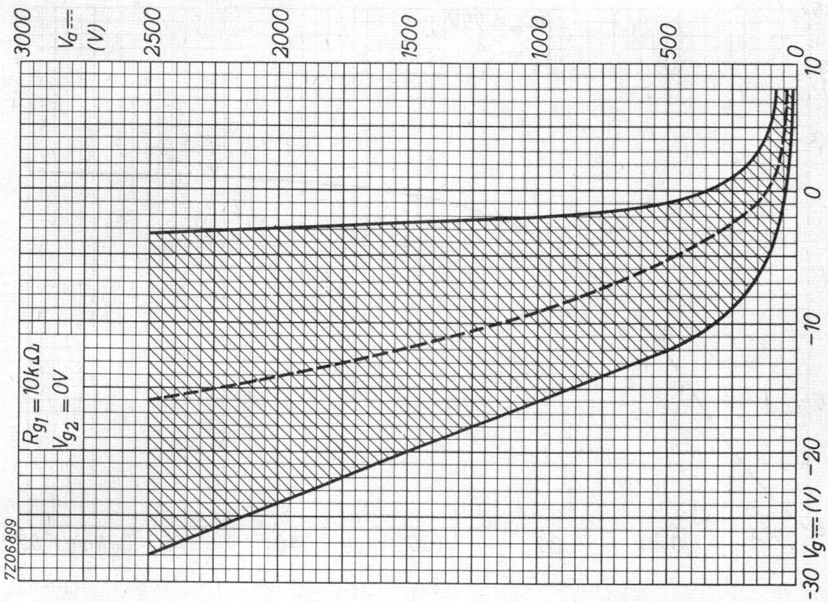
7Z2 7649

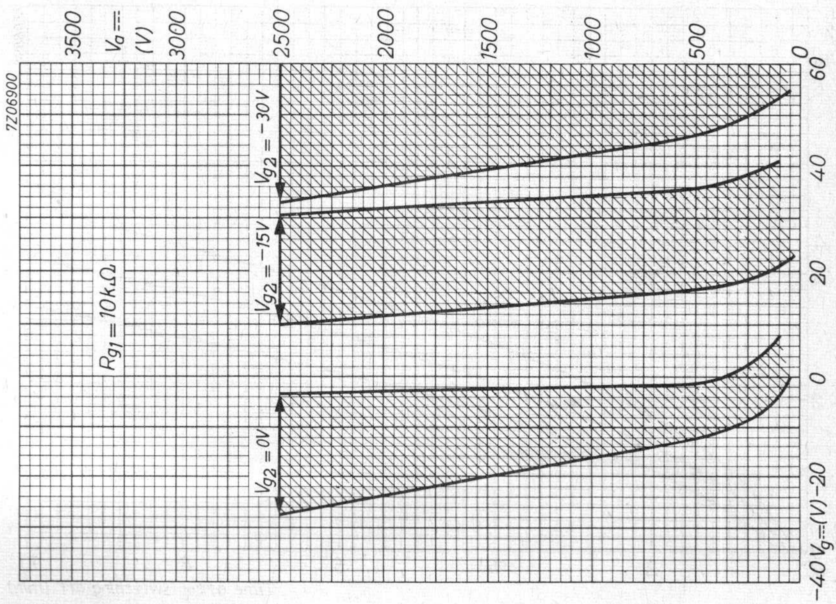
Continuous service

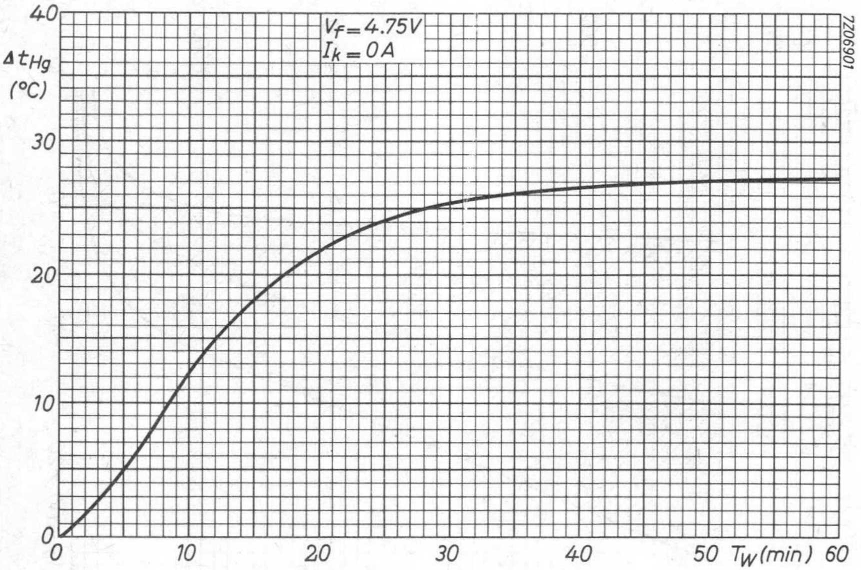
LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{a_p}	max.	2500	V
peak inverse	V_{inv_p}	max.	2500	V
Grid No. 2 voltage	$-V_{g_2}$	max.	500	V
tube conducting	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage	$-V_{g_1}$	max.	1000	V
tube conducting	$-V_{g_1}$	max.	10	V
Anode current, peak ($f < 25$ Hz)	I_{a_p}	max.	12.8	A
($f \geq 25$ Hz)	I_{a_p}	max.	40	A
average (T_{av} = max. 15 s)	I_a	max.	6.4	A
Surge current (T = max. 0.1 s)	I_{surge}	max.	400	A
Grid No. 2 current, peak	$I_{g_{2p}}$	max.	2.0	A
average (T_{av} = max. 15 s)	I_{g_2}	max.	0.5	A
Grid No. 1 current, peak	$I_{g_{1p}}$	max.	1.0	A
average (T_{av} = max. 15 s)	I_{g_1}	max.	0.25	A
Grid No. 2 resistor	R_{g_2}	max.	10	kΩ
recommended value	R_{g_2}		10	kΩ
Grid No. 1 resistor	R_{g_1}	max.	100	kΩ
recommended value	R_{g_1}		10	kΩ
Mercury temperature	t_{Hg}		40 to 80	°C
recommended value	t_{Hg}		60	°C

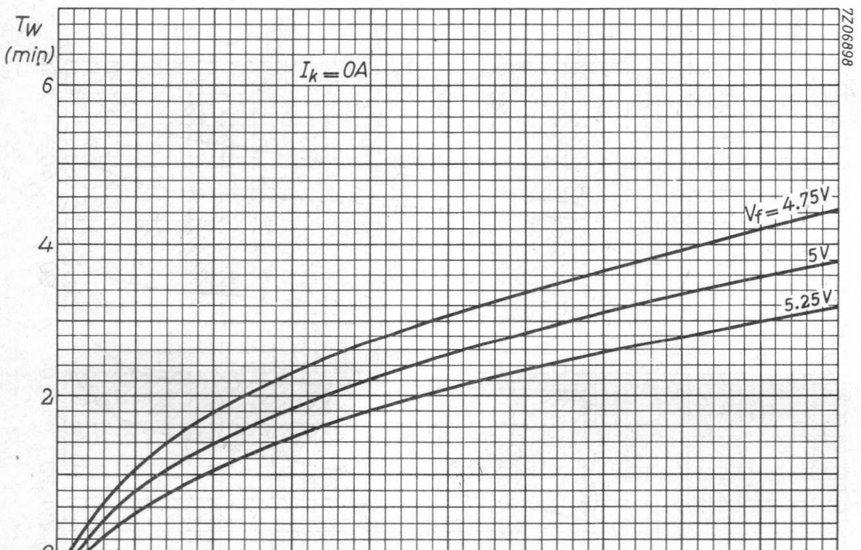
7Z2 7650


7Z06899
Rg1 = 10 kΩ
Vg2 = 0V
Va ⎓ (V)
3000
2500
2000
1500
1000
500
0
Vg ⎓ (V)
-30
-20
-10
0
10

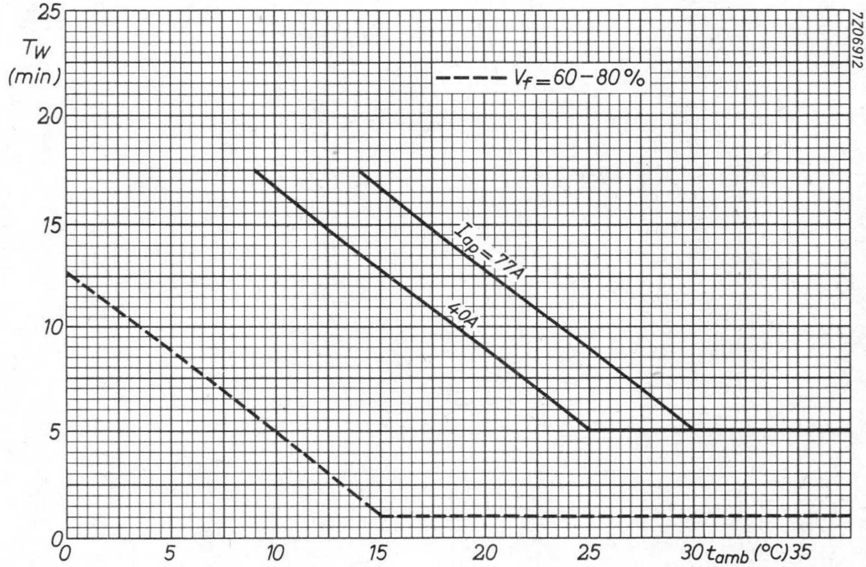

7Z06900
Rg1 = 10 kΩ
Vg2 = 0V
Vg2 = −15V
Vg2 = −30V
Va ⎓ (V)
3500
3000
2500
2000
1500
1000
500
0
Vg ⎓ (V)
-40
-20
0
20
40
60



$V_f = 4.75V$
$I_k = 0A$
Δt_{Hg} (°C)
40
30
20
10
0
0
10
20
30
40
50
T_W (min)
60
7Z06901



T_W (min)
$I_k = 0A$
6
4
2
0
$V_f = 4.75V$
5V
5.25V
0
2
4
6
8
10
Time after switching off (min)
7Z06898


25
T_W
(min)
20
15
10
5
0
---- V_f = 60 − 80 %
I_{ap} = 77A
40A
7Z06912
0
5
10
15
20
25
30 t_{amb} (°C) 35

THYRATRON

Mercury vapour and inert gas-filled triode thyratron intended for use in motor control, A.C. control and other industrial applications.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	2000	V
peak inverse	V_{invp}	max.	2000	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	6.4	A
peak	I_{kp}	max.	80	A

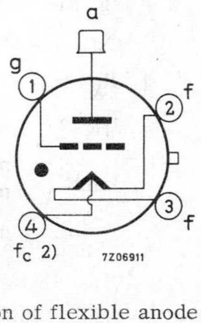
HEATING: direct

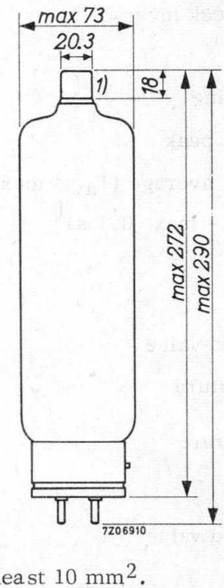
Filament voltage	V_f		2.5	V
Filament current	I_f		22	A
Waiting time	T_w	min.	30	s
recommended value	T_w		60	s

MECHANICAL DATA

Dimensions in mm

Base: Super Jumbo with bayonet





[1]) Cross section of flexible anode lead at least 10 mm^2.
[2]) f_c should preferably be used as cathode return connection.

7Z2 7651

Mounting position: vertical, base down

Net weight: 480 g

Accessories

Cap connector type 40620

CAPACITANCES

Anode to grid	C_{ag}	9	pF
Grid to filament	C_{gf}	19	pF

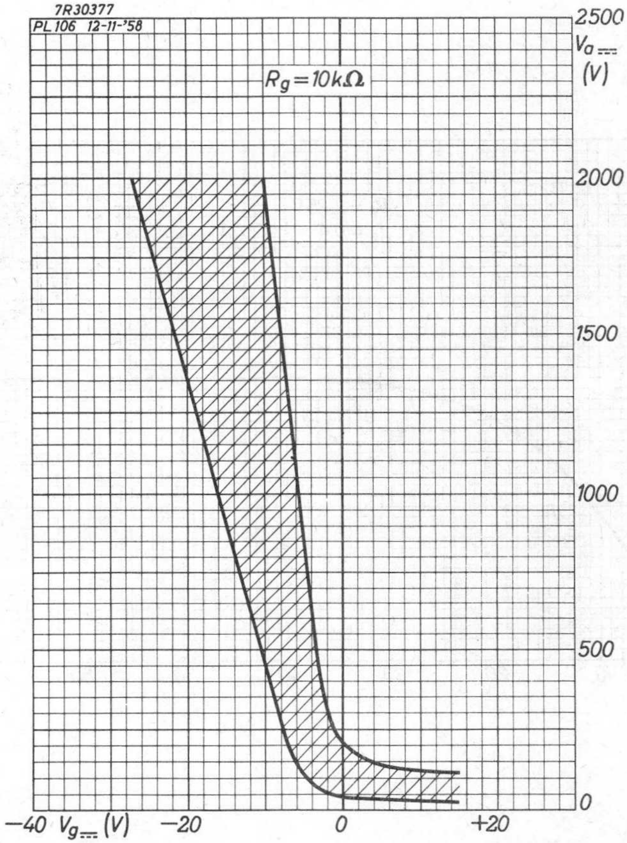
TYPICAL CHARACTERISTICS

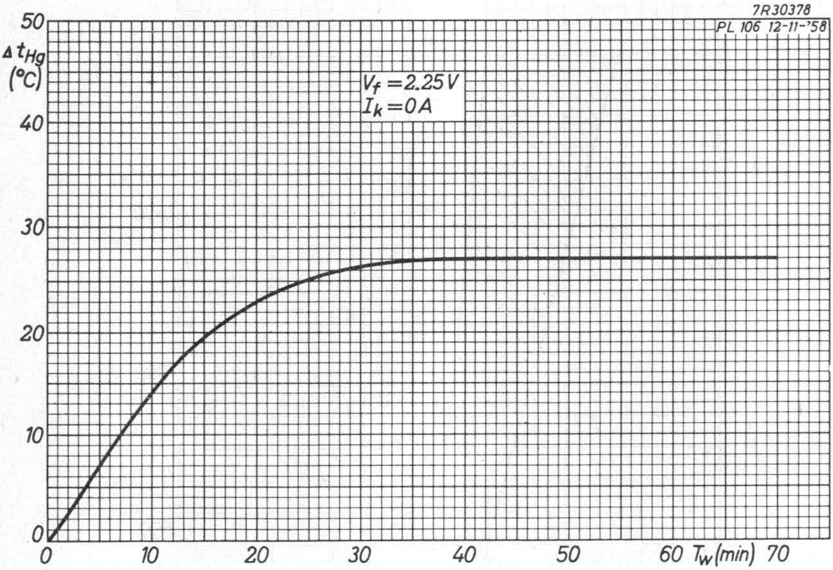
Arc voltage	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time)	T_{dion}	500	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{ap}	max.	2000	V
peak inverse	V_{inv_p}	max.	2000	V
Grid voltage	$-V_g$	max.	500	V
tube conducting	$-V_g$	max.	10	V
Cathode current, peak	I_{k_p}	max.	80	A
average (T_{av} = max. 15 s)	I_k	max.	6.4	A
Surge current (T = max= 0.1 s)	I_{surge}	max.	800	A
Grid current	I_g	max.	0.25	A
Grid resistor	R_g	max.	100	kΩ
recommended value	R_g		30	kΩ
Mercury temperature	t_{Hg}		25 to 80	°C
Ambient temperature	t_{amb}	min. max.	-40 +50	°C °C
Anode fuse		max.	20	A
recommended value			15	A

7Z2 7652


7R30377
PL 106 12-11-'58
$R_g = 10k\Omega$
2500
V_a (V)
2000
1500
1000
500
0
−40
V_g (V)
−20
0
+20


7R30378
PL 106 12-11-'58
50
Δ t_{Hg}
(°C)
40
30
20
10
0
V_f = 2.25 V
I_k = 0 A
0
10
20
30
40
50
60
T_w (min)
70

THYRATRON

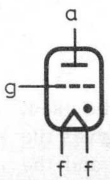
Mercury vapour and inert gas-filled triode thyratron intended for use in cinema rectifiers, battery chargers, rectifiers for feeding bookkeeping machines etc.

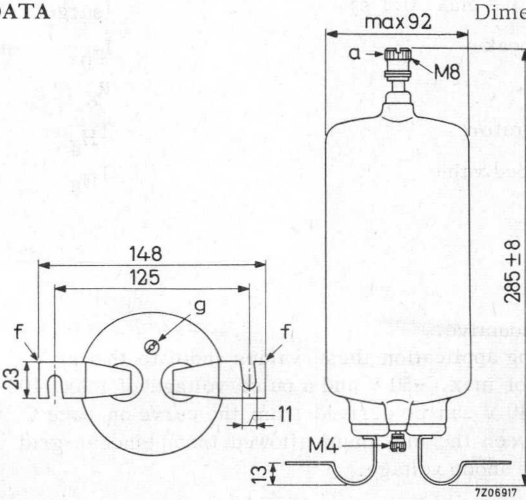
QUICK REFERENCE DATA				
Intermittent service				
Anode voltage, peak forward	V_{ap}	max.	120	V
peak inverse	V_{invp}	max.	250	V
Anode current, average (T_{av} = max. 15 s)	I_a	max.	17	A
peak	I_{ap}	max.	65	A

HEATING: direct

Filament voltage	V_f	1.9	V ± 5%
Filament current	I_f	26	A
Waiting time (See also curve page B)	T_w	min. 1	min.

MECHANICAL DATA Dimensions in mm





7Z2 7653

Mounting position: vertical, base down

Net weight: 550 g

CAPACITANCES

Grid to filament	C_{gf}	8	pF
Anode to grid	C_{ag}	28	pF

TYPICAL CHARACTERISTICS

Arc voltage (I_a = 15 A)	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time)	T_{dion}	1000	μs

Continuous service

LIMITING VALUES (Absolute max. rating system)

Grid voltage (V_a = neg)	$-V_g$	max.	150	V [1]
(V_a = 0 V)	$-V_g$	max.	150	V [1]
(V_{ap} = 240 V)	$-V_g$	max.	50	V [1]
Anode current, peak	I_{ap}	max.	90	A
average (T_{av} = max. 15 s)	I_a	max.	15	A
Surge current (T = max. 0.1 s)	I_{surge}	max.	750	A
Grid current, peak	I_{gp}	max.	0.1	A
Grid resistor	R_g		10 to 33	kΩ
Mercury temperature	T_{Hg}		40 to 80	°C
recommended value	T_{Hg}		60 to 70	°C

[1]) Tube non conductive.
In pulse firing application these values indicate that at V_{ap} = 240 V a D.C. bias voltage of max. −50 V and a pulse voltage of max. 100 V can be used. For V_{ap} < 240 V can be derived from the curve on page C, which gives the relation between the maximum allowed instantaneous grid voltage and the instantaneous anode voltage.

7Z2 7654

LIMITING VALUES (continued)

Without phase control

Anode voltage, peak forward	V_{ap}	max. 250	V
peak inverse	V_{invp}	max. 500	V

With phase control (with or without a back E.M.F.)

	Load	
	non inductive	inductive
Number of phases	Anode voltage	
max. 3 [1]	V_{aRMS} max. 170 V	V_{aRMS} max. 85 V
max. 6	V_{aRMS} max. 110 V	V_{aRMS} max. 55 V

Intermittent service (cinema rectifiers [2])

LIMITING VALUES (Absolute max. rating system)

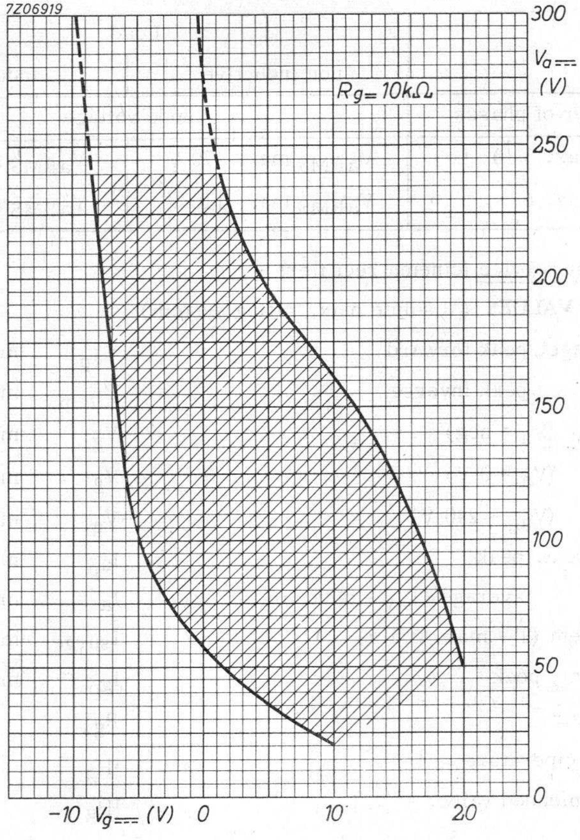
Anode voltage, peak forward	V_{ap}	max.	120	V
peak inverse	V_{invp}	max.	250	V
Grid voltage (V_a = neg)	$-V_g$	max.	150	V [3]
(V_a = 0 V)	$-V_g$	max.	150	V [3]
(V_{ap} = 240 V)	$-V_g$	max.	50	V [3]
Anode current, peak	I_{ap}	max.	65	A
average (T_{av} = max. 15 s)	I_a	max.	17	A
Surge current (T = max. 0.1 s)	I_{surge}	max.	750	A
Grid current, peak	I_{gp}	max.	0.1	A
Grid resistor	R_g		10 to 33	kΩ
Mercury temperature	t_{Hg}		40 to 80	°C
recommended value	t_{Hg}		60 to 70	°C

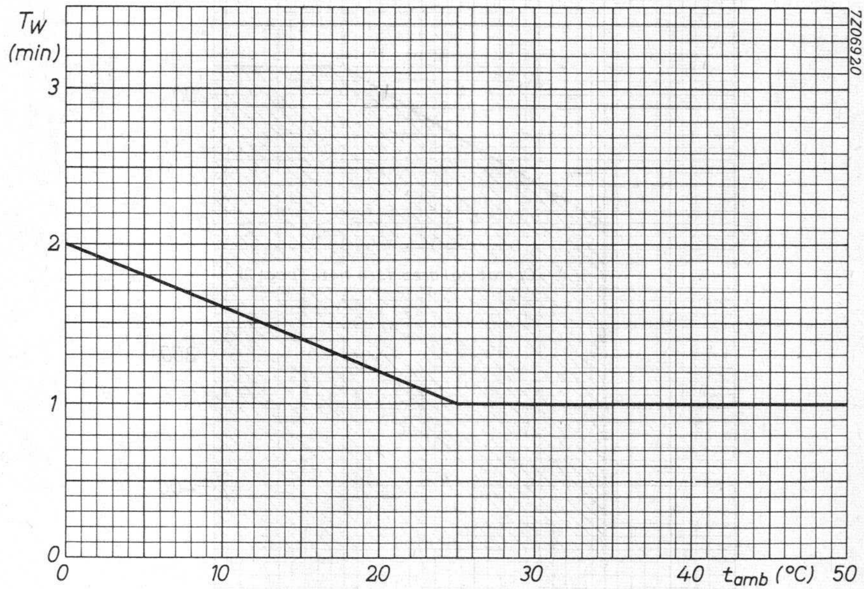
[1]) Double 3 phase with interphase choke included.

[2]) Operating period max. 20 min. followed by an "off" period lasting at least 75% of the "on" period.

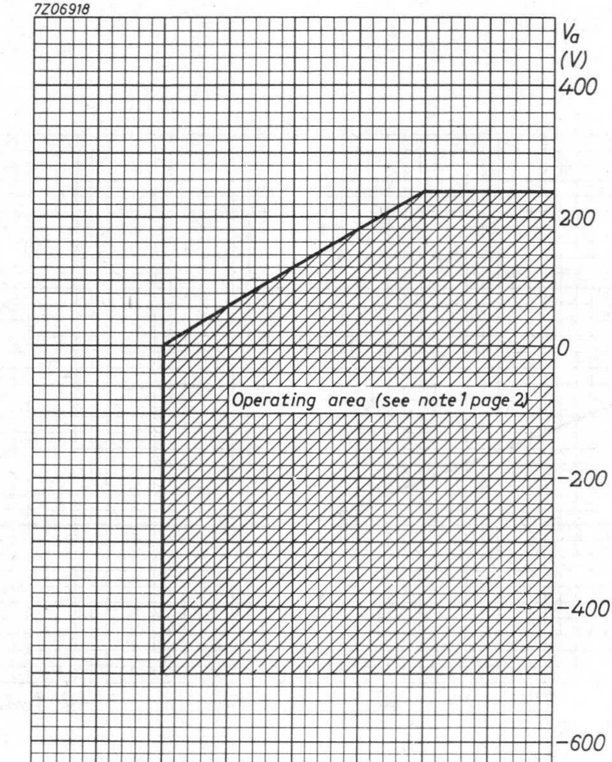
[3]) See note [1]) page 2.

7Z2 7655


7Z06919
300
V_a ===
(V)
R_g = 10kΩ
250
200
150
100
50
0
−10
V_g === (V)
0
10
20



T_W
(min)
3
2
1
0
0
10
20
30
40
t_{amb} (°C)
50
7Z06920


7Z06918
V_a
(V)
400
200
0
Operating area (see note 1 page 2)
−200
−400
−600
−200 V_g (V) −150
−100
−50
0

THYRATRON

Mercury-vapour triode thyratron intended for use in motor control equipment and resistance welding equipment.

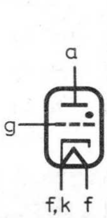
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	1500	V
peak inverse	V_{inv_p}	max.	2500	V
Cathode current, average (T_{av} = max. 10 s)	I_k	max.	10	A
peak	I_{k_p}	max.	100	A

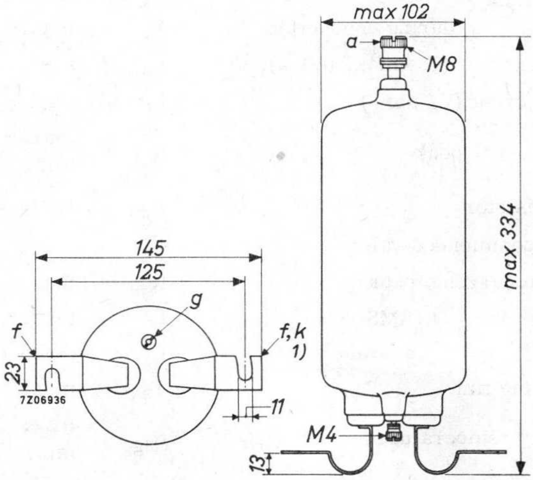
HEATING: indirect

Heater voltage	V_f		5.0	V
Heater current	I_f		11	A
	I_f	max.	13	A
Waiting time (See also page A)	T_w	min.	10	min

If during long periods of service interruption (e.g. during night hours) the heater voltage is maintained at 5 V, the waiting time can be omitted.

MECHANICAL DATA Dimensions in mm





[1]) Marked red.

7Z2 7670

MECHANICAL DATA (continued)

Mounting position: vertical, base down

Net weight: 820 g

MERCURY TEMPERATURE

V_f = 5.0 V the temperature rise above ambient is approximately 10 °C.

CAPACITANCES

Grid to all except anode	$C_{g(a)}$	30	pF
Anode to grid	C_{ag}	8	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time)	T_{dion}	1000	μs

Continuous service (motor control)

LIMITING VALUES (Absolute max. rating system)

Frequency	f	max.			150	Hz
Anode voltage, peak forward	V_{ap}	max.			1500	V
peak inverse	V_{inv_p}	max.			2500	V
Grid voltage, before conduction	$-V_g$	max.			300	V
during conduction	$-V_g$	max.			10	V
Surge current (T = max. 0.1 s)	I_{surge}	max.			1500	A
Grid current, (V_a pos.)	I_g	max.			0.25	A
peak	I_{gp}	max.			1	A
		min.			0.5	A
Grid resistor	R_g	max.			50	kΩ
recommended value	R_g				10	kΩ
Cathode current, peak	I_{kp}	max.	80	100	160 [1])	A
RMS	I_k	max.	30	30	50 [1])	A
average	I_k	max.	12.5	10	20 [1])	A
Averaging time	T_{av}	max.	15	15	[2])	s
Mercury temperature	t_{Hg}	max.	75	75	75	°C
		min.	35	40	40	°C
recommended value	t_{Hg}		60	60	60	°C

[1]) Overload during max. 5 s in each 5 minutes operation period.

[2]) Max. 1 cycle.

7Z2 7671

A.C. control and welding control

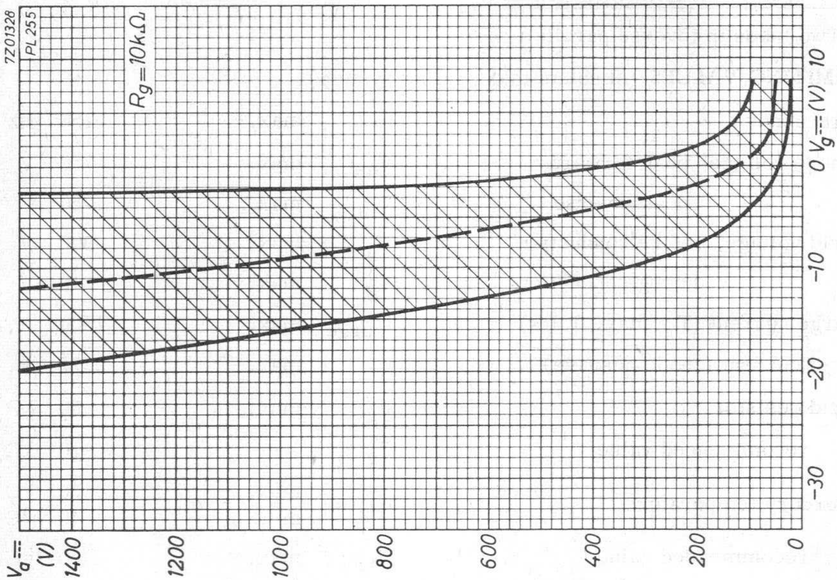
Two tubes in inverse parallel

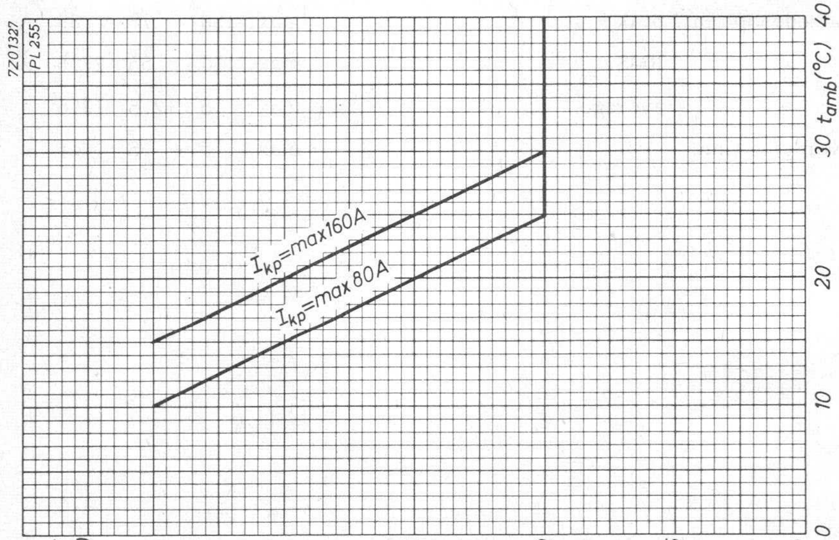
LIMITING VALUES (Absolute max. rating system)

Frequency	f	max.			150	Hz
Anode voltage, peak forward	V_{a_p}	max.			750	V
peak inverse	V_{inv_p}	max.			750	V
Grid voltage, before conduction	$-V_g$	max.			300	V
during conduction	$-V_g$	max.			10	V
Surge current (T = max. 0.1 s)	I_{surge}	max.			1500	A
Grid current (anode positive)	I_g	max.			0.25	A
Grid resistor	R_g	max.			50	kΩ
recommended value	R_g				10	kΩ
Mercury temperature	t_{Hg}	max.			80	°C
		min.			40	°C
recommended value	t_{Hg}	max.			60	°C
Duty factor	δ		0.1	0.5	1	
Cathode current, peak	I_{k_p}	max.	156	78	39	A
RMS	I_k	max.	110	55	27.5	A
average	I_k	max.	5	12.5	12.5	A
Averaging time	T_{av}	max.	5	5	15	s

7Z2 7672

PL255


7Z01328
PL 255
$R_g = 10 k\Omega$
V_a (V)
1400
1200
1000
800
600
400
200
0
−30
−20
−10
0 V_g (V)
10


7Z01327
PL 255
I_{kp}=max160A
I_{kp}=max 80A
30
Tw
(min)
25
20
15
10
5
0
0
10
20
30 t_{amb}(°C) 40

THYRATRON

Mercury-vapour triode thyratron intended for use in motor control equipment, relay service and other industrial applications.

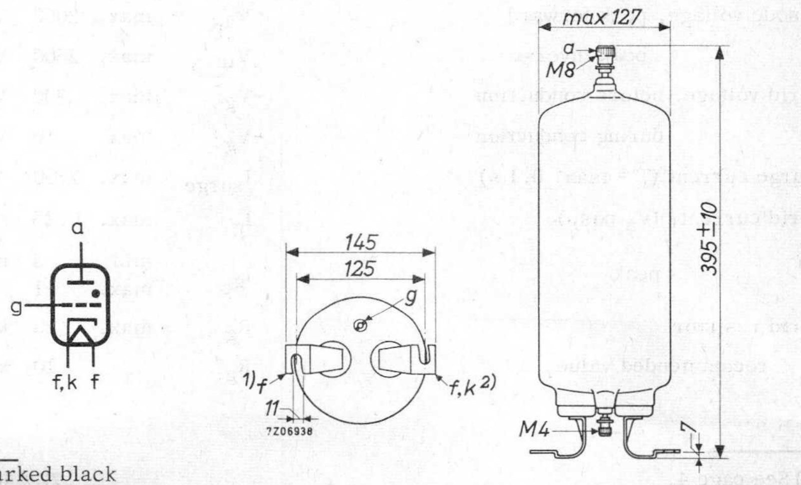
QUICK REFERENCE DATA			
Continuous service			
Anode voltage, peak forward	V_{ap}	max. 2000	V
peak inverse	V_{invp}	max. 2500	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max. 60	A
peak	I_{kp}	max. 200	A

HEATING: indirect

Heater voltage	V_f	5	V
Heater current	I_f	19	A
	I_f	max. 21	A
Waiting time (See also page B)	T_W	min. 10	min

During long periods of interrupted service (e.g. during night hours) it is recommended to reduce V_f to 60-80% of the nominal value instead of switching off the heater. In this way the value of T_W can be decreased according to the dotted curve.

MECHANICAL DATA Dimensions in mm



1) Marked black
2) Marked red

7Z2 7673

MECHANICAL DATA (continued)

Mounting position: vertical, base down

Net weight: 1600 g

MERCURY TEMPERATURE

At V_f = 5.0 V the temperature rise above ambient of the mercury is approximately 10 °C.

CAPACITANCES

Grid to all except anode	$C_{g(a)}$	60	pF
Anode to grid	C_{ag}	15	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time)	T_{dion}	1000	μs

Continuous service

LIMITING VALUES (Absolute max. rating system)

Frequency	f	max.	150	Hz
Anode voltage, peak forward	V_{a_p}	max.	2000	V
peak inverse	V_{inv_p}	max.	2500	V
Grid voltage, before conduction	$-V_g$	max.	300	V
during conduction	$-V_g$	max.	10	V
Surge current (T = max. 0.1 s)	I_{surge}	max.	2500	A
Grid current, (V_a pos.)	I_g	max.	0.25	A [1])
peak	I_{g_p}	min. max.	3 1	mA A
Grid resistor	R_g	max.	20	kΩ
recommended value	R_g		10	kΩ

[1]) See page 4.

7Z2 7674

Continuous service (continued)

LIMITING VALUES (Absolute max. rating system)

Anode fuse		max.			80		A
recommended value					60		A
Cathode current, peak	I_{k_p}	max.	160	200	300	[2]	A
RMS	I_k	max.	60	60	100	[2]	A
average	I_k	max.	25	20	40	[2]	A
Averaging time	T_{av}	max.	15	15		[2]	s
Mercury temperature	t_{Hg}	max.	75	75	75	[2]	°C
		min.	35	35	40	[2]	°C
recommended value	t_{Hg}		60	60	60		°C

A.C. control and welding control

Two tubes in inverse parallel

LIMITING VALUES (Absolute max. rating system)

Frequency	f	max.			150	Hz
Anode voltage, peak forward	V_{a_p}	max.			750	V
peak inverse	V_{inv_p}	max.			750	V
Grid voltage, before conduction	$-V_g$	max.			300	V
during conduction	$-V_g$	max.			10	V
Surge current, (T = max. 0.1 s)	I_{surge}	max.			2500	A
Grid current (V_a pos.)	I_g	max.			0.25	A [1]
Grid resistor	R_g	max.			20	kΩ
recommended value	R_g				10	kΩ
Mercury temperature	t_{Hg}	max.			80	°C
		min.			40	°C
recommended value	t_{Hg}				60	°C
Duty factor	δ		0.1	0.5	1	
Cathode current, peak	I_{k_p}	max.	285	156	78	A
average	I_k	max.	9	25	25	A
Averaging time	T_{av}	max.	5	5	15	s
Output current, RMS	I_o	max.	200	110	55	A

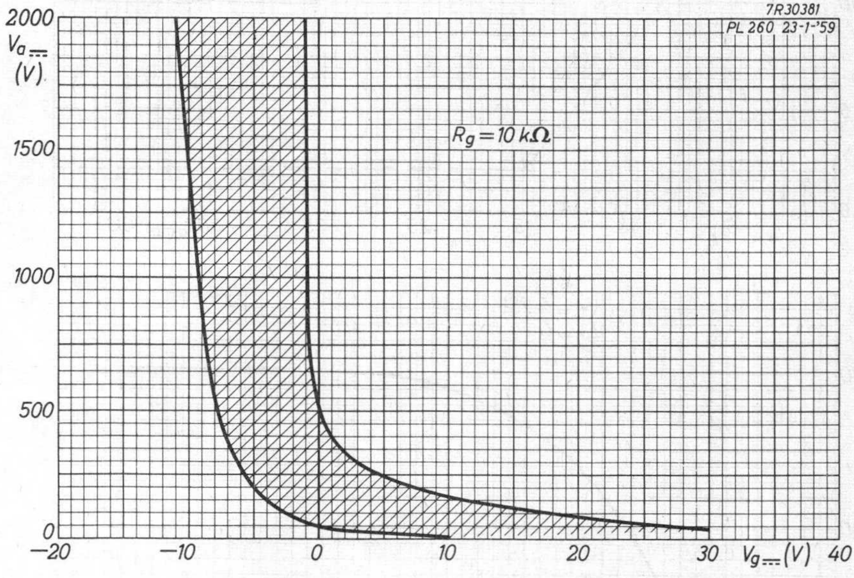
[1]) See page 4.

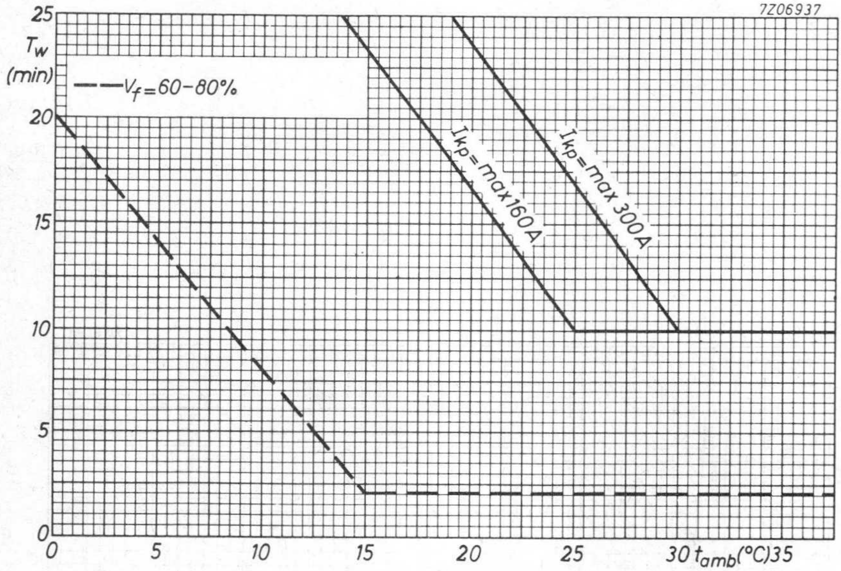
7Z2 7675

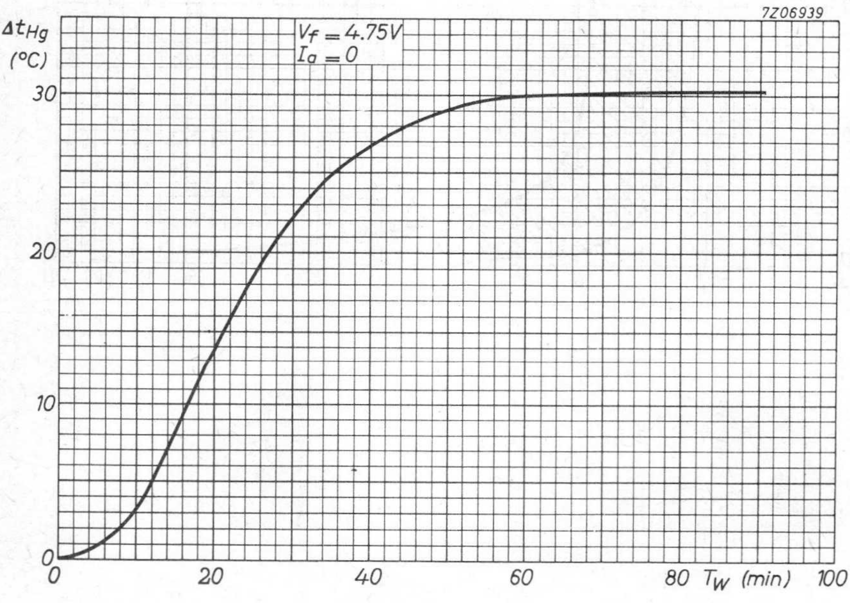
NOTES

1. In order to facilitate the ignition of the tube a positive grid current of at least 3 mA is necessary. The use of a fixed negative grid bias (30 V to 50 V for D.C. output voltages of 220 V to 600 V) and a sharp grid pulse (100 V to 130 V) is recommended (R_g = 10 kΩ, impedance of pulse transformer max. 10 kΩ). If a sinusoidal grid voltage is used for control, this voltage should be at least 60 V_{RMS}. The bias source impedance should be low compaired with the total grid series impedance.
2. Overload during max. 5 s in each 5 minutes operating period. T_{av} = max. 1 cycle.

7Z2 7676


7R30381
PL 260 23-1-'59
2000
V_a
(V)
1500
1000
500
0
−20
−10
0
10
20
30
V_g (V)
40
$R_g = 10\ k\Omega$


7Z06937
T_w (min)
V_f = 60–80%
I_{kp} = max 160 A
I_{kp} = max 300 A
t_{amb} (°C)
0
5
10
15
20
25
30
35


7Z06939
Δt_{Hg} (°C)
V_f = 4.75 V
I_a = 0
T_W (min)
0
10
20
30
40
60
80
100

THYRATRON

Xenon-filled tetrode intended for use in electronic timers, in grid-controlled rectifiers with variable or constant output voltage.

QUICK REFERENCE DATA					
Anode voltage,	peak forward	V_{ap}	max.	650	V
	peak inverse	V_{inv_p}	max.	650	V
Anode current,	average (T_{av} = max. 5 s)	I_a	max.	0.5	A
	peak (f ≥ 25 Hz)	I_{ap}	max.	2	A

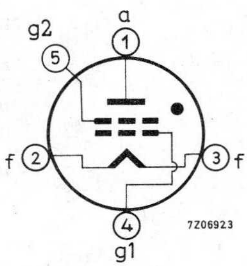
HEATING: direct

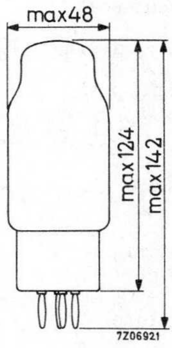
Filament voltage	V_f		2.0	V ± 5%
Filament current	I_f		2.6	A
Waiting time	T_W	min.	30	s

MECHANICAL DATA

Dimensions in mm

Base: O





Pin 3 cathode return

Mounting position: any

Accessories

Socket type 40465

Net weight 75 g

7Z2 7656

CAPACITANCES

Anode to grid No. 1	C_{ag_1}		0.55	pF
Anode to grid No. 2	C_{ag_2}		12	pF

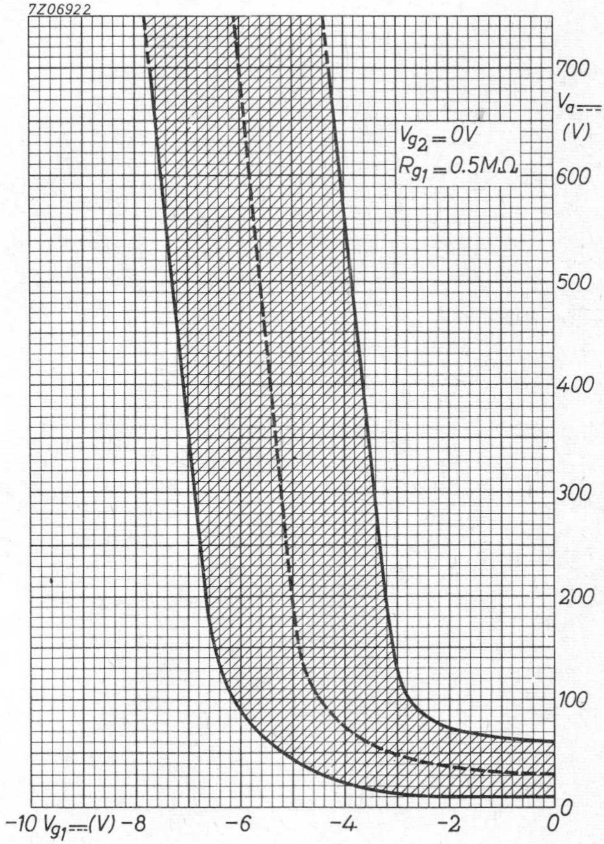
TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}		15	V
Recovery time (Deionization time)	T_{dion}		500	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{a_p}	max.	650	V
peak inverse	V_{inv_p}	max.	650	V
Grid No. 2 voltage, before conduction	$-V_{g_2}$	max.	100	V
during conduction	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage, before conduction	$-V_{g_1}$	max.	100	V
during conduction	$-V_{g_1}$	max.	10	V
Anode current, peak ($f < 25$ Hz)	I_{a_p}	max.	1	A
peak ($f > 25$ Hz)	I_{a_p}	max.	2	A
average (T_{av} = max. 15 s)	I_a	max.	0.5	A
Grid No. 2 current, peak	$I_{g_{2p}}$	max.	0.25	A
average (T_{av} = max. 15 s)	I_{g_2}	max.	0.05	A
Grid No. 1 current, peak	$I_{g_{1p}}$	max.	0.25	A
average (T_{av} = max. 15 s)	I_{g_1}	max.	0.05	A
Grid No. 2 resistor	R_{g_2}	max.	1	MΩ
		min.	0.1	MΩ
Grid No. 1 resistor	R_{g_1}	max.	5	MΩ
		min.	0.1	MΩ
Ambient temperature	t_{amb}	max.	+90	°C
		min.	-75	°C

7Z2 7657


7Z06922
700
600
500
400
300
200
100
0
Va=== (V)
Vg2 = 0V
Rg1 = 0.5MΩ
-10 Vg1===(V) -8
-6
-4
-2
0

THYRATRON

Xenon-filled triode thyratron intended for use in motor control equipment and similar applications.

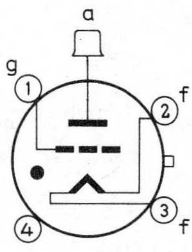
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	1500	V
peak inverse	V_{inv_p}	max.	1500	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	3.2	A
peak	I_{k_p}	max.	40	A

HEATING: direct

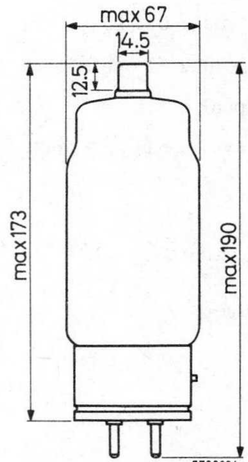
Filament voltage	V_f		2.5	V ± 5%
Filament current	I_f		12	A
Waiting time	T_W	min.	60	s

MECHANICAL DATA Dimensions in mm

Base: Super Jumbo with bayonet



7Z06895



7Z06894

Mounting position: Arbitrary between horizontal and vertical with base down

Accessories

Socket	type	40403/00
Cap connector		40619
Net weight		300 g

7Z2 7640

CAPACITANCES

Anode to grid	C_{ag}	0.8	pF
Grid to filament	C_{gf}	45	pF

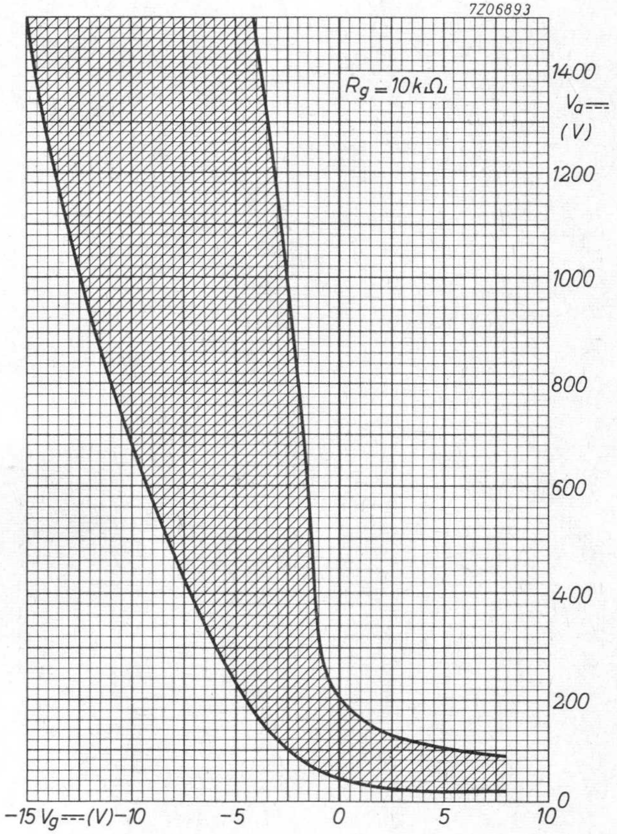
TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time), (V_g = −250 V)	T_{dion}	40	μs
(V_g = −12 V)	T_{dion}	400	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{ap}	max.	1500	V
peak inverse	V_{inv_p}	max.	1500	V
Grid voltage, before conduction	$-V_g$	max.	250	V
during conduction	$-V_g$	max.	10	V
Surge current (T = max. 0.1 s)	I_{surge}	max.	560	A
Grid current (T_{av} = max. 1 cycle)	I_g	max.	0.2	A
Cathode current, peak	I_{k_p}	max.	40	A
average (T_{av} = max. 15 s)	I_k	max.	3.2	A
Grid resistor	R_g	max.	100	kΩ
		min.	0.5	kΩ
recommended value	R_g		10	kΩ
Ambient temperature	t_{amb}	max.	70	°C
		min.	−55	°C

7Z2 7641



7Z06893
$R_g = 10\,k\Omega$
1400
V_a === (V)
1200
1000
800
600
400
200
0
−15 V_g === (V) −10
−5
0
5
10

THYRATRON

Xenon-filled triode thyratron intended for use in motor control equipment and similar applications.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	1500	V
peak inverse	V_{inv_p}	max.	1500	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	6.4	A
peak	I_{kp}	max.	80	A

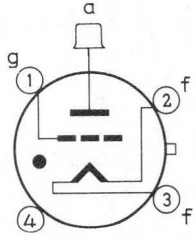
HEATING: direct

Filament voltage	V_f		2.5	V ± 5%
Filament current	I_f		21	A
Waiting time	T_w	min.	60	s

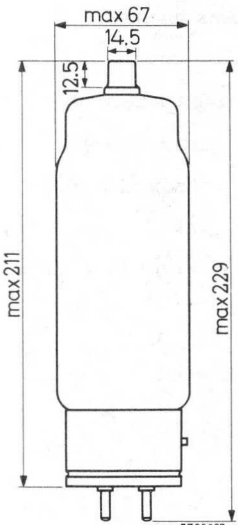
MECHANICAL DATA

Dimensions in mm

Base: Super Jumbo with bayonet



7Z06895



7Z06897

Mounting position: Arbitrary between horizontal and vertical with base down

Accessories

Socket	type	40403/00
Cap connector		40619

7Z2 7642

MECHANICAL DATA (continued)

Net weight 340 g

CAPACITANCES

Anode to grid	C_{ag}	0.8 pF
Grid to filament	C_{gf}	45 pF

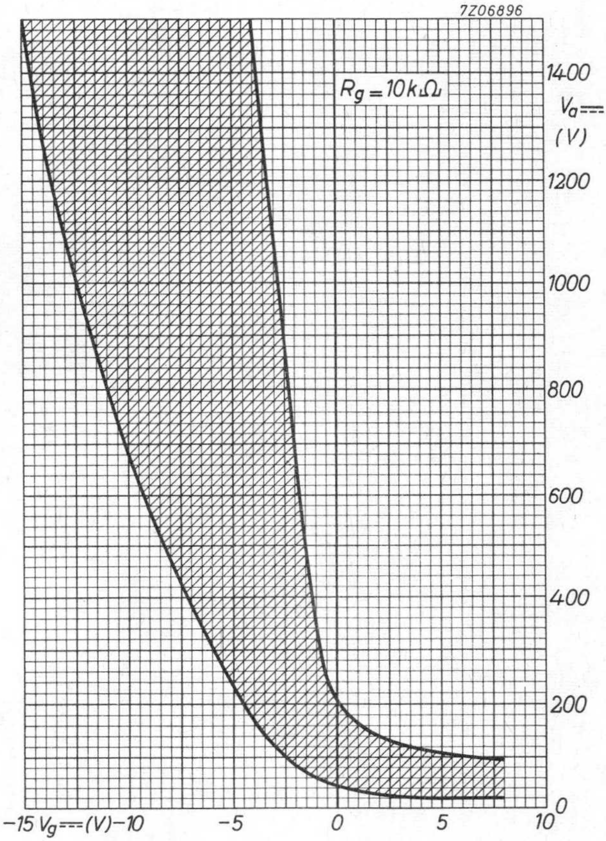
TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12 V
Ionization time	T_{ion}	10 μs
Recovery time (Deionization time) (V_g = −250 V)	T_{dion}	50 μs
(V_g = −12 V)	T_{dion}	500 μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak forward	V_{a_p}	max.	1500	V
peak inverse	V_{inv_p}	max.	1500	V
Grid voltage, before conduction	$-V_g$	max.	250	V
during conduction	$-V_g$	max.	10	V
Surge current (T = max. 0.1 s)	I_{surge}	max.	1120	A
Grid current (T_{av} = max. 1 cycle)	I_g	max.	0.2	A
Cathode current, peak	I_{k_p}	max.	80	A
average (T_{av} = max. 15 s)	I_k	max.	6.4	A
Grid resistor	R_g	max. min.	100 0.5	kΩ kΩ
recommended value	R_g		10	kΩ
Ambient temperature	t_{amb}	max. min.	+70 −55	°C °C

7Z2 7643


7Z06896
$R_g = 10\,k\Omega$
1400
V_a ===
(V)
1200
1000
800
600
400
200
0
−15 V_g === (V) −10
−5
0
5
10

THYRATRON

Thyratron, mercury-vapour triode, for relay service, alarm and protection installations, D.C. and A.C. motor control, circuits for obtaining a variable A.C. output current (inverse parallel circuit), rectifier in a half-wave or full-wave circuit (with or without grid control).

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	2500	V
peak inverse	$V_{a\,inv\,p}$	max.	5000	V
Anode current, peak	I_{ap}	max.	2	A
average	I_a	max.	0.5	A

HEATING: direct

Filament voltage	V_f	2.5	V
Filament current	I_f	5.0	A
Waiting time, recommended	T_w	10	s
minimum	T_w	min. 5	s [1]

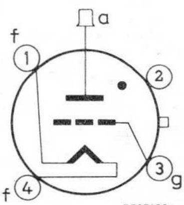
MECHANICAL DATA Dimensions in mm

Base: Medium 4p with bayonet

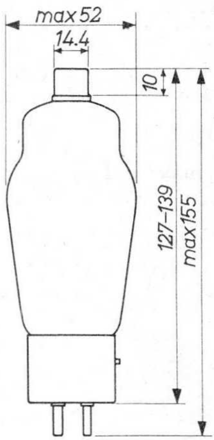
Socket: 2422 511 90003

Net weight: 100 g

Mounting position: vertical, base down



7Z07499



7Z2 8349

[1]) See curve page B.

CAPACITANCES

Anode to grid	C_{ag}	3.3	pF
Grid to filament	C_{gf}	5.0	pF

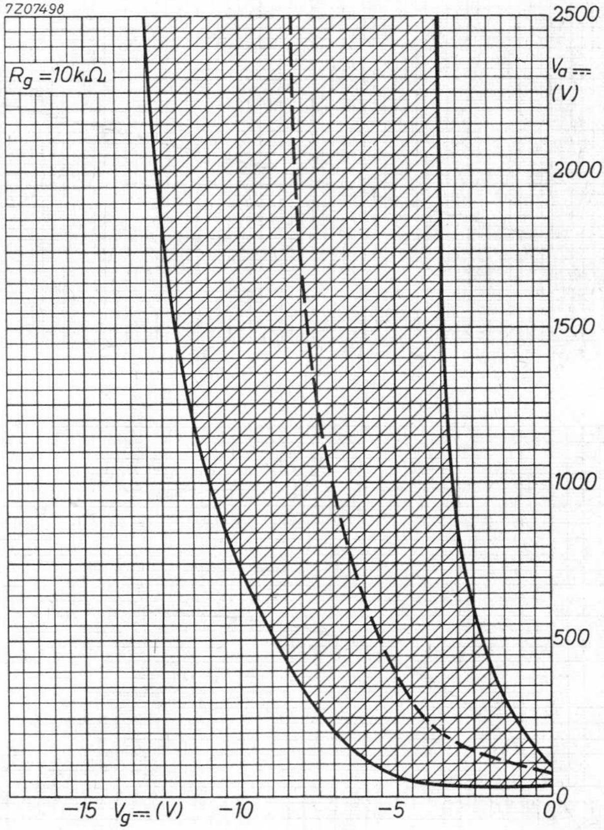
TYPICAL CHARACTERISTICS

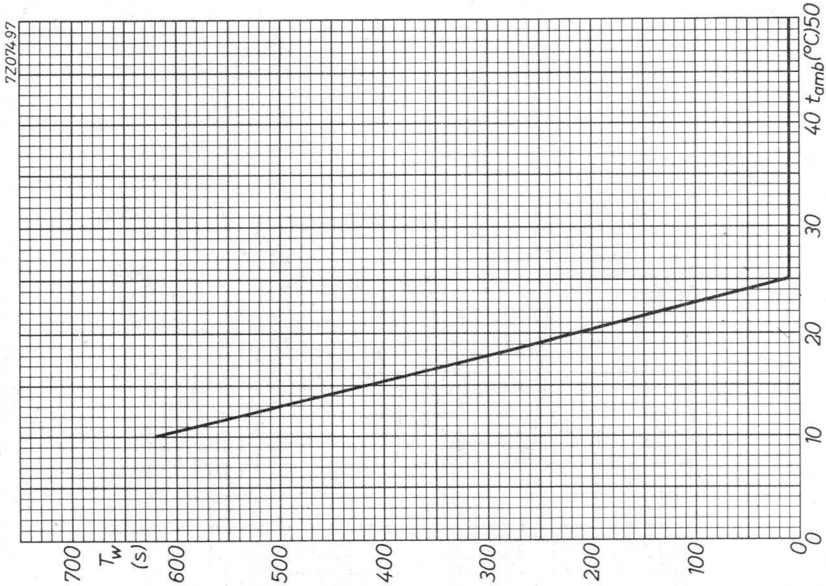
Arc voltage	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Deionization time	T_{dion}	1000	μs
Frequency	f	max. 150	Hz

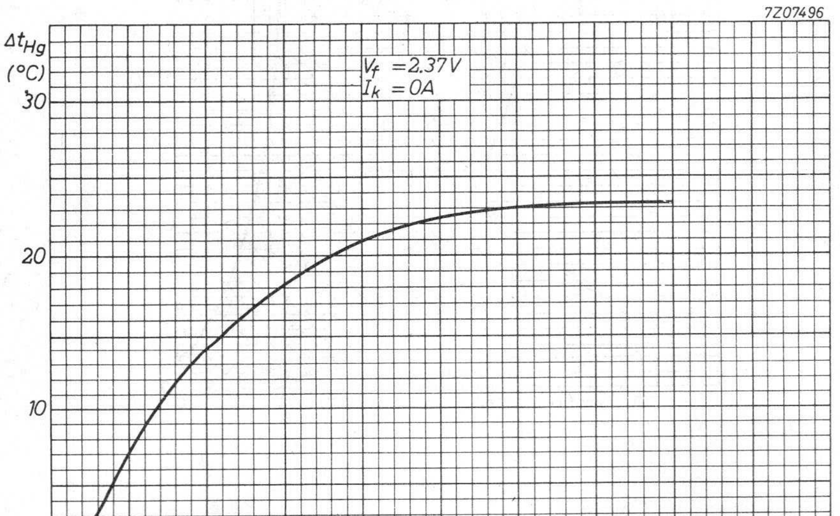
LIMITING VALUES (Absolute max. rating system)

Anode voltage, forward peak	V_{ap}	max. 2500	V
inverse peak	$V_{a\,invp}$	max. 5000	V
Grid voltage	$-V_g$	max. 500	V
tube conductive	$-V_g$	max. 10	V
Anode current, peak ($f < 25$ Hz)	I_{ap}	max. 1	A
($f \geq 25$ Hz)	I_{ap}	max. 2	A
average (T_{av} = max. 15 s)	I_a	max. 0.5	A
Grid current, average (T_{av} = max. 15 s)	I_g	max. 0.05	A
Grid circuit resistance	R_g	max. 100	kΩ
recommended value	R_g	10	kΩ
Mercury temperature	t_{Hg}	35 to 80	^oC
recommended value	t_{Hg}	50	^oC
Surge current (T = max. 0.1 s)	I_{surge}	max. 40	A

7Z2 8350


7Z07498
$R_g = 10k\Omega$
2500
V_a (V)
2000
1500
1000
500
0
−15
V_g (V)
−10
−5
0


7Z07497
t_{amb} (°C)
0
10
20
30
40
50
T_w (s)
0
100
200
300
400
500
600
700


7Z07496
Δt_{Hg} (°C)
V_f = 2.37 V
I_k = 0A
0
10
20
30
40
50
T_w (min)

THYRATRON

Thyratron, mercury-vapour triode, for relay service, motor control, variable and stabilised output rectifiers, automatically operated battery chargers. In anti-parallel circuits the tube can also be used for controlling and switching A.C. power and for firing ignitrons.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	1000	V
peak inverse	$V_{a\,inv\,p}$	max.	1000	V
Cathode current, peak	I_{k_p}	max.	15	A
average	I_k	max.	2.5	A

HEATING: indirect

Heater voltage	V_f		5.0	V ±5 %
Heater current	I_f		4.5	A
Waiting time	T_w	min.	5	min. [1]

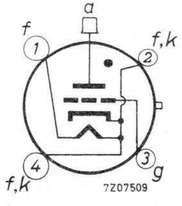
MECHANICAL DATA Dimensions in mm

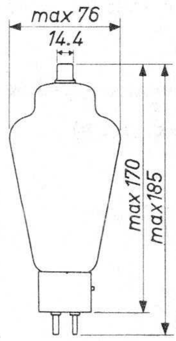
Base : Medium 4 p with bayonet

Socket : 2422 511 90003

Net weight: 125 g

Mounting position: Vertical, base down





[1]) See curve page A.

7Z2 8351

CAPACITANCES

Anode to grid	C_{ag}		3.6	pF
Grid to cathode	C_{gk}		7.8	pF

TYPICAL CHARACTERISTICS

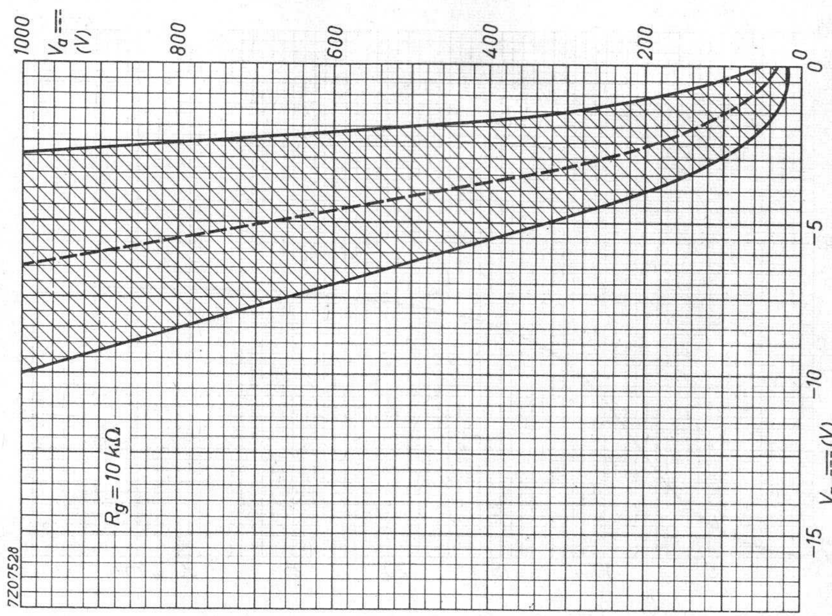
Arc voltage	V_{arc}		12	V
Ionisation time	T_{ion}		10	μs
Deionisation time	T_{dion}		1000	μs
Frequency	f	max.	150	Hz

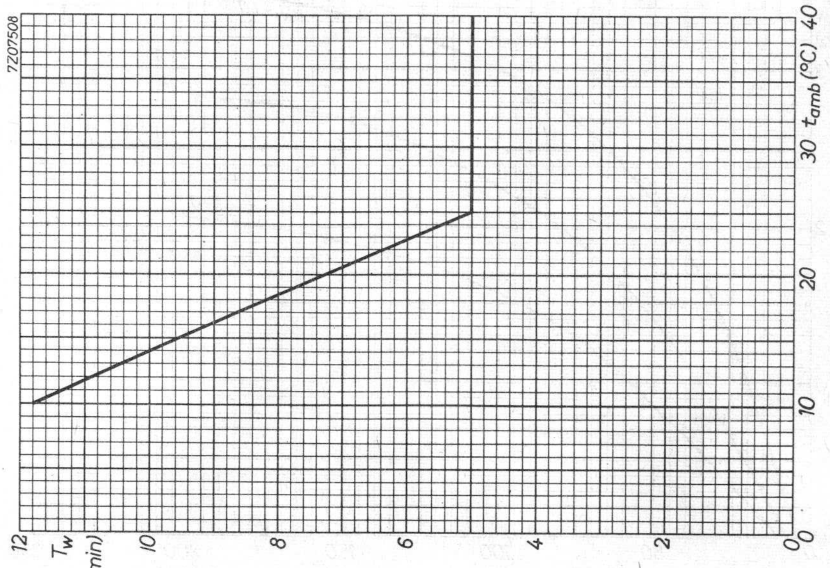
LIMITING VALUES (Absolute max. rating system)

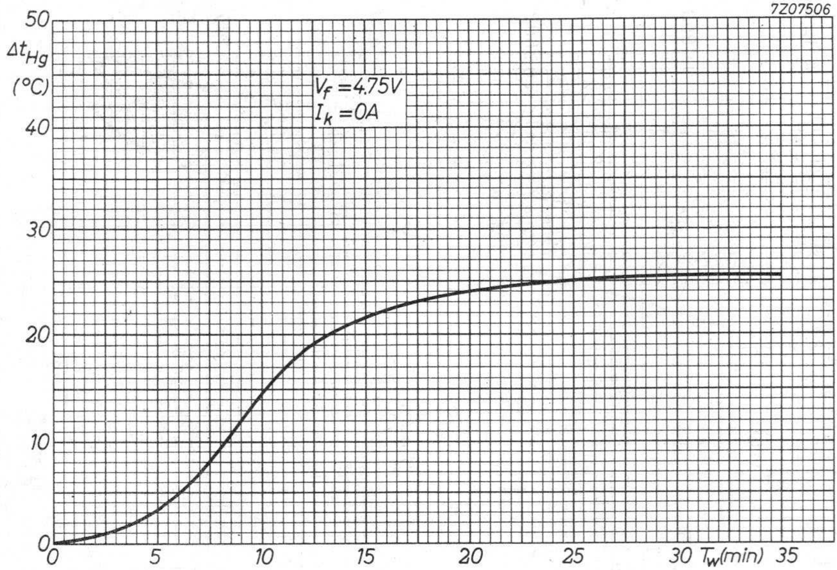
Anode voltage, forward peak	V_{ap}	max.	1000	V
inverse peak	$V_{a\,inv\,p}$	max.	1000	V
Grid voltage,	$-V_g$	max.	500	V
tube conductive	$-V_g$	max.	10	V
Cathode current, peak (f < 25 Hz)	I_{kp}	max.	5	A
(f ≥ 25 Hz)	I_{kp}	max. max.	15 40	A A [1]
average (T_{av} = max. 15 s)	I_k	max. max.	2.5 1	A A [1]
Grid current, average (T_{av} = max. 15 s)	I_g	max.	0.25	A
Grid circuit resistance	R_g	max.	100	kΩ
recommended value	R_g		10	kΩ
Mercury temperature	t_{Hg}		40 to 80	°C
recommended value	t_{Hg}		60	°C
Surge current (T = max. 0.1 s)	I_{surge}	max.	200	A

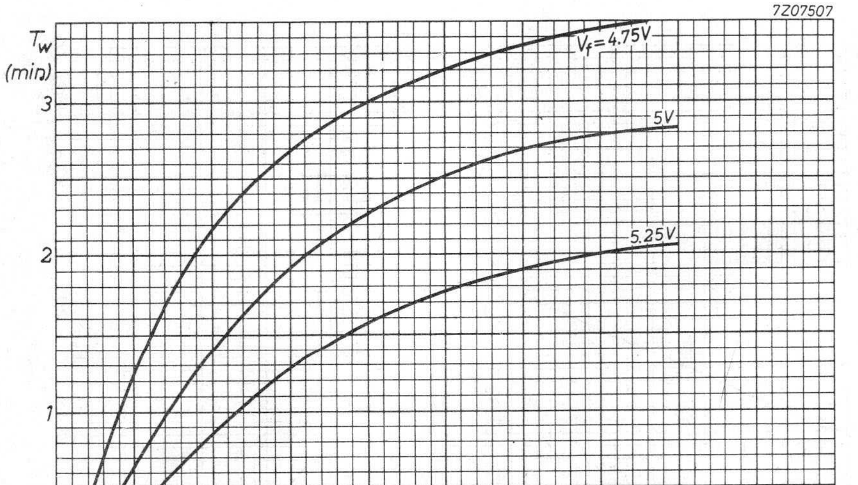
[1]) In firing circuits of ignitrons.

7Z2 8352


7Z07528
R_g = 10 kΩ
V_a (V)
1000
800
600
400
200
0
0
−5
−10
−15
V_g (V)


7Z07508
T_w (min)
12
10
8
6
4
2
0
0
10
20
30
40
t_amb (°C)


7Z07506
50
Δt_{Hg}
(°C)
40
30
20
10
0
V_f =4.75V
I_k =0A
0
5
10
15
20
25
30 T_w(min) 35


7Z07507
T_w
(min)
3
2
1
0
V_f=4.75V
5V
5.25V
0
50
100
150
200
250
Time after switching off (s)

THYRATRON

Thyratron, xenon-filled triode with negative control characteristic, for relay service, motor control, ignitor firing service.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	900	V
peak inverse	$V_{a\,inv_p}$	max.	1250	V
Cathode current, peak	I_{k_p}	max.	30	A
average	I_k	max.	2.5	A

HEATING: direct

Filament voltage	V_f	2.5	V
Filament current	I_f	9	A
Waiting time, recommended	T_w	60	s
minimum	T_w	min. 30	s

MECHANICAL DATA Dimensions in mm

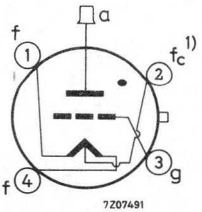
Base: Medium 4p with bayonet

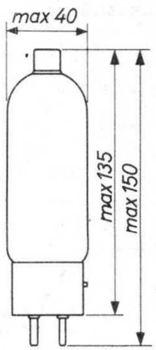
Socket: 2422 511 90003

Cap connector: 40619

Net weight: 95 g

Mounting position: any





7Z2 8353

1) Load return

CAPACITANCES

Anode to grid	C_{ag}	3	pF
Grid to filament	C_{gf}	14	pF

TYPICAL CHARACTERISTICS

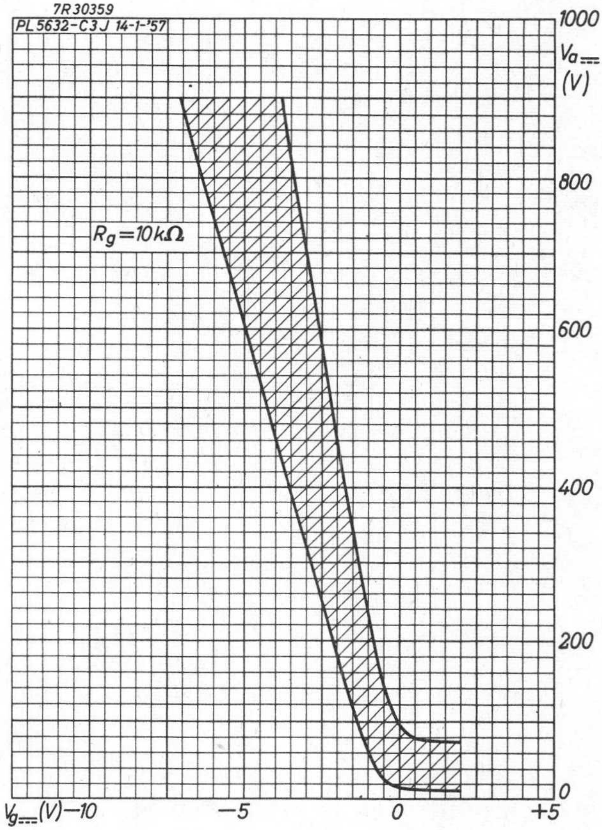
Arc voltage	V_{arc}	10	V
Ionization time	T_{ion}	10	μs
Deionization time	T_{dion}	1000	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, forward peak	V_{a_p}	max.	900	V
inverse peak	$V_{a\,inv_p}$	max.	1250	V
Grid voltage	$-V_g$	max.	300	V
tube conductive	$-V_g$	max.	10	V
Cathode current, peak	I_{k_p}	max.	30	A
average (T_{av} = max. 5 s)	I_k	max.	2.5	A
Grid current, peak	I_{g_p}	max.	0.5	A
average (T_{av} = 1 cycle)	I_g	max.	0.1	A
Grid circuit resistance	R_g		10 to 100	kΩ
recommended value	R_g		33	kΩ
Ambient temperature	t_{amb}		-55 to +75	^{o}C
Surge current (T = max. 0.1 s)	I_{surge}	max.	300	A [1]
Commutation factor			$0.7 \frac{V}{\mu s} \times \frac{A}{\mu s}$	

[1]) Fuse in anode circuit max. 10 A (recommended 6 A).

7Z2 8354


7R30359
PL 5632-C3J 14-1-'57
1000
$V_{a=}$
(V)
800
600
400
200
0
$R_g = 10 k\Omega$
$V_{g=}$(V) −10
−5
0
+5

THYRATRON

Thyratron, xenon-filled triode with negative control characteristic, for relay service, motor control, ignitor firing service.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	1000	V
peak inverse	$V_{a\,inv_p}$	max.	1250	V
Cathode current, peak	I_{k_p}	max.	30	A
average	I_k	max.	2.5	A

HEATING: direct

Filament voltage	V_f		2.5	V
Filament current	I_f		9	A
Waiting time, recommended	T_w		60	s
minimum	T_w	min.	30	s

MECHANICAL DATA Dimensions in mm

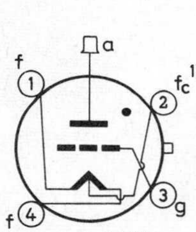
Base: Medium 4 p with bayonet

Socket: 2422 511 90003

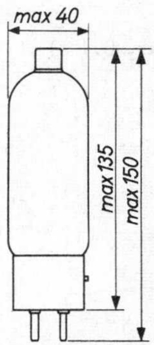
Cap connector: 40619

Net weight: 95 g

Mounting position: any



7Z07491



1) Load return

7Z2 8355

CAPACITANCES

Anode to grid	C_{ag}	3	pF
Grid to filament	C_{gf}	14	pF

TYPICAL CHARACTERISTICS

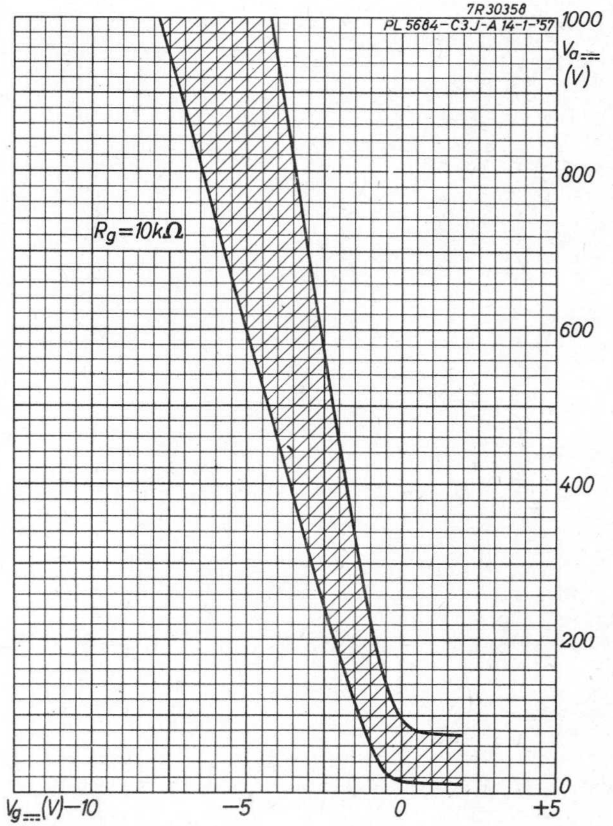
Arc voltage	V_{arc}	10	V
Ionization time	T_{ion}	10	μs
Deionization time	T_{dion}	1000	μs

LIMITING VALUES (Absolute max. rating system)

Anode voltage, forward peak	V_{a_p}	max.	1000	V
inverse peak	V_{inv_p}	max.	1250	V
Grid voltage	$-V_g$	max.	300	V
up to V_a = 900 V and R_g = 50 to 100 kΩ	$-V_g$	max.	400	V
tube conductive	$-V_g$	max.	10	V
Cathode current, peak	I_{k_p}	max.	30	A
average (T_{av} = max. 5 s)	I_k	max.	2.5	A
Grid current, peak	I_{g_p}	max.	0.5	A
average (T_{av} = 1 cycle)	I_g	max.	0.1	A
Grid circuit resistance	R_g		10 to 60	kΩ
recommended value	R_g		33	kΩ
Ambient temperature	t_{amb}		-55 to +75	°C
Surge current (T = max. 0.1 s)	I_{surge}	max.	300	A [1]
Commutation factor			$0.7 \frac{V}{\mu s} \times \frac{A}{\mu s}$	

[1]) Fuse in anode circuit max. 10 A (recommended 6 A).

7Z2 8356


7R30358
PL 5684-C3J-A 14-1-'57
1000
V_a
(V)
800
600
400
200
0
R_g=10kΩ
V_g (V) −10
−5
0
+5

THYRATRON

Thyratron, inert gas-filled tetrode, for relay service, pulse modulator, grid-controlled rectifier service, servo control, ignitron ignition.
The PL5727 is a special quality type, is shock and vibration resistant and designed for use in mobile equipment.

QUICK REFERENCE DATA				
Peak anode voltage	V_{a_p}	=	650	V
Cathode current, peak	I_{k_p}	=	0.5	A
average	I_k	=	0.1	A

HEATING

Indirect by A.C. or D.C.

Heater voltage	V_f	=	6.3	V
Heater current	I_f	=	600	mA
Waiting time	T_W	=	20	s [1])

CAPACITANCES

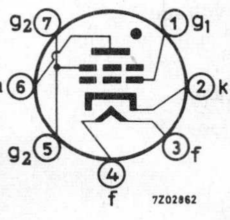
Grid No.1 to all	C_{g_1}	=	2.4	pF
Anode to all	C_a	=	1.6	pF
Anode to grid No.1	C_{ag_1}	=	26	mpF

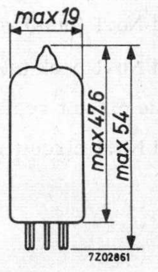
MECHANICAL DATA

Dimensions in mm

Base : 7 pin miniature

Net weight: 10 g





Mounting position: any

1) If urgently wanted T_W may be decreased to min. 10 s. 7Z2 5110

TYPICAL CHARACTERISTICS

Ionization time at $V_{a=}$ = 100 V, grid No.1 over-voltage = 50 V (substantial square pulse) Anode peak current during conduction = 0.5 A	T_{ion}	=		0.5	μs
Deionization time at $V_{a=}$ = 125 V, V_{g_1} = −100 V, R_{g_1} = 1000 Ω, I_a = 0.1 A	T_{dion}	=		35	μs
Deionization time at $V_{a=}$ = 125 V, V_{g_1} = −10 V, R_{g_1} = 1000 Ω, I_a = 0.1 A	T_{dion}	=		75	μs
Critical grid No.1 current at $V_{a\sim}$ = 125 V_{RMS}, I_a = 0.1 A	I_{g_1}	=		0.5	μA
Maintaining voltage	V_{arc}	=		8	V
Control ratio grid No.1 at striking point R_{g_1} = 0 Ω, V_{g_2} = 0 V	$\frac{V_a}{V_{g_1}}$	=		250	
Control ratio grid No.2 at striking point V_{g_1} = 0 V, R_{g_1} = 0 Ω, R_{g_2} = 0 Ω	$\frac{V_a}{V_{g_2}}$	=		1000	

OPERATING CONDITIONS for relay service

Anode voltage	$V_{a\sim}$	=	117	400	V_{RMS}
Grid No.2 voltage	V_{g_2}	=	0	0	V
Grid No.1 (bias) voltage	$V_{g_1\sim}$	=	5	−	V_{RMS} [1])
Grid No.1 (bias) voltage	V_{g_1}	=	−	−6	V
Grid No.1 peak (signal) voltage	$V_{g_{1p}}$	=	5	6	V
Anode circuit resistance	R_a	=	1.2	2.0	kΩ
Grid No.1 circuit resistance	R_{g_1}	=	1.0	1.0	MΩ

[1]) Phase difference between V_a and V_{g_1} approx. 180°.

7Z2 5111

LIMITING VALUES for relay- and grid controlled service
(Absolute max. rating system)

Anode voltage,				
forward peak	V_{ap}	= max.	650	V
inverse peak	$V_{a\,inv_p}$	= max.	1300	V
Grid No.2 voltage,				
peak before conduction	$-V_{g_{2p}}$	= max.	100	V
average during conduction T_{av} = max. 30 s	$-V_{g_2}$	= max.	10	V
Grid No.1 voltage,				
peak before conduction	$-V_{g_{1p}}$	= max.	100	V
average during conduction T_{av} = max. 30 s	$-V_{g_1}$	= max.	10	V
Cathode current,				
peak	I_{k_p}	= max.	0.5	A
average, T_{av} = max. 30 s	I_k	= max.	0.1	A
surge, T = max. 0.1 s	I_{surge}	= max.	10	A
Grid No.2 current,				
average, T_{av} = max. 30 s	I_{g_2}	= max.	10	mA [1])
Grid No.1 current,				
average, T_{av} = max. 30 s	I_{g_1}	= max.	10	mA
Cathode to heater voltage,				
k pos., peak	V_{+kf-p}	= max.	100	V
k neg., peak	V_{-kf+p}	= max.	25	V
Heater voltage	V_f	= max.	6.9	V
		= min.	5.7	V
Ambient temperature	t_{amb}	= min.	-75	°C
Bulb temperature	t_{bulb}	= max.	150	°C

CIRCUIT DESIGN VALUES

Grid No.1 circuit resistance	R_{g_1}	= max.	10	MΩ
recommended value	R_{g_1}	=	1	MΩ

1) In order not to exceed this maximum value it is recommended to insert a resistor of 1000 Ω in the grid No.2 lead.

7Z2 5112

LIMITING VALUES for pulse modulator service (Absolute max. rating system)

Anode voltage,					
forward peak	V_{a_p}	=	max.	500	V [1])
inverse peak	$V_{a\,inv_p}$	=	max.	100	V
Grid No.2 voltage,					
peak before conduction	$-V_{g_{2p}}$	=	max.	50	V
average during conduction	$-V_{g_2}$	=	max.	10	V
Grid No.1 voltage,					
peak before conduction	$-V_{g_{1p}}$	=	max.	100	V
average during conduction	$-V_{g_1}$	=	max.	10	V
Cathode current,					
peak	I_{k_p}	=	max.	10	A
average	I_k	=	max.	10	mA
rate of change	dI_k/dT	=	max.	100	A/μs
Grid No.2 current, peak	$I_{g_{2p}}$	=	max.	20	mA
Grid No.1 current, peak	$I_{g_{1p}}$	=	max.	20	mA
Impulse duration	T_{imp}	=	max.	5	μs
Impulse repetition frequency	f	=	max.	500	pps
Duty factor	δ	=	max.	0.001	
Cathode to heater voltage, peak	V_{kf_p}	=	max.	0	V
Heater voltage	V_f	=	max.	6.0	V
		=	min.	6.9	V
Ambient temperature	t_{amb}	=	min.	-75	°C
Bulb temperature	t_{bulb}	=	max.	150	°C

CIRCUIT DESIGN VALUES

Grid No.2 circuit resistance	R_{g_2}	=	min.	2	kΩ
		=	max.	25	kΩ
Grid No.1 circuit resistance	R_{g_1}	=	max.	500	kΩ

[1]) After completion of an impulse, a 20 μs delay is required before a positive voltage of more than 10 V is applied to the tube.

7Z2 5113

LIMITING VALUES for use in capacitor discharge circuit for ignitron ignition (Absolute max. rating system)

See also data sheet ignitron ZX1000 under the heading "Life expectancy"

Anode voltage,					
forward peak	V_{a_p}	=	max.	650	V
inverse peak	$V_{a\,inv_p}$	=	max.	100	V
Grid No.2 voltage,					
peak before conduction	$-V_{g_{2p}}$	=	max.	50	V
average during conduction	$-V_{g_2}$	=	max.	10	V
Grid No.1 voltage,					
peak before conduction	$-V_{g_{1p}}$	=	max.	100	V
average during conduction	$-V_{g_1}$	=	max.	10	V
Cathode current,					
peak	I_{k_p}	=	max.	10	A
average	I_k	=	max.	5	mA
rate of change	dI_k/dT	=	max.	6	A/μs
Grid No.2 current, peak	$I_{g_{2p}}$	=	max.	20	mA
Grid No.1 current, peak	$I_{g_{1p}}$	=	max.	20	mA
Impulse duration (half sine wave)	T_{imp}	=	max.	15	μs
Impulse repetition frequency	f	=	max.	60	pps
Cathode to heater voltage, peak	V_{kf_p}	=	max.	3	V
Heater voltage	V_f	=	min.	5.7	V
		=	max.	6.9	V
Ambient temperature	t_{amb}	=	min.	-75	^oC
Bulb temperature	t_{bulb}	=	max.	150	^oC

CIRCUIT DESIGN VALUES

Grid No.2 circuit resistance	R_{g_2}	=	min.	1	kΩ
		=	max.	25	kΩ
Grid No.1 circuit resistance	R_{g_1}	=	max.	100	kΩ

7Z2 5114

SHOCK AND VIBRATION RESISTANCE

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

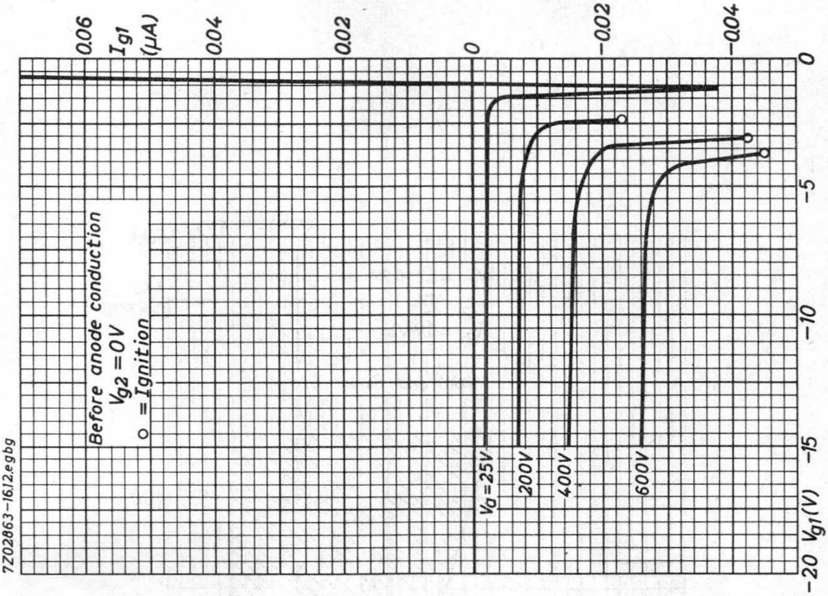
Shock resistance: 750 g

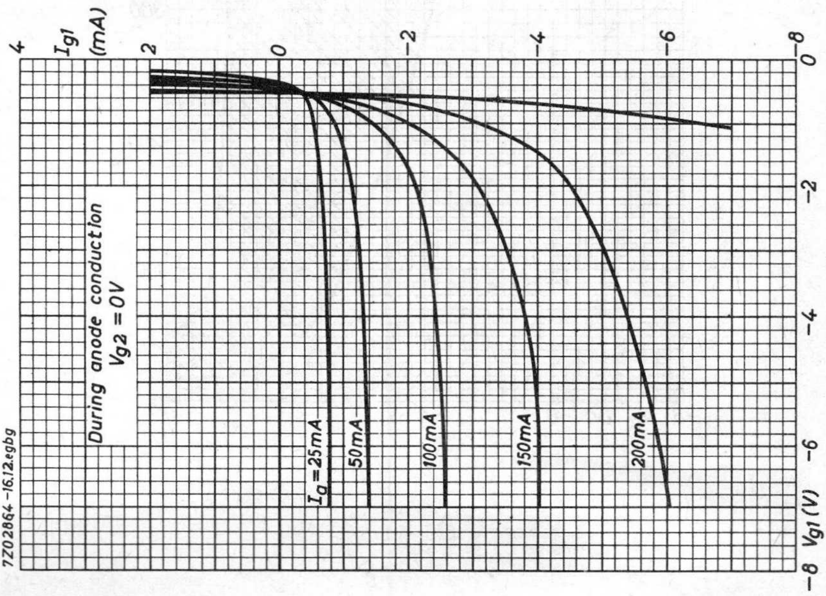
Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 48^{o} in each of 4 different positions of the tube.

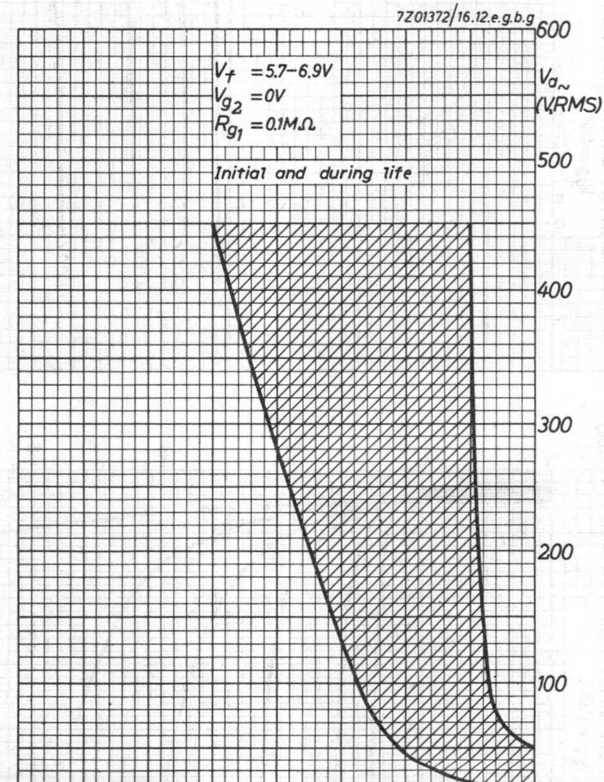
Vibration resistance: 2.5 g

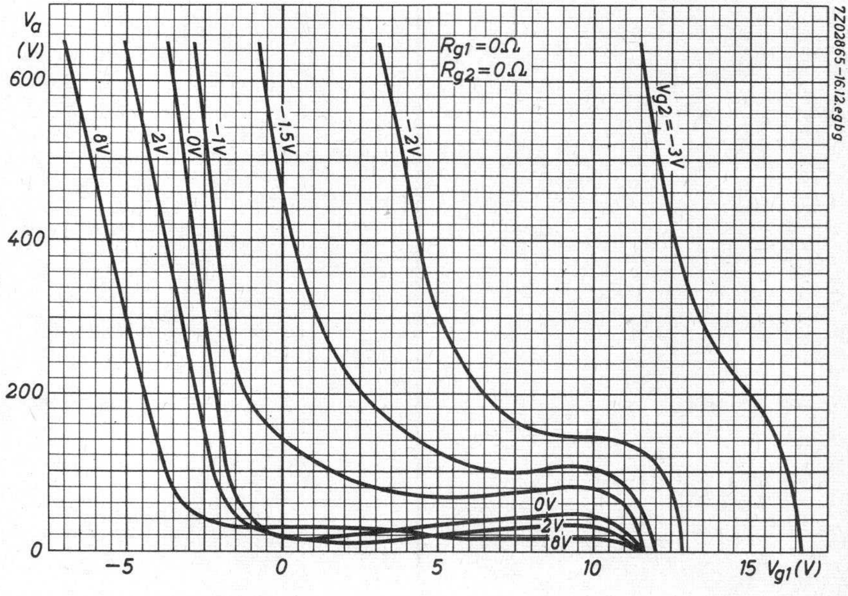
Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

7Z2 5115


7Z02863-16.12.egbg
Before anode conduction
Vg2 = 0V
o = Ignition
Ig1 (μA)
0.06
0.04
0.02
0
-0.02
-0.04
Va=25V
200V
400V
600V
0
-5
-10
-15
-20
Vg1 (V)


7Z02864-16.12.egbg
During anode conduction
Vg2 = 0V
Ig1 (mA)
4
2
0
-2
-4
-6
-8
Ia=25mA
50mA
100mA
150mA
200mA
0
-2
-4
-6
-8
Vg1 (V)


7Z01372/16.12.e.g.b.g
V_f = 5.7–6.9V
V_{g2} = 0V
R_{g1} = 0.1MΩ
Initial and during life
600
$V_{a\sim}$ (V,RMS)
500
400
300
200
100
0
-8
V_{g1} (V)
-6
-4
-2
0


Va
(V)
600
400
200
0
−5
0
5
10
15 Vg1(V)
Rg1 = 0Ω
Rg2 = 0Ω
8V
2V
0V
−1V
−1.5V
−2V
Vg2 = −3V
0V
2V
8V
7Z02865-16.12.egbg

THYRATRON

Thyratron, inert gas filled tetrode, with negative control characteristic.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	650	V
Cathode current, peak	I_{kp}	max.	2	A
average	I_k	max.	300	mA

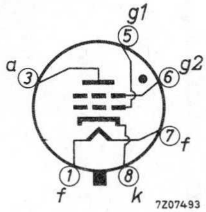
HEATING: direct

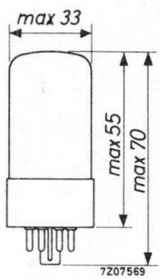
Heater voltage	V_f	6.3	V
Heater current	I_f	950	mA
Waiting time	T_w	min. 15	s

MECHANICAL DATA Dimensions in mm

Base: octal

Mounting position: any





TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ratio V_a/V_{g_1}, at striking point (V_{g_2} = 0 V, R_{g_1} = 0 Ω)	V_a/V_{g_1}	275	-
Ratio V_a/V_{g_2}, at striking point (V_{g_1} = 0 V, R_{g_2} = 0 Ω)	V_a/V_{g_2}	370	-

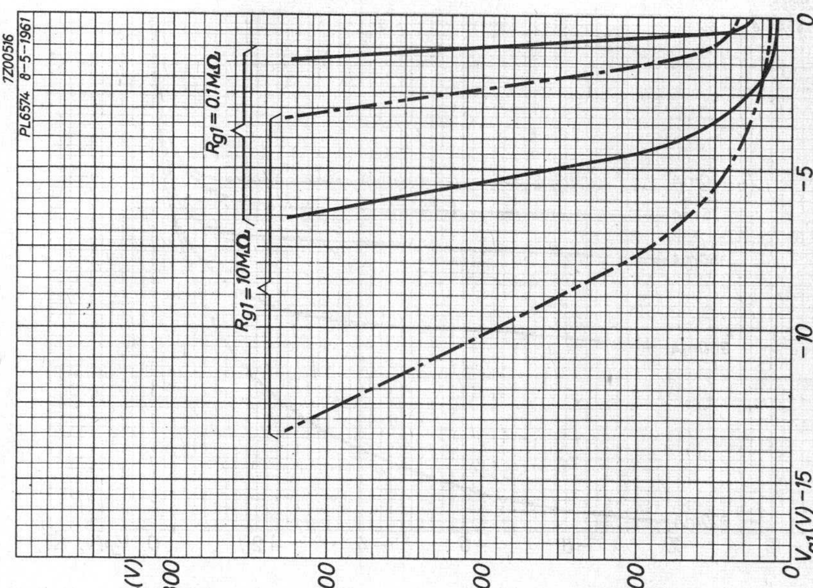
7Z2 8357

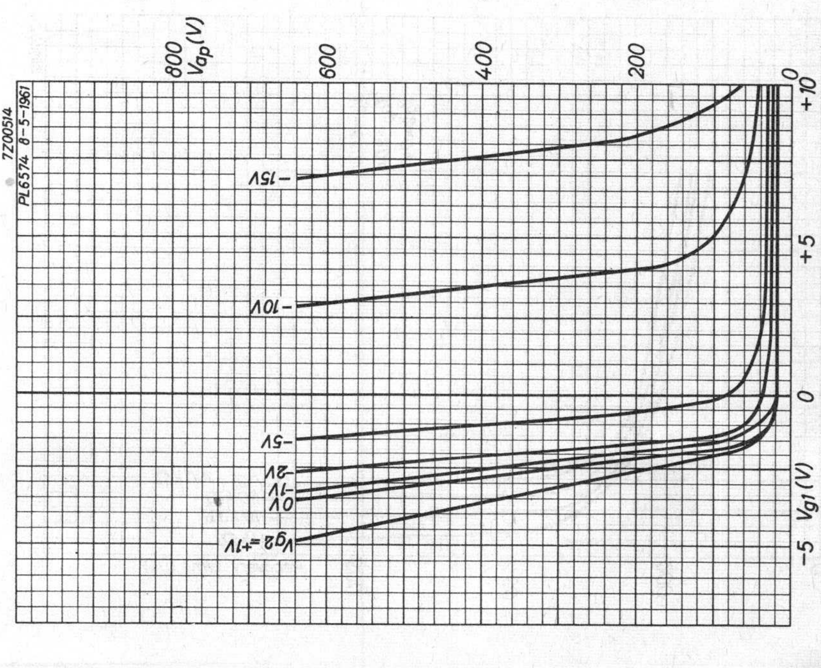
LIMITING VALUES (Absolute max. rating system)

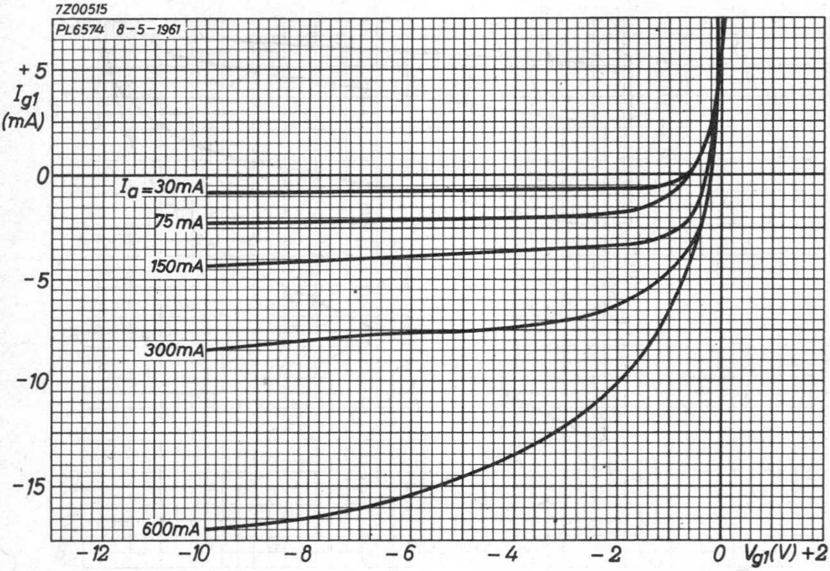
Anode voltage, peak forward	V_{a_p}	max. 650	V
peak inverse	$V_{a\,inv_p}$	max. 1.3	kV
Grid No.2 voltage	V_{g_2}	max. 100	V
tube conductive	V_{g_2}	max. 10	V
Grid No.1 voltage	$-V_{g_1}$	max. 250	V
tube conductive	$-V_{g_1}$	max. 10	V
Cathode current, peak	I_{k_p}	max. 2	A
average (T_{av} = max. 15 s)	I_k	max. 300	mA
Grid No.1 current, peak	$I_{g_{1p}}$	max. 1	mA [1]
average ($V_a > -10$ V)(T_{av} = 1 cycle)	I_{g_1}	max. 20	mA
Grid No.2 current ($V_a > -10$ V)(T_{av} = 1 cycle)	I_{g_2}	max. 20	mA
Grid No.1 circuit resistance (I_k = 200 mA)	R_{g_1}	max. 10	MΩ
Ambient temperature	t_{amb}	-75 to +90	°C
Surge current (T = max. 0.1 s)	I_{surge}	max. 10	A
Cathode to heater voltage, k pos.	V_{kf}	max. 100	V
k neg.	V_{kf}	max. 25	V

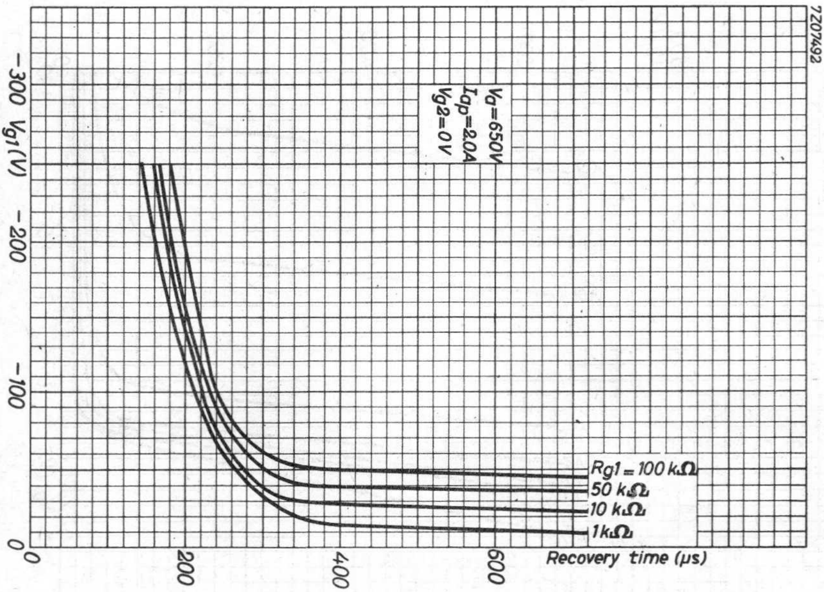
[1]) During the period that V_a is more negative than −10 V.

7Z2 8358


7Z00516
PL6574 8-5-1961
R_{g1} = 0.1MΩ
R_{g1} = 10MΩ
V_a(V)
800
600
400
200
0
V_{g1}(V) −15
−10
−5
0


7Z00514
PL6574 8-5-1961
800
V_{ap}(V)
600
400
200
0
−15V
−10V
−5V
−2V
−1V
0V
V_{g2} = +1V
−5
V_{g1} (V)
0
+5
+10


7Z00515
PL6574 8-5-1961
+5
I_{g1} (mA)
0
-5
-10
-15
I_a = 30mA
75 mA
150mA
300mA
600mA
-12
-10
-8
-6
-4
-2
0
V_{g1}(V) +2


7Z07492
V_a = 650V
I_{ap} = 2.0A
V_{g2} = 0V
-300
V_{g1}(V)
-200
-100
0
0
200
400
600
Recovery time (µs)
Rg1 = 100 kΩ
50 kΩ
10 kΩ
1 kΩ

THYRATRON

Thyratron, for mercury vapour and inert gas filled triode.
Dimming installations for stage lighting, fluorescent lighting, etc, for motor control service, variable and stabilized output rectifiers, ignitor firing, A.C. control.

QUICK REFERENCE DATA				
Anode voltage peak forward	V_{ap}	max.	2000	V
Cathode current, peak	I_{kp}	max.	40	A
average	I_k	max.	3.6	A

HEATING: direct

Filament voltage	V_f		2.5	V [1])
Filament current	I_f		11	A
Waiting time	T_W	min.	30	sec

CAPACITANCES

Anode to grid	C_{ag}	7	pF
Grid to filament	C_{gf}	10	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ionisation time	T_{ion}	10	μs
Deionisation time	T_{dion}	500	μs

[1]) Short-circuit voltage of the transformer 5 to 10%.

7Z2 8359

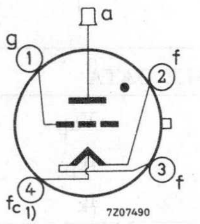
MECHANICAL DATA . Dimensions in mm

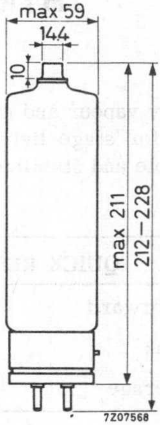
Base : Super jumbo with bayonet

Socket : 2422 511 01001

Cap connector: 40619

Net weight : 345 g





Mounting position: Vertical with base down.

The cross section of the flexible anode lead should be at least 4 mm^2

f_c should preferably be used as the cathode return connection

REMARK

The difference between ambient and condensed mercury temperature with natural cooling is about 30 °C. By directing a low velocity air flow of ambient temperature or lower to the glass just above the base, the difference between ambient and condensed mercury temperature can be decreased. This is important at high ambient temperatures (40 to 70 °C) and high peak inverse and forward voltages (2 kV).

1) Load return.

7Z2 8360

LIMITING VALUES (Absolute limits)

Anode voltage, peak forward	V_{a_p}	max. 2000	V
peak inverse	$V_{a\,inv\,p}$	max. 2000	V
Grid voltage,	$-V_g$	max. 300	V
tube conductive	$-V_g$	max. 10	V
Grid current	I_g	max. 0.25	A
Grid circuit resistance	R_g	max. 0.03	MΩ [1]
Cathode current, peak	I_{k_p}	max. 40	A
average (T_{av} = max. 15 s)	I_k	max. 3.6	A
Surge current (T = max. 0.1 s)	I_{surge}	max. 200	A
Frequency	f	max. 150	Hz
Ambient temperature	t_{amb}	0 to 55	°C [2]

---

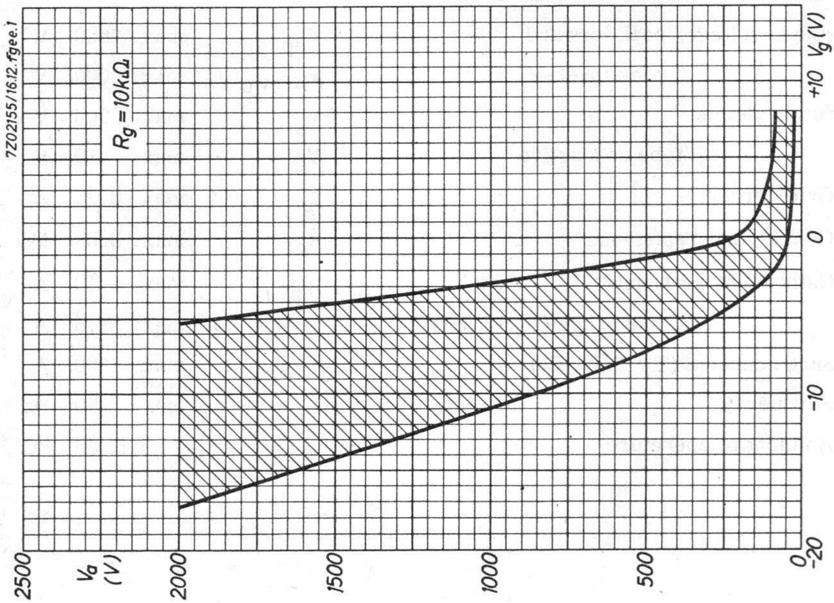
[1]) Higher values of R_g (up to 0.1 MΩ) are permissible for grid controlled circuits which are insensitive to grid current.

[2]) The ambient temperature is defined as the temperature of the surrounding air and shall be measured under the following conditions:

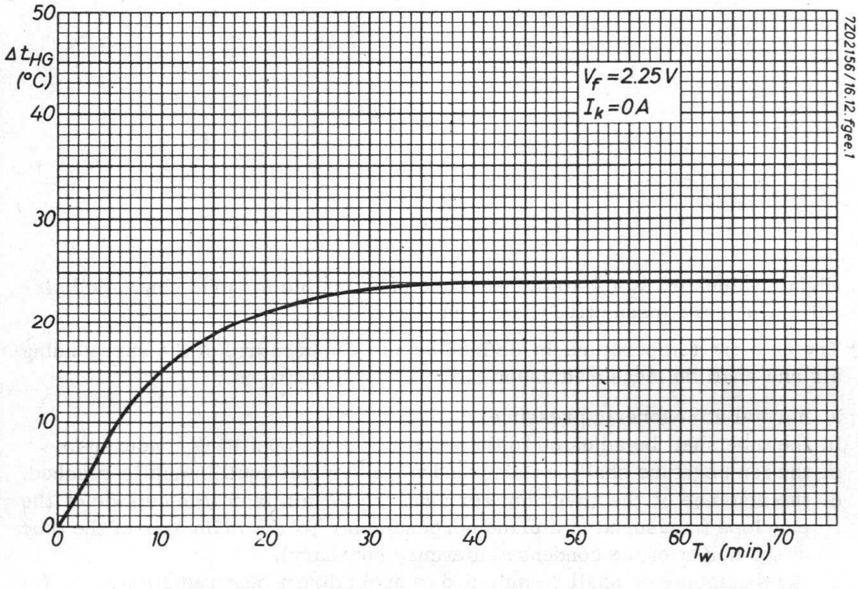
a. normal atmospheric pressure,
b. the tube shall be adjusted to the worst probable operating conditions,
c. the temperature shall be measured when thermal equilibrium is reached,
d. the distance of the thermometer shall be 59 mm from the outside of the envelope (measured in a plane perpendicular to the main axis of the tube at the height of the condensed mercury boundary),
e. the thermometer shall be shielded to avoid direct heat radiation.

7Z2 8361

PL6755A



7Z02155/16.12.fgee.1
$R_g = 10\,k\Omega$
V_a (V)
2500
2000
1500
1000
500
0
V_g (V)
+10
0
−10
−20



Δt_{HG} (°C)
50
40
30
20
10
0
$V_f = 2.25\,V$
$I_k = 0\,A$
0
10
20
30
40
50
60
70
T_w (min)
7Z02156/16.12.fgee.1

THYRATRON

Thyratron, inert gas-filled triode for power control and ignitor firing.

QUICK REFERENCE DATA				
Peak anode voltage	V_{a_p}	max.	1.5	kV
Cathode current, peak	I_{k_p}	max.	30	A
average	I_k	max.	2.5	A

HEATING: direct by A.C.

Filament voltage	V_f		2.5	V
Filament current at V_f = 2.5 V and I_k = 0	I_f	7.5 to	9.5	A
Filament voltage	V_f	min.	2.25	V
at I_k > 0.5 A	V_f	max.	2.75	V
at I_k < 0.5 A	V_f	max.	3.0	V

The centre tap of the filament should be connected to the centre tap of the filament transformer. This connection is essential when the average current exceeds 6.4 A averaged over any 1 second period. When two or more tubes are used with one filament transformer, the filament centre taps must never be connected together without further connection to the centre tap of the filament transformer.

Waiting time				
for I_{k_p} < 20 A	T_w	min.	10	s
for I_{k_p} > 20 A	T_w	min.	30	s [1]

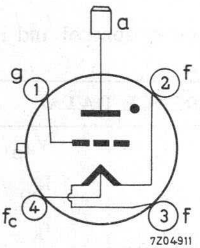
CAPACITANCES

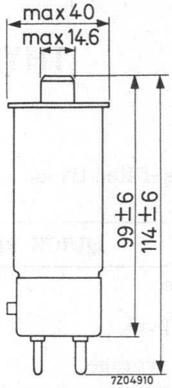
Anode to grid	C_{ag}	0.35 pF
Grid to cathode	C_{gf}	10 pF

[1]) Recommended value 60 s.

7Z2 6537

MECHANICAL DATA Dimensions in mm





Base	Medium 4-pin with bayonet	
Top cap	CT3	
Mounting position:	any between horizontal and vertical with base down	
Net weight	approx.	115 g
Cooling	convection	
Accessories		
Socket	type	40218/03
Top cap connector	type	40619

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	approx.	10 V
Commutation factor			10 $VA/\mu s^2$
Ignition delay time	T_{delay}	See page B	
Recovery (deionisation time)			
V_g = −250 V	T_{dion}		200 μs
V_g = −100 V	T_{dion}		300 μs
Critical grid current at V_a = 1.5 kV	I_g		< 20 μA

7Z2 6538

LIMITING VALUES (Absolute maximum rating system)

Anode voltage, forward and inverse peak				
$I_k < 1.6$ A, $I_{k_p} < 20$ A	V_{a_p}, $V_{a_{invp}}$	max.	1.5	kV
$I_k > 1.6$ A	V_{a_p}, $V_{a_{invp}}$	max.	1.25	kV
Grid voltage				
before conduction	$-V_g$	max.	300	V
during conduction	$-V_g$	max.	10	V
Grid current during the time that the anode voltage is more positive than −10 V,				
peak	I_{g_p}	max.	1.25	A
average, T_{av} = max. 20 ms	I_g	max.	100	mA
Grid current during the time that the anode voltage is more negative than −10 V	I_{g_p}	max.	5.0	mA
Cathode current				
peak (25 Hz and above) [1]				
$V_a < 1.25$ kV	I_{k_p}	max.	30	A
V_a 1.5 kV	I_{k_p}	max.	20	A
average (see page C)				
T_{av} = max. 15 s, V_a = 1.5 kV	I_k	max.	1.6	A
T_{av} = max. 10 s, $V_a < 1.25$ kV	I_k	max.	2.5	A
surge (fault protection, T = max. 0.1 s)	I_{surge}	max.	300	A [2]
Ambient temperature [3]	t_{amb}		−55 to +75	°C

CIRCUIT DESIGN VALUES

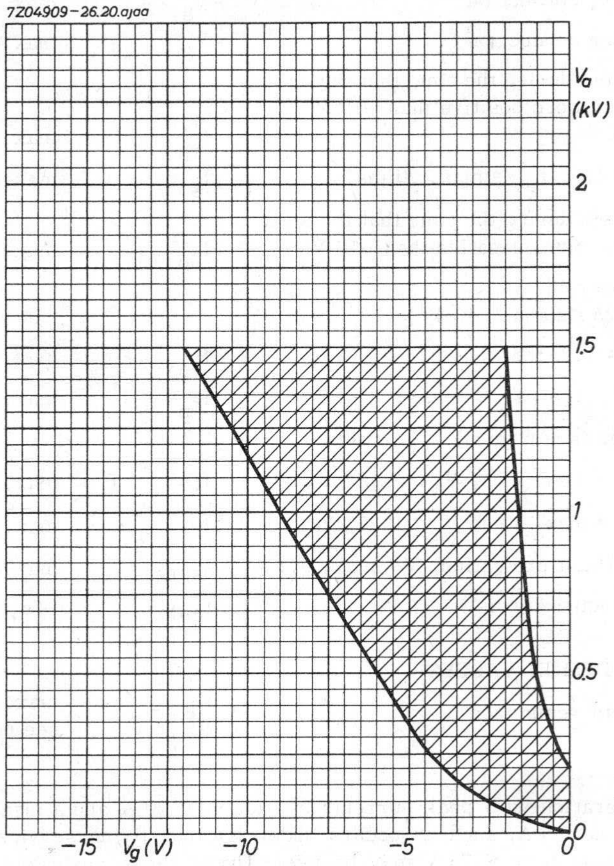
Grid circuit resistance	R_g	max.	100	kΩ
	R_g	see page D		

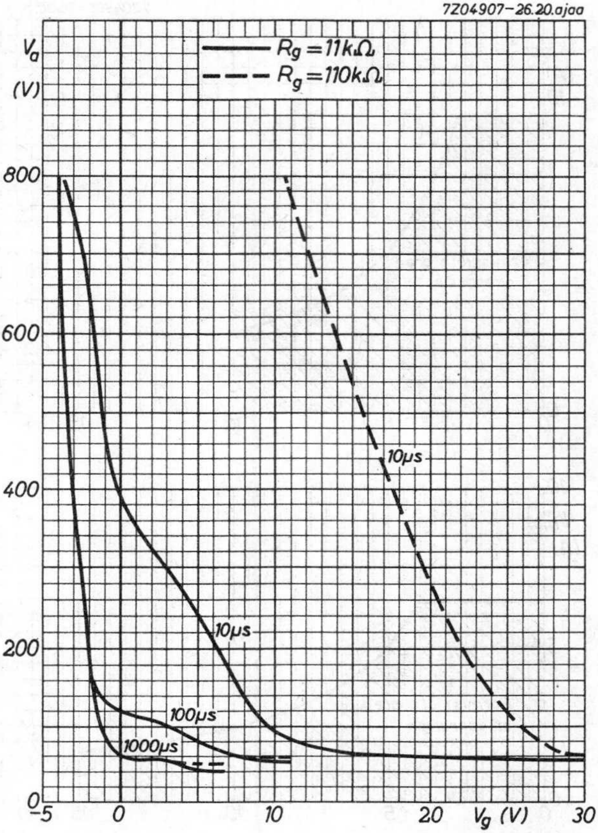
[1] For operation with peak currents in excess of 20 A and a mean current of less than 0.5 A, such as occurs under ignitron firing service, a nominal heater voltage of 2.75 V may be used. Under these conditions a maximum peak anode voltage of 1.5 kV is permissible.

[2] The rating applies when the filament and filament transformer centre taps are connected together. The maximum surge current must not exceed 140 A if the cathode current return is to only one of these points.

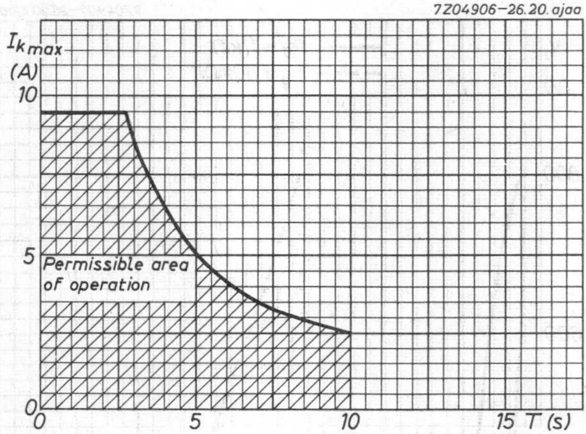
[3] The anode structure must be left free to ensure cooling by free convection.

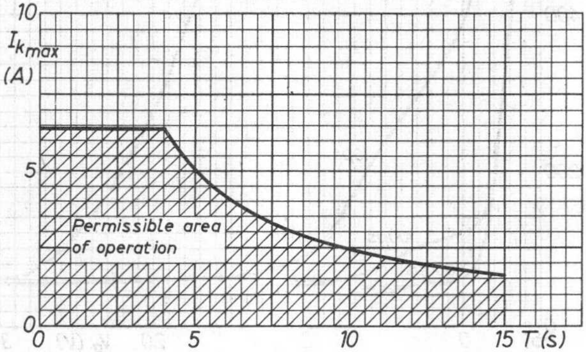
7Z2 6539


7Z04909–26.20.ajaa
V_a
(kV)
2
1.5
1
0.5
0
–15
V_g (V)
–10
–5
0

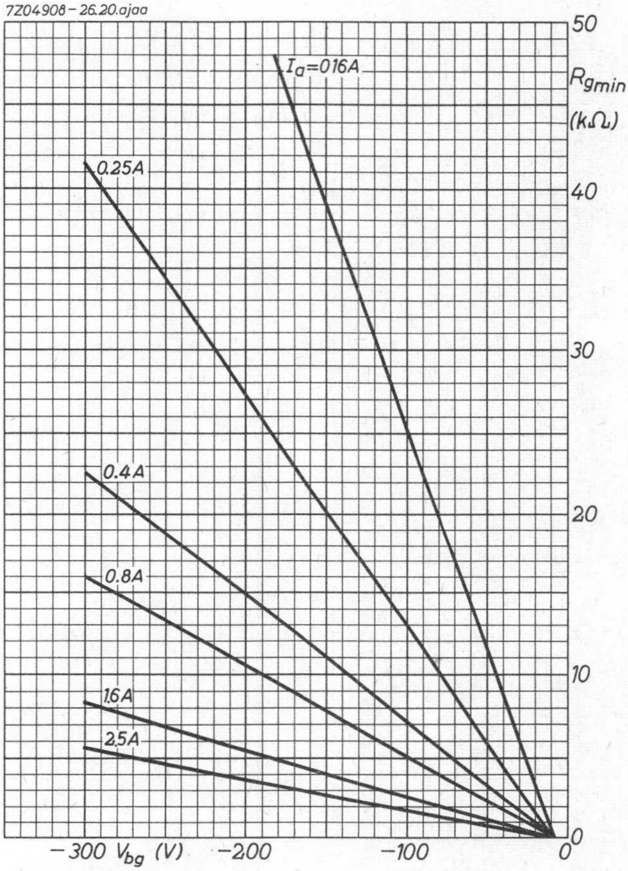


Nominal variation between anode and grid voltages
for different ignition delay times





The top curve shows the maximum number of seconds in any 10 second period for which a given average current may be drawn from a sinusoidal supply if the peak voltage applied to the tube is less than 1.25 kV. The bottom curve shows the maximum number of seconds in any 15 second period for which a given average current may be drawn from a sinusoidal supply if the applied peak voltage lies between 1.25 and 1.5 kV.


7Z04908 - 26.20.ajaa
50
R_{gmin}
(kΩ)
40
30
20
10
0
I_a=016A
0.25A
0.4A
0.8A
1.6A
2.5A
-300 V_{bg} (V)
-200
-100
0

HYDROGEN THYRATRON

QUICK REFERENCE DATA			
Maximum peak forward voltage	V_{a_p}	= max. 3	kV
Maximum peak inverse voltage	$V_{a\ inv_p}$	= max. 3	kV
Maximum peak anode current	I_{a_p}	= max. 35	A
Maximum average anode current	I_a	= max. 45	mA
The tube has a positive control characteristic			

APPLICATION

Service in pulse modulator circuits of radar systems.
The properties of the tube suggest other applications such as frequency converter (high efficiency induction heating), shock excitation of tuned circuits, in pulse time modulation circuits, use in control circuits.

HEATING: indirect

Heater voltage	V_f	= 6.3	$V^{+5\%}_{-10\%}$
Heater current at $V_f = 6.3$ V	I_f	= 2.0 to 2.5	A
Waiting time	T_w	= min. 2	min.

7Z2 3945

LIMITING VALUES (Absolute limits)

Ambient temperature	t_{amb}	=	-50 to +90 °C
Anode			
Anode supply voltage (D.C.)	V_{b_a}	= min.	800 V
Peak forward anode voltage	V_{a_p}	= max.	3 kV [1]
Peak inverse anode voltage	$V_{a\ inv_p}$	= max.	3 kV [2]
		= min.	0.05 V_{a_p}
Peak anode current	I_{a_p}	= max.	35 A
Average anode current	I_a	= max.	45 mA
Rate of rise of cathode current	dI_k/dt	= max.	750 A/μsec
Operating factor	$V_{a_p} \cdot I_{a_p} \cdot f_{imp}$	= max.	0.3×10^9 VAHz
Grid			
Peak inverse grid voltage	$V_{g\ inv_p}$	= max.	200 V

Grid drive requirements, measured at the tube socket with the grid disconnected.

Peak voltage	V_p	= min.	175 V
Pulse duration at amplitude of min. 50 V	T_{imp}	= min.	2 μsec
Time of rise of voltage pulse	T_{r_v}	= max.	0.5 μsec
Impedance of grid drive circuit	R_S	= max.	1500 Ω

REMARKS

1. Cooling of the anode lead is permissible but no stream of cooling air should be directly applied to the tube envelope.
2. The tube should be kept away from strong fields which could ionise the gas in the tube.

---

[1]) In case where the anode voltage is applied instantaneously the max. value should not be reached in less than 0.04 sec.

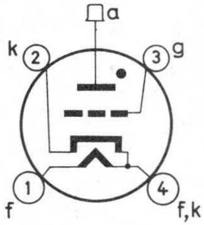
[2]) In pulsed operation the inverse voltage should not exceed 1.5 kV during the first 25 μsec after the pulse (except for a spike of max. 0.05 μsec duration).

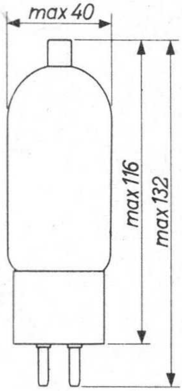
7Z2 3946

MECHANICAL DATA Dimensions in mm

Base : medium 4 p

Net weight: 70 g





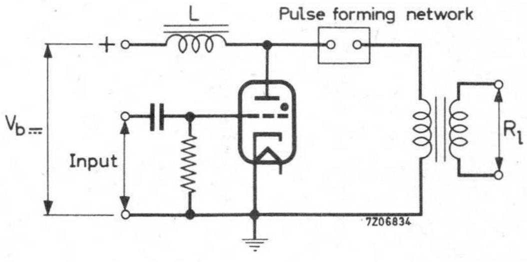
Mounting position: any; clamping at the base and/or at the bulb in the region up to 5 cm above the top of the base.

ACCESSORIES

Socket : 40218/03 [1])

Cap : Small

Simplified diagram of a typical modulator circuit employing the hydrogen thyratron.



[1]) At voltages above 2.5 kV the socket must be insulated from the chassis.

7Z2 3947

HYDROGEN THYRATRON

QUICK REFERENCE DATA					
Maximum peak forward voltage	V_{a_p}	=	max.	8	kV
Maximum peak inverse voltage	$V_{a\,inv_p}$	=	max.	8	kV
Maximum peak anode current	I_{a_p}	=	max.	90	A
Maximum average anode current	I_a	=	max.	100	mA
The tube has a positive control characteristic					

APPLICATION

Service in pulse modulator circuits of radar systems.
The properties of the tube suggest other applications such as frequency converter (high efficiency induction heating), shock excitation of tuned circuits, in pulse time modulation circuits, use in control circuits.

HEATING: indirect

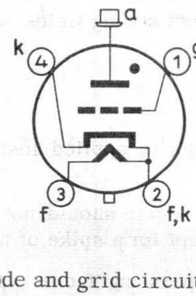
Heater voltage	V_f	=	6.3	V $^{+5\%}_{-10\%}$
Heater current at V_f = 6.3 V	I_f	=	5.5 to 6.7	A
Waiting time	T_w	=	min. 3	min

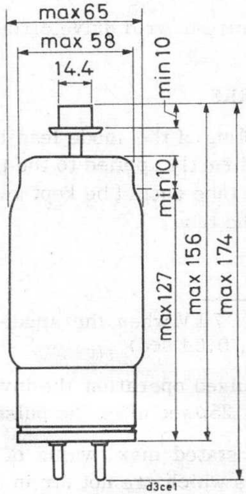
MECHANICAL DATA

Base : Super Jumbo with bayonet

Net weight: 200 g

Dimensions in mm





The return lead of the anode and grid circuits should be connected to pin 4.

Mounting position: any; clamping is advisable only at the base

7Z2 3940

LIMITING VALUES (Absolute limits)

Ambient temperature	t_{amb}	=	−50 to +90	°C
Anode				
Anode supply voltage (DC)	V_{b_a}	=	min. 2.5	kV
Peak forward anode voltage	V_{a_p}	=	max. 8	kV [1]
Peak inverse anode voltage	$V_{a\ inv_p}$	=	max. 8	kV [2]
		=	min. 0.05	V_{a_p}
Peak anode current	I_{a_p}	=	max. 90	A
Average anode current	I_a	=	max. 100	mA
Rate of rise of cathode current	dI_k/dt	=	max. 1000	A/μsec
Operating factor	$V_{a_p}.I_{a_p}.f_{imp}$	=	max. $2x10^9$	VAHz [3]
Grid				
Peak inverse grid voltage	$V_{g\ inv_p}$	=	max. 200	V

Grid drive requirements, measured at the tube socket with the grid disconnected

Peak voltage	V_p	=	min. 175	V
Pulse duration at amplitude of min. 50 V	T_{imp}	=	min. 2	μsec
Time of rise of voltage pulse	T_{r_v}	=	max. 0.5	μsec
Impedance of grid drive circuit	R_S	=	max. 1500	Ω

REMARKS

1. Cooling of the anode lead is permissible but no stream of cooling air should be directly applied to the tube envelope.
2. The tube should be kept away from strong fields which could ionise the gas in the tube.

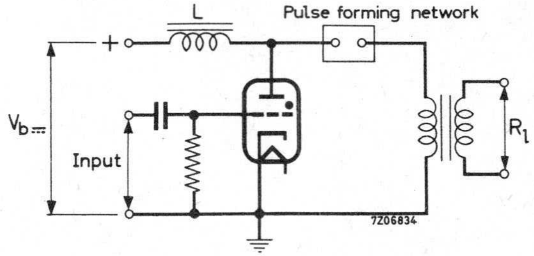
---

[1]) Max. 7 kV when the anode voltage is applied instantaneously (time of rise min. 0.04 sec)

[2]) In pulsed operation the inverse voltage should not exceed 2.5 kV during the first 25μsec after the pulse (except for a spike of max. 0.05 μsec duration).

[3]) The stated max. value of the operating factor applies to pulse repetition rates which are not far in excess of 2800 pulses per second. For considerably higher values it is advisable to apply to the manufacturer. 7Z2 3941

Simplified diagram of a typical modulation circuit employing the hydrogen thyratron



Measured at 3 kV in a typical circuit the time jitter is max. 0.02 μsec. Under practical operating conditions the average value of the anode time jitter is about 0.004 μsec.

7Z2 3942

HYDROGEN THYRATRON

QUICK REFERENCE DATA				
Maximum peak forward voltage	V_{ap}	= max.	16	kV
Maximum peak inverse voltage	$V_{a\ inv_p}$	= max.	16	kV
Maximum peak anode current	I_{ap}	= max.	325	A
Maximum average anode current	I_a	= max.	200	mA
The tube has a positive control characteristic				

APPLICATION

Service in pulse modulator circuits of radar systems.
The properties of the tube suggest other applications such as frequency converter (high efficiency induction heating), shock excitation of tuned circuits, in pulse time modulation circuits, use in control circuits.

HEATING: indirect

Heater voltage	V_f	=	6.3	V ±7.5%
Heater current	I_f	=	9.6 to 11.6	A
Waiting time	T_w	= min.	5	min

7Z2 3937

LIMITING VALUES (Absolute limits)

Ambient temperature	t_{amb}	=		-50 to +90	°C
Anode					
Anode supply voltage (DC)	V_{b_a}	=	min.	4.5	kV
Peak forward anode voltage	V_{a_p}	=	max.	16	kV 1)
Peak inverse anode voltage	$V_{a\,inv_p}$	=	max. min.	16 0.05	kV 2) V_{a_p}
Peak anode current	I_{a_p}	=	max.	325	A
Average anode current	I_a	=	max.	200	mA
Rate of rise of cathode current	dI_k/dt	=	max.	1500	A/μsec
Operating factor	$V_{a_p}.I_{a_p}.f_{imp}$	=	max.	3.2×10^9	VAHz 3)
Grid					
Peak inverse grid voltage	$V_{g\,inv_p}$	=	max.	200	V

Grid drive requirements, measured at the tube socket with the grid disconnected

Peak voltage	V_p	=	min.	200	V
Pulse duration at amplitude of min.50 V	T_{imp}	=	min.	2	μsec
Time of rise of voltage	T_{r_v}	=	max.	0.5	μsec
Impedance of grid drive circuit	R_S	=	max.	500	Ω

REMARKS

1. Cooling of the anode lead is permissible but no stream of cooling air should be directly applied to the tube envelope
2. The tube should be kept away from strong fields which could ionise the gas in the tube

---

1) Max. 13.5 kV when the anode voltage is applied instantaneously (time of rise min. 0.04 sec)

2) In pulsed operation the inverse voltage should not exceed 5 kV during the first 25 μsec after the pulse (except for a spike of max. 0.05 μsec duration).

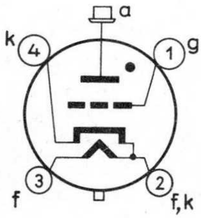
3) The stated max. value of the operating factor applies to pulse repetition rates which are not far in excess of 1000 pulses per second. For considerably higher values it is advisable to apply to the manufacturer.

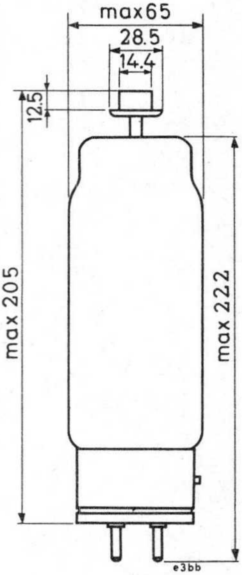
7Z2 3938

MECHANICAL DATA Dimensions in mm

Base : super jumbo with bayonet

Net weight: 280 g

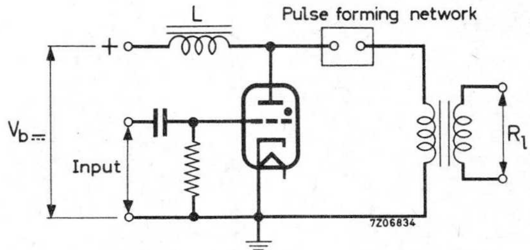




The return lead of the anode and grid circuits should be connected to pin 4

Mounting position: any; clamping is advisable only at the base

SIMPLIFIED DIAGRAM of a typical modulator circuit employing the hydrogen thyratron



Measured at 5 kV in a typical circuit the time jitter is max. 0.02 μsec. Under practical operating conditions the average value of the anode time jitter is about 0.004 μsec.

7Z2 3939

THYRATRON

Thyratron, inert gas filled tetrode, subminiature intended for use in counter-control circuits and as grid controlled rectifier.
The 5643 is shock and vibration resistant.

QUICK REFERENCE DATA			
Peak anode voltage	V_{a_p}	500	V
Cathode current, peak	I_{k_p}	100	mA
average	I_k	22	mA

HEATING

Indirect by A.C. or D.C.

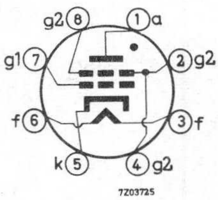
Heater voltage	V_f	6.3	V ± 10 %
Heater current	I_f	150	mA
Waiting time	T_w	10	s

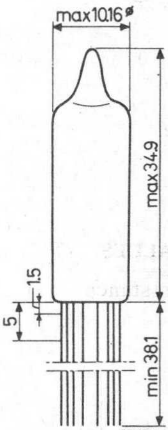
CAPACITANCES (with external shield of 10.3 mm diameter)

Grid No. 1 to all	C_{g_1}	1.7	pF
Anode to all	C_a	1.6	pF
Anode to grid No.1	C_{ag_1}	0.08	pF

MECHANICAL DATA

Dimensions in mm





7Z2 5267

Mounting position: any

The tube may be soldered directly into the circuit but heat conducted to the glass should be kept to a minimum by the use of a thermal shunt.
The leads may be dip-soldered to minimum 5 mm from the glass to metal seals at a solder temperature of 240 °C during max. 10 seconds.
Care should be taken not to bend the leads nearer than 1.5 mm from the seals.

TYPICAL CHARACTERISTIC

Maintaining voltage at I_a = 20 mA	V_{arc}		10	V

LIMITING VALUES (Absolute max. rating system)

Anode voltage,				
forward peak	V_{a_p}	max.	500	V
inverse peak	$V_{a\,inv_p}$	max.	500	V
Grid No. 2 voltage,				
before conduction	$-V_{g_2}$	max.	100	V
Grid No. 1 voltage,				
before conduction	$-V_{g_1}$	max.	200	V
Cathode current,				
peak	I_{k_p}	max.	100	mA
average	I_k	max.	22	mA
Cathode to heater voltage				
k pos	V_{+kf-}	max.	100	V
k neg	V_{-kf+}	max.	25	V
Ambient temperature	t_{amb}	max.	100	°C
		min.	-55	°C
Altitude	h	max.	24	km

CIRCUIT DESIGN VALUES

Grid No. 1 circuit resistance	R_{g_1}	max.	10	MΩ

7Z2 5268

SHOCK AND VIBRATION

These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

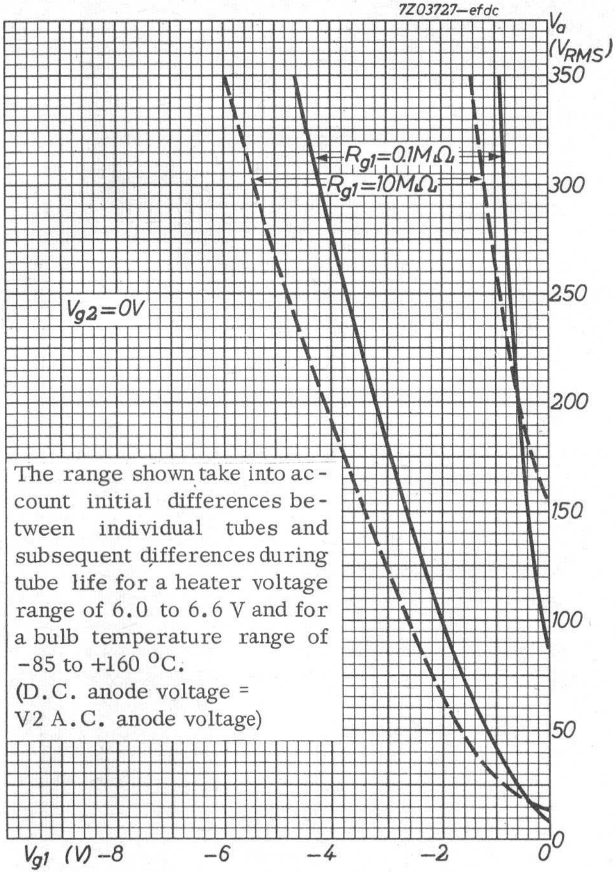
Shock resistance: 500 g

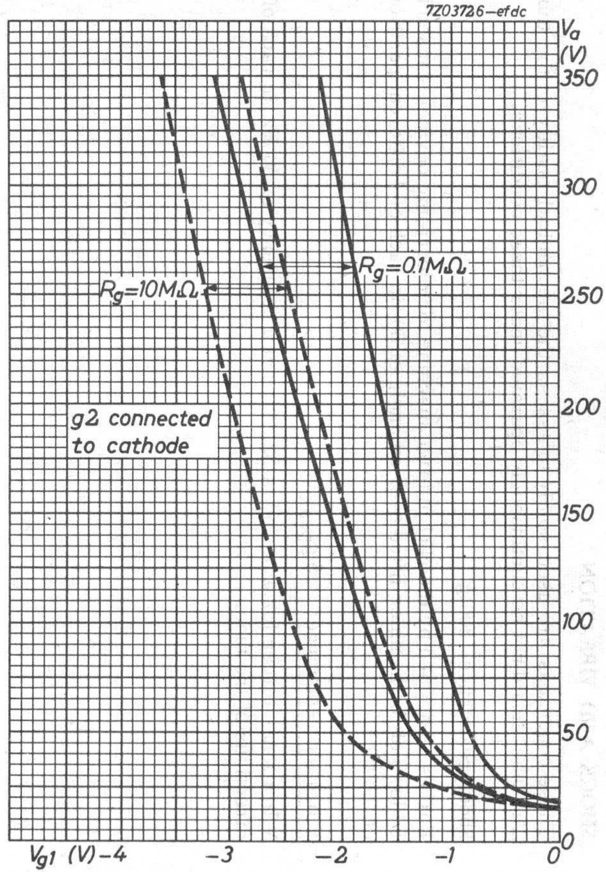
Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30° in each of 4 different positions of the tube.

Vibration resistance: 2.5 g_{peak}

Vibrational forces for a period of 32 hours at a frequency of 50 Hz in each of 3 directions of the tube.

7Z2 8451


7Z03727-efdc
V_a (V_{RMS})
350
300
250
200
150
100
50
0
V_{g1} (V) -8
-6
-4
-2
0
R_{g1}=0.1MΩ
R_{g1}=10MΩ
V_{g2}=0V
The range shown take into account initial differences between individual tubes and subsequent differences during tube life for a heater voltage range of 6.0 to 6.6 V and for a bulb temperature range of -85 to +160 °C.
(D.C. anode voltage = V2 A.C. anode voltage)


7Z03726-efdc
V_a (V)
350
300
250
200
150
100
50
0
V_{g1} (V) -4
-3
-2
-1
0
R_g=0.1MΩ
R_g=10MΩ
g2 connected to cathode

THYRATRON

Thyratron, inert gas filled tetrode intended for industrial applications.

QUICK REFERENCE DATA			
Peak anode voltage	V_{a_p}	500	V
Cathode current, peak	I_{k_p}	100	mA
average	I_k	25	mA

HEATING

Indirect by A.C. or D.C.

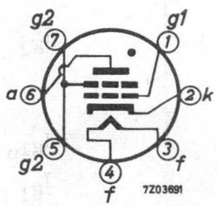
Heater voltage	V_f	6.3	V
Heater current	I_f	150	mA
Waiting time	T_W	10	s

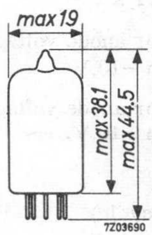
CAPACITANCES

Grid No.1 to all	C_{g_1}	2.0	pF
Anode to all	C_a	1.5	pF
Anode to grid No.1	C_{ag_1}	0.03	pF

MECHANICAL DATA Dimensions in mm

Base: 7 pin miniature





Mounting position: any

7Z2 5270

TYPICAL CHARACTERISTICS

Recovery time at V_a = 500 V, V_{g_1} = −50 V				
R_{g_1} = 50 kΩ, I_{k_p} = 100 mA (20 μs pulse)	T_{dion}		40	μs
Critical grid No. 1 current at $V_{a\sim}$ = 350 $V_{r.m.s}$	I_{g_1}		0.5	μA
Maintaining voltage	V_{arc}		10	V
Control ratio grid No. 1 at striking point R_{g_2} = 0 Ω	$\frac{V_a}{V_{g_1}}$		250	
Control ratio grid No. 2 at striking point R_{g_1} = 0 Ω	$\frac{V_a}{V_{g_2}}$		15	

LIMITING VALUES (Absolute max. rating system)

Anode voltage,				
forward peak	V_{a_p}	max.	500	V
inverse peak	$V_{a\,inv_p}$	max.	500	V
Grid No. 2 voltage,				
before conduction	$-V_{g_2}$	max.	50	V
during conduction	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage,				
before conduction	$-V_{g_1}$	max.	100	V
during conduction	$-V_{g_1}$	max.	10	V
Cathode current,				
peak	I_{k_p}	max.	100	mA
average, T_{av} = max. 30 s	I_k	max.	25	mA
surge T = max. 0.1 s	I_{surge}	max.	2.0	A
Grid No. 2 current for anode voltage more positive than −10 V	I_{g_2}	max.	5.0	mA
Grid No. 1 current for anode voltage more positive than −10 V,				
peak	$I_{g_{1p}}$	max.	25	mA
average (T_{av} = 1 cycle)	I_{g_1}	max.	5.0	mA

7Z2 5271

LIMITING VALUES (continued)

Grid No. 1 current for anode voltage more negative than −10 V,				
peak	$I_{g_{1p}}$	max.	30	μA
Cathode to heater voltage,				
k pos, peak	V_{+kf-p}	max.	25	V
k neg, peak	V_{-kf+p}	max.	100	V
Ambient temperature	t_{amb}	min.	−55	°C
		max.	+90	°C

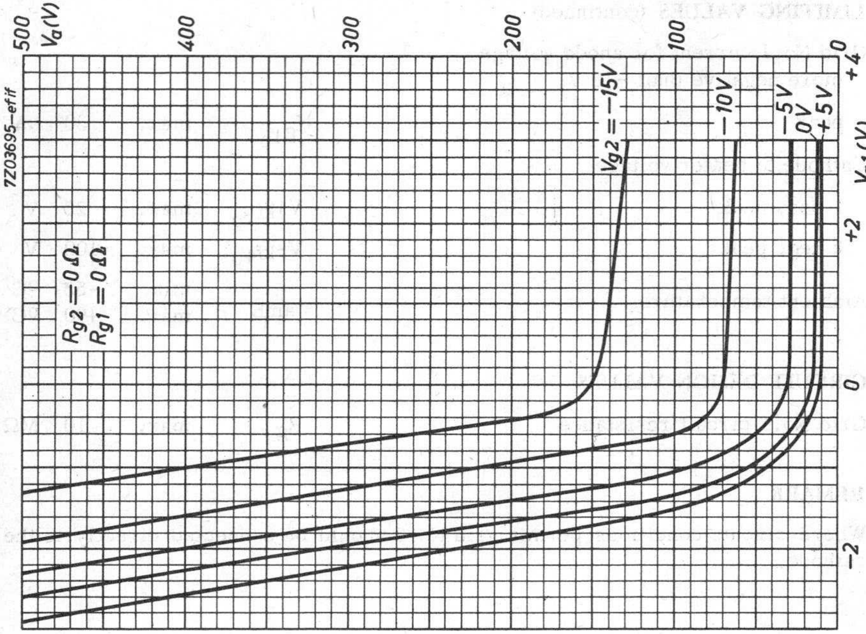
CIRCUIT DESIGN VALUES

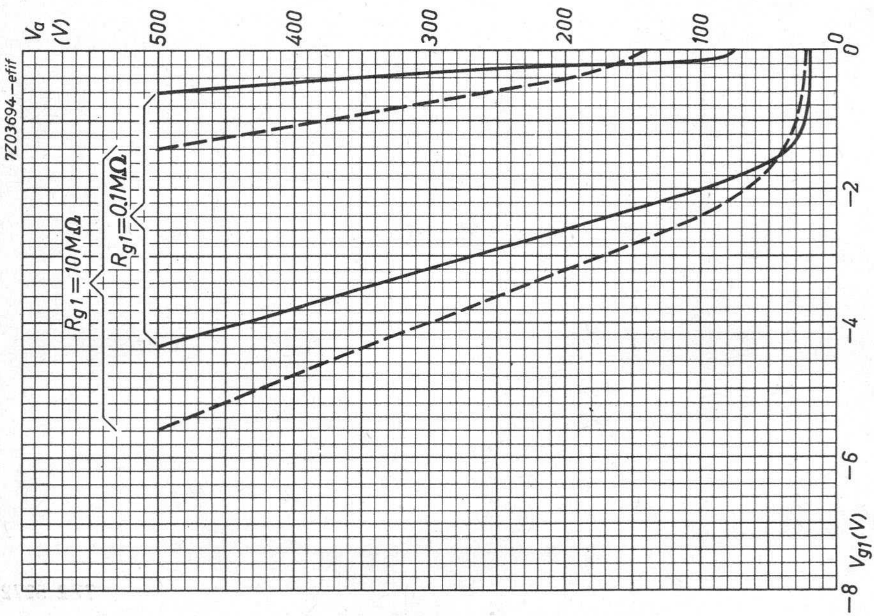
Grid No. 1 circuit resistance	R_{g_1}	max.	10	MΩ

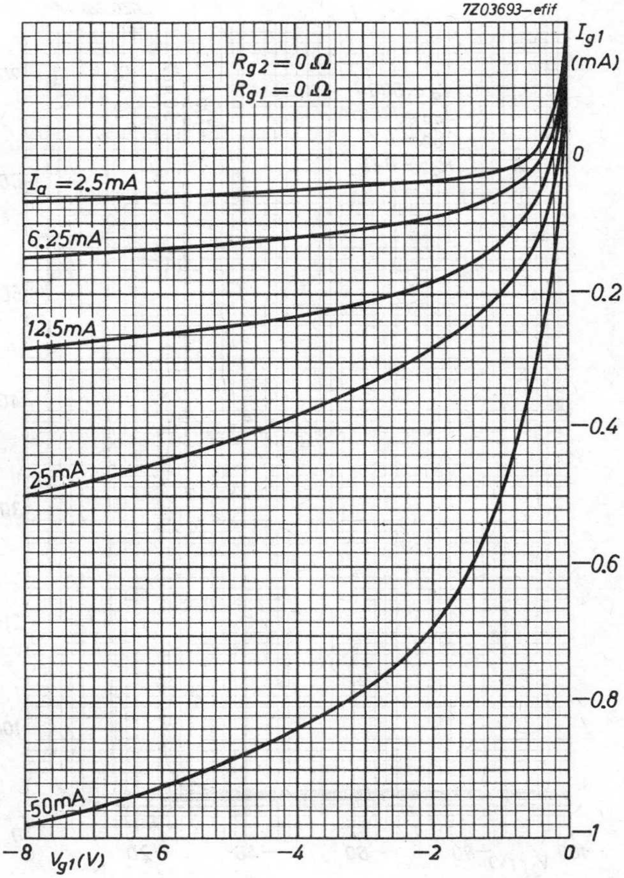
REMARK

Where circuit conditions permit grid No. 2 should be connected directly to the cathode.

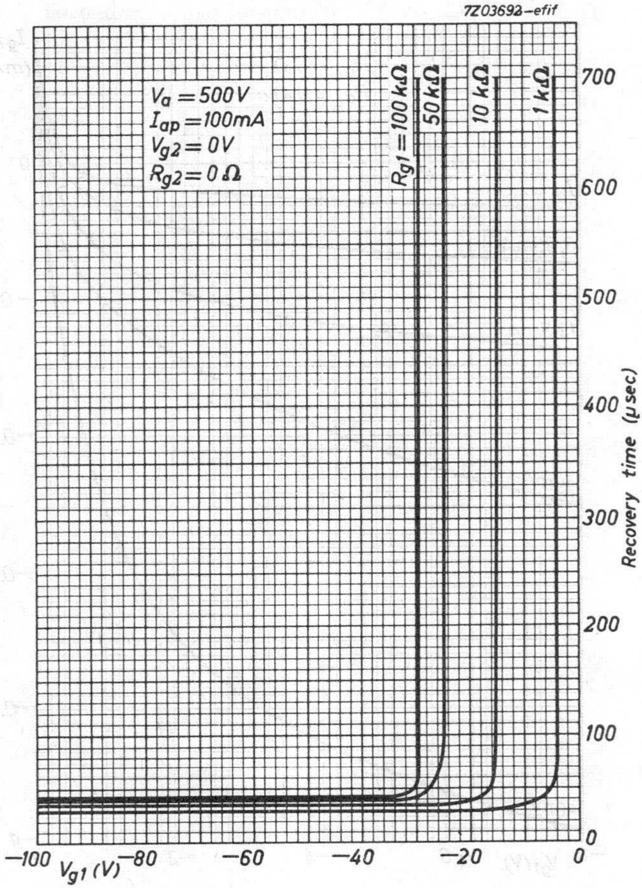
7Z2 5272


7Z03695—efif
V_a(V)
500
400
300
200
100
0
$R_{g2} = 0\,\Omega$
$R_{g1} = 0\,\Omega$
$V_{g2} = -15$V
−10V
−5V
0V
+5V
V_{g1}(V)
+4
+2
0
−2


7Z03694—efif
V_a (V)
500
400
300
200
100
0
$R_{g1} = 10\,M\Omega$
$R_{g1} = 0.1\,M\Omega$
V_{g1}(V)
0
−2
−4
−6
−8



7Z03693-efif
$R_{g2} = 0\,\Omega$
$R_{g1} = 0\,\Omega$
I_a = 2.5mA
6.25mA
12.5mA
25mA
50mA
I_{g1} (mA)
0
−0.2
−0.4
−0.6
−0.8
−1
−8
V_{g1} (V)
−6
−4
−2
0


7Z03692-efif
$V_a = 500V$
$I_{ap} = 100mA$
$V_{g2} = 0V$
$R_{g2} = 0\,\Omega$
$R_{g1} = 100\,k\Omega$
$50\,k\Omega$
$10\,k\Omega$
$1\,k\Omega$
Recovery time (μsec)
700
600
500
400
300
200
100
0
−100
V_{g1} (V)
−80
−60
−40
−20
0

HYDROGEN THYRATRON

QUICK REFERENCE DATA					
Maximum peak forward voltage	V_{a_p}	=	max.	25	kV
Maximum peak inverse voltage	$V_{a\,inv_p}$	=	max.	25	kV
Maximum peak anode current	I_{a_p}	=	max.	500	A
Maximum average anode current	I_a	=	max.	0.5	A
The tube has a positive control characteristic					

APPLICATION

Service in pulse modulator circuits of radar systems.
The properties of the tube suggest other applications such as frequency converter (high efficiency induction heating), shock excitation of tuned circuits, in pulse time modulation circuits, use in control circuits.

HEATING: indirect

Heater voltage	V_f	=		6.3	V ±5%
Heater current at V_f = 6.3 V	I_f	=	15 to	22	A
Replenisher voltage	V_{repl}	=	3 to	5.5	V
Replenisher current at V_{repl} = 4.5 V	I_{repl}	=	2 to	5	A
Waiting time (cathode and replenisher)	T_w	=	min.	15	min

The optimum replenisher voltage is inscribed on the base of the tube and must be held to within ±5%. Too high a voltage will oppose the deionisation between pulses and the tube would then run into continuous conduction. It reduces, moreover, the maximum peak forward voltage. If the replenisher voltage is too low, the anode dissipation will rise resulting in a visible heating of the anode.
The indicated replenisher voltage value applies to the published typical operation. At conditions widely varying from these conditions it may be necessary to redetermine the optimum voltage value.

Warning

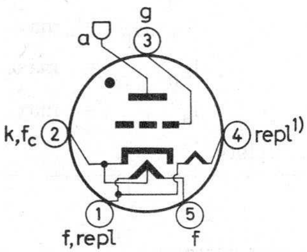
High-voltage hydrogen thyratrons emit X-rays. The intensity of the X-rays is maximum in a narrow beam emanating in a circle from the grid-anode region. Proper precautions should be taken so that personnel operating with or testing these tubes are shielded adequately for X-rays.

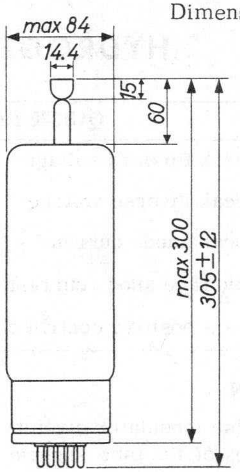
7Z2 3934

MECHANICAL DATA Dimensions in mm

Base : special 5 p

Net weight: 570 g





1) repl = replenisher

Mounting position: any. Vertical position with base down is recommended.

LIMITING VALUES (Absolute limits)

Ambient temperature	t_{amb}	=		−55 to +75	°C
<u>Anode</u>					
Anode supply voltage (DC)	V_{b_a}	=	min.	5	kV
Peak forward anode voltage	V_{a_p}	=	max.	25	kV 2)
			min.	10	kV
Peak inverse anode voltage	$V_{a\ inv_p}$	=	max.	25	kV 3)
			min.	0.05	V_{a_p}
Peak anode current	I_{a_p}	=	max.	500	A
Average anode current	I_a	=	max.	0.5	A
Rate of rise of cathode current	dI_k/dt	=	max.	2500	A/µsec
Operating factor	$V_{a_p}.I_{a_p}.f_{imp}$	=	max.	6.25×10^9	VAHz 4)

2) Instantaneous starting is not recommended. However, when it is absolutely necessary the maximum permissible peak forward voltage is 18 kV and should not be reached in less than 0.04 sec

3) In pulsed operation the inverse voltage should not exceed 5 kV during the first 25 µsec after the pulse (except for a spike of max. 0.05 µsec duration).

4) The stated max. value of the operating factor applies to pulse repetition rates up to 2000 pulses per second. For higher pulse repetition rates it is advisable to consult the tube manufacturer. 7Z2 3935

LIMITING VALUES (continued)

Grid

Peak inverse grid voltage	$V_{g\ inv_p}$	=	max.	450	V

Grid drive requirements, measured at the tube socket with the grid disconnected.

Peak voltage	V_p	=	max.	1000	V
		=	min.	550	V
Pulse duration	T_{imp}	=	min.	2	µsec
Rate of rise of voltage	$\frac{\Delta V}{\Delta T_{r_V}}$	=	min.	1800	V/µsec
Impedance of grid drive circuit	R_S	=		50 to 200	Ω

TYPICAL OPERATING CHARACTERISTICS as pulse modulator; DC resonance charging

Incase the operating conditions are much severer than those listed below, it is suggested that the customer requests a recommendation for his specific application.

Peak anode voltage	V_{a_p}	=	25	20	kV
Peak anode current	I_{a_p}	=	500	200	A
Pulse duration	T_{imp}	=	2	1	µsec
Pulse repetition rate	f_{imp}	=	500	1200	Hz

REMARKS

1. Cooling of the anode lead is permissible but no stream of cooling air should be directly applied to the tube envelope.
2. The tube should be kept away from strong fields which could ionise the gas in the tube.
3. The anode terminal may reach a temperature of about 200 °C. The anode clip should be soldered to its cable by means of an appropriate type of solder.

7Z2 3936

Industrial rectifying tubes

APPLICATION DIRECTIONS
INDUSTRIAL RECTIFYING TUBES

The following instructions and recommendations apply in general to all types of industrial rectifiers. If there are deviations for any type of tube they will be indicated on the published data sheets of the type in question.

MOUNTING

Normally the tubes must be mounted vertically with the base or filament strips at the lower end. They must be mounted so that air can circulate freely around them. Where additional cooling is necessary forced air should assist the natural convection. (This is of great importance in the case of mercury-vapour filled tubes, in order to condense the mercury in the lower part of the tube.) The clearance between the tubes and other components of the circuit and between the tubes and cabinet walls should be at least half the maximum tube diameter.

When 2 or more tubes are used the minimum clearance between them should be 3/4 the maximum tube diameter. When the tube is mounted in a closed cabinet the heat dissipated by the tube and other components should be taken into account. While the tube is working it must not touch any other part of the installation or be exposed to falling drops of liquid. The tubes should be mounted in such a way that they are not subjected to dangerous shock or vibration.

In general, if shock or vibration exceeds 0.5 g a shock absorbing device should be used. The electrode connections, except for those of the tube holder, must be flexible. The nuts (e.g. of the anode connections) should be well tightened but care must be taken to ensure that no undue forces are exerted on the tube. The contacts must be checked at regular intervals and their surfaces kept clean in order to avoid excessive heating of the glass-metal seals. The cross section of the conductors and leads should be sufficient to carry the r.m.s. value of the current. (It should be noted that in rectifier circuits the r.m.s. value of the anode current may reach 2.5 x the average D.C. value.)

FILAMENT SUPPLY

In order to obtain the maximum life of a directly heated tube, a filament transformer with centre-tap and a phase shift of $90^{o} \pm 30^{o}$ between V_a and V_f is recommended.

The filament voltage at nominal mains voltage must be measured at the terminals of the tube. Deviations with a maximum of 2.5% from the published value can be accepted. It is therefore recommended to have tappings on the filament

7Z2 7577

transformer. The mains fluctuations should, in general, not exceed 5%. During short intervals fluctuations of 10% are admissible.

In calculating the ratings of the filament transformer a variation in the filament current of plus and minus 10% from tube to tube should be taken into account, whilst for directly heated tubes the D.C. current flowing through the filament winding should also be considered.

TEMPERATURE

1. For tubes filled with a mixture of mercury vapour and inert gas.

   For these tubes temperature limits for the condensed mercury are given in the published data. Care should be taken to ensure that the temperature during operation is between these limits. The condensed mercury temperature can be measured with a thermo-element placed against the envelope. The measurement should be made at the coldest part of the bulb where the mercury condenses; in general this will be just above the base or the lower connections. Good technique and instruments are necessary for accurate thermocouple measurements.

   In addition to the temperature limits for the condensed mercury sometimes limits for the ambient temperature are given.

   The latter are only intended as a guide, as the difference between the ambient and the condensed mercury temperature largely depends on mounting and cooling.

   The condensed mercury temperature is decisive in all cases

   The ambient temperature can be measured with a thermometer which has been screened against direct heat radiation.

   The measurement should be carried out at various points around the lower part of the tube.

2. Tubes with inert gas-filling

   For these tubes only the limits of the ambient temperature are given. These limits are in general minimum $-55\ ^{o}C$ and maximum $+75\ ^{o}C$.

SWITCHING ON

It is necessary to allow some time for the cathode to reach its operating temperature before drawing cathode current. Therefore the minimum cathode heating time is given on the published data sheets. In general two values are published; the minimum may be used if a short time is absolutely necessary but it is advisable to use the longer value.

After the heating of the cathode the anode voltage may be applied provided that the ambient temperature is not too low.

7Z2 7578

For tubes filled with a mixture of mercury-vapour and inert gas the minimum value of ambient temperature is 0 ^{o}C; for tubes with only an inert-gas filling it is the minimum value of the ambient temperature published.

Switching on after transport or after a considerable time of interruption of operation should be done according to the instructions for use which are packed with the tube.

LIMITING VALUES

In general these values are given as absolute maxima; i.e. maxima which should not be exceeded under any conditions (thus they may not be exceeded owing to mains voltage fluctuations, load variations, tolerances on components, overvoltages, etc.)

For each rating of maximum average current a maximum averaging time is quoted. This is to ensure than an anode current greater than the maximum continuously permissible average value is not drawn for such a length of time as would give rise to an excessive temperature within the tube. The maximum peak anode current is determined by the available safe cathode emission, whereas the average current is limited by its heating effects.

An exception has been made for the maximum average current of tubes used in battery chargers. The rated value then holds for the nominal battery voltage. In the uncharged condition this rated value may then be exceeded by approximately 25%. However, it must have decreased to the published maximum value within 30 minutes.

Under no circumstances may the peak current exceed its maximum published value. For the determination of the actual value of the peak inverse voltage and the peak anode current, the values measured with an osciloscope or by other means are decisive.

TYPICAL CHARACTERISTICS

1. Arc voltage

   The value published for V_{arc} applies to average operating conditions; under high peak current conditions, e.g. 6 phase rectification, V_{arc} will be higher. The spread which is dependent on the circuit can be expected to be plus and minus 1 V.

   During life an increase of approximately 2 V must be taken into account.

2. Ignition voltage

   The published value of V_{ign} is an average value which can be used as a basis for calculation of the transformer voltage required.

7Z2 7579

From the given value the minimum transformer voltage can be calculated. However, owing to mutual variations between the tubes, fluctuations of the mains voltage, temperature variations and variation during life the required transformer voltage must be higher than the minimum calculated value.

In the case of battery charging an increase of 15% to 20% will, in general, be sufficient.

3. Frequency

Unless otherwise stated the maximum frequency at which the tubes may run under full load is 150 Hz.

Under special conditions higher frequencies may be used; details should be obtained from the manufacturer.

OPERATING CHARACTERISTICS

The data under this heading are based on normal practical conditions.

SHORT CIRCUIT PROTECTION

In order to prevent the tube from being damaged by passing too high a peak current a minimum value for the protective resistance R_t or a maximum value for the surge current is given.

The figure given for the maximum surge current is intended as a guide to equipment designers. It indicates the maximum value of a transient current resulting from a sudden overload or short circuit which the rectifier can pass for a period not exceeding 0.1 second without resulting in its immediate destruction. Several overloads of this nature will, however, considerably reduce the life of the tube.

The equipment designer has to take into account this maximum surge current rating when calculating the short-circuit impedance of the equipment.

This surge current value is not intended as a peak current that may occur on switching or durring operation

A simple method to limit the surge current to maximum rating is to incorporate a series resistance in the anode circuit.

If a value for R_t is specified on the published data sheets the maximum surge current rating will not be exceeded in the event of a short circuit, sudden overload, etc. when the total resistance of the secondary (anode) circuit of a normal transformer has at least this value.

7Z2 7580

SCREENING AND INTERFERENCE

In order to prevent unwanted ionisation of the gas filling (and consequent flash over) due to strong R.F. fields, it may be necessary to enclose the rectifier in a separate earthed screening box.

In circuits with gas-filled tubes oscillation in the transformer windings may occur.

These oscillations should be reduced by suitable circuits as excessive peak inverse voltages may occur, causing arc back.

SMOOTING CIRCUITS

In order to limit the peak anode current in a rectifier it is necessary that a choke precedes the first smoothing capacitor.

In some rectifier circuits the initial surge of current can be limited by use of a starting resistor in series with the primary of the transformer. Moreover, when such a starting resistor is used it may be possible to reduce the inductance value of the choke.

To ensure good voltage regulation on fluctuating loads the inductance value of the chocke should be large enough to give uninterrupted current at minimum load.

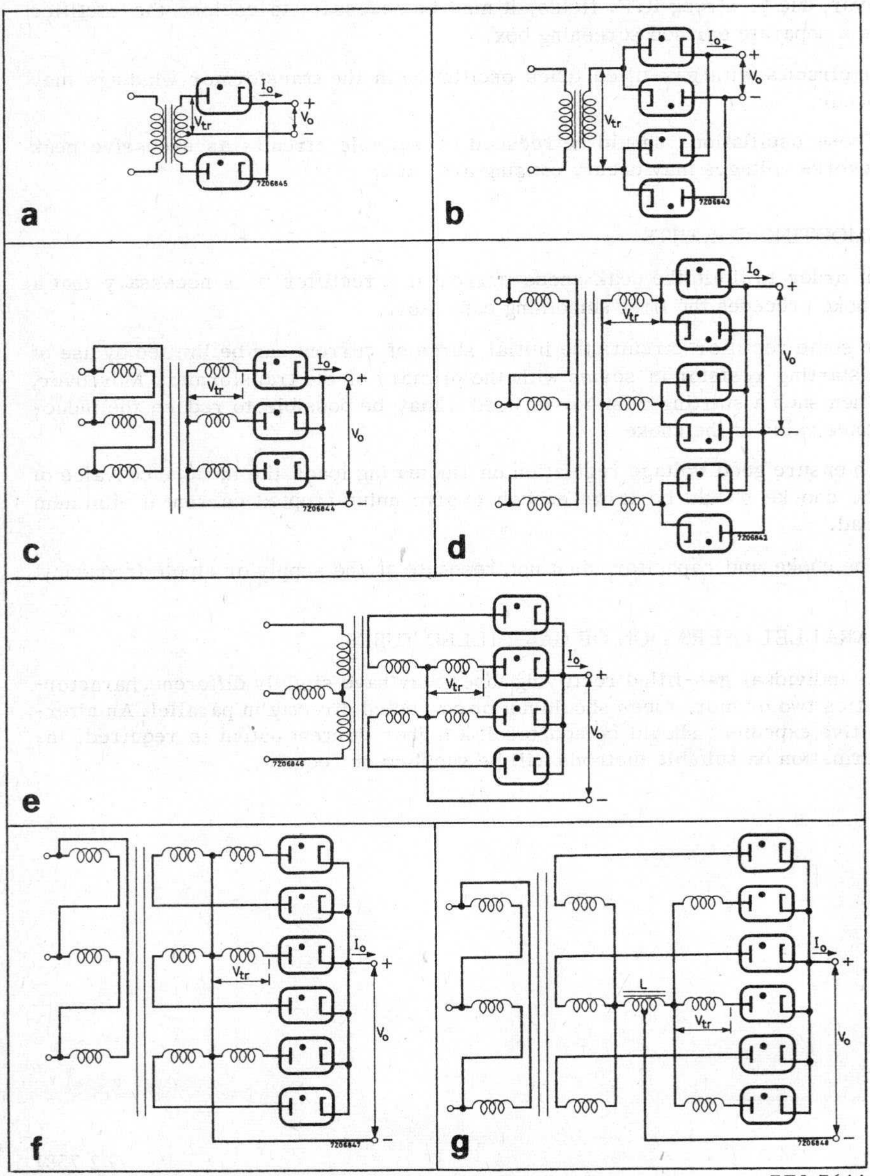
The choke and capacitor must not resonate at the supply or ripple frequency.

PARALLEL OPERATION OF GAS-FILLED TUBES

As individual gas-filled rectifying tubes may have slightly different characteristics two or more tubes should not be connected directly in parallel. An alternative expedient should be adopted if a higher current output is required. Information on suitable methods will be supplied on request.

7Z2 7581

RECTIFYING TUBE CIRCUITS



7Z2 7644

RATING SYSTEM

(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.

7Z2 5065

DOUBLE ANODE RECTIFYING TUBE

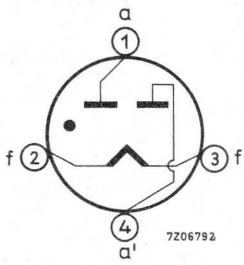
Gasfilled double anode rectifying tube intended for use in battery chargers 1.3 A each tube, max. 6 Pb-cells.

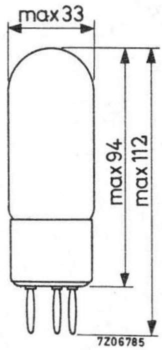
HEATING: direct by A.C., oxide coated filament.

Filament voltage	V_f	1.9	V
Filament current	I_f	3.0	A
Waiting time	T_w	15	s [1])

MECHANICAL DATA — Dimensions in mm

Base: A





Socket: 40465

Mounting position: vertical, base down

Net weight: 35 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	7	V
Ignition voltage	V_{ign}	16	V

[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

7Z2 7582

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}		28		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	11	13	16	V
D.C. current	I_o	1.5	1.3	1.0	A
Anode current, peak	I_{ap}		3		A
Protecting resistance	R_t		6.5		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainvp}	max.	90	V
Anode current, average	I_a	max.	0.65	A
peak	I_{ap}	max.	4	A
Protecting resistance	R_t	min.	3	Ω
Ambient temperature	t_{amb}	min.	-55	°C
		max.	+75	°C

7Z2 7583

SINGLE ANODE RECTIFYING TUBE

Gas-filled single anode rectifying tube intended for use in battery chargers. 2 A each tube, max. 4 Pb cells.

HEATING: direct; oxide coated filament

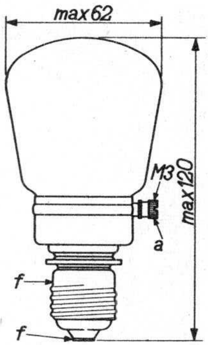
Filament voltage	V_f	1.9	V
Filament current	I_f	5.5	A
Waiting time	T_w	30	s [1]

MECHANICAL DATA — Dimensions in mm

Base: Edison 23

Net weight 750 g

Mounting position: vertical, base down



TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	8	V
Ignition voltage	V_{ign}	16	V

[1] If urgently wanted this value may be decreased to 0 s.

7Z2 8525

LIMITING VALUES (Absolute max. rating system)

Transformer voltage	V_{tr}	max.	20	130	V_{RMS}
		min.	15	15	V_{RMS}
Anode voltage, peak inverse	$V_{a_{inv_p}}$	max.	65	400	V
Anode current, peak	I_{ap}	max.	10	1.25	A
average	I_a	max.	2	0.25	A
Protecting resistance	R_t	min.	4	50	Ω
Ambient temperature	t_{amb}	min.	−55		^oC
		max.	+75		^oC

7Z2 8526

DOUBLE ANODE RECTIFYING TUBE

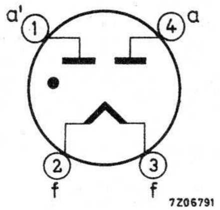
Gasfilled double anode rectifying tube intended for use in battery chargers 6 A each tube, max. 12 Pb-cells.

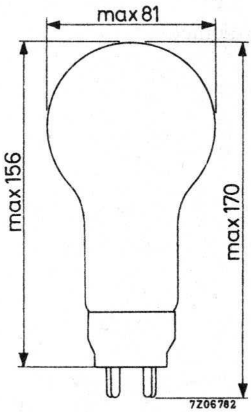
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	8	A
Waiting time	T_w	30	s [1])

MECHANICAL DATA Dimensions in mm

Base: W





Socket: 40221

Mounting position: vertical, base down

Net weight: 90 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

7Z2 7584

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}		45		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	22	26	32	V
D.C. current	I_o	7.2	6	4	A
Anode current, peak	I_{ap}		15		A
Protecting resistance	R_t		1.9		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	140	V
Anode current, average	I_a	max.	3	A
peak	I_{ap}	max.	18	A
Protecting resistance	R_t	min.	1	Ω
Ambient temperature	t_{amb}	min.	-55	^oC
		max.	+75	^oC

7Z2 7585

DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gasfilled double anode rectifying tube intended for use in battery chargers 1.3 A each tube, max. 3 Pb-cells.

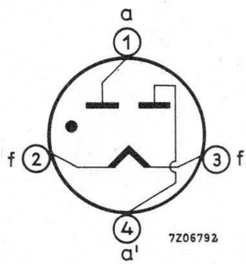
HEATING: direct by A.C., oxide coated filament

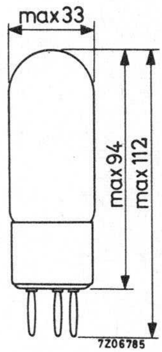
Filament voltage	V_f	1.9	V
Filament current	I_f	2.8	A
Waiting time	T_w	15	s [1])

MECHANICAL DATA

Dimensions in mm

Base: A





Socket: 40465

Mounting position: vertical, base down

Net weight: 40 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	7	V
Ignition voltage	V_{ign}	11	V

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[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

7Z2 7586

LIMITING VALUES (Absolute max. rating system)

Transformer voltage	V_{tr}	max.	16	V_{RMS}
		min.	10	V_{RMS}
Anode voltage, inverse peak	$V_{a_{inv_p}}$	max.	50	V
Anode current, average	I_a	max.	0.65	A
peak	I_{a_p}	max.	4	A
Protecting resistance	R_t	min.	3	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	75	°C

7Z2 7587

DOUBLE ANODE RECTIFYING TUBE

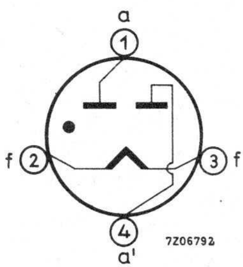
Gasfilled double anode rectifying tube intended for use in battery chargers 1.3 A each tube, max. 20 Pb-cells.

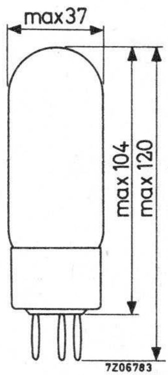
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	3.5	A
Waiting time	T_w	15	s [1])

MECHANICAL DATA Dimensions in mm

Base: A





Socket: 40465

Net weight: 50 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

7Z2 7588

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage V_{tr} 60 V_{RMS}

		discharged	nominal	charged	
Battery voltage	V_{bat}	36	44	54	V
D.C. current	I_o	1.7	1.2	0.7	A
Anode current, peak	I_{ap}		3.2		A
Protecting resistance	R_t		10		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	185	V
Anode current, average	I_a	max.	0.65	A
peak	I_{ap}	max.	4	A
Protecting resistance	R_t	min.	10	Ω
Ambient temperature	t_{amb}	min.	-55	°C
		max.	+75	°C

7Z2 7589

DOUBLE ANODE RECTIFYING TUBE

Mercury-vapour and gasfilled double anode rectifying tube intended for use in battery chargers 6 A each tube, max. 20 Pb-cells.

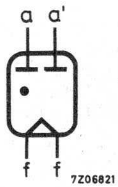
HEATING: direct by A.C., oxide coated filament

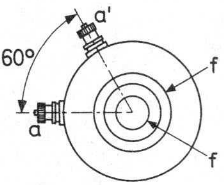
Filament voltage	V_f	1.9	V
Filament current	I_f	11	A
Waiting time	T_W	2	min [1])

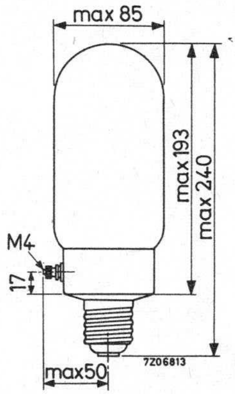
MECHANICAL DATA

Dimensions in mm

Base: Goliath







Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 290 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

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[1]) See page 2.

7Z2 7590

LIMITING VALUES (Absolute max. rating system)

Transformer voltage	V_{tr}	max.	60	V_{RMS}
		min.	15	V_{RMS}
Anode voltage, inverse peak	$V_{a_{invp}}$	max.	185	V
Anode current, average	I_a	max.	3	A
peak	I_{a_p}	max.	18	A
Protecting resistance	R_t	min.	1.75	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7591

DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gas-filled double anode rectifying tube intended for use in battery chargers. 15 A each tube, max. 20 Pb cells.

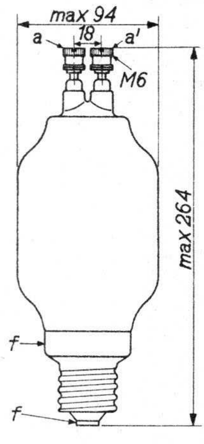
HEATING: direct by A.C.; oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	20	A
Waiting time	T_W	2	min [1])

MECHANICAL DATA Dimensions in mm

Base: Goliath

Net weight 340 g



Mounting position: vertical, base down

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of a time delay switch (e.g. type 4152/02). After transport or after long interruption of service T_W = 5 min.

7Z2 8527

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage			60		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	36	44	54	V
D.C. current	I_o	19	13.5	8	A
Anode current, peak	I_{a_p}		37		A
Protecting resistance	R_t		0.85		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak inverse	$V_{a_{invp}}$	max.	185	V
Anode current, peak	I_{a_p}	max.	45	A
average	I_a	max.	7.5	A
Protecting resistance	R_t	min.	0.75	Ω
Mercury temperature	t_{Hg}		30 to 80	^oC

7Z2 8528

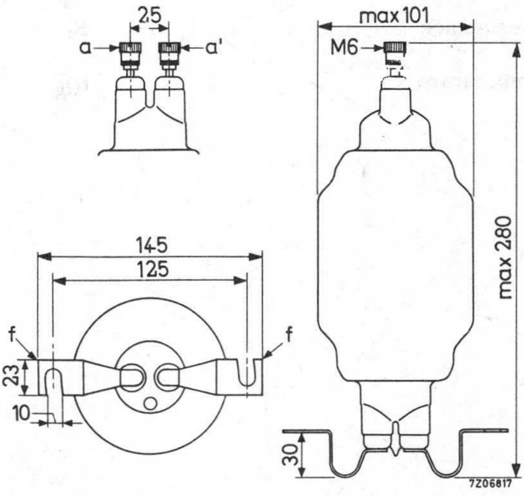
DOUBLE ANODE RECTIFYING TUBE

Mercury-vapour and gasfilled double anode rectifying tube intended for use in battery chargers 25 A each tube, max. 20 Pb-cells.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	28.5	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm



Mounting position: vertical, base down

Net weight: 520 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

1) See page 2.

7Z2 7592

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}		60		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	36	44	54	V
D.C. current	I_o	32	22	13	A
Anode current, peak	I_{ap}		60		A
Protecting resistance	R_t		0.5		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	185	V
Anode current, average	I_a	max.	12.5	A
peak	I_{ap}	max.	75	A
Protecting resistance	R_t	min.	0.3	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes.

7Z2 7593

DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gas-filled double anode rectifying tube intended for use in welding rectifiers (40 A each tube).

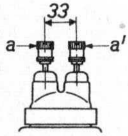
HEATING: direct by A.C.; oxide coated filament

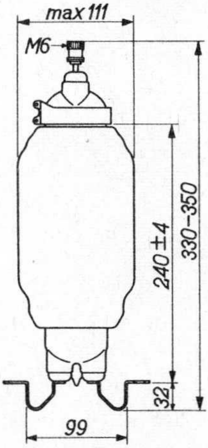
Filament voltage	V_f	1.9	V
Filament current	I_f	68	A
Waiting time	T_w	2	min [1]

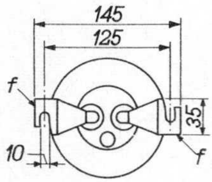
MECHANICAL DATA

Dimensions in mm

Net weight: 950 g







Mounting position: vertical, base down

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V	
Ignition voltage	V_{ign}	16	V	V

[1]) If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of a time delay switch (e.g. type 4152/0). After transport or after a long interruption of service T_w = 5 min. 7Z2 8529

LIMITING VALUES (Absolute max. rating system)

Transformer voltage	V_{tr}	max.	48	V_{RMS}
		min.	20	V_{RMS}
Anode voltage, peak inverse	$V_{a_{invp}}$	max.	150	V
Anode current, peak	I_{ap}	max.	120	A
average	I_a	max.	20	A
Protecting resistance	R_t	min.	0.18	Ω
Mercury temperature	t_{Hg}		30 to 80	°C

7Z2 8530

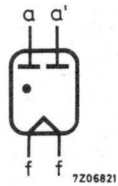
DOUBLE ANODE RECTIFYING TUBE

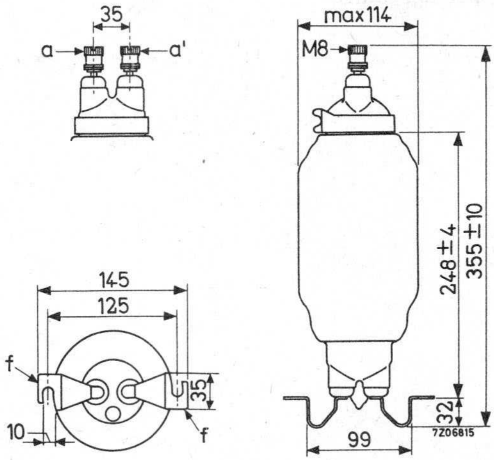
Mercury-vapour and gasfilled double anode rectifying tube intended for use in welding rectifiers 60 A each tube.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	3.25	V
Filament current	I_f	70	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm





Mounting position: vertical, base down

Net weight: 1000 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	16	V

[1]) See page 2.

7Z2 7594

OPERATING CHARACTERISTICS

Circuit See Appl. dir.	V_{tr} (V_{RMS})	V_o (V)	I_o 2) (A)
e	55	50	120
f	55	55	180
g	55	45	180

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	170	V
Anode current, average	I_a (T_{av} = max. 15 sec)	max.	30	A 2)
peak	I_{a_p}	max.	200	A
Protecting resistance	R_t	min.	0.12	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	75	°C

1) Recommended value. If urgently wanted this value may be decreased to 1 min.

2) With fan cooling.

7Z2 7595

DOUBLE ANODE RECTIFYING TUBE

Gasfilled double anode rectifying tube intended for use in battery chargers 2 A each tube, max. 20 Pb-cells.

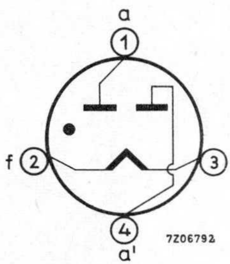
HEATING: direct by A.C., oxide coated filament

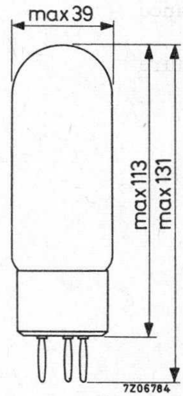
Filament voltage	V_f	1.9	V
Filament current	I_f	3.5	A
Waiting time	T_w	15	s [1])

MECHANICAL DATA

Dimensions in mm

Base: A





Socket: 40465

Mounting position: vertical, base down

Net weight: 55 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) See page 2.

7Z2 7596

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}		60		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	36	44	54	V
D.C. current	I_o	2	1.4 [2])	0.85	A
Anode current, peak	I_{a_p}		3.8		A
Protecting resistance	R_t		8		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	185	V
Anode current, average	I_a	max.	0.85	A
peak	I_{a_p}	max.	5	A
Protecting resistance	R_t	min.	4	Ω
Ambient temperature	t_{amb}	min.	-55	°C
		max.	+75	°C

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[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

[2]) When a barretter is used this value may be increased to 2 A.

7Z2 7597

DOUBLE ANODE RECTIFYING TUBE

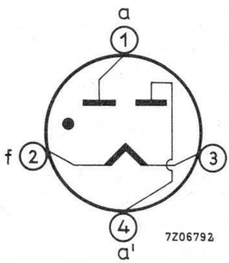
Gasfilled double anode rectifying tube intended for use in battery chargers 3 A each tube, max. 12 Pb-cells.

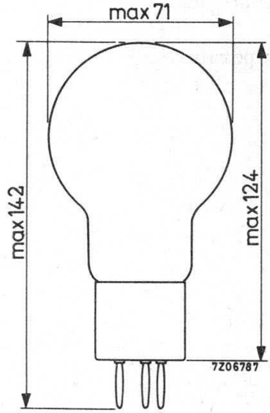
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	5.8	A
Waiting time	T_w	30	s [1])

MECHANICAL DATA Dimensions in mm

Base: A





Socket: 40465

Mounting position: vertical, base down

Net weight: 75 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) See page 2.

7Z2 7598

OPERATING CHARACTERISTICS

Circuit: a (See Applications directions)

Transformer voltage	V_{tr}		45		V_{RMS}
		discharged	nominal	charged	
Battery voltage	V_{bat}	22	26	32	V
D.C. current	I_o	3.6	3.0	2.1	A
Anode current, peak	I_{a_p}		7.5		A
Protecting resistance	R_t		3.75		Ω

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainvp}	max.	140	V
Anode current, average	I_a	max.	1.5	A
peak	I_{a_p}	max.	9	A
Protecting resistance	R_t	min.	1.8	Ω
Ambient temperature	t_{amb}	min.	-55	°C
		max.	+75	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 15 sec.

7Z2 7599

SINGLE ANODE RECTIFYING TUBE

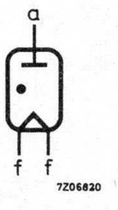
Mercury vapour and gasfilled single anode rectifying tube intended for use in battery chargers and cinema rectifiers 15 A each tube, max. 30 Pb-cells.

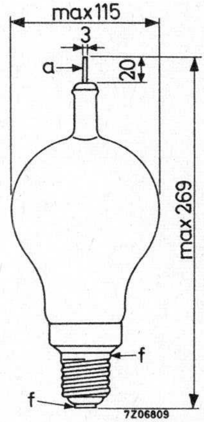
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	2.5	V
Filament current	I_f	27	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm

Base: Goliath





Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 240 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	16	V

[1]) See page 2.

7Z2 7600

LIMITING VALUES (Absolute max. rating system)

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	max.	85	V_{RMS}
		min.	20	V_{RMS}
Anode voltage, inverse peak	$V_{a_{invp}}$	max.	275	V
Anode current, average	I_a	max.	15	A
peak	I_{ap}	max.	85	A
Protecting resistance	R_t	min.	0.3	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7601

SINGLE ANODE RECTIFYING TUBE

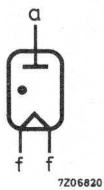
Gasfilled single anode rectifying tube intended for use in battery chargers 6 A each tube, max. 36 Pb-cells.

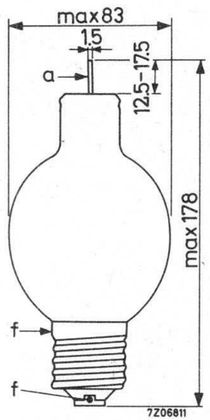
HEATING: direct by A.C., thoriated tungsten

Filament voltage	V_f	2.25	V
Filament current	I_f	17	A
Waiting time	T_W	0	s [1])

MECHANICAL DATA Dimensions in mm

Base: Goliath





Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 110 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

[1]) Recommended value 3 sec.

7Z2 7602

LIMITING VALUES (Absolute max. rating system)

Circuit See Appl. dir.	a, c, e, f, g	b, d
V_{tr}	max. 130 V_{RMS}	max. 90 V_{RMS}
V_{tr}	min. 20 V_{RMS}	min. 20 V_{RMS}
$V_{a_{inv_p}}$	max. 375 V	max. 250 V
I_a	max. 6 A	max. 6 A
I_{a_p}	max. 36 A	max. 36 A
R_t	min. 0.5 Ω	min. 0.5 Ω
t_{amb}	min. -55 °C	min. -55 °C
	max. +75 °C	max. +75 °C

7Z2 7603

SINGLE ANODE RECTIFYING TUBE

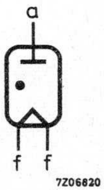
Gasfilled single anode rectifying tube intended for use in battery chargers and cinema rectifiers 15 A each tube, max. 30 Pb-cells.

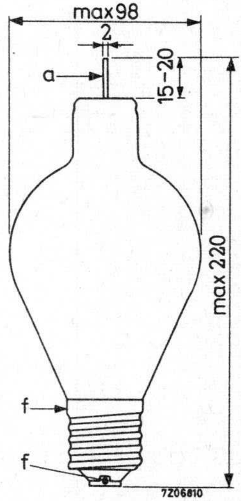
HEATING: direct by A.C., thoriated tungsten

Filament voltage	V_f	2,5	V
Filament current	I_f	25	A
Waiting time	T_w	15	s

MECHANICAL DATA Dimensions in mm

Base: Goliath





Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 150 g

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	16	V

7Z2 7604

LIMITING VALUES (Absolute max. rating system)

Circuit See Appl.dir.	a, c, e, f, g	b, d
V_{tr}	max. 80 V_{RMS}	max. 60 V_{RMS}
V_{tr}	min. 20 V_{RMS}	min. 20 V_{RMS}
$V_{a_{invp}}$	max. 225 V	max. 165 V
I_a	max. 15 A	max. 15 A
I_{ap}	max. 90 A	max. 90 A
R_t	min. 0.3 Ω	min. 0.3 Ω
t_{amb}	min. -55 °C	min. -55 °C
	max. +75 °C	max. +75 °C

7Z2 7605

SINGLE ANODE RECTIFYING TUBE

Mercury vapour and gas-filled single anode rectifying tube intended for use in battery chargers, 4 A each tube, max. 100 Pb-cells.

HEATING: direct by A.C., oxide coated filament

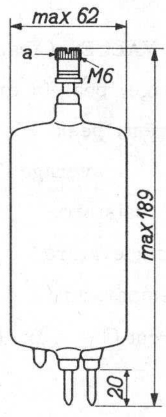
Filament voltage	V_f	1.9	V
Filament current	I_f	13	A
Waiting time	T_w	1	min [1]

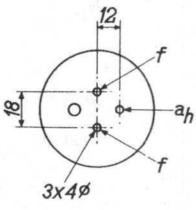
MECHANICAL DATA

Base : Spec. 3p

Socket: 1287

Net weight 165 g





Mounting position: vertical base down

[1] If urgently wanted this value may be decreased to 45 s. In order to obtain a suitable time delay use can be made of a time delay switch (e.g. type 4152/02). After transport or after a long interruption of service T_w = 5 min.

7Z2 8531

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ignition voltage	V_{ign}	22	V

OPERATING CHARACTERISTICS

Circuit	Transformer voltage (V_{RMS})	D.C. voltage (V)	D.C. current (A)
a	275	230	8
b	540	440	8
c	220	240	12
d	210	440	12
e	205	240	16
f	200	240	24
g	220	240	24

Circuits: See Applications directions.

LIMITING VALUES (Absolute max. rating system)

Anode voltage, peak inverse	$V_{a_{invp}}$	max.	685	850	V
Anode current, peak	I_{a_p}	max.	24	20	A
average (T_{av} = max. 5 s)	I_a	max.	4	4	A
Protecting resistance	R_t	min.	0.75	0.75	Ω
Mercury temperature	t_{Hg}		30 to 80	30 to 75	°C
Ambient temperature	t_{amb}		10 to 50	10 to 45	°C
Surge current (T = max. 0.1 s)	I_{surge}	max.	240	200	A

7Z2 8532

SINGLE ANODE RECTIFYING TUBE

Mercury vapour and gasfilled single anode rectifying tube intended for use in industrial rectifiers 6 A each tube, max. 110 Pb-cells.

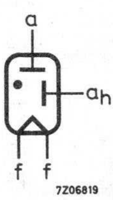
HEATING: direct by A.C., oxide coated filament .

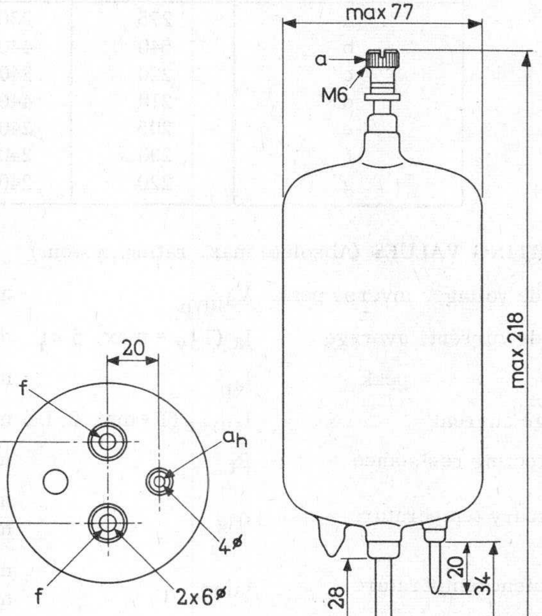
Filament voltage	V_f	1.9	V
Filament current	I_f	12	A
Waiting time	T_W	60	s [1])

MECHANICAL DATA

Dimensions in mm

Base: Spec. 3p





Socket: 1285

Mounting position: vertical, base down

Net weight: 285 g

[1]) See page 2.

7Z2 7606

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ignition voltage	V_{ign}	22	V

In order to obtain the above-mentioned ignition voltage of 22 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (–). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl. dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	275	230	12
b	540	440	12
c	220	240	18
d	210	440	18
e	205	240	24
f	200	240	36
g	220	240	36

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	685	850	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	6	6	A
peak	I_{ap}	max.	36	30	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	360	300	A
Protecting resistance	R_t	min.	0.5	0.5	Ω
Mercury temperature	t_{Hg}	min.	30	30	°C
		max.	80	75	°C
Ambient temperature	t_{amb}	min.	10	10	°C
		max.	50	45	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 45 sec. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7607

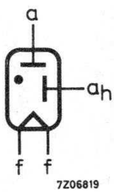
SINGLE ANODE RECTIFYING TUBE

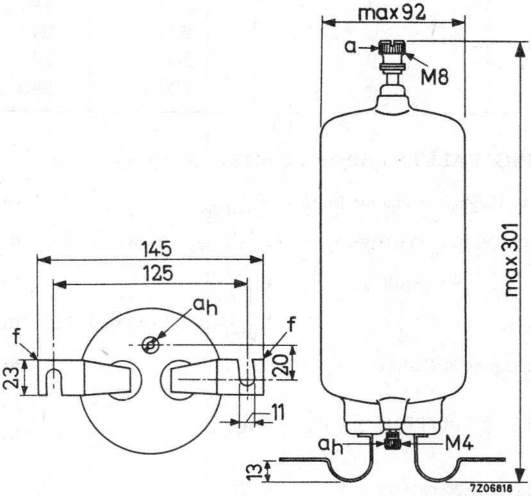
Mercury vapour and gasfilled single anode rectifying tube intended for use in industrial rectifiers 15 A each tube, max. 110 Pb-cells.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	28	A
Waiting time	T_W	2	min [1])

MECHANICAL DATA Dimensions in mm





Mounting position: vertical, base down

Net weight: 600 g

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes. 7Z2 7608

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ignition voltage	V_{ign}	22	V

In order to obtain the above-mentioned ignition voltage of 22 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (−). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl.dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	275	230	30
b	540	440	30
c	220	240	45
d	210	440	45
e	205	240	60
f	200	240	90
g	220	240	90

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	685	850	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	15	15	A
peak	I_{a_p}	max.	90	75	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	900	750	A
Protecting resistance	R_t	min.	0.2	0.2	Ω
Mercury temperature	t_{Hg}	min.	30	30	°C
		max.	80	75	°C
Ambient temperature	t_{amb}	min.	10	10	°C
		max.	50	45	°C

7Z2 7609

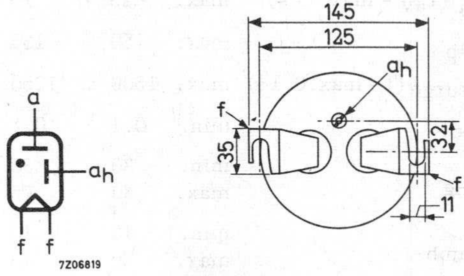
SINGLE ANODE RECTIFYING TUBE

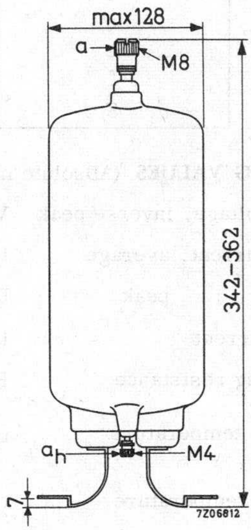
Mercury vapour and gasfilled single anode rectifying tube intended for use in industrial rectifiers 25 A each tube, max. 110 Pb-cells.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	60	A
Waiting time	T_W	2	min [1])

MECHANICAL DATA





Mounting position: vertical, base down

Net weight: 1060 g

[1]) See page 2.

7Z2 7610

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ignition voltage	V_{ign}	28	V

In order to obtain the above-mentioned ignition voltage of 28 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (−). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl. dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	275	230	50
b	540	440	50
c	220	240	75
d	210	440	75
e	205	240	100
f	200	250	150
g	220	240	150

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	685	850	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	25	25	A
peak	I_{a_p}	max.	150	135	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	1500	1250	A
Protecting resistance	R_t	min.	0.1	0.1	Ω
Mercury temperature	t_{Hg}	min.	30	30	°C
		max.	80	75	°C
Ambient temperature	t_{amb}	min.	10	10	°C
		max.	50	45	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7611

DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gasfilled double anode rectifying tube intended for use in magnetic chucks 3 A each tube.

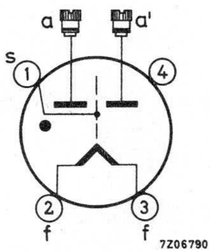
HEATING: direct by A.C., oxide coated filament

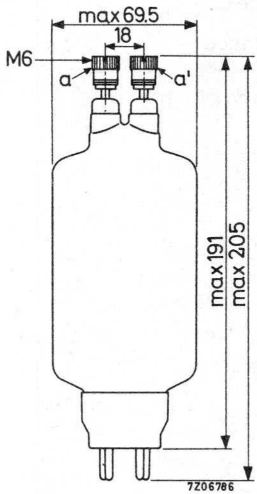
Filament voltage	V_f	1.9	V
Filament current	I_f	8	A
Waiting time	T_W	30	s [1])

MECHANICAL DATA

Dimensions in mm

Base: W





The screen s must be connected to the cathode via a resistor of 10 kΩ, 0.5 W.

Socket: 40221

Mounting position: vertical, base down

Net weight: 170 g

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[1]) Recommended value. If urgently wanted this value may be decreased to 15 sec.

7Z2 7612

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10 V
Ignition voltage	V_{ign}	22 V

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	150 V_{RMS}
D.C. voltage	V_o	110 V
D.C. current	I_o	3 A

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	470	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	1.5	A
peak	I_{ap}	max.	9	A
Protecting resistance	R_t	min.	2.5	Ω
Mercury temperature	t_{Hg}	min.	30	^{o}C
		max.	80	^{o}C

7Z2 7613

DOUBLE ANODE RECTIFYING TUBE

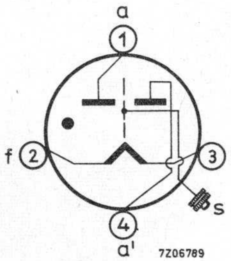
Gasfilled double anode rectifying tube intended for use in magnetic chucks 1.3 A each tube.

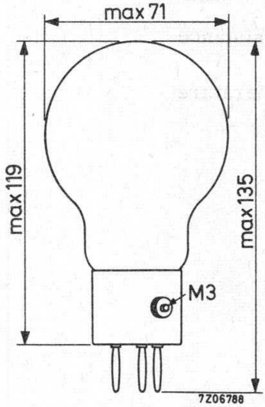
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	3.5	A
Waiting time	T_w	15	s [1])

MECHANICAL DATA Dimensions in mm

Base: A





The screen s must be connected to the cathode via a resistor of 10 kΩ, 0.5 W.

Socket: 40465

Mounting position: vertical, base down

Net weight: 75 g

[1]) Recommended value. If urgently wanted this value may be decreased to 0 sec.

7Z2 7614

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	22	V

OPERATING CHARACTERISTICS

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	150	V_{RMS}
D.C. voltage	V_o	110	V
D.C. current	I_o	1.3	A

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{invp}}$	max.	470	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	0.65	A
peak	I_{a_p}	max.	4	A
Protecting resistance	R_t	min.	5	Ω
Ambient temperature	t_{amb}	min.	-55	°C
		max.	+75	°C

7Z2 7615

DOUBLE ANODE RECTIFYING TUBE

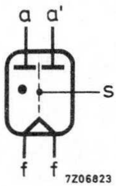
Mercury vapour and gasfilled double anode rectifying tube intended for use in battery chargers 15 A each tube, max. 36 Pb-cells.

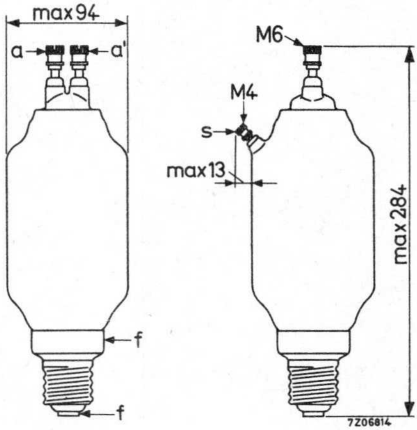
HEATING: direct by A.C., oxide-coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	18	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm

Base: Goliath





The screen s must be connected to the cathode via a resistor of 10 kΩ, 0.5 W.

Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 370 g

[1]) See page 2.

7Z2 7638

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	20	V

LIMITING VALUES (Absolute max. rating system)

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	max.	95	V_{RMS}
		min.	20	V_{RMS}
Anode voltage, inverse peak	$V_{a_{inv_p}}$	max.	300	V
Anode current, average	I_a	max.	7.5	A
peak	I_{a_p}	max.	45	A
Protecting resistance	R_t	min.	0.2	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

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1) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes.

7Z2 7639

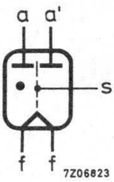
DOUBLE ANODE RECTIFYING TUBE

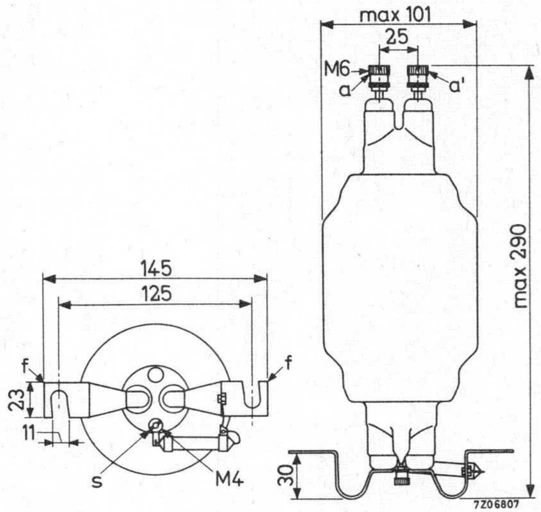
Mercury vapour and gasfilled double anode rectifying tube intended for use in cinema rectifiers 25 A each tube, max. 36 Pb-cells.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	25	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm





The screen s is connected to the cathode via a resistor.

Mounting position: vertical, base down

Net weight: 600 g

1) See page 2.

7Z2 7616

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	22	V

LIMITING VALUES (Absolute max. rating system)

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	max.	95	V_{RMS}
		min.	30	V_{RMS}
Anode voltage, inverse peak	V_{ainv_p}	max.	300	V
Anode current, average	I_a	max.	12.5	A
peak	I_{a_p}	max.	75	A
Protecting resistance	R_t	min.	0.1	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes.

7Z2 7617

DOUBLE ANODE RECTIFYING TUBE

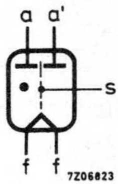
Mercury vapour and gasfilled double anode rectifying tube intended for use in battery chargers 10 A each tube, max. 36 Pb-cells.

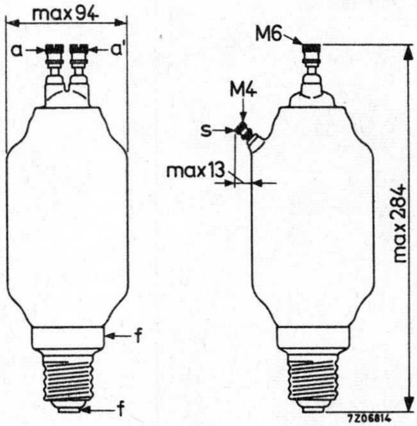
HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	11	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm

Base: Goliath





The screen s must be connected to the cathode via a resistor of 10 kΩ, 0.5 W.

Socket: 65909 BG/01

Mounting position: vertical, base down

Net weight: 350 g

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[1]) See page 2.

7Z2 7618

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	9	V
Ignition voltage	V_{ign}	22	V

LIMITING VALUES (Absolute max. rating system)

Circuit: a (See Application directions)

Transformer voltage	V_{tr}	max.	95	V_{RMS}
		min.	20	V_{RMS}
Anode voltage, inverse peak	V_{ainv_p}	max.	300	V
Anode current, average	I_a	max.	5	A
peak	I_{a_p}	max.	30	A
Protecting resistance	R_t	min.	0.3	Ω
Mercury temperature	t_{Hg}	min.	30	^oC
		max.	80	^oC

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[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes.

7Z2 7619

DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gasfilled double anode rectifying tube intended for use in cinema rectifiers 15 A each tube.

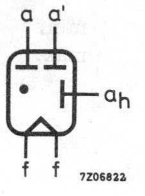
HEATING: direct by A.C., oxide-coated filament

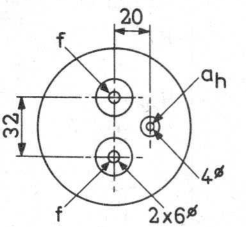
Filament voltage	V_f	1.9	V
Filament current	I_f	21.5	A
Waiting time	T_w	2	min [1])

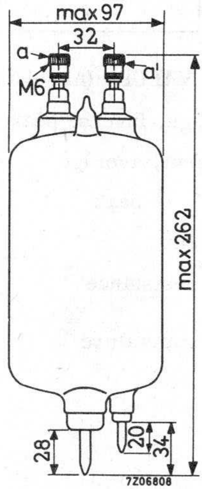
MECHANICAL DATA

Dimensions in mm

Base: Spec. 3p







Socket: 1285

Mounting position: vertical, base down

Net weight: 500 g

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[1]) See page 2.

7Z2 7620

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	22	V

In order to obtain the above-mentioned ignition voltage of 22 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (-). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl. dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	115	85	15
e	115	120	30
f	105	120	45
g	115	110	45

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	360	V
Anode current, average	I_a (T_{av} = max. 5 s)	max.	7.5	A
peak	I_{ap}	max.	45	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	375	A
Protecting resistance	R_t	min.	0.25	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7621

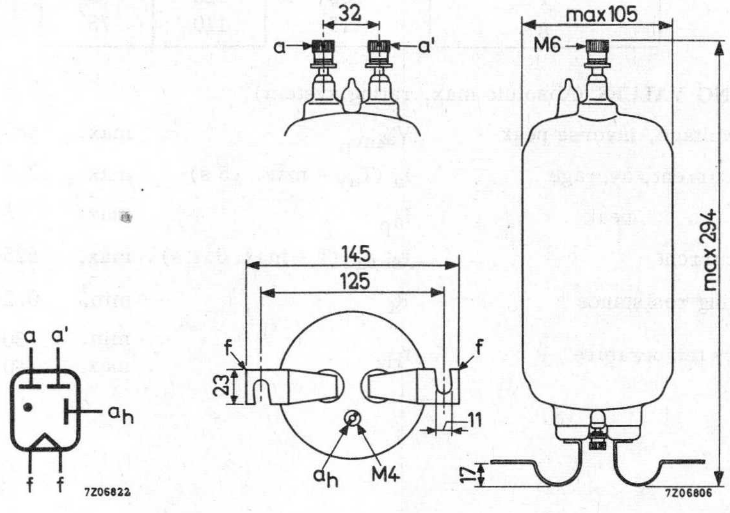
DOUBLE ANODE RECTIFYING TUBE

Mercury vapour and gasfilled double anode rectifying tube intended for use in cinema rectifier 25 A each tube.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	29	A
Waiting time	T_w	2	min [1]

MECHANICAL DATA Dimensions in mm



Mounting position: vertical, base down

Net weight: 600 g

[1]) See page 2. 7Z2 7622

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	10	V
Ignition voltage	V_{ign}	22	V

In order to obtain the above-mentioned ignition voltage of 22 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (-). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl.dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	115	85	25
e	115	120	50
f	105	120	75
g	115	110	75

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	V_{ainv_p}	max.	360	V
Anode current, average	I_a (T_{av} = max. 15 s)	max.	12.5	A
peak	I_{ap}	max.	75	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	625	A
Protecting resistance	R_t	min.	0.2	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_W = 5 minutes.

7Z2 7623

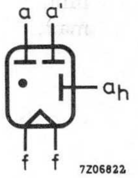
DOUBLE ANODE RECTIFYING TUBE

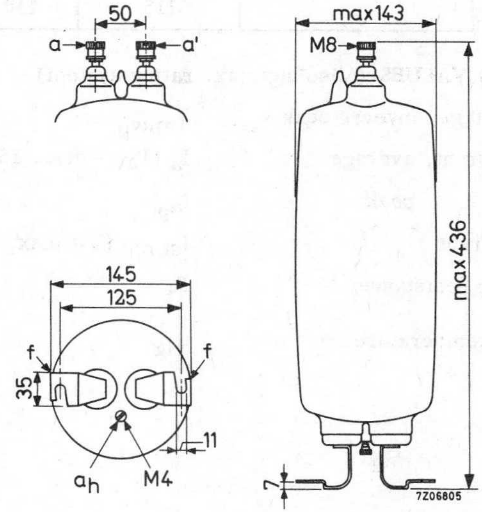
Mercury vapour and gasfilled double anode rectifying tube intended for use in cinema rectifiers 50 A each tube.

HEATING: direct by A.C., oxide coated filament

Filament voltage	V_f	1.9	V
Filament current	I_f	60	A
Waiting time	T_w	2	min [1])

MECHANICAL DATA Dimensions in mm





Mounting position: vertical, base down

Net weight: 1650 g

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[1]) See page 2.

7Z2 7624

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ignition voltage	V_{ign}	28	V

In order to obtain the above-mentioned ignition voltage of 28 V, an auxiliary D.C. supply unit delivering min. 40 V, 10 mA power, should be connected via a current-limiting resistor to the auxiliary ignition electrode a_h (+) and to the cathode (–). The Philips Auxiliary Ignition Unit type 1289 is recommended for this purpose.

OPERATING CHARACTERISTICS

Circuit See Appl. dir.	V_{tr} (V_{RMS})	V_o (V)	I_o (A)
a	115	85	50
e	115	120	100
f	105	120	150
g	115	110	150

LIMITING VALUES (Absolute max. rating system)

Anode voltage, inverse peak	$V_{a_{inv_p}}$	max.	360	V
Anode current, average	I_a (T_{av} = max. 15 s)	max.	25	A
peak	I_{a_p}	max.	150	A
Surge current	I_{surge} (T = max. 0.1 s)	max.	1250	A
Protecting resistance	R_t	min.	0.1	Ω
Mercury temperature	t_{Hg}	min.	30	°C
		max.	80	°C

[1]) Recommended value. If urgently wanted this value may be decreased to 1 min. In order to obtain a suitable time delay use can be made of the time delay switch type 4152. After transport or after a long interruption of service T_w = 5 minutes.

7Z2 7625

Ignitrons

APPLICATION DIRECTIONS
IGNITRONS

The following instructions and recommendations are generally applicable to all ignitron types. When there are variations for a particular type of tube, specific recommendations are given on the appropriate data sheets.
The absolute maximum rating system is used for ignitrons.

MOUNTING

Ignitrons must be mounted vertically to within $\pm 3^{o}$ the cathode terminal facing downwards. The tubes should be mounted so that the leads and supporting members do not impose stresses on the metal-to-glass seals.
The cross-section of the tube supports should be sufficient to bear the weight of the tube and to carry the required current.
The tube cathode connection must be fixed to its support by means of steel bolts, which should be well tightened.
The anode cable must be fixed to the corresponding terminal on the apparatus using a steel bolt.
Where applicable the anode cable must also be connected to the tube lead-in with a steel bolt using two wrenches.
A check should be made periodically to ensure that the bolts are securely fixed and the contact surfaces still clean. This must be done in any case after the first few hours of operation following the installation of a new tube. Discolouration of the contact area is indicative of a poor contact.

In making the cathode and ignitor connections, care should be taken not to damage the ignitor lead-in. It is recommended to use the ignitor cable supplied by the manufacturer.

Ignitrons are mechanically strong and will withstand moderate shocks. Operation will be most stable however, if they are protected against shock and vibration which would disturb the surface of the mercury pool and tend to change the tube operating characteristics.
Ignitrons must be shielded against strong R.F. and magnetic fields.

7Z2 8336

WATER COOLING

The cooling water must satisfy the following requirements as regards the content of solids and soluble chemicals:

1. pH 7 to 9
2. Max. weight of chlorides per litre 15 mg.
   Max. weight of nitrates per litre 25 mg.
   Max. weight of sulphates per litre 25 mg.
3. Max. weight of insoluble solids per litre 25 mg.
4. Total hardness per litre max. 10 German degrees/18 French degrees/12.5 English degrees/10.5 US degrees.
5. Specific resistance min. 2000 Ωcm.

In most cases tap-water will satisfy these requirements. If the water locally available is unsuitable a system of cooling employing a heat exchanger with sufficient suitable water in circulation can alternatively be used.
The temperature of the cooling water should be at least 10 ^{o}C.
The water-hoses must be of electrically insulating material and should be connected to the ignitrons so that the water enters the water jacket at the bottom and leaves it at the top. Up to 3 tubes may be cooled in series. The hoses should have a length of at least 50 cm in order to ensure that the electrical resistance of the internal water column is sufficiently high. They should be fixed by means of clamps to the hose nipples, care being taken that no leakage can occur. The water must be allowed to flow freely from the last tube into a funnel, which enables the water flow to be easily checked and prevents the water pressure in the jackets from becoming excessive. The water pressure in the tube jackets should never exceed 3.5 atm (50 pounds/square inch).

The water jackets of ignitrons are normally connected to the mains and thus have mains potential to earth. When thermostatic switches are used they must therefore be capable of withstanding this operating voltage. Should the thermostat not be rated for mains voltages an isolating step-down transformer can be used to protect it from damage.
The tubes should not be put into operation until all air is removed from the cooling system and filling completed. This is indicated by water flowing from the outlet pipe on the last tube.
The cooling system should be installed so that the water jackets are not emptied by the water flowing or syphoning away. As an aid to ensuring that the tubes have been correctly installed a useful test is to momentary close the stop valve after filling and check that after a brief interval the outflow of water ceases. A continuous flow of water when the stop valve is closed is evidence of faulty installation and may result in the tubes being completely drained when the equipment is finally shut down. When recommencing operations unless an interval is allowed for refilling this may endanger the tubes.

7Z2 8337

Important note

In the tube data, ratings are given for the required waterflow as a function of the average tube current and water inlet temperature. It is often more economical to use continuous water cooling according to the reduced cooling ratings rather than a water saving thermostat and solenoid valve. This enables a more constant tube temperature to be obtained which, moreover improves the life expectancy of the tube.

TUBE PROTECTION

Care must be taken to ensure that the prescribed temperature limits of ignitrons are never exceeded. When the tubes are cooled with tapwater the temperature of which remains within the rated limits, it is generally sufficient to ensure that an adequate quantity of water flows through the jacket. To prevent the temperature of the tubes becoming excessive in the event of a failure of the water supply, e.g.: stopped-up or defective hoses, insufficient pressure of the water mains, accidentally closed main cock etc. a protecting thermostat should be used. If the temperature limit set by the protecting thermostat is exceeded either the ignition circuits of the ignitrons are interrupted or the main circuit breaker is tripped by means of a relay. The protecting thermostat, which should be mounted on the last tube of a series, should not actuate its relay under normal operating conditions.
In a three phase welding service using 6 tubes it is recommended that not more than 3 tubes are connected hydraulically in series for cooling purposes. When ignitrons are used for heavy power switching at a high duty factor the internal tube temperature rises very rapidly. Under such conditions it is advisable for the cooling water to circulate through the jackets as soon as the master switch is closed.

Note

When ignitrons are used as rectifiers with the cathode not at earth potential, an electrolytic erosion target connected to the metal envelope may be used to avoid corrosion of tube parts.

SWITCHING

Before firing and during operation the anode and lead-in insulator should always be at a higher temperature than the cooling water. If necessary, a suitable heating device can be used to maintain the required temperature difference.

Care must be taken not to touch live parts, such as the water jackets which are at full line voltage. Some tube types have a plastic-coated water jacket which can withstand voltages up to 3 kV. With this type water condensation on the jacket is kept to a minimum under conditions of high humidity and low cooling water temperature. The uncoated tube parts are at full line voltage.

7Z2 8338

To prevent mercury from re-condensing on the anode and the anode insulator when the installation is switched off, the cooling water should be allowed to flow through the tubes so that all internal parts are evenly cooled down; this normally takes from 15 to 30 minutes.

Incompletely cooled tubes must always be kept with the anode connection uppermost.

Mercury may also condense on the anode insulator as a result of cold air draught in the vicinity of the tube. It is then necessary either to prevent the occurence of the air flow or to ensure that the anode and anode insulator are not cooled down to a temperature below that of the cooling water.

SPARE TUBES

In order to have some tubes available in a ready-for-use condition it is advisable to place an adequate number of tubes with the anodes uppermost under a lighted incandescent lamp. The heat produced by the lamp is sufficient to remove any mercury deposits on the anode insulator.

TUBE RATINGS

Parameters of the particular ignitron type are the demand and max. average currents.

The demand current is the total permissible current which an ignitron contactor can handle in a single-phase control system (acting as a power switch). It is equal to the product of the R.M.S. value of line voltage and contactor current.

The max. average current is valid for a limited demand (or peak current) only. For higher demands or higher peak currents the permissible average current must be reduced as indicated on the particular derating curve.

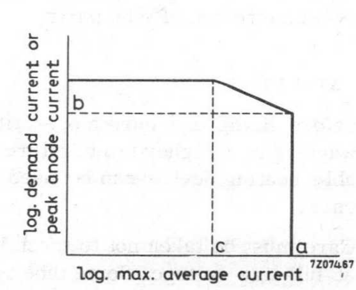
The longest time over which the max. average current may be calculated is the max. averaging time.

Diagram showing the relationship between max. average anode current and demand or peak anode current respectively:

a) Max. average anode current for lower demand or peak currents.

b) Demand (peak current) up to which this value applies.

c) Max. average current at max. demand or peak current.



7Z2 8339

All data assumes full cycle conduction with an equally distributed load on all ignitrons, regardless of whether phase control is used.
The load must be limited so that at zero phase delay no overload will result.
The parameters of a particular ignitron give the derived values, depending on line voltage. The parameters may be calculated as follows:

1) Demand current: $I_{RMS} = \frac{P\ (kVA)}{V\ (V_{RMS})} \cdot 1000\ (A_{RMS})$ — P = demand, V = line voltage

2) Max. duty factor: $\delta = 2.22 \frac{I_{AV}}{I_{RMS}} \cdot 100\ (\%)$ — I_{AV} = max. av. current

3) Max. number of cycles within max. averaging time:

$$n = f \cdot \frac{\delta}{100} \cdot T_{AVmax}$$ f = mains frequency

4) Integrated R.M.S. load current:

$$I_F = I_{RMS} \cdot \sqrt{\frac{\delta}{100}}\ (A_{RMS})$$

The tube parameters are tabulated for every ignitron type at several values of mains voltage.

IGNITOR RATINGS

The ignitor of an ignitron should never carry a negative current, i.e. current resulting from the ignitor being negative with respect to cathode.
The possibility of this occuring can be avoided by incorporating a rectifying element in the ignitor circuit.
The ignitor current and voltage required to ensure reliable firing of the tube is given on the ignitron data sheet. In addition, maximum limiting values are quoted which must not be exceeded.

IGNITION CIRCUITS

Two types of excitation are in common use:

A. Self (anode) excitation used in single phase resistance welding and similar applications.
B. Separate excitation used in all other applications.

Typical examples are given in fig.1 (self excitation) and fig.2 (separate excitation).
For both circuits two fuses, F_1 and F_2 are recommended.
F_1 safeguards the ignition circuit; F_2 is connected directly in series with the ignitor, protecting it against shorting between the main anode and ignition circuits.

7Z2 8340

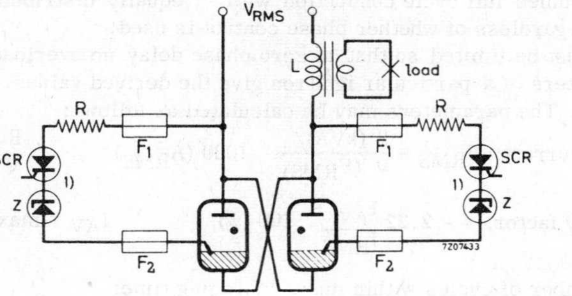


Fig.1

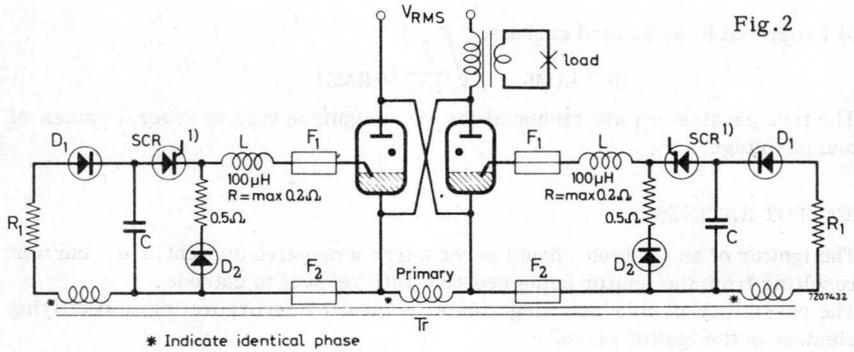


Fig.2

The ignitor must be connected to its control circuit by a screened lead which affords protection against R.F. fields. It is inadvisable to operate separate excitation in the absence of anode mains voltage.

A. Anode excitation (fig.1)

The "Ignitor voltage required to fire", must not be interpreted as the instantaneous value of mains voltage at the instant of ignition, but as the voltage measured between the ignitor lead-in and cathode. The values of the resistors in the ignition circuit and the level of supply voltage should be chosen so that the prescribed value of voltage is applied to the ignitor.
Recommended values of R are given in the data sheets. Deviations from these recommended values may impair the performance of the tube.
To ensure a short and reproducible delay between the firing of the ignitor and anode take-over, the rate of rise of ignition current must be sufficiently high. The current rise time is mainly determined by the reactance of the load and at high load reactances it may be too small for proper ignition. In such circumstances separate excitation can be successfully used.

7Z2 8341

B. Separate excitation (fig.2)

With separate excitation ignition of the ignitron is independent of the anode circuit parameters. This method is therefore suitable for rectifiers and for A.C. control circuits where the available voltage at the desired ignition angle is, or is very nearly, below the required minimum value for reliable firing.

AUXILIARY ANODE CIRCUIT

When a rectifier feeds a load which generates a back e.m.f., the available voltage between the main anode and cathode will often be insufficient to ensure takeover of the arc discharge when the tube is fired. Moreover, if the ignition current is too small, the main discharge may cease prematurely.
For this reason ignitrons designed for use in rectifying equipment are provided with an auxiliary anode which maintains the arc discharge during the period when the main anode voltage falls below the minimum value necessary for continued conduction of the tube. The auxiliary anode should be connected to a low voltage A.C. source so that auxiliary anode current flows throughout tube conduction.

MAIN CIRCUIT

When the main discharge of an ignitron is interrupted voltage transients are produced in the transformer primary due to its self-inductance, which may puncture the insulation of the transformer.
In resistance welding circuits the transients may be reduced by a damping resistor mounted across the transformer primary terminals. The values of the current drawn by this resistor are determined by the duty factor of the machine.
In rectifier circuits damping is obtained by a series R.C. circuit shunted across the transformer primary.
Cathode and/or anode breakers are usually required in addition to the supply switches, particularly when back e.m.f.'s are present.

7Z2 8342

IGNITRON

B size ignitron intended for use in single-phase and three-phase resistance welding control and similar A.C. control appplications.

The tube has a stainless steel water cooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA		
Maximum demand power (two tubes in inverse parallel)	600	kVA
Maximum average current	56	A
Ignitor voltage	max. 200	V
Ignitor current	max. 12	A

MECHANICAL DATA

Dimensions and connections	see page 2
Net weight	1420 g
Shipping weight	2040 g
Mounting position	vertical $\pm 3^{o}$, anode connection up

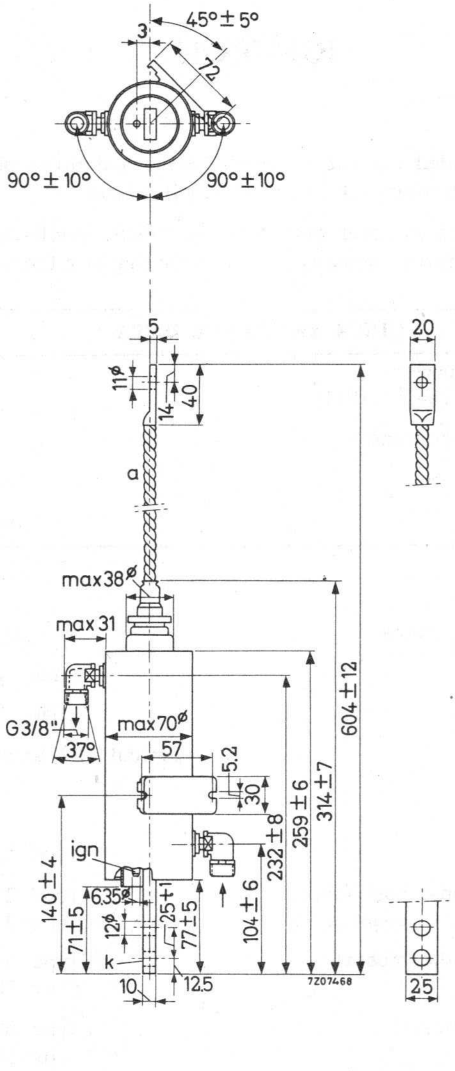
Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Overload protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8273

DIMENSIONS AND CONNECTIONS

Dimensions in mm



7Z2 8274

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 3 l/min)	p_i	max.	0.1	kg/cm^2
Temperature rise at max. average current (q = 3 l/min)	$t_o - t_i$	max.	5	^{o}C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page A)	q	min.	3	l/min
Inlet temperature [1]	t_i	min.	10	^{o}C
		max.	40	^{o}C
Temperature of thermostat mount [2]	t_m	max.	50	^{o}C

Intermittent rectifier service or three-phase welding service

Required water flow at max. average current (See also page A)	q	min.	3	l/min
Inlet temperature [1]	t_i	min.	10	^{o}C
		max.	35	^{o}C
Temperature of thermostat mount [2]	t_m	max.	45	^{o}C

Pulse service

Under conditions of pulse service with low average load (less than 1 A) continuous cooling is normally not required. The cooling jacket can e.g. be permanently filled with oil.
Care should be taken to prevent condensation of mercury at the anode or glass seal. See also "Application directions ignitrons".

Recommended condensed mercury temperature	t_{Hg}	25 to 30	^{o}C

[1]) When a number of tubes is cooled in series, $t_{i\,min}$ refers to the coldest tube and $t_{i\,max.}$ to the hottest tube.

[2]) WARNING. The thermostat mount is at full line voltage
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8275

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.

The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection

Table I. See also pages B, C and E.

Mains frequency range	f	25 to 60					Hz
Mains voltage	V	220 1)	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	18	18	11.8	9	7.5	s
A. Max. demand power							
Max. demand power	P_{max}	530	600	600	600	600	kVA
Corresponding max. average current	I_{av}	30.2	30.2	30.2	30.2	30.2	A
Demand current	I_{RMS}	2400	2400	1600	1200	1000	A_{RMS}
Duty factor	δ	2.8	2.8	4.2	5.6	6.7	%
Number of cycles within T_{av} max. 2)	n	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	I_F	400	400	320	280	260	A_{RMS}
B. Max. average current							
Max. average current	I_{av} max	56	56	56	56	56	A
Corresponding max. demand power	P	180	200	200	200	200	kVA
Demand current	I_{RMS}	800	800	530	400	330	A_{RMS}
Duty factor	δ	15.6	15.6	23.5	31.1	37.7	%
Number of cycles within T_{av} max. 2)	n	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	I_F	320	320	260	220	200	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	6700	6700	4500	3400	2800	A

1) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

2) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time: n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8276

LIMITING VALUES (Absolute max. rating system; continued)

Intermittent rectifier service or frequency changer resistance welding service

Mains frequency range	f	50 to 60		Hz
Anode voltage, forward peak	$V_{a\,fwd_p}$ max	1200	1500	V
inverse peak	$V_{a\,inv_p}$ max	1200	1500	V
A. Max. peak current				
Anode current, peak	I_{a_p} max.	600	480	A
Corresponding average current	I_{av}	5	4	A
B. Max. average current				
Anode current, average	I_{av} max.	22.5	18	A
Corresponding peak	I_{a_p}	135	108	A
Averaging time	T_{av} max	10	10	s
Ratio I_a/I_{ap} (T_{av} = max. 0.5 s)	I_a/I_{a_p} max	1/6	1/6	
Ratio I_{surge}/I_{ap} (T_{max} = 0.15 s)	I_{surge}/I_{ap} max	12.5	12.5	

Pulse service

Under certain conditions this ignitron may be used to switch aperiodic current pulses to a very high value (up to 50 kA) and voltages up to 10 kV. The performance depends on the circuit in which the tube is used. The manufacturer should be consulted.

7Z2 8277

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage, forward peak	V_{igp}	max.	2000	V
inverse peak (including any transients)	$-V_{igp}$	max.	5	V
Ignitor current, forward peak	I_{igp}	max.	100	A
inverse peak	$-I_{igp}$	max.	0	A
forward RMS	I_{igRMS}	max.	10	A
forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max.	200	V
Firing current	I_{ign}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ign}	max.	100	µs[1]

Ignition circuit requirements

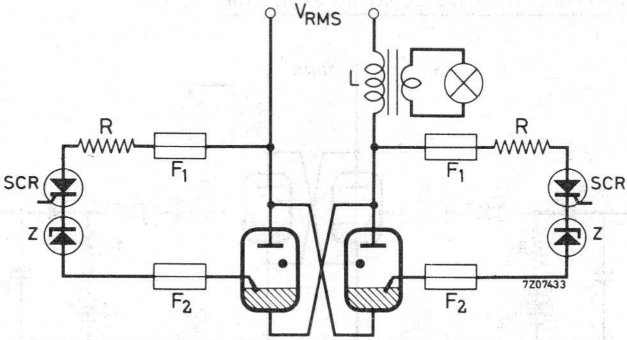
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dt	min.	0.1	A/µs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

7Z2 8278

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

Recommended circuits for anode excitation



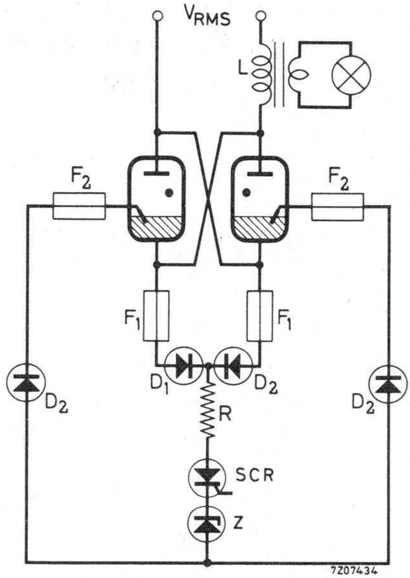
Anode excitation with individual thyristors

V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage $\geq$ 18 V



Anode excitation with common thyristor

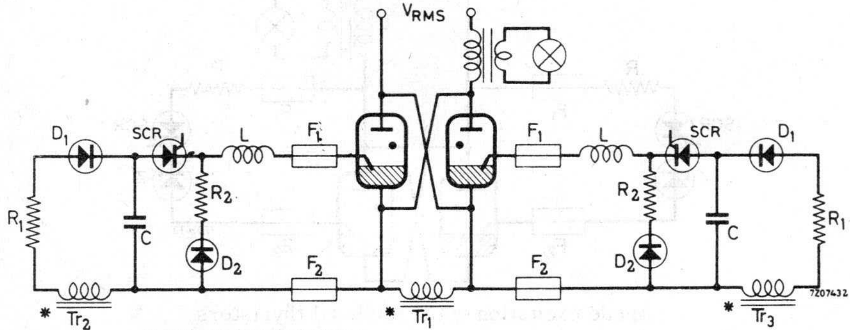
[1]) The thyristor-zener diode combination may be substituted by a thyratron.

7Z2 8279

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

B. Separate excitation

Recommended circuit for separate excitation

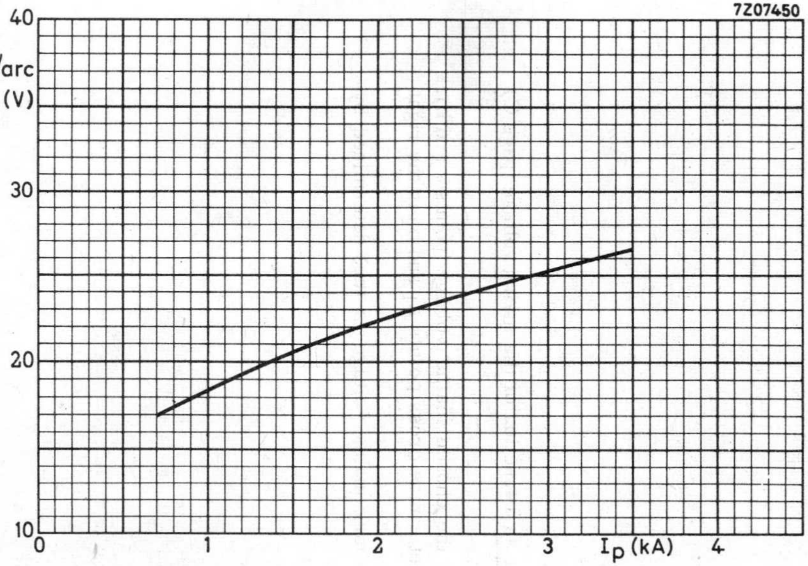


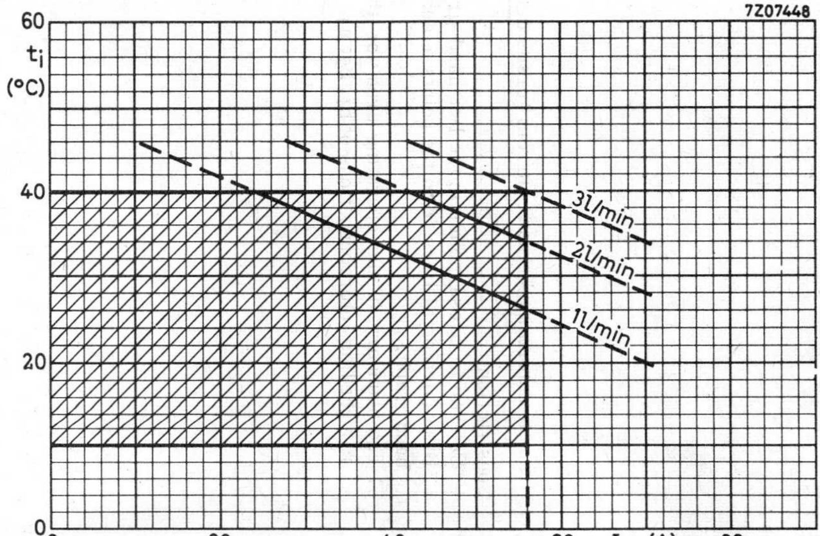
Capacitor value	C	2	μF
Capacitor voltage	V_C	650	V ±10%
Peak value of closed circuit current		80 to 100	A

---

1) The thyristor may be substituted by a thyratron.

7Z2 8280





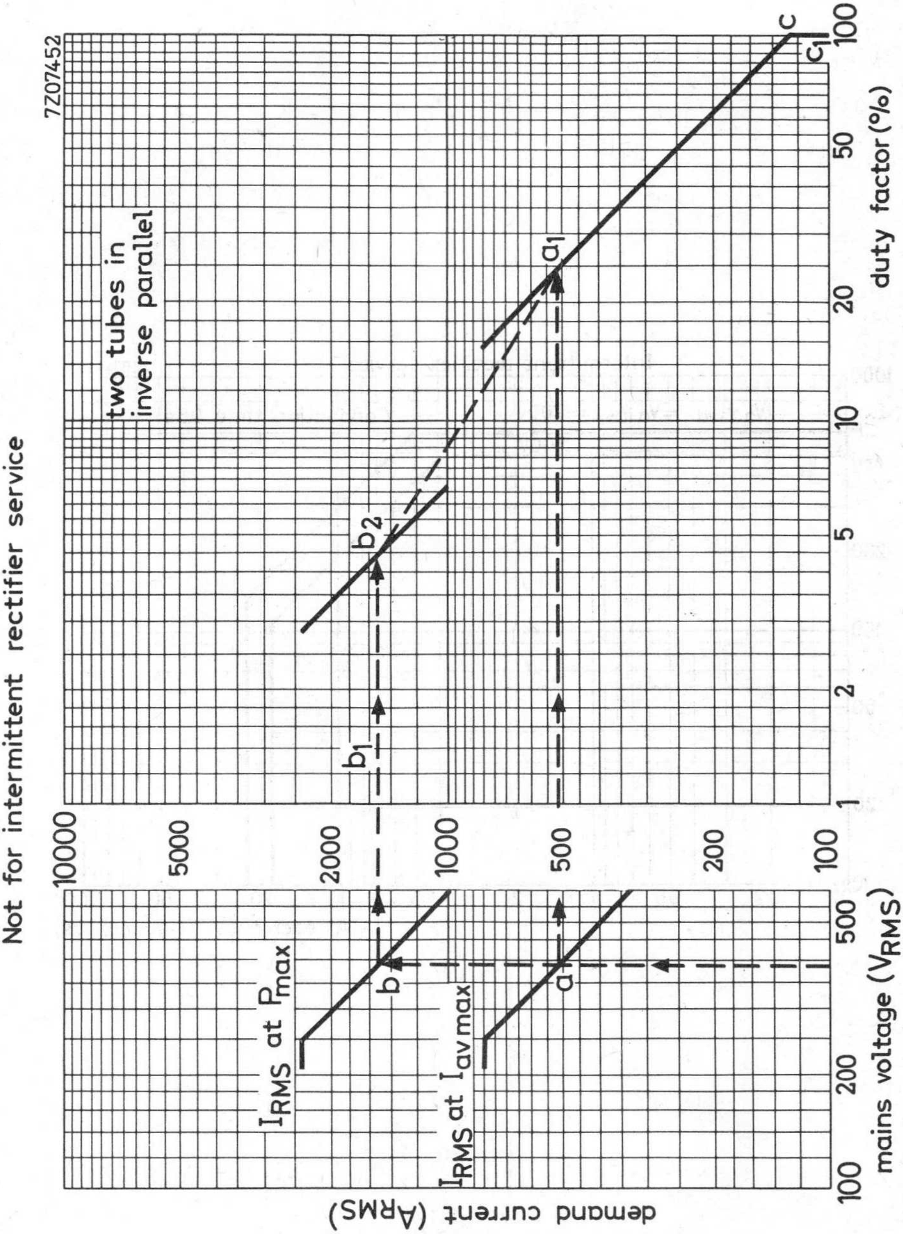
Minimum required continuous waterflow (two tubes cooled in series)

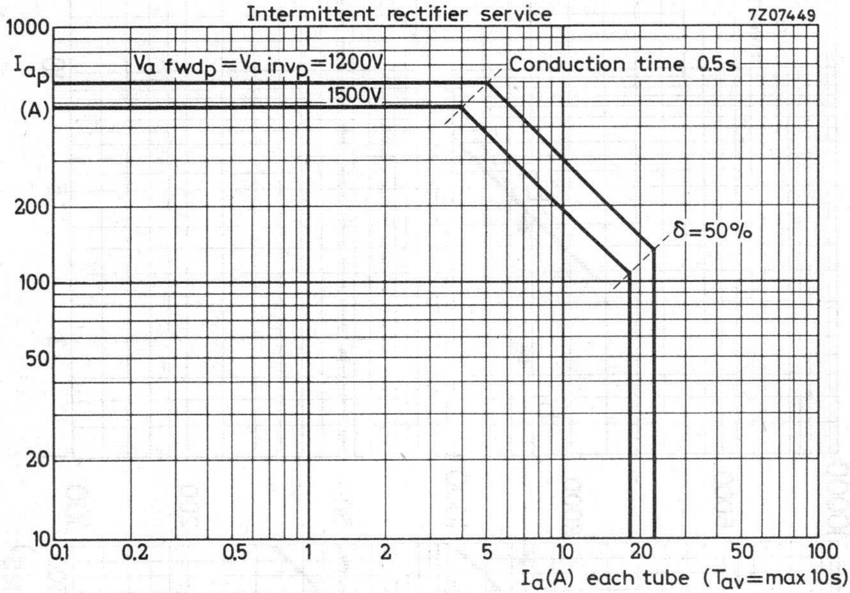
Graph to determine demand current versus duty factor as a function of the mains voltage (page C)

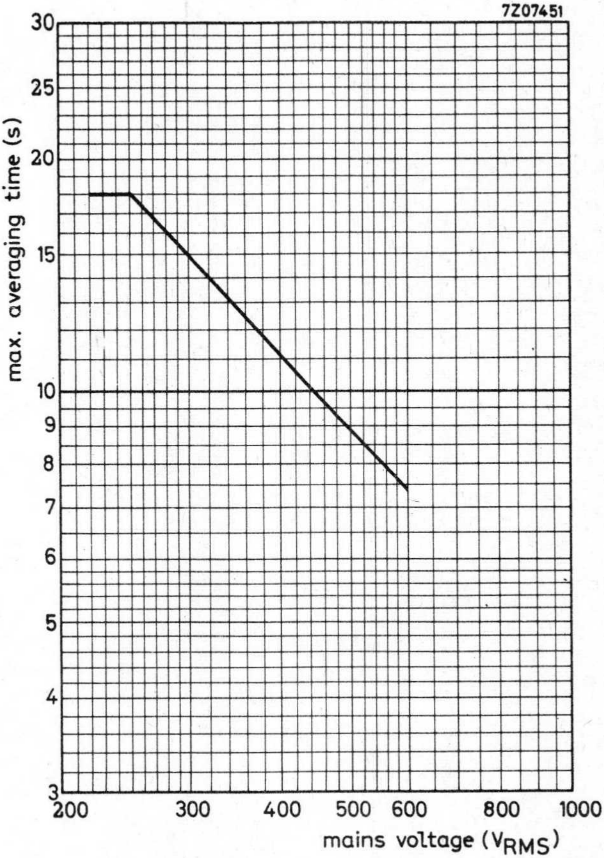
Construction:

1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

7Z2 8330


Not for intermittent rectifier service
7Z07452
two tubes in
inverse parallel
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1
demand current (A_{RMS})
10000
5000
2000
1000
500
200
100
mains voltage (V_{RMS})
100
200
500
duty factor (%)
1
2
5
10
20
50
100


Intermittent rectifier service
7Z07449
1000
I_{a_p}
(A)
$V_a\ fwd_p = V_a\ inv_p = 1200V$
1500V
Conduction time 0.5s
200
100
δ=50%
50
20
10
0,1
0,2
0,5
1
2
5
10
20
50
100
I_a(A) each tube (T_{av}=max 10s)


7Z07451
30
25
20
15
10
9
8
7
6
5
4
3
max. averaging time (s)
200
300
400
500
600
800
1000
mains voltage (V_{RMS})

IGNITRON

C size ignitron intended for use in single-phase resistance welding control and similar A.C. control applications.

The tube has a stainless steel watercooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel)		1200	kVa
Maximum average current		140	A
Ignitor voltage	max.	200	V
Ignitor current	max.	12	A

MECHANICAL DATA

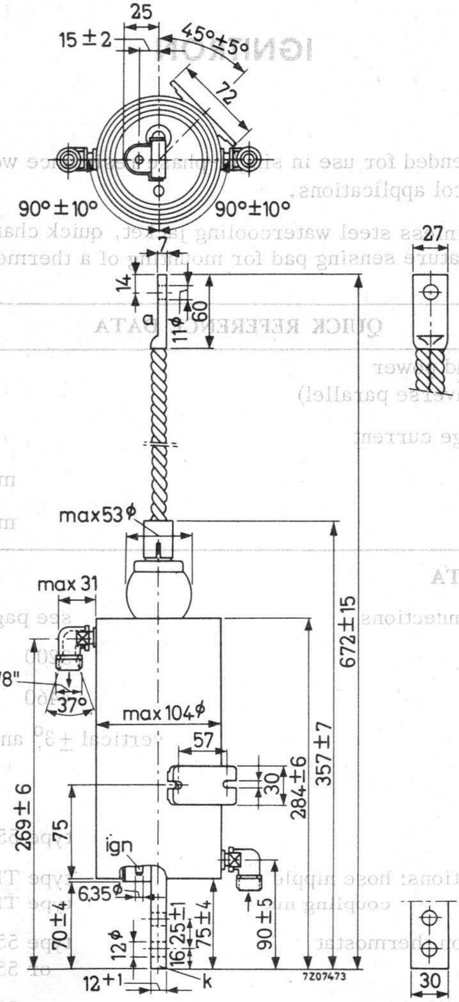
Dimensions and connections	see page 2
Net weight	3200 g
Shipping weight	4460 g
Mounting position	vertical $\pm 3^{o}$, anode connection up

Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Over load protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8281

DIMENSIONS AND CONNECTIONS Dimensions in mm



7Z2 8282

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 6 l/min)	p_i	max.	0.2 kg/cm^2
Temperature rise at max. average current (q = 6 l/min)	$t_o - t_i$	max.	4 °C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page C)	q	min.	6 l/min.
Inlet temperature [1]	t_i	min.	10 °C
		max.	40 °C
Temperature of thermostat mount [2]	t_m	max.	50 °C

Pulse service

Under conditions of pulse service with low average load (less than 1 A) continuous cooling is normally not required. The cooling jacket can e.g. be permanently filled with oil.
Care should be taken to prevent condensation of mercury at the anode or glass seal. See also "Application directions Ignitrons"

Recommended condensed mercury temperature	t_{Hg}	25 to 30 °C

[1]) When a number of tubes is cooled in series, $t_{i\ min}$ refers to the coldest tube and $t_{i\ max.}$ to the hottest tube.

[2]) WARNING. The thermostat mount is at full line voltage.
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8283

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.
The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection

Table I. See also pages A, B and D.

Mains frequency range	f	25 to 60					Hz
Mains voltage	V	220[1]	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	14	14	9.4	7	5.8	s
A. Max. demand power							
Max. demand power	P_{max}	1060	1200	1200	1200	1200	kVA
Corresponding max. average current	I_{av}	75.6	75.6	75.6	75.6	75.6	A
Demand current	I_{RMS}	4800	4800	3150	2400	2000	A_{RMS}
Duty factor	δ	3.5	3.5	5.3	7.0	8.4	%
Number of cycles within T_{av} max. [2]	n	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	I_F	900	900	720	630	580	A_{RMS}
B. Max. average current							
Max. average current	I_{av} max	140	140	140	140	140	A
Corresponding max. demand power	P	350	400	400	400	400	kVA
Demand current	I_{RMS}	1600	1600	1050	800	660	A_{RMS}
Duty factor	δ	19.4	19.4	29.5	39.0	47.0	%
Number of cycles within T_{av} max. [2]	n	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	I_F	700	700	570	500	450	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	13.5	13.5	9.0	6.7	5.6	kA

[1]) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

[2]) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time:
n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8284

ELECTRICAL DATA

Pulse service

Under certain conditions this ignitron may be used to switch aperiodic current pulses to a very high value (up to 100 kA) and voltages up to 10 kV. The performance depends on the circuit in which the tube is used. The manufacturer should be consulted.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{ig_p}	max.	2000	V
	inverse peak (including any transients)	$-V_{ig_p}$	max.	5	V
Ignitor current,	forward peak	I_{ig_p}	max.	100	A
	inverse peak	$-I_{ig_p}$	max.	0	A
	forward RMS	I_{igRMS}	max.	10	A
	forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max.	200	V
Firing current	I_{ign}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ign}	max.	100	μs [1]

Ignition circuit requirements

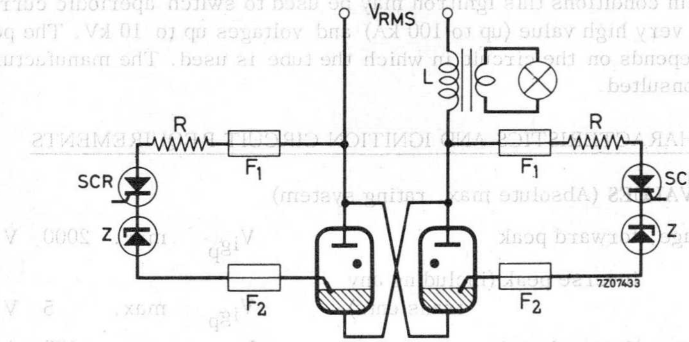
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dt	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

7Z2 8285

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

Recommended circuits for anode excitation



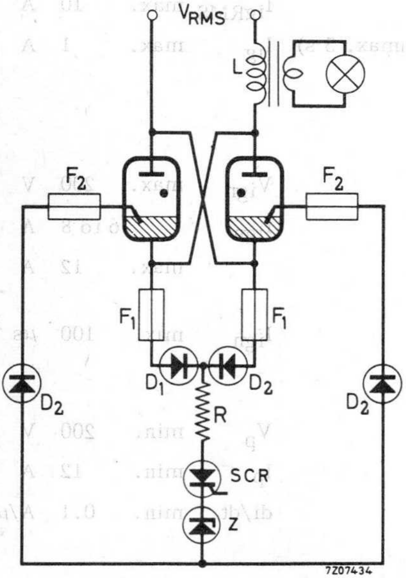
Anode excitation with individual thyristors

V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage ≥ 18 V



Anode excitation with common thyristor

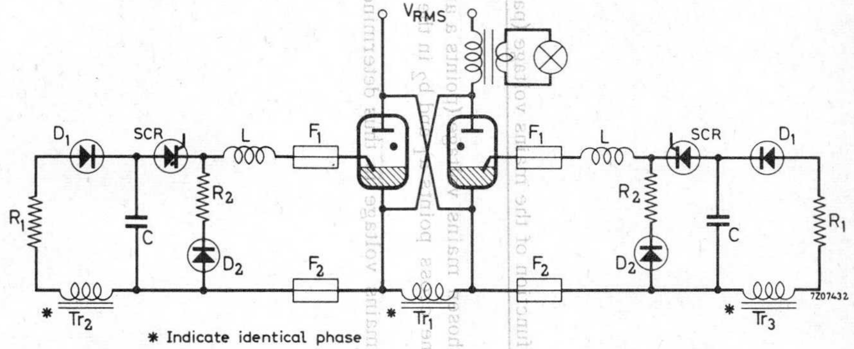
[1]) The thyristor-zener diode combination may be substituted by a thyratron.

7Z2 8286

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

B. Separate excitation

Recommended circuit for separate excitation[1]



Capacitor value	C	2 μF
Capacitor voltage	V_c	650 V $\pm$10%
Peak value of closed circuit current		80 to 100 A

1) The thyristor may be substituted by a thyratron.

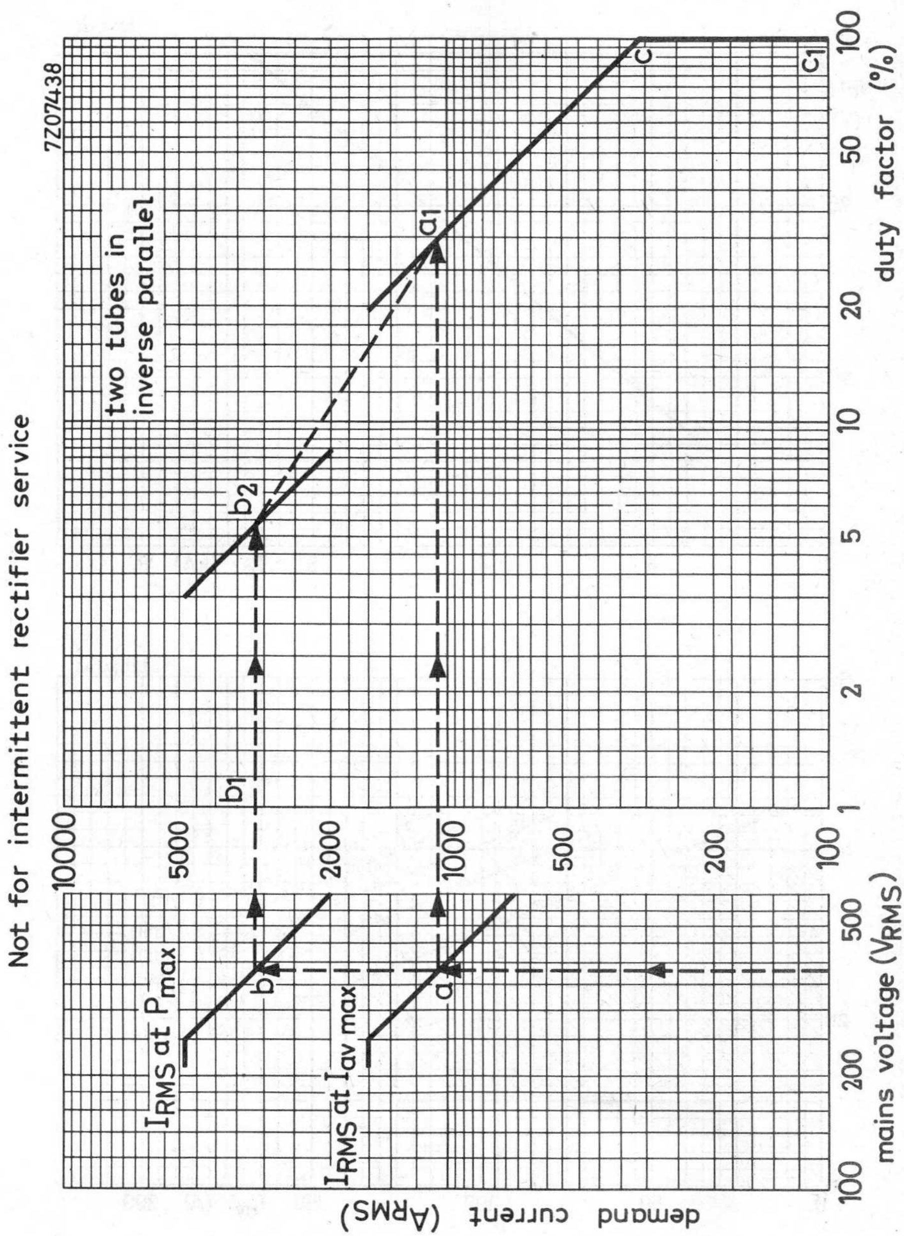
7Z2 8287

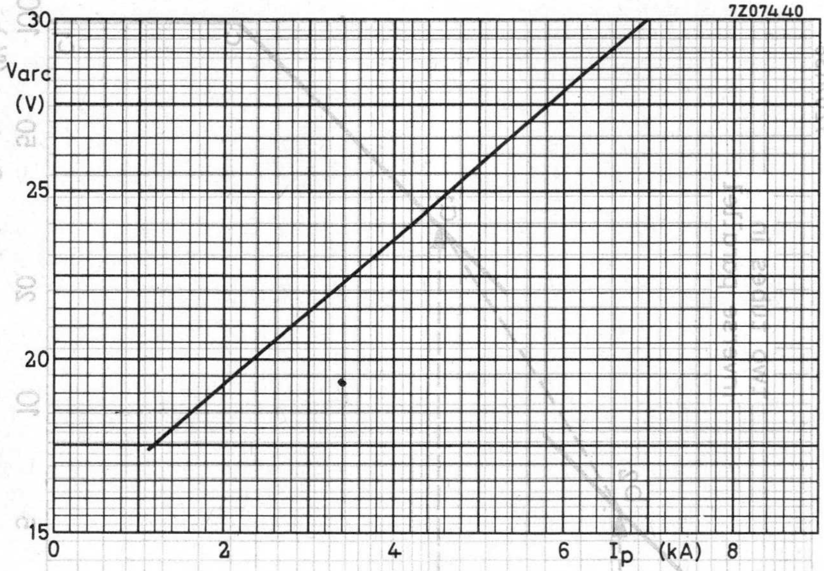
Graph to determine demand current versus duty factor as a function of the mains voltage (page B)

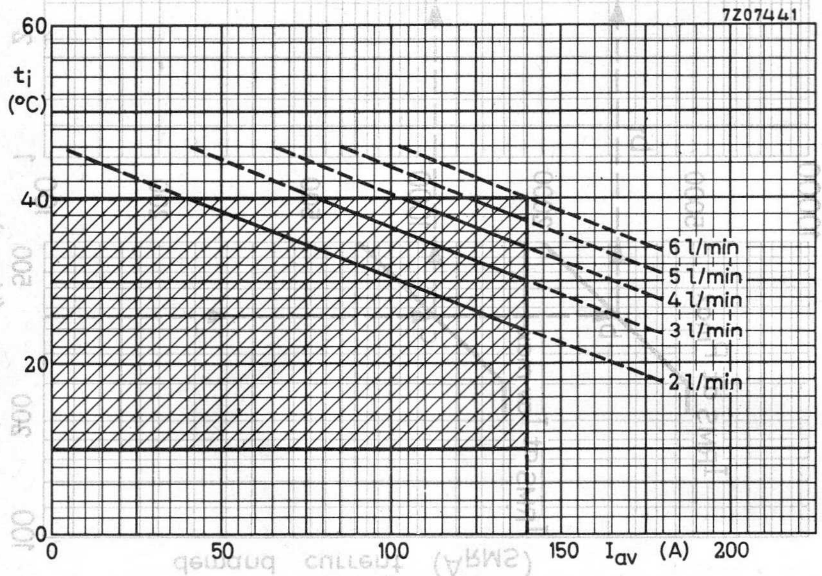
Construction:

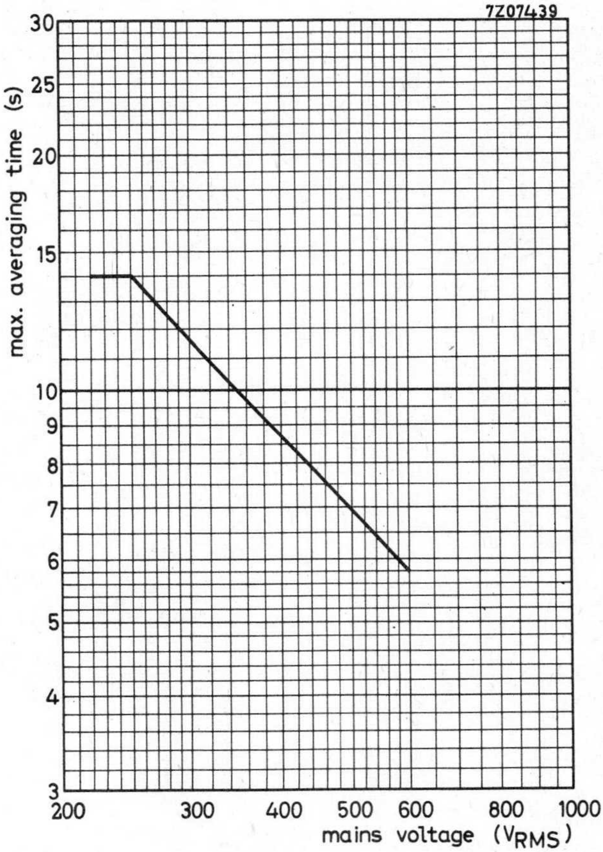
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

7Z2 8331


Not for intermittent rectifier service
7Z07438
two tubes in inverse parallel
demand current (A_{RMS})
10000
5000
2000
1000
500
200
100
mains voltage (V_{RMS})
100
200
500
duty factor (%)
1
2
5
10
20
50
100
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1


7Z07440
Varc
(V)
30
25
20
15
0
2
4
6
8
Ip (kA)


7Z07441
ti
(°C)
60
40
20
0
6 l/min
5 l/min
4 l/min
3 l/min
2 l/min
0
50
100
150
200
Iav (A)


7Z07439
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3
200
300
400
500
600
800
1000
mains voltage (V_{RMS})

IGNITRON

D size ignitron intended for use in single-phase and three-phase resistance welding control and similar A.C. control applications.

The tube has a stainless steel watercooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel)		2400	kVA
Maximum average current		355	A
Ignitor voltage	max.	200	V
Ignitor current		15 - 30	A

MECHANICAL DATA

Dimensions and connections	see page 2
Net weight	9.4 kg
Shipping weight	12 kg
Mounting position	vertical $\pm 3^{\circ}$, anode connection up

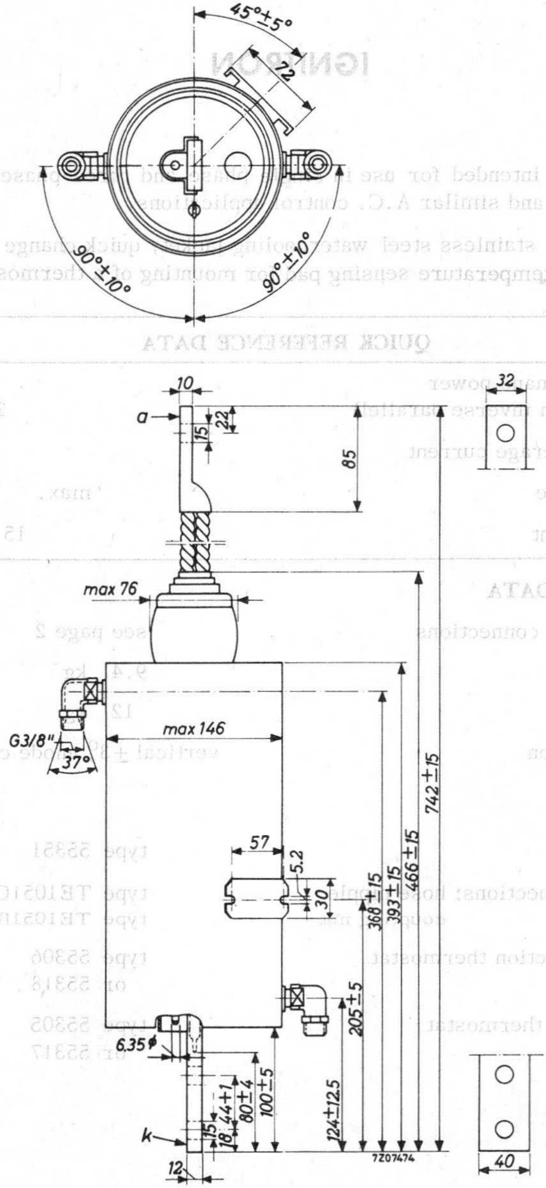
Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Overload protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8300

DIMENSIONS AND CONNECTIONS

Dimensions in mm



7Z2 8301

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 9 l/min)	p_i	max.	0.35	kg/cm^2
Temperature rise at max. average current (q = 9 l/min)	$t_o - t_i$	max.	9	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current	q	min.	9	l/min.
Inlet temperature [1]	t_i	min.	10	^oC
		max.	40	^oC
Temperature of thermostat mount [2]	t_m	max.	50	^oC

Intermittent rectifier service or three-phase welding service

Required water flow at max. average current	q	min.	9	l/min.
Inlet temperature [1]	t_i	min.	10	^oC
		max.	35	^oC
Temperature of thermostat mount [2]	t_m	max	45	^oC

[1]) When a number of tubes is cooled in series, $t_{i\ min}$ refers to the coldest tube and $t_{i\ max.}$ to the hottest tube.

[2]) WARNING. The thermostat mount is at full line voltage.
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8302

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.
The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection

Table I. See also pages B, C and D

Mains frequency range	f	25 to 60					Hz
Mains voltage	V	220[1]	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	11	11	7.3	5.6	4.6	s
A. Max. demand power							
Max. demand power	P max	2120	2400	2400	2400	2400	kVA
Corresponding max. average current	I_{av}	192	192	192	192	192	A
Demand current	I_{RMS}	9600	9600	6300	4800	4000	A_{RMS}
Duty factor	δ	4.4	4.4	6.8	8.8	10.6	%
Number of cycles within T_{av} max. [2]	n	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	I_F	2000	2000	1640	1420	1300	A_{RMS}
B. Max. average current							
Max. average current	$I_{av\,max}$	355	355	355	355	355	A
Corresponding max. demand power	P	700	800	800	800	800	kVA
Demand current	I_{RMS}	3200	3200	2100	1600	1320	A_{RMS}
Duty factor	δ	24.6	24.6	37.5	49.3	60.0	%
Number of cycles within T_{av} max. [2]	n	140	140	140	140	140	c/T_{av}max
Integrated RMS load current	I_F	1600	1600	1300	1130	1020	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	27	27	17.8	13.5	11.2	kA

[1]) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

[2]) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time;
n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8303

LIMITING VALUES (Absolute max. rating system; continued)

Intermittent rectifier service or frequency changer resistance welding service

Mains frequency range	f	50 to 60			Hz
Anode voltage, forward peak	$V_{a\ fwd_p}$ max	600	1200	1500	V
inverse peak	$V_{a\ inv_p}$ max	600	1200	1500	V
A. Max. peak current					
Anode current, peak	I_{a_p} max	4000	3000	2400	A
Corresponding average current	I_{av}	54	40	32	A
B. Max. average current					
Anode current, average	I_{av} max	190	140	112	A
Corresponding peak	I_{a_p}	1140	840	672	A
Averaging time	T_{av} max	6.25	6.25	6.25	s
Ratio I_a/I_{a_p} (T_{av} = max. 0.5 s)	I_a/I_{a_p} max	1/6	1/6	1/6	
Ratio I_{surge}/I_{a_p} (T_{max} = 0.15 s)	I_{surge}/I_{a_p} max	12.5	12.5	12.5	

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{igp}	max.	2000	V
	inverse peak (including any transients)	$-V_{igp}$	max.	5	V
Ignitor current,	forward peak	I_{igp}	max.	100	A
	inverse peak	$-I_{igp}$	max.	0	A
	forward RMS	I_{igRMS}	max.	10	A
	forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

7Z2 8304

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS
(continued)

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max. 200	V
Firing current	I_{ign}	6 to 8	A
		max. 12	A
Ignition time at the above voltage or current	t_{ign}	max. 100	μs [1]

Ignition circuit requirements

Peak voltage required to fire	V_p	min. 200	V
Peak current required for anode take over	I_p	15 to 30	A [2]
Rate of rise of ignitor current	di/dt	min. 0.1	A/μs

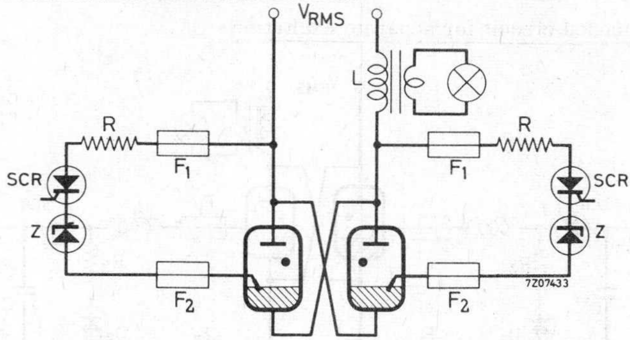
[1] Ignition time is taken from the instant that the stated voltage and current are reached.

[2] The higher value holds for the lower anode voltage and the lower cooling water temp., the lower value for higher anode voltage and higher cooling water temp.

7Z2 8305

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

Recommended circuits for anode excitation



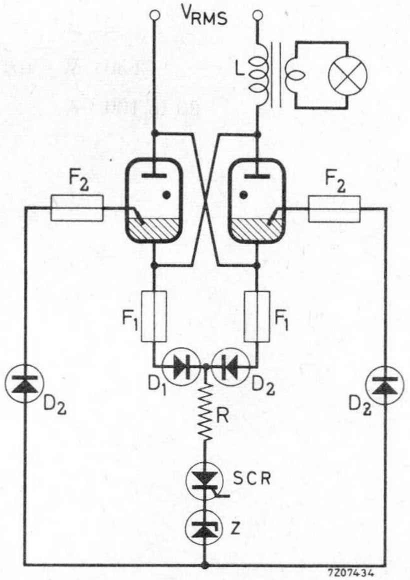
Anode excitation with individual thyristors

V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage ≥ 18 V



Anode excitation with common thyristor

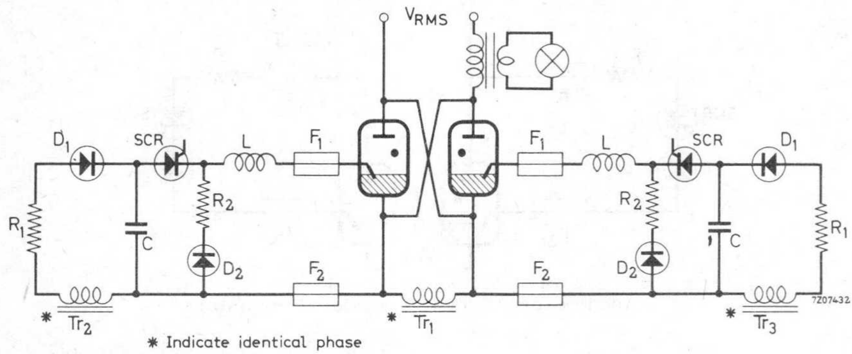
1) The thyristor-zener diode combination may be substituted by a thyratron.

7Z2 8306

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

B. Separate excitation

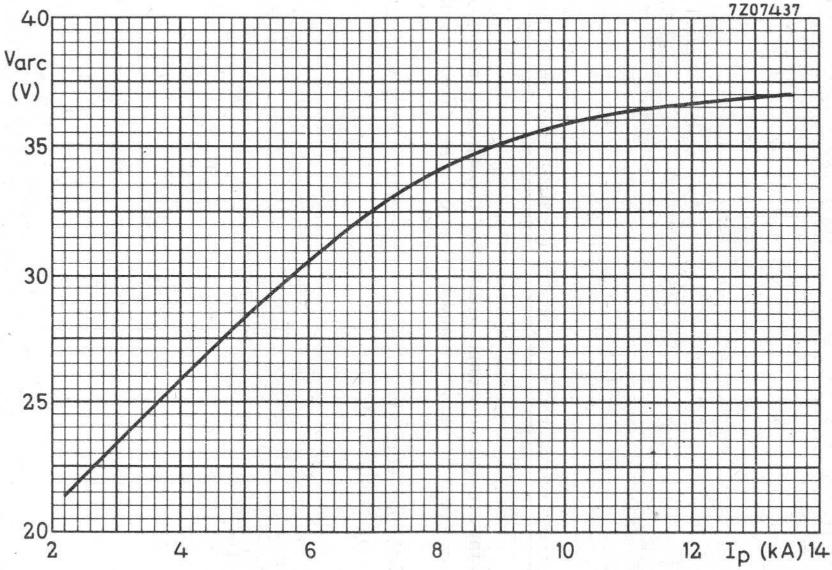
Recommended circuit for separate excitation



Capacitor value	2	μF
Capacitor voltage	650	V ± 10%
Peak value of closed circuit current	80 to 100	A

[1]) The thyristor may be substituted by a thyratron.

7Z2 8307

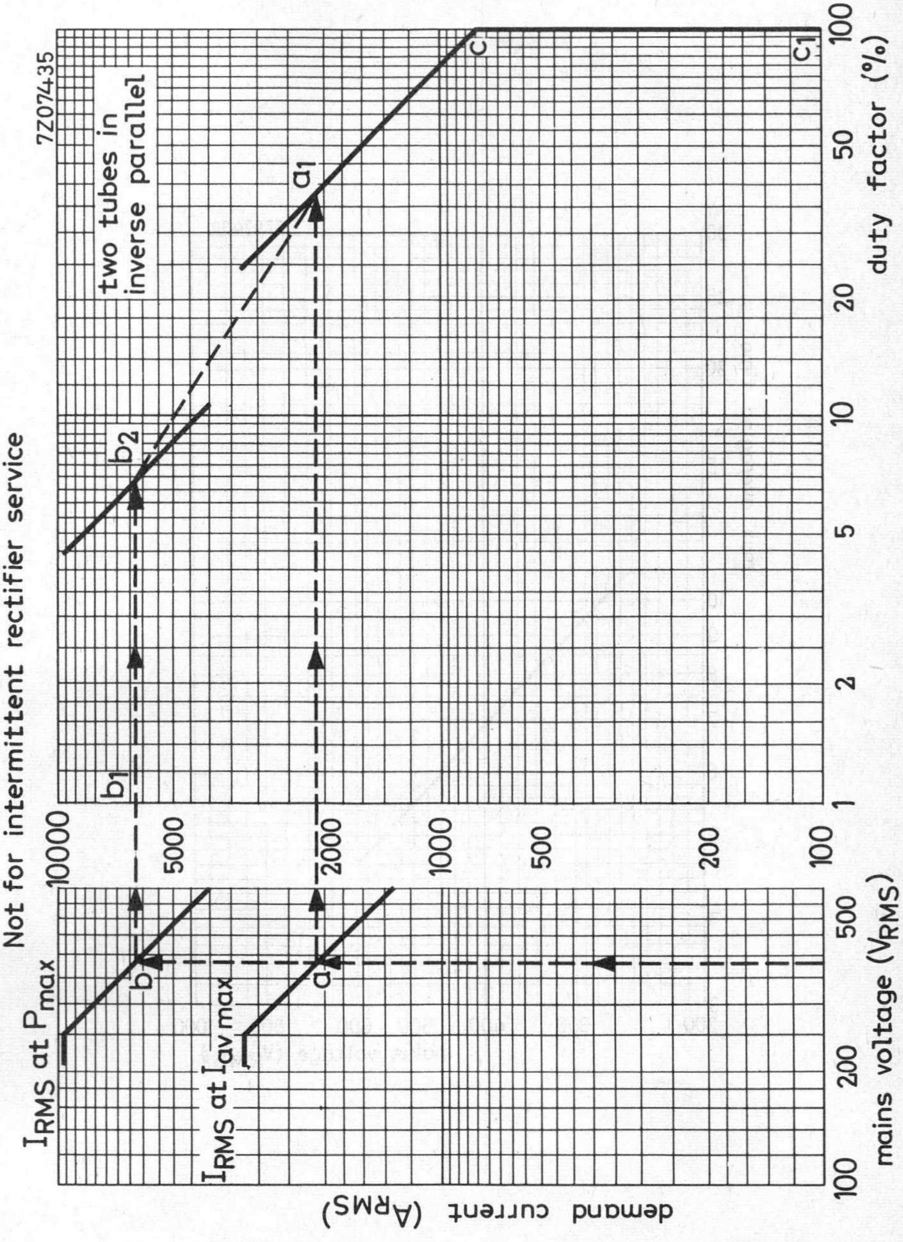

7Z07437
40
V_{arc}
(V)
35
30
25
20
2
4
6
8
10
12
I_p (kA)
14

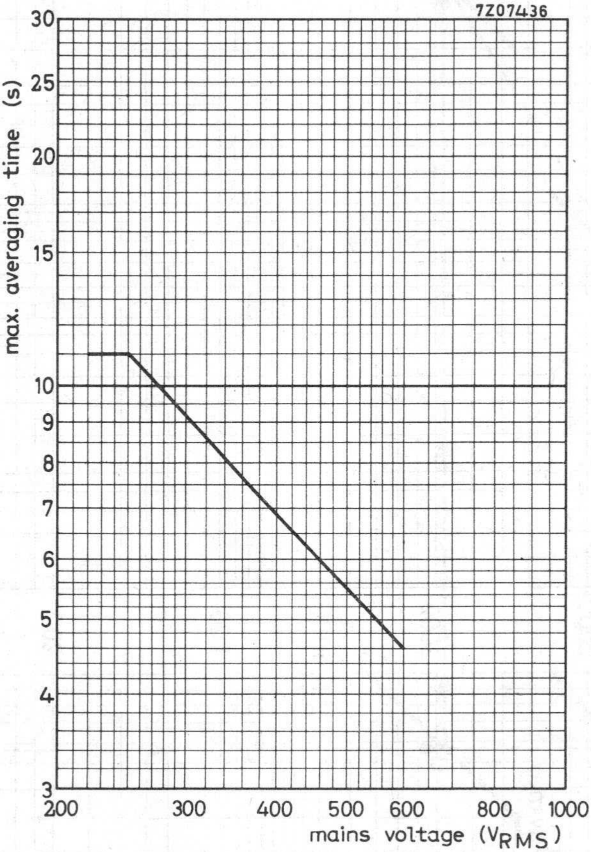
Graph to determine demand current versus duty factor as a function of the mains voltage (page C)

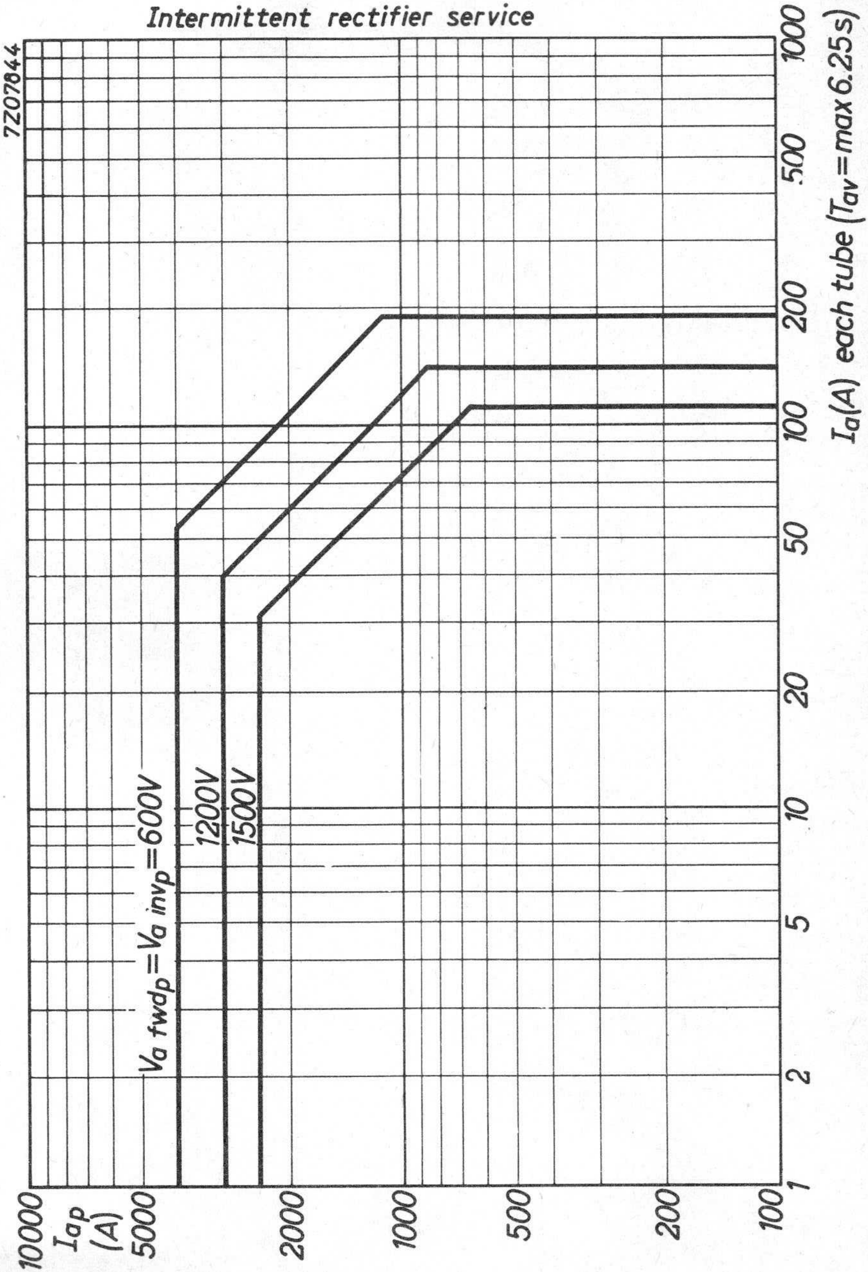
Construction:

1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

7Z2 8332


7Z07435
Not for intermittent rectifier service
two tubes in inverse parallel
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1
demand current (A_{RMS})
10000
5000
2000
1000
500
200
100
mains voltage (V_{RMS})
100
200
500
duty factor (%)
1
2
5
10
20
50
100


7Z07436
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3
200
300
400
500
600
800
1000
mains voltage (VRMS)


Intermittent rectifier service
7Z07844
I_a(A) each tube (T_{av}=max 6.25s)
1000
500
200
100
50
20
10
5
2
1
I_{ap} (A)
10000
5000
2000
1000
500
200
100
$V_{a\,fwdp}$=$V_{a\,invp}$=600V
1200V
1500V

IGNITRON

Ignitron for 200 kVA (two tubes) with separate quick-change water or air cooler. The stainless steel jacketed tube contains an anode, an ignitor, an auxiliary electrode and a mercury pool cathode.

Application: Single-phase welding control and similar applications.

TYPICAL CHARACTERISTICS:	Arc voltage	See page A
	Ignition time	9 μsec
WEIGHT:	Net weight	500 g
	Shipping weight	750 g

ACCESSORIES	type number	net weight	shipping weight
Water cooler	40700	250 g	500 g
Air cooler	40701	300 g	550 g
Connector for ignitor and auxiliary electrode	40702 (supplied with tube)		

LIMITING VALUES (Absolute limits)

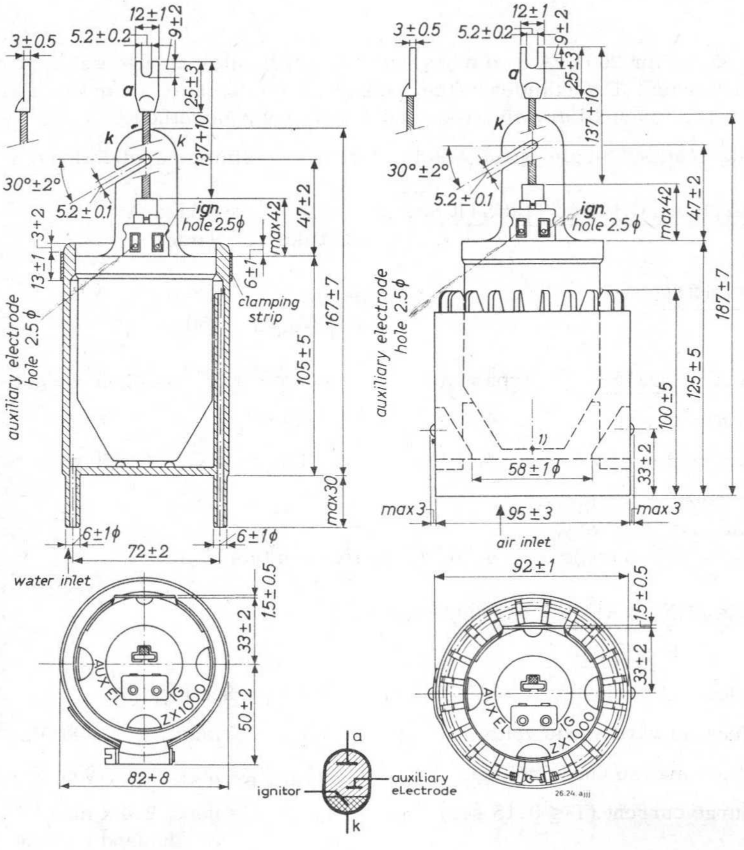
A. Electrical

Demand power	P	See page A	
Peak forward anode voltage	V_{ap}	= max.	800 V
Peak inverse anode voltage	$V_{a\ inv\ p}$	= max.	800 V
Surge current ($T \leq 0.15$ sec)	I_{surge}	= max.	2.8 x max. demand current
Frequency range	f	= min.	25 c/s
	f	= max.	60 c/s
Averaging time	T_{av}	See page D	

7Z2 3151

Dimensions in mm

Water cooling Air cooling



MOUNTING POSITION

Vertical, anode connection up

---

[1]) Reference point for temperature measurement. 7Z2 3152

LIMITING VALUES (Absolute limits) (continued)

B. Cooling

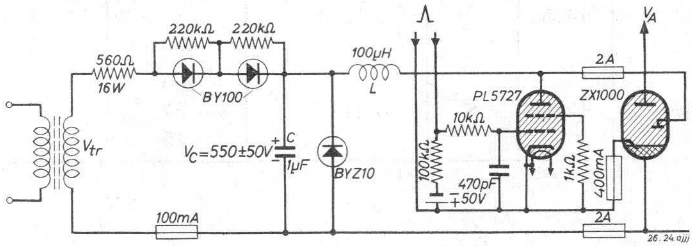
1. Water cooling system

Continuous water flow at max. load	= max. 1 l/min.
	= min. 0.2 l/min.
Pressure drop at 0.2 l/min.	= max. 0.05 kg/cm^2
Water temperature at inlet of cooling system	See page E

2. Forced air cooling system

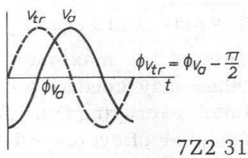
Continuous air flow through each air cooler at max. load	= min. 600 l/min.
Cooling air temperature at 600 l/min	See page E
Cathode temperature at maximum average current	= max. 120 °C
Cathode temperature at max. demand	= max. 65 °C
Cathode temperature	= min. 10 °C

C. Ignition circuit



Tolerance of passive components = max. 10 %

Circuit resistance = max. 0.5 Ω



7Z2 3153

OPERATING CHARACTERISTICS for two tubes in inverse parallel

Frequency range = 25 to 60 c/s

Columns I = water cooling at t_i = 32 °C
Columns II = forced air cooling at t_i = 25 °C
For higher inlet temperatures derate according to page E

Page D			Lim. values	Page A	
mains voltage	max. averaging time		max. surge current 1)	demand power	average current per tube
V_{rms}	sec I	sec II	A	kVA	A
220	25.6	12	2260	176 58 6	7 13 13
250	25.6	12	2260	200 67 7	7 13 13
380	16.8	10	1490	200 67 11	7 13 13
440	14.5	9	1270	200 67 13	7 13 13
500	12.8	8	1130	200 67 15	7 13 13

[1]) T = max. 0.15 sec.

[2]) This is the maximum integrated number of cycles each pair of tubes may conduct with or without interruption during the maximum averaging time at 50 c/s.
(Number of cycles = duty factor x T_{av} x mains frequency).

7Z2 3154

(continued)

Pages B and C		Derivated values			Values obtained by going out from:
demand current	duty factor	number of cycles of mains voltage 2)		load current 3)	
		cycles			
A_{rms}	%	I	II	A_{rms}	
800	1.9	25	12	110	max. dem. curr.
267	10.7	138	65	87	max. avg. curr.
29	100	cont.	cont.	29	contin. duty
800	1.9	25	12	110	max. kVA
267	10.7	138	65	87	max. avg. curr.
29	100	cont.	cont.	29	contin. duty
526	3.0	25	15	91	max. kVA
175	16.4	138	82	71	max. avg. curr.
29	100	cont.	cont.	29	contin. duty
454	3.5	25	16	85	max. kVA
151	19.2	138	86	66	max. avg. curr.
29	100	cont.	cont.	29	contin. duty
400	3.9	25	16	79	max. kVA
133	21.6	138	86	62	max. avg. curr.
29	100	cont.	cont.	29	contin. duty

2) See page 4.

3) Average r.m.s. current through load and mains
= demand current x $\sqrt{\text{duty factor}}$

7Z2 3155

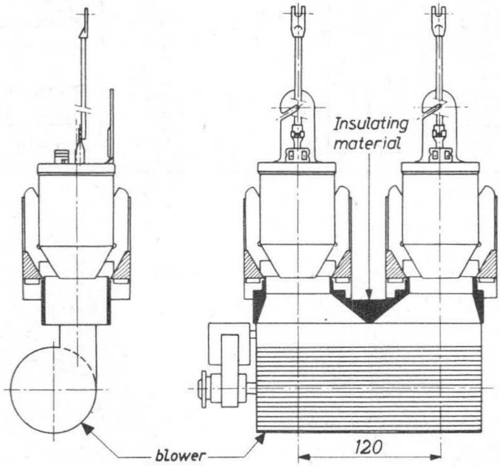
LIFE EXPECTANCY

Expected life = 50 x10^6 ignitions assuming that the end of life is reached when 1 omission per 10^5 ignitions occurs. Page E shows the life expectancy in hours and years. One year is assumed to be 50 weeks of 40 hours. A rough division in applications has been made.

OPERATING NOTES

1. A voltage between main anode and cathode of about 20 V is necessary when the anode must take over the discharge from the auxiliary electrode.
2. To prevent condensation of mercury on the anode or on the anode insulator, the temperature of anode lead-in and insulator shall always be higher than the cathode temperature. If necessary, a heating device must be used to maintain the required temperature difference.
3. The life expectancy of the PL5727 in the recommended ignition circuit is at least equal to that of the ZX1000. It is recommended to replace the PL5727 together with the ZX1000.

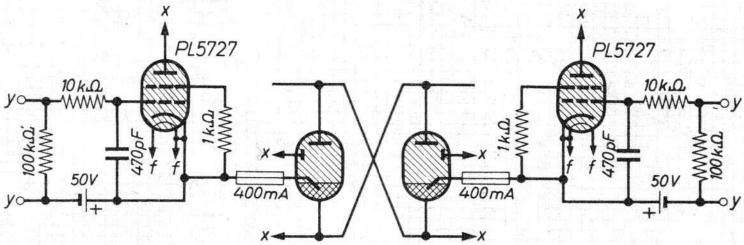
TYPICAL INSTALLATION of two air cooled ignitrons ZX1000



7Z2 3156

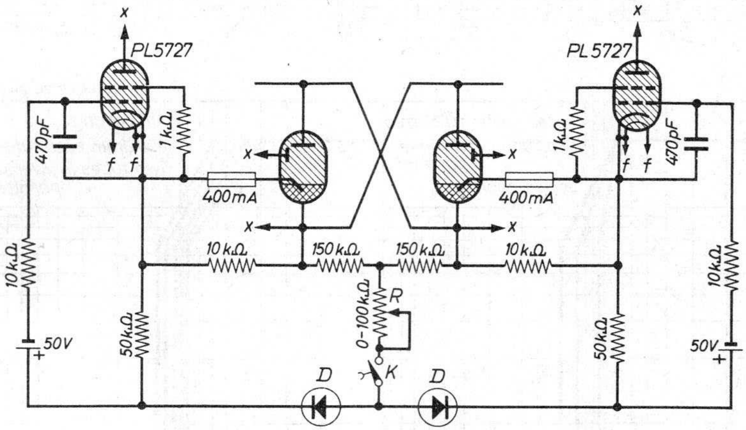
SUGGESTED GRID CONTROL CIRCUITS

A. Synchronous control (welding timer)



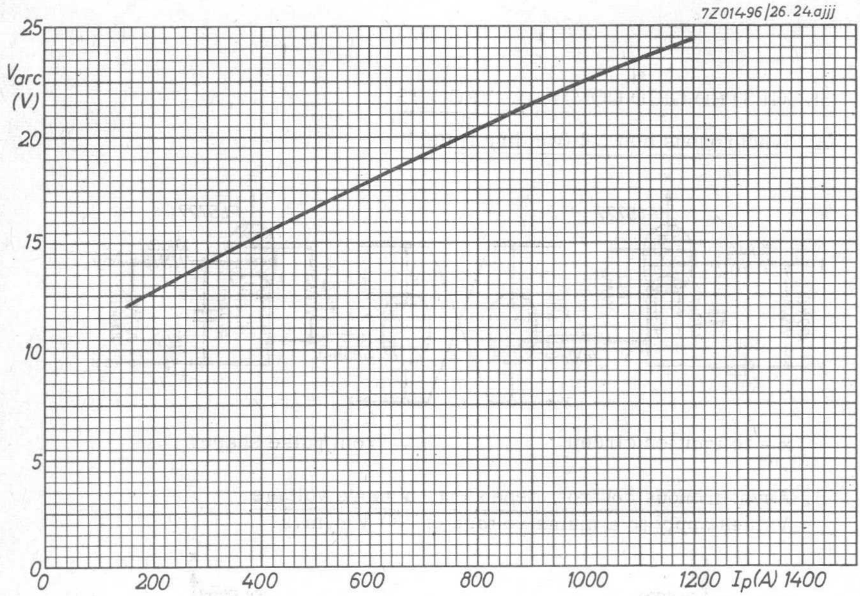
x = to ignition circuit　　　　y = from pulse shaper

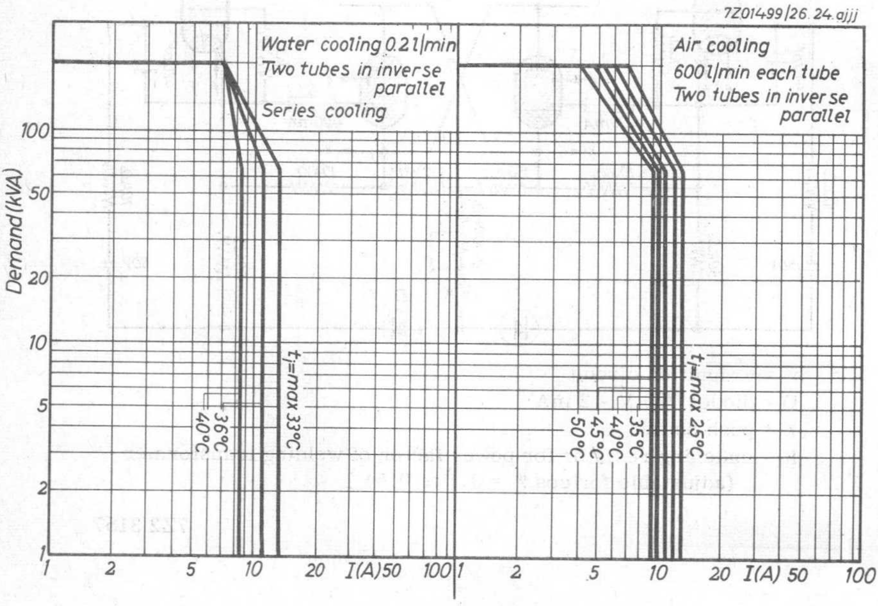
B. Asynchronous control, dependent on anode voltage
Values apply to a mains voltage of 380 V r.m.s.

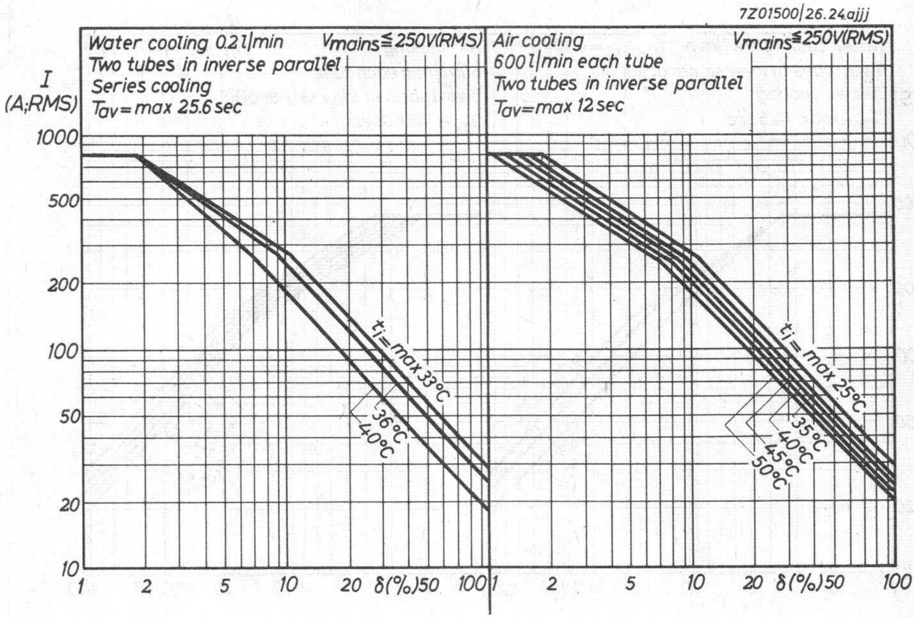


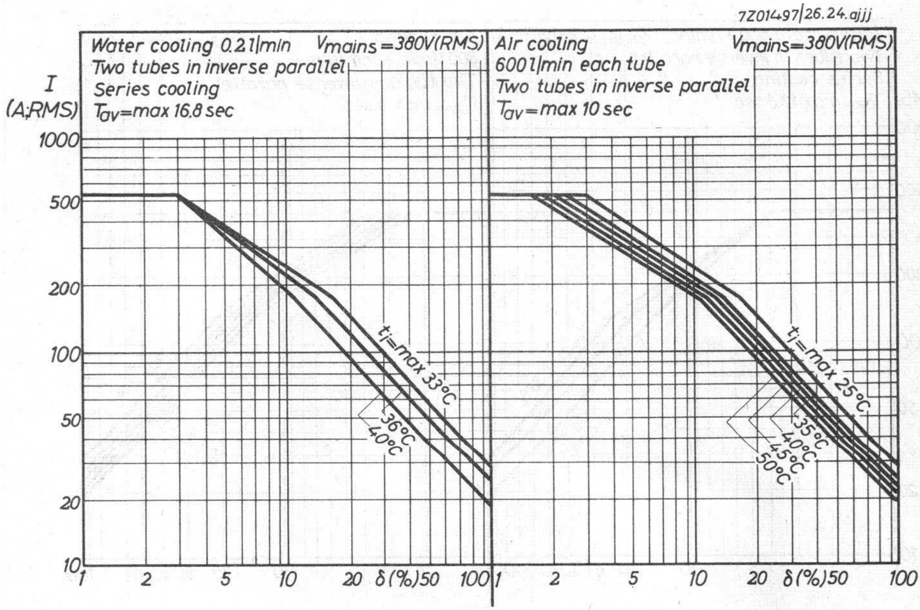
x = to ignition circuit
D = diodes 700 V - 2 mA
K = push button
R = matching resistor for power factor of welding transformer
(adjustable for cos φ = 0.1 to 0.5)

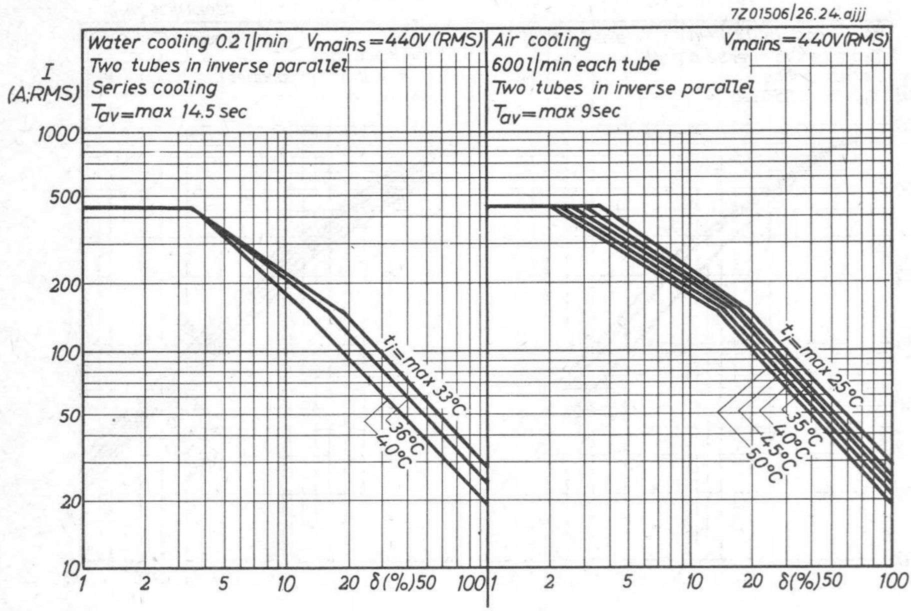
7Z2 3157

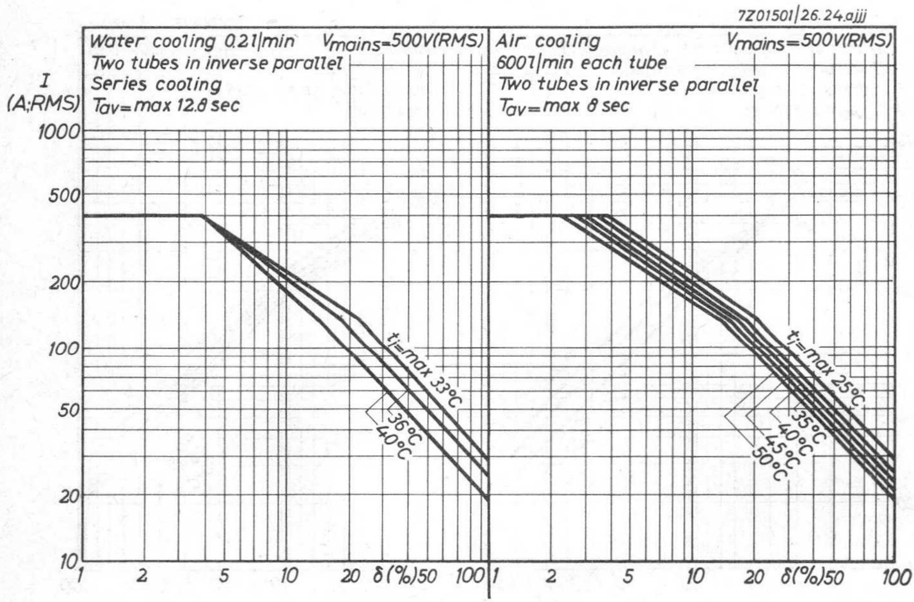

7Z01496/26.24.ajjj
25
V_{arc} (V)
20
15
10
5
0
0
200
400
600
800
1000
1200
I_p(A)
1400

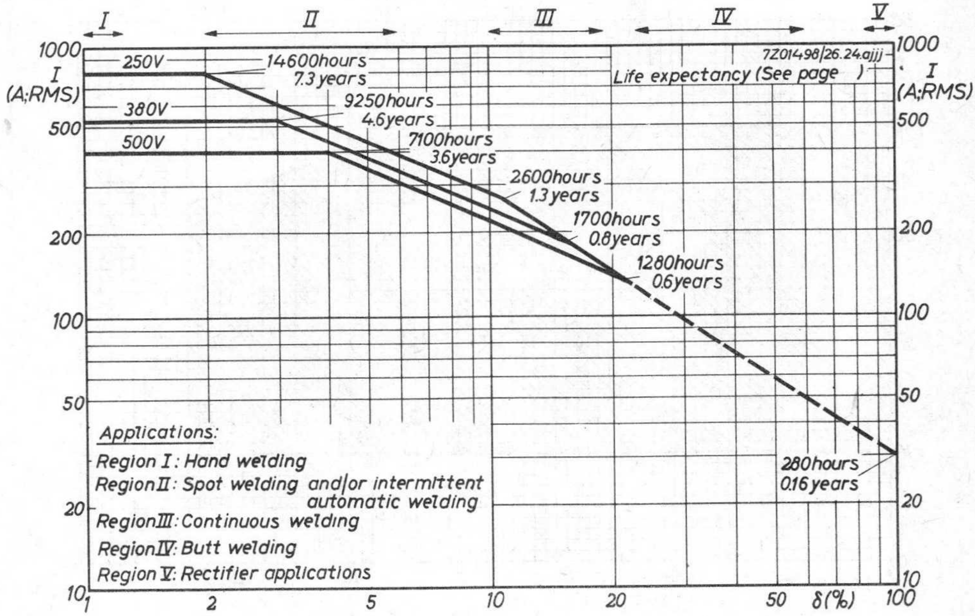

7Z01499/26.24.ajjj
Water cooling 0.2 l/min
Two tubes in inverse parallel
Series cooling
Demand (kVA)
100
50
20
10
5
2
1
t_j=max 33°C
36°C
40°C
1
2
5
10
20
I(A)
50
100
Air cooling
600 l/min each tube
Two tubes in inverse parallel
t_j=max 25°C
35°C
40°C
45°C
50°C
1
2
5
10
20
I(A)
50
100

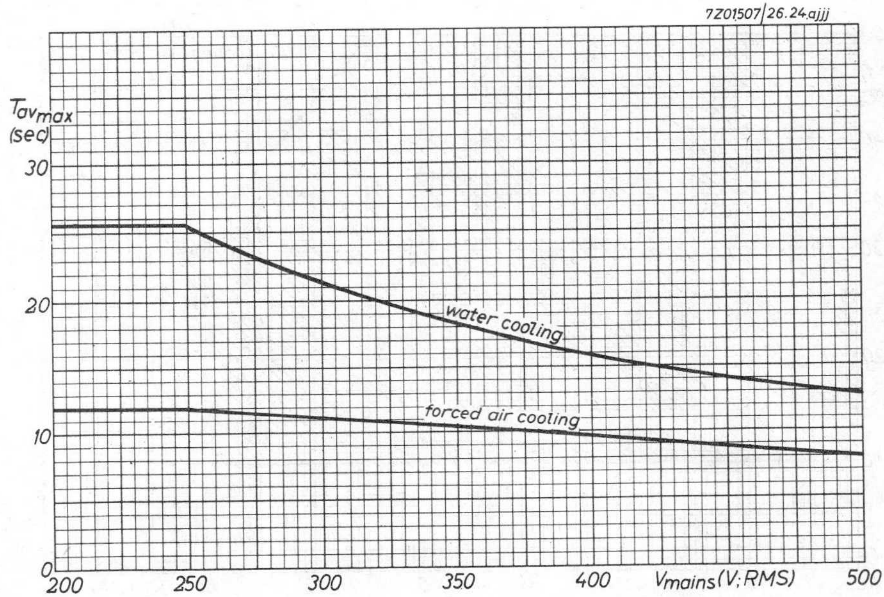

7Z01500/26.24.ajjj
Water cooling 0.2 l/min
Two tubes in inverse parallel
Series cooling
T_{av} = max 25.6 sec
V_{mains} ≦ 250V(RMS)
I (A;RMS)
t_j = max 33°C
36°C
40°C
δ(%)
Air cooling
600 l/min each tube
Two tubes in inverse parallel
T_{av} = max 12 sec
V_{mains} ≦ 250V(RMS)
t_j = max 25°C
35°C
40°C
45°C
50°C
δ(%)

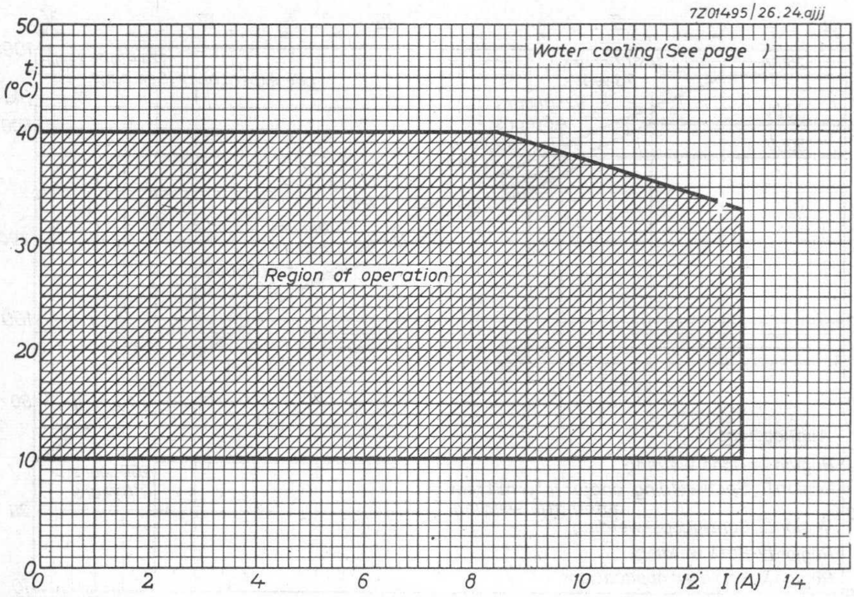

7Z01497/26.24.ajjj
Water cooling 0.2 l/min
Two tubes in inverse parallel
Series cooling
T_{av} = max 16.8 sec
V_{mains} = 380V(RMS)
I (A;RMS)
t_j = max 33°C
36°C
40°C
δ(%)
Air cooling
600 l/min each tube
Two tubes in inverse parallel
T_{av} = max 10 sec
V_{mains} = 380V(RMS)
t_j = max 25°C
35°C
40°C
45°C
50°C
δ(%)

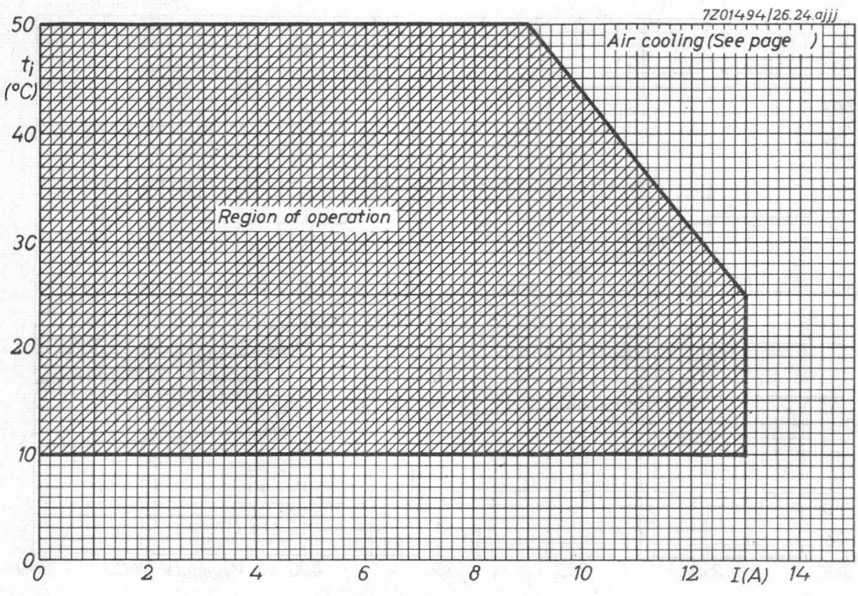

7Z01506/26.24.ajjj
I (A;RMS)
Water cooling 0.2 l/min
V_{mains}=440V (RMS)
Two tubes in inverse parallel
Series cooling
T_{av}=max 14.5 sec
t_j=max 33°C
36°C
40°C
Air cooling
V_{mains}=440V(RMS)
600 l/min each tube
Two tubes in inverse parallel
T_{av}=max 9sec
t_j=max 25°C
35°C
40°C
45°C
50°C
1000
500
200
100
50
20
10
1
2
5
10
20
δ(%)50
100


7Z01501/26.24.ajjj
I (A;RMS)
Water cooling 0.2 l/min
V_{mains}=500V(RMS)
Two tubes in inverse parallel
Series cooling
T_{av}= max 12.8 sec
t_j=max 33°C
36°C
40°C
Air cooling
V_{mains}=500V(RMS)
600 l/min each tube
Two tubes in inverse parallel
T_{av}=max 8 sec
t_j=max 25°C
35°C
40°C
45°C
50°C
1000
500
200
100
50
20
10
1
2
5
10
20
δ(%)50
100


I
II
III
IV
V
7Z01498/26.24.ajjj
Life expectancy (See page)
I (A;RMS)
250V
380V
500V
14600hours 7.3 years
9250hours 4.6years
7100hours 3.6years
2600hours 1.3 years
1700hours 0.8years
1280hours 0.6years
280hours 0.16years
Applications:
Region I : Hand welding
Region II: Spot welding and/or intermittent automatic welding
Region III: Continuous welding
Region IV: Butt welding
Region V: Rectifier applications
δ(%)


7Z01507/26.24.ajjj
$T_{av_{max}}$ (sec)
water cooling
forced air cooling
V_{mains}(V; RMS)


7Z01495/26.24.ajjj
Water cooling (See page)
t_j (°C)
50
40
30
20
10
0
Region of operation
0
2
4
6
8
10
12
I (A)
14


7Z01494/26.24.ajjj
Air cooling (See page)
t_j (°C)
50
40
30
20
10
0
Region of operation
0
2
4
6
8
10
12
I(A)
14

IGNITRON

B size ignitron intended for use in single-phase and three-phase resistance welding control and similar A.C. control applications.

The tube has a plastic coated stainless steel watercooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel)		600	kVA
Maximum average current		56	A
Ignitor voltage	max.	150	V
Ignitor current	max.	12	A

MECHANICAL DATA

Dimensions and connections	see page 2
Net weight	1420 g
Shipping weight	2040 g
Mounting position	vertical $\pm$ 3°, anode connection up

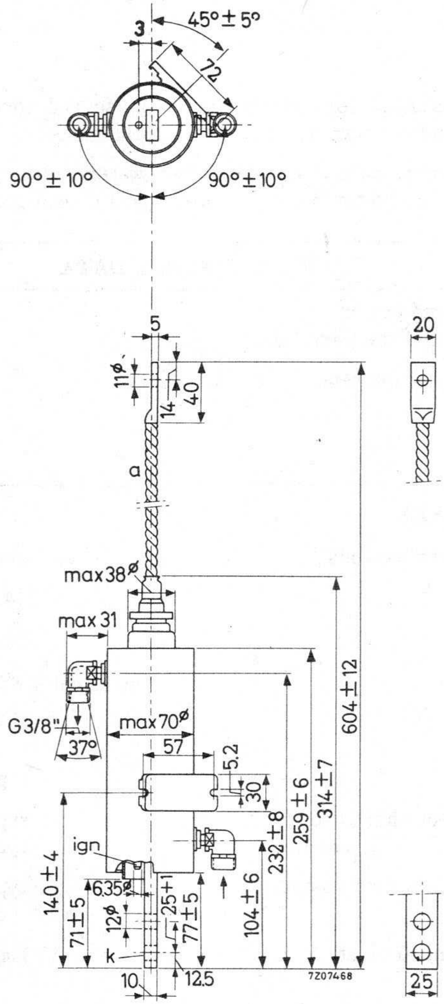
Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Overload protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8308

DIMENSIONS AND CONNECTIONS

Dimensions in mm



7Z2 8309

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 3 l/min)	p_i	max. 0.1	kg/cm^2
Temperature rise at max. average current (q = 3 l/min)	t_o-t_i	max. 5	^{o}C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page A)	q	min. 3	l/min
Inlet temperature [1])	t_i	min. 10 max. 40	^{o}C ^{o}C
Temperature of thermostat mount [2])	t_m	max. 50	^{o}C

Intermittent rectifier service or three-phase welding service

Required water flow at max. average current (See also page A)	q	min. 3	l/min
Inlet temperature [1])	t_i	min. 10 max. 35	^{o}C ^{o}C
Temperature of thermostat mount [2])	t_m	max. 45	^{o}C

Pulse service

Under conditions of pulse service with low average load (less than 1 A) continuous cooling is normally not required. The cooling jacket can e.g. be permanently filled with oil.
Care should be taken to prevent condensation of mercury at the anode or glass seal. See also "Application directions ignitrons".

Recommended condensed mercury temperature	t_{Hg}	25 to 30	^{o}C

[1]) When a number of tubes is cooled in series, $t_{i\ min}$ refers to the coldest tube and $t_{i\ max.}$ to the hottest tube.

2) WARNING. The thermostat mount is at full line voltage.
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8310

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.
The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection.

Table I. See also pages B, C and E

Mains frequency range	f	25 to 60					Hz
Mains voltage	V	220[1]	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	18	18	11.8	9	7.5	s
A. Max. demand power							
Max. demand power	P_{max}	530	600	600	600	600	kVA
Corresponding max. average current	I_{av}	30.2	30.2	30.2	30.2	30.2	A
Demand current	I_{RMS}	2400	2400	1600	1200	1000	A_{RMS}
Duty factor	δ	2.8	2.8	4.2	5.6	6.7	%
Number of cycles within T_{av} max. [2]	n	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	I_F	400	400	320	280	260	A_{RMS}
B. Max. average current							
Max. average current	I_{av} max	56	56	56	56	56	A
Corresponding max. demand power	P	180	200	200	200	200	kVA
Demand current	I_{RMS}	800	800	530	400	330	A_{RMS}
Duty factor	δ	15.6	15.6	23.5	31.1	37.7	%
Number of cycles within T_{av} max. [2]	n	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	I_F	320	320	260	220	200	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	6700	6700	4500	3400	2800	A

1) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

2) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time: n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8311

LIMITING VALUES (Absolute max. rating system; continued)

Intermittent rectifier service or frequency changer resistance welding service

Mains frequency range	f	50 to 60		Hz
Anode voltage, forward peak	$V_{a\ fwd_p}$ max	1200	1500	V
inverse peak	$V_{a\ inv_p}$ max	1200	1500	V
A. Max. peak current				
Anode current, peak	I_{ap} max	600	480	A
Corresponding average current	I_{av}	5	4	A
B. Max. average current				
Anode current, average	I_{av} max	22.5	18	A
Corresponding peak	I_{ap}	135	108	A
Averaging time	T_{av} max	10	10	s
Ratio I_a/I_{ap} (T_{av} = max. 0.5 s)	I_a/I_{ap} max	1/6	1/6	
Ratio I_{surge}/I_{ap} (T_{max} = 0.15 s)	I_{surge}/I_{ap} max	12.5	12.5	

Pulse service

Under certain conditions this ignitron may be used to switch aperiodic current pulses to a very high value (up to 50 kA) and voltages up to 10 kV. The performance depends on the circuit in which the tube is used. The manufacturer should be consulted.

7Z2 8312

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{ig_p}	max.	2000	V
	inverse peak (including any transients)	$-V_{ig_p}$	max.	5	V
Ignitor current,	forward peak	I_{ig_p}	max.	100	A
	inverse peak	$-I_{ig_p}$	max.	0	A
	forward RMS	I_{igRMS}	max.	10	A
	forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max.	150	V
Firing current	I_{ign}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ign}	max.	50	μs [1]

Ignition circuit requirements

Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dt	min.	0.1	A/μs

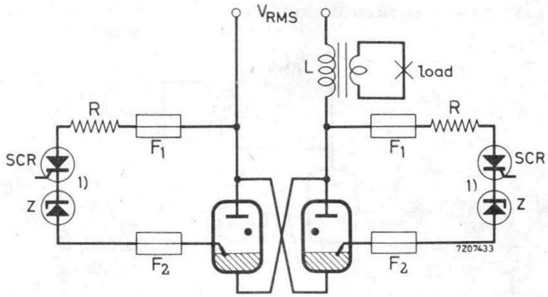
[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

7Z2 8313

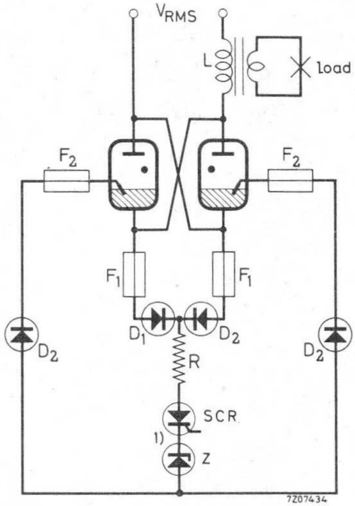
IGNITOR CHARACTERISTICS AND IGNITRON CIRCUIT REQUIREMENTS

(continued)

Recommended circuits for anode excitation



Anode excitation with individual thyristors



V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage ≥ 18 V

Anode excitation with common thyristor

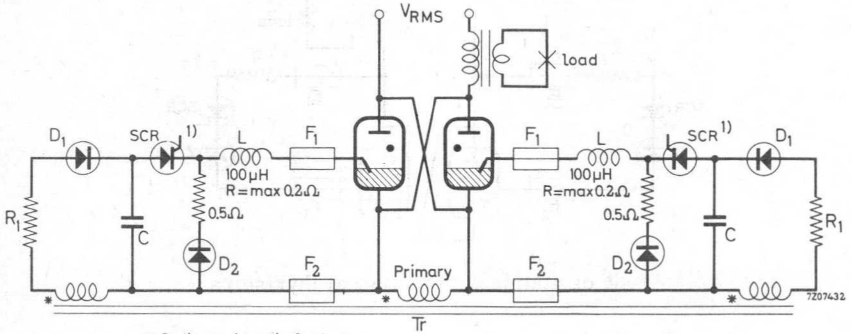
[1]) The thyristor-zener diode combination may be substituted by a thyratron.

7Z2 8314

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS
(continued)

B. Separate excitation

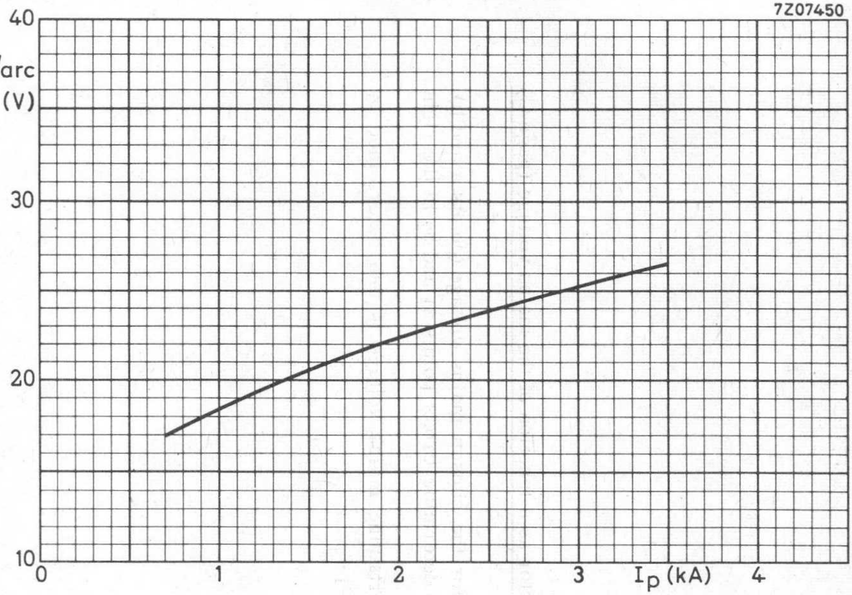
Recommended circuit for separate excitation

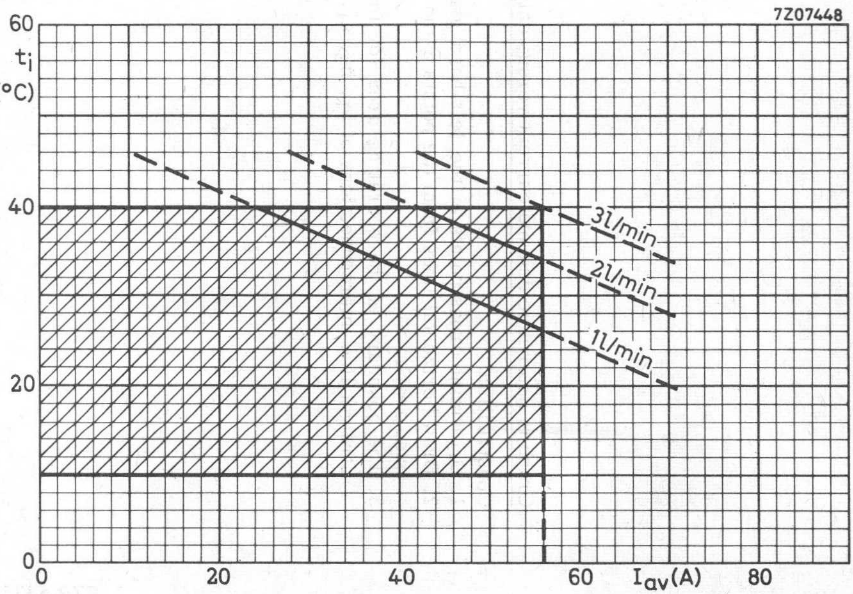


Capacitor value	C	2	8	μF
Capacitor voltage	V_C	650	400	V ± 10%
Peak value of closed circuit current		80 to 100		A

1) The thyristor may be substituted by a thyratron.

7Z2 8315





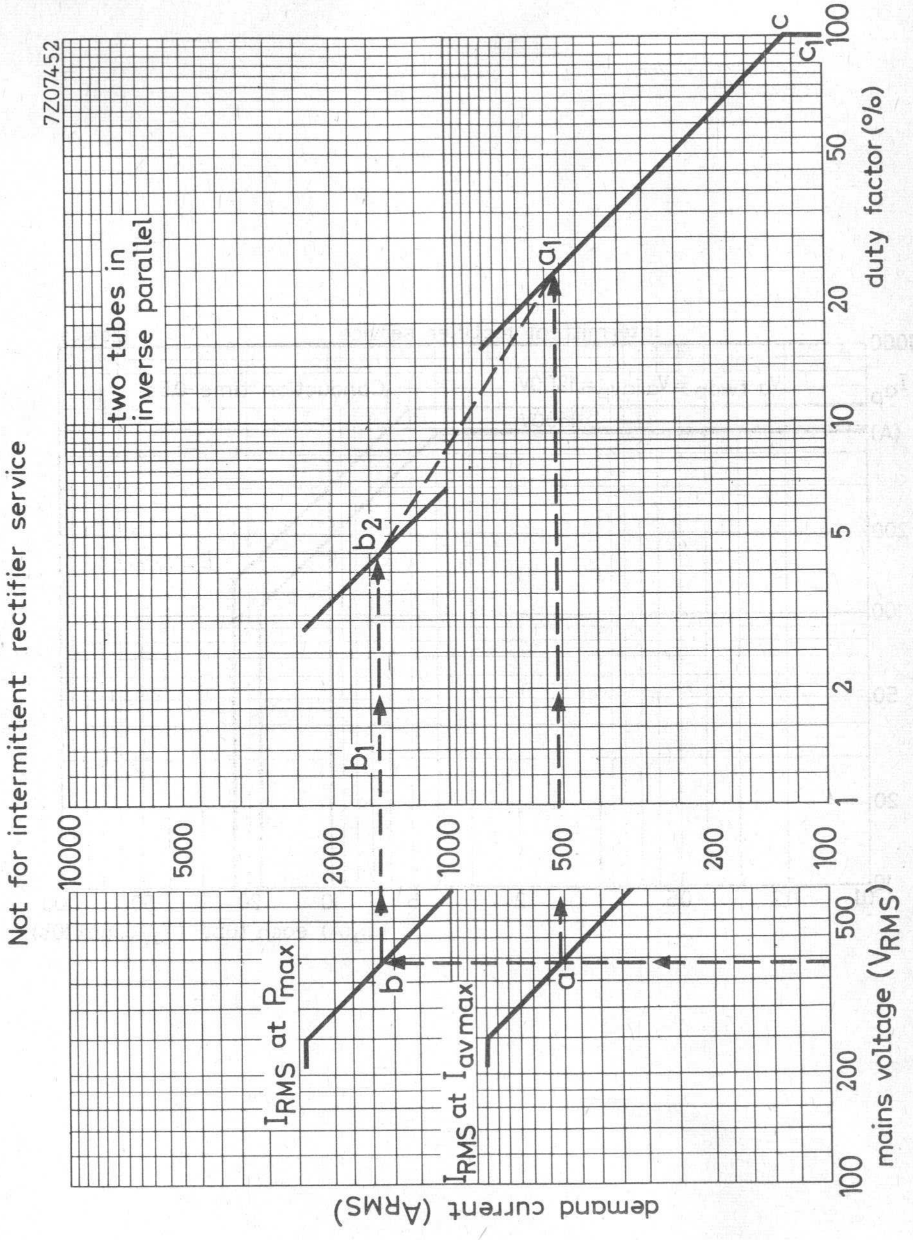
Minimum required continuous waterflow (two tubes cooled in series)

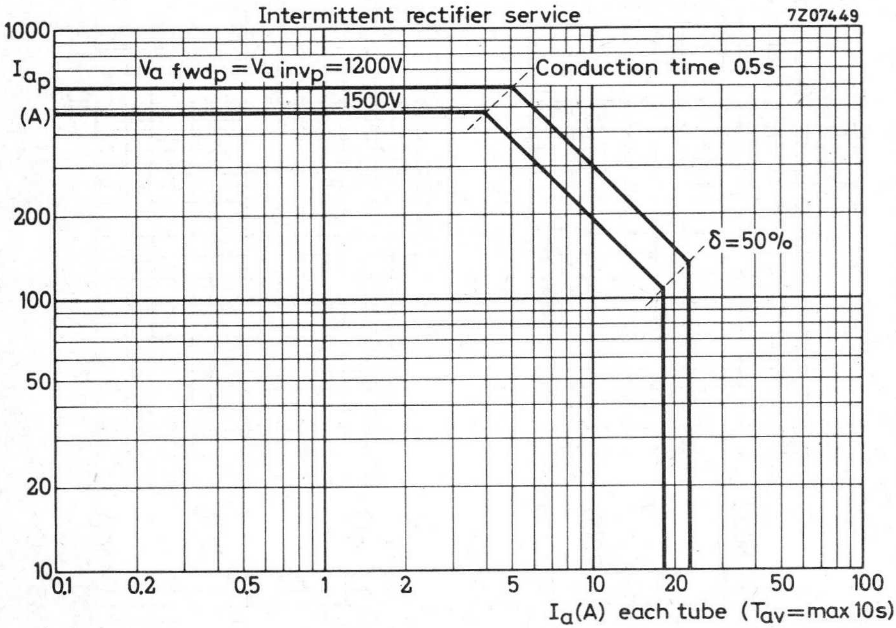
Graph to determine demand current versus duty factor as a function of the mains voltage (page C)

Construction:

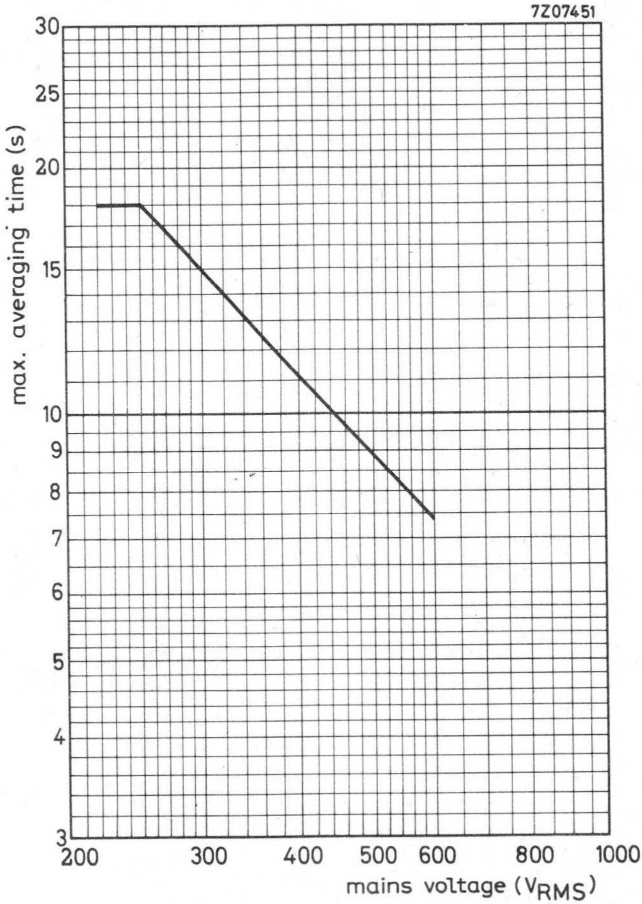
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

7Z2 8333


Not for intermittent rectifier service
7Z07452
two tubes in inverse parallel
demand current (A_{RMS})
10000
5000
2000
1000
500
200
100
mains voltage (V_{RMS})
100
200
500
duty factor (%)
1
2
5
10
20
50
100
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1



Intermittent rectifier service
7Z07449
1000
I_{a_p}
(A)
200
100
50
20
10
$V_{a\ fwd_p} = V_{a\ inv_p} = 1200V$
1500V
Conduction time 0.5s
δ=50%
0.1
0.2
0.5
1
2
5
10
20
50
100
I_a(A) each tube (T_{av}=max 10s)



7Z07451
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3
200
300
400
500
600
800
1000
mains voltage (V_{RMS})

IGNITRON

C size ignitron intended for use in single-phase resistance welding control and similar A.C. control applications.

The tube has a plastic coated stainless steel watercooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel)		1200	kVA
Maximum average current		140	A
Ignitor voltage	max.	150	V
Ignitor current	max.	12	A

MECHANICAL DATA

Dimensions and connections	see page 2
Net weight	2820 g
Shipping weight	4080 g
Mounting position	vertical $\pm 3^{\circ}$, anode connection up

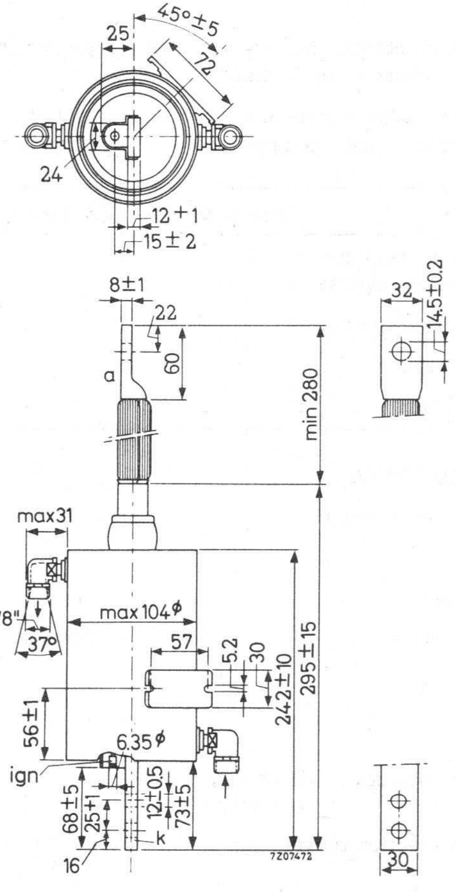
Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Overload protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8316

DIMENSIONS AND CONNECTIONS

Dimensions in mm



7Z2 8317

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 5 l/min)	p_i	max.	0.16	kg/cm^2
Temperature rise at max. average current (q = 5 l/min)	t_o-t_i	max.	6	^{o}C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page C)	q	min.	5	l/min.
Inlet temperature [1])	t_i	min.	10	^{o}C
		max.	40	^{o}C
Temperature of thermostat mount [2])	t_m	max.	50	^{o}C

Pulse service

Under conditions of pulse service with low average load (less than 1 A) continuous cooling is normally not required. The cooling jacket can e.g. be permanently filled with oil.
Care should be taken to prevent condensation of mercury at the anode or glass seal. See also "Application directions ignitrons"

Recommended condensed mercury temperature	t_{Hg}	25 to 30	^{o}C

[1]) When a number of tubes is cooled in series, $t_{i\,min}$ refers to the coldest tube and $t_{i\,max.}$ to the hottest tube.

[2]) WARNING: The thermostat mount is at full line voltage.
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8318

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.
The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection.

Table I. See also pages A, B and D

Mains frequency range	f	25 to 60					Hz
Mains voltage	V	220[1]	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	14	14	9.4	7	5.8	s
A. Max. demand power							
Max. demand power	P_{max}	1060	1200	1200	1200	1200	kVA
Corresponding max. average current	I_{av}	75.6	75.6	75.6	75.6	75.6	A
Demand current	I_{RMS}	4800	4800	3150	2400	2000	A_{RMS}
Duty factor	δ	3.5	3.5	5.3	7.0	8.4	%
Number of cycles within T_{av} max. [2]	n	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	I_F	900	900	720	630	580	A_{RMS}
B. Max. average current							
Max. average current	I_{av} max	140	140	140	140	140	A
Corresponding max. demand power	P	350	400	400	400	400	kVA
Demand current	I_{RMS}	1600	1600	1050	800	660	A_{RMS}
Duty factor	δ	19.4	19.4	29.5	39.0	47.0	%
Number of cycles within T_{av} max. [2]	n	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	I_F	700	700	570	500	450	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	13.5	13.5	9.0	6.7	5.7	kA

[1]) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

[2]) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time:
n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8319

ELECTRICAL DATA (continued)

Pulse service

Under certain conditions this ignitron may be used to switch aperiodic current pulses to a very high value (up to 100 kA) and voltages up to 10 kV. The performance depends on the circuit in which the tube is used. The manufacturer should be consulted.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{igp}	max.	2000	V
	inverse peak (including any transients)	$-V_{igp}$	max.	5	V
Ignitor current,	forward peak	I_{igp}	max.	100	A
	inverse peak	$-I_{igp}$	max.	0	A
	forward RMS	I_{igRMS}	max.	10	A
	forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max.	150	V
Firing current	I_{ign}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ign}	max.	50	μs [1]

Ignition circuit requirements

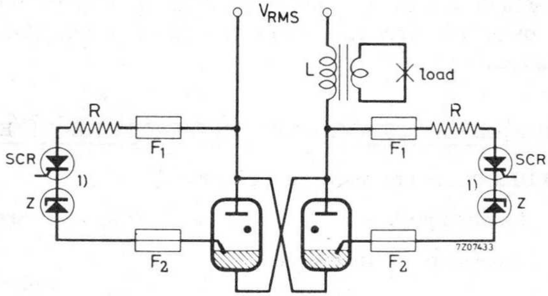
Peak voltage required to fire	V_p	min.	150	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dt	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

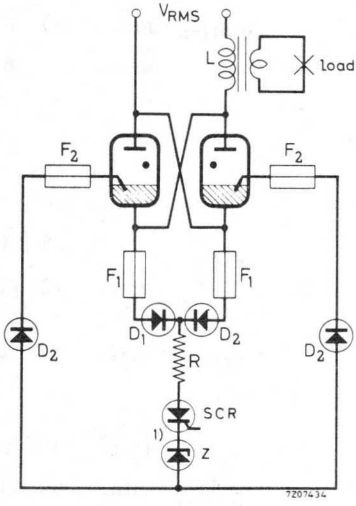
7Z2 8320

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS
(continued)

Recommended circuits for anode excitation



Anode excitation with individual thyristors



V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage ≥ 18 V

Anode excitation with common thyristor

[1]) The thyristor-zener diode combination may be substituted by a thyratron.

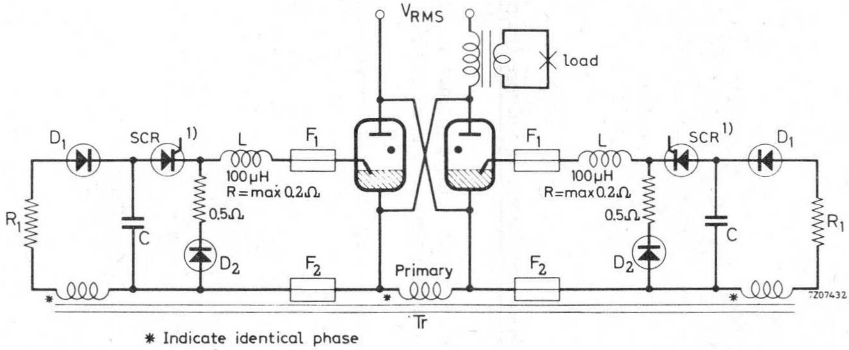
7Z2 8321

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(continued)

B. Separate excitation

Recommended circuit for separate excitation



Capacitor value	C	2	8	µF
Capacitor voltage	V_c	650	400	V ±10%
Peak value of closed circuit current		80 to 100		A

1) The thyristor may be substituted by a thyratron.

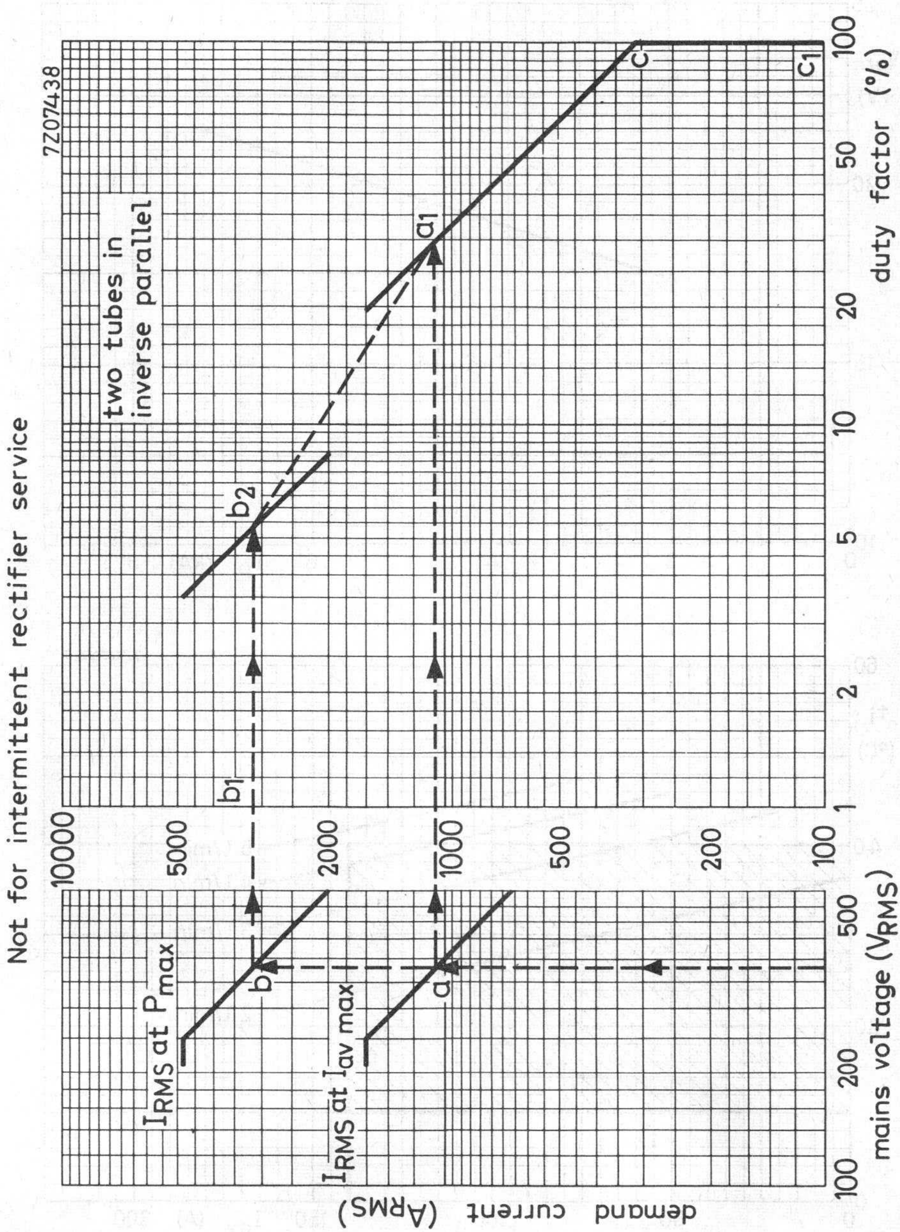
7Z2 8322

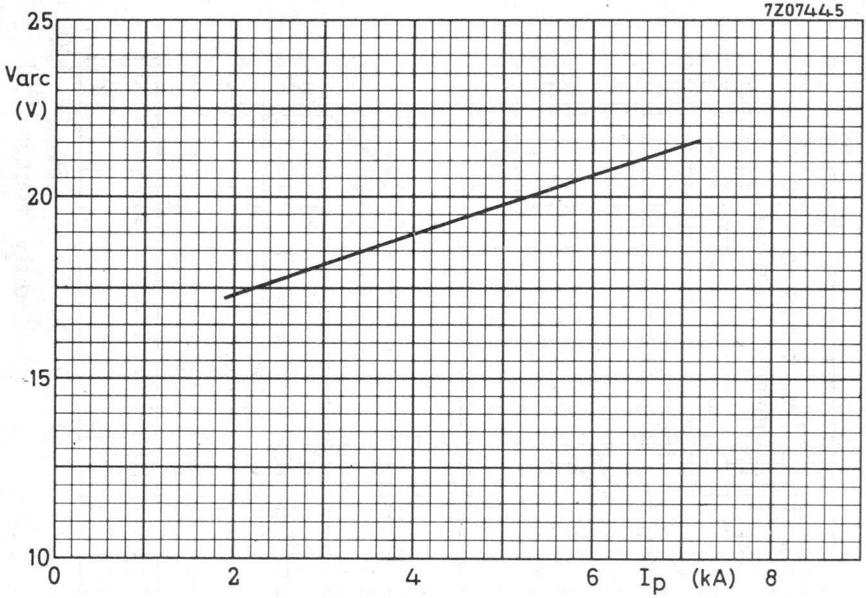
Graph to determine demand current versus duty factor as a function of the mains voltage (page B)

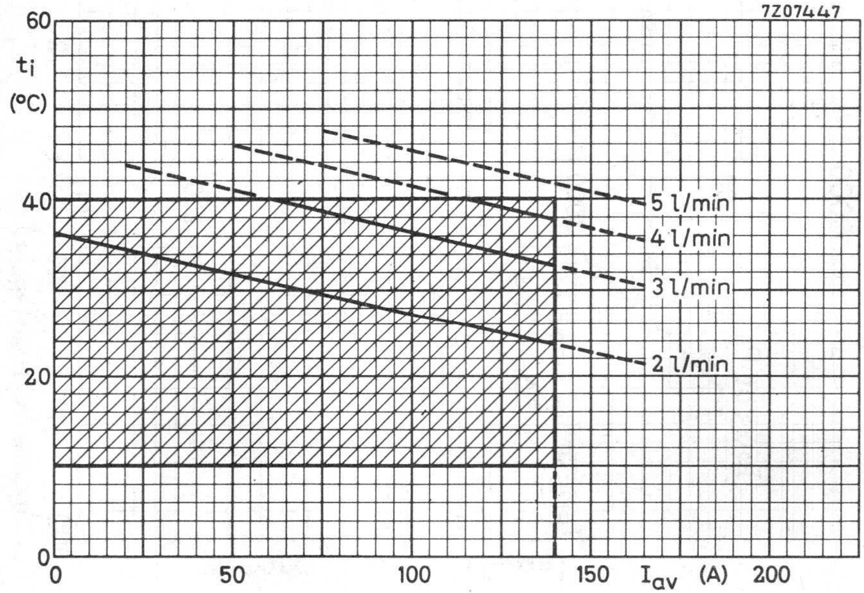
Construction:

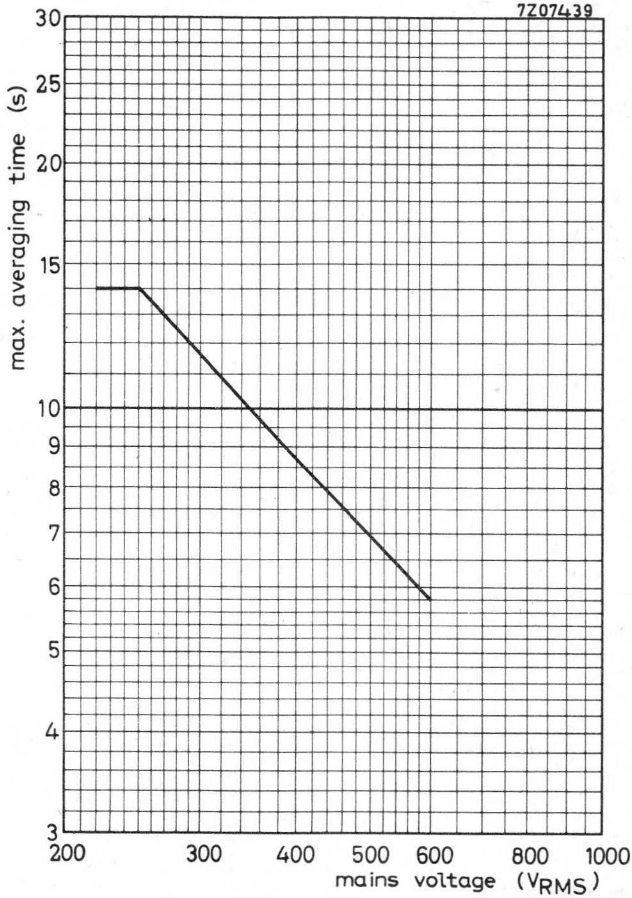
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

7Z2 8334


Not for intermittent rectifier service
two tubes in inverse parallel
7Z07438
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1
10000
5000
2000
1000
500
200
100
demand current (A_{RMS})
100
200
500
mains voltage (V_{RMS})
1
2
5
10
20
50
100
duty factor (%)


7Z07445
25
V_{arc}
(V)
20
15
10
0
2
4
6
I_p (kA)
8


7Z07447
60
t_i
(°C)
40
20
0
0
50
100
150
I_{av} (A)
200
5 l/min
4 l/min
3 l/min
2 l/min


7Z07439
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3
200
300
400
500
600
800
1000
mains voltage (V_RMS)

IGNITRON

Uprated C size ignitron intended for use in single-phase resistance welding control and similar A.C. control applications.

The tube has a plastic coated stainless steel watercooling jacket, quick change water connections and a temperature sensing pad for mounting of a thermostat.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel) at 600 V_{RMS}		2300	kVA
Maximum average current		180	A
Ignitor voltage	max.	150	V
Ignitor current	max.	12	A

MECHANICAL DATA

Dimensions and connections	see page 2
Net weight	2900 g
Shipping weight	4160 g
Mounting position	vertical $\pm 3^{o}$, anode connection up

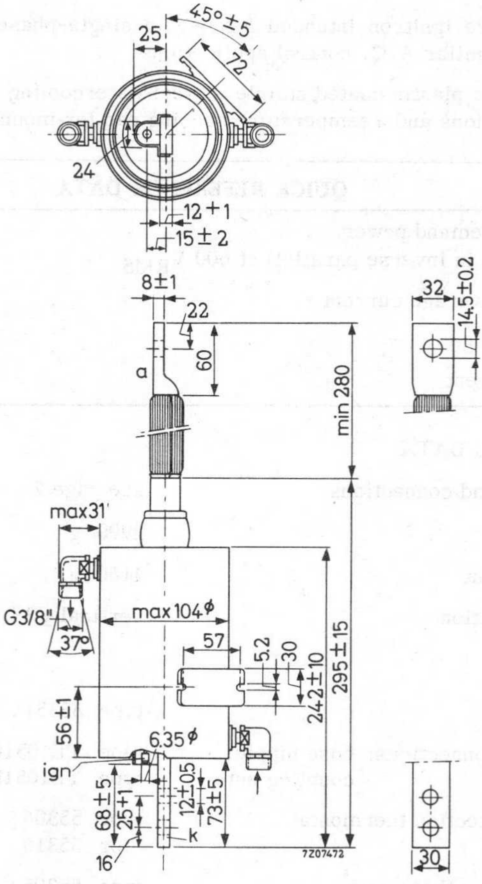
Accessories

Ignitor cable	type 55351
Water hose connections: hose nipple	type TE1051C
coupling nut	type TE1051B
Overload protection thermostat	type 55306 or 55318
Water economy thermostat	type 55305 or 55317

7Z2 8323

DIMENSIONS AND CONNECTIONS

Dimensions in mm



7Z2 8324

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 6 l/min)	p_i	max. 0.2	kg/cm^2
Temperature rise at max. average current (q = 6 l/min)	t_o-t_i	max. 6	^{o}C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page C)	q	min. 6	l/min
Inlet temperature [1])	t_i	min. 10	^{o}C
		max. 40	^{o}C
Temperature of thermostat mount [2])	t_m	max. 50	^{o}C

Pulse service

Under conditions of pulse service with low average load (less than 1 A) continuous cooling is normally not required. The cooling jacket can e.g. be permanently filled with oil.
Care should be taken to prevent condensation of mercury at the anode or glass seal. See also "Application directions ignitrons"

Recommended condensed mercury temperature	t_{Hg}	25 to 30	^{o}C

[1]) When a number of tubes is cooled in series, $t_{i\,min}$ refers to the coldest tube and $t_{i\,max.}$ to the hottest tube.

[2]) WARNING: The thermostat mount is at full line voltage.
When the cooling systems of a number of tubes are connected in series the overload protecting thermostat should be mounted on the last and the water economy thermostat on the last but one tube.

7Z2 8325

ELECTRICAL DATA

LIMITING VALUES (Absolute max. rating system)

The limiting values are based on full cycle conduction duty, with equally distributed load on all ignitrons, regardless of whether phase control is used or not.
The load must be limited so that at zero phase delay no overload will result.

Single phase A.C. control, two tubes in inverse parallel connection.

Table I. See also pages A, B and D

Mains frequency range		25 to 60					Hz
Mains voltage	V	220[1])	250	380	500	600	V_{RMS}
Max. averaging time	T_{av} max	21.0	21.0	13.8	10.5	8.7	s
A. Max. demand power							
Max. demand power	P_{max}	1100	1250	1650	2000	2300	kVA
Corresponding max. average current	I_{av}	110	110	110	110	110	A
Demand current	I_{RMS}	5000	5000	4350	4000	3800	A_{RMS}
Duty factor	δ	4.9	4.9	5.6	6.1	6.4	%
Number of cycles within T_{av} max. 2)	n	51	51	38	32	27	c/T_{av} max
Integrated RMS load current	I_F	1100	1100	1030	990	970	A_{RMS}
B. Max. average current							
Max. average current	I_{av} max	180	180	180	180	180	A
Corresponding max. demand power	P	340	415	550	670	760	kVA
Demand current	I_{RMS}	1650	1650	1450	1330	1270	A_{RMS}
Duty factor	δ	24.2	24.2	27.2	30.0	31.4	%
Number of cycles within T_{av} max. 2)	n	254	254	190	157	136	c/T_{av} max
Integrated RMS load current	I_F	810	810	760	730	710	A_{RMS}
Max. surge current (T_{max} = 0.15 s)	I_{surge}	14.0	14.0	12.2	11.2	10.6	kA

1) For mains voltages below 250 V_{RMS} the max. demand current and max. averaging time valid at 250 V shall not be exceeded.

2) This is the maximum integrated number of cycles a pair of tubes may conduct with or without interruption during the maximum averaging time:
n_{max} = duty factor x T_{av} max x mains frequency.

7Z2 8326

ELECTRICAL DATA (continued)

Pulse service

Under certain conditions this ignitron may be used to switch aperiodic current pulses to a very high value (up to 100 kA) and voltages up to 10 kV. The performance depends on the circuit in which the tube is used. The manufacturer should be consulted.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{igp}	max.	2000	V
	inverse peak (including any transients)	$-V_{igp}$	max.	5	V
Ignitor current,	forward peak	I_{igp}	max.	100	A
	inverse peak	$-I_{igp}$	max.	0	A
	forward RMS	$I_{ig\,RMS}$	max.	10	A
	forward average (T_{av} = max. 5 s)	I_{ig}	max.	1	A

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ign}	max.	150	V
Firing current	I_{ign}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ign}	max.	50	μs [1]

Ignition circuit requirements

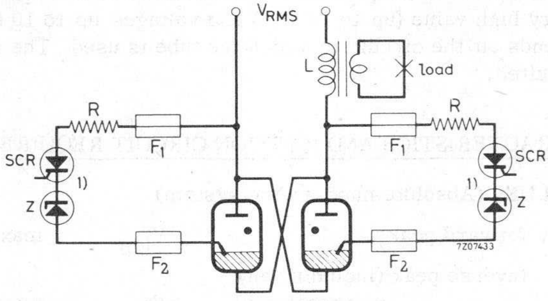
Peak voltage required to fire	V_p	min.	150	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dt	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

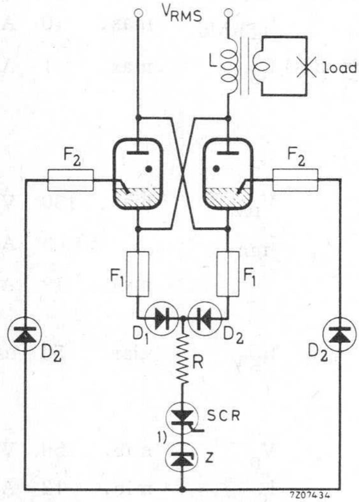
7Z2 8327

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS (continued)

Recommended circuits for anode excitation



Anode excitation with individual thyristors



Anode excitation with common thyristor

V_{RMS}	220	250	380	500	600	V
R	2	2	4	5	6	Ω

F_1 = 2 A fast response time

F_2 = 10 A fast response time

Z = zener voltage ≥18 V

1) The thyristor-zener diode combination may be substituted by a thyratron.

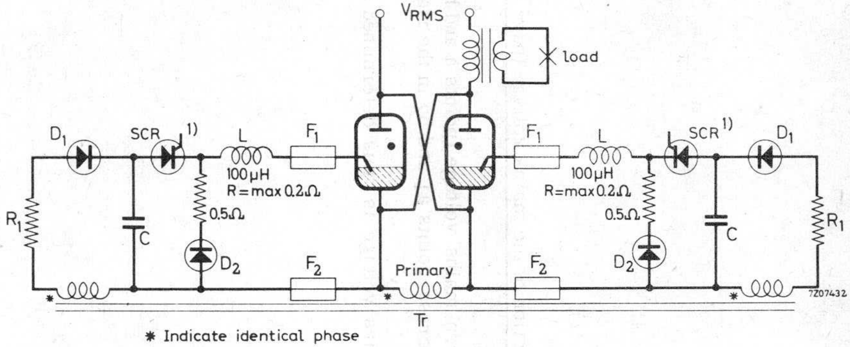
7Z2 8328

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(continued)

B. Separate excitation

Recommended circuit for separate excitation



Capacitor value	C	2	8	μF
Capacitor voltage	V_c	650	400	V ±10%
Peak value of closed circuit current		80 to 100		A

1) The thyristor may be substituted by a thyratron.

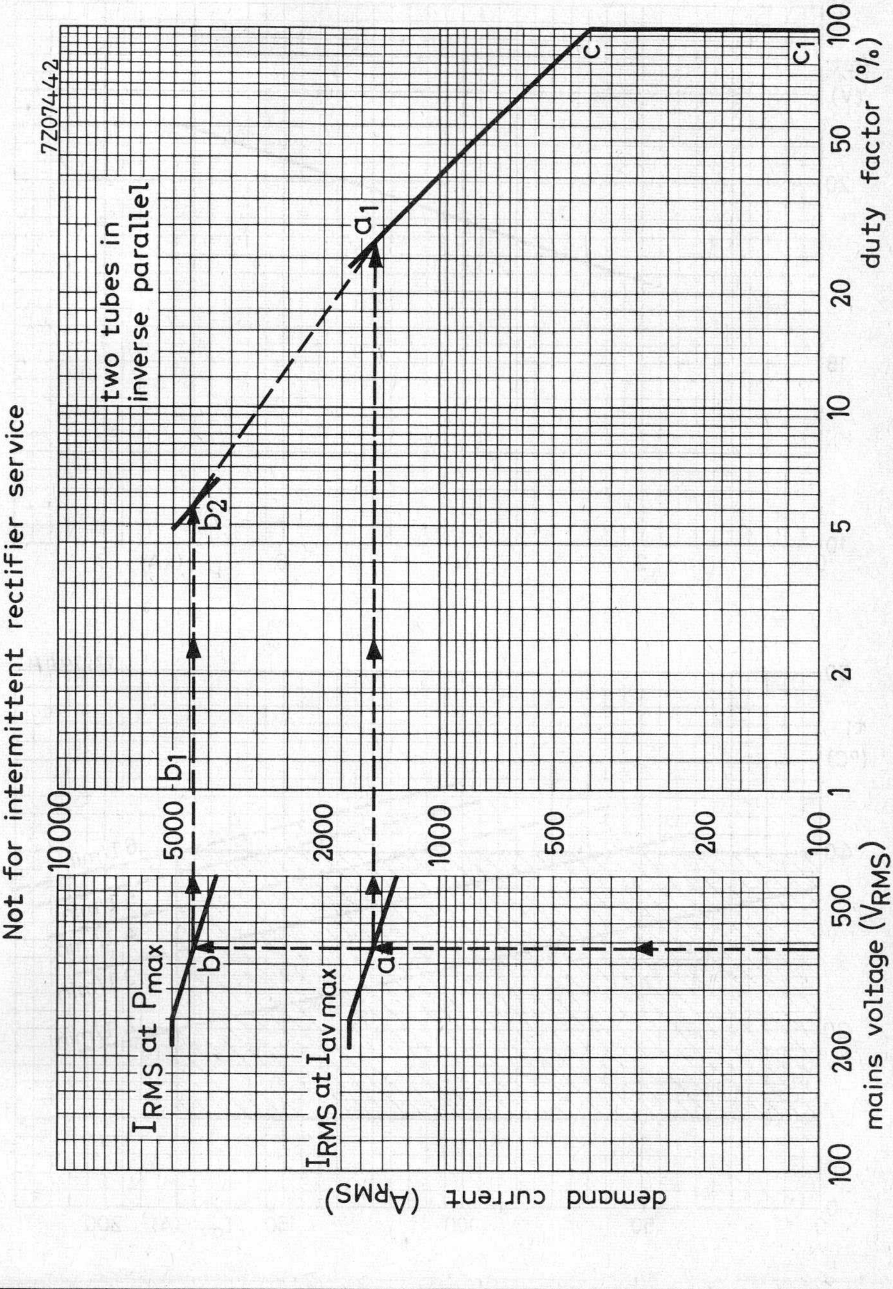
7Z2 8329

Graph to determine demand current versus duty factor as a function of the mains voltage (page B)

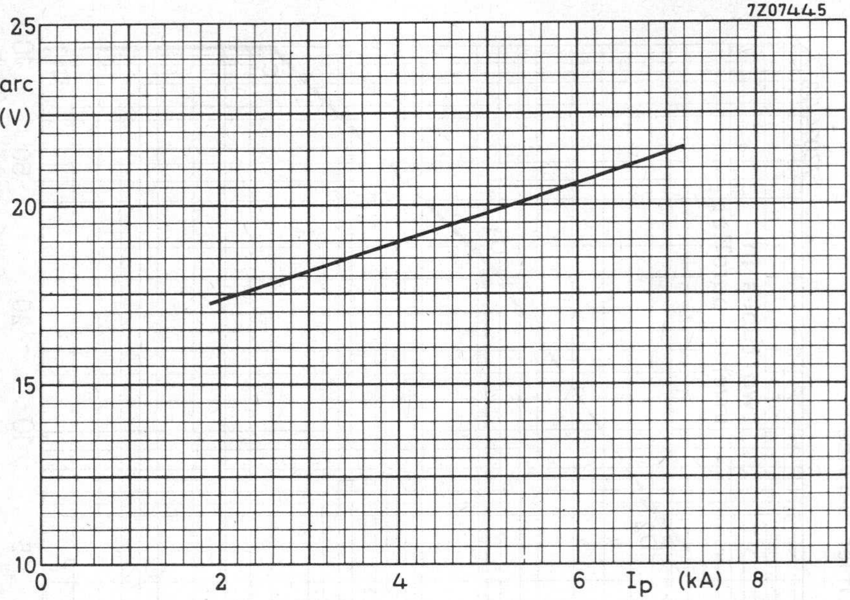
Construction:

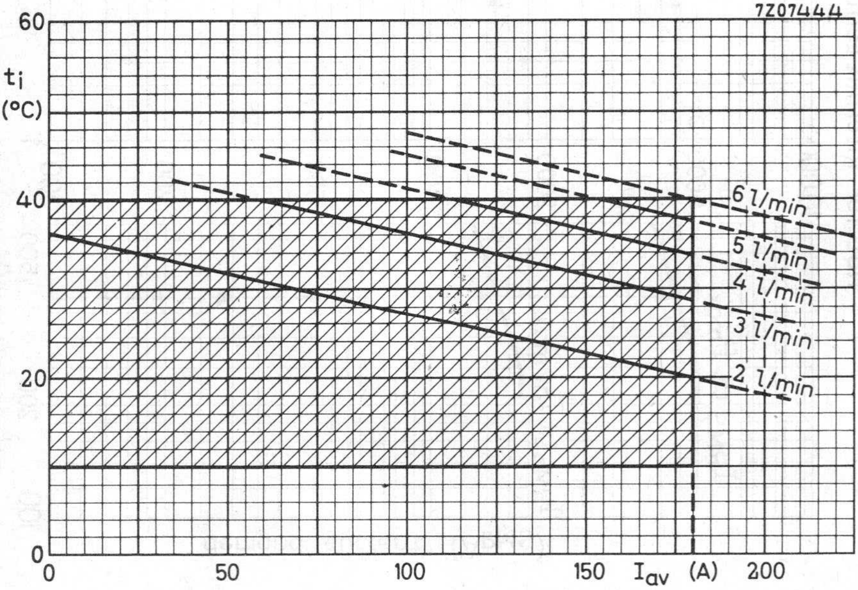
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.

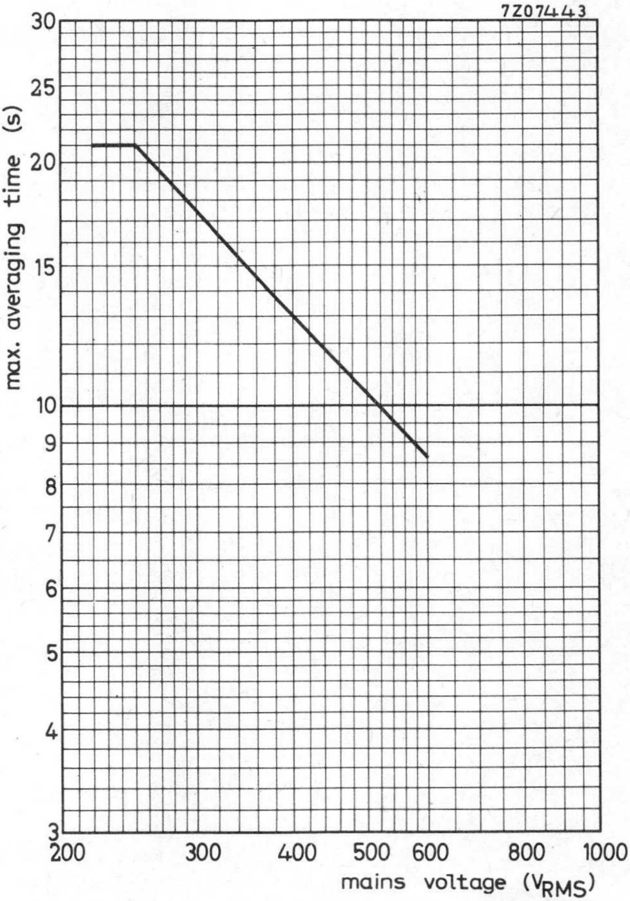
7Z2 8335



Not for intermittent rectifier service
two tubes in inverse parallel
7Z07442
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
a_1
b_1
b_2
c
c_1
demand current (A_{RMS})
mains voltage (V_{RMS})
duty factor (%)
10000
5000
2000
1000
500
200
100
1
2
5
10
20
50
100
200
500


7Z07445
25
V_{arc}
(V)
20
15
10
0
2
4
6
I_p (kA)
8


7Z07444
60
t_i
(°C)
40
20
0
0
50
100
150
I_{av} (A)
200
6 l/min
5 l/min
4 l/min
3 l/min
2 l/min



7Z07443
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3
200
300
400
500
600
800
1000
mains voltage (V_{RMS})

Radiation Counter Tubes

RADIATION COUNTER TUBES APPLICATION DIRECTIONS

1. GENERAL

1.1 A radiation counter tube is a gas-filled device which reacts to individual ionizing events, thus enabling them to be counted.

1.2 A radiation counter tube basically consists of an electrode at a positive potential (anode), surrounded by a metal cylinder at a negative potential (cathode). The cathode forms part of the envelope or is enclosed in a glass envelope. Quanta or particles may enter the counter tube either through a foil (the window) or through the cylinder wall itself.

1.3 Typical quanta or particles are:

alpha rays,
beta rays,
X- or gamma rays,
thermal neutrons.

1.4 The gas filling normally consists of a mixture of rare gases and a quenching agent (self quenched counter tube).

1.5 Quenching is the process of terminating a pulse of ionization current in a counter tube.

1.5.1 For tubes provided with a quenching agent the voltage drop across the load resistor, normally used, is sufficient for terminating the discharge.

2. CAPACITANCES

The capacitance of a counter tube is the capacitance between anode and cathode, the connections being completely shielded.

3. OPERATING CHARACTERISTICS

3.1 Starting voltage. This is the minimum supply voltage applied to a radiation counter tube at which pulses of 1 V amplitude appear across the tube.

3.2 Operating voltage. This is the anode supply voltage at which the radiation counter tube should be used.
If this is not quoted the middle of the minimum plateau (i.e. $\frac{V_1+V_2}{2}$) should be considered as the recommended operating voltage.

7Z2 8445

3.3 Plateau. The range of applied potential difference in which the count rate varies relatively little under constant conditions of irradiation. Unless otherwise stated, the plateau is measured at a count rate of approximately 100 counts/s.

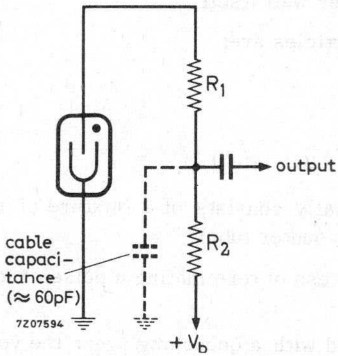
3.4 Plateau slope. The percentage change in count rate for a given change (usually 1 V) in applied voltage.

3.5 Background. The count rate of a counter tube in the absence of the radiation which the tube is ment to measure.

3.6 Dead time. This is the time interval after the initiation of a voltage pulse during which (assuming no interference by an external circuit) a subsequent ionizing event does not produce a discharge.
Unless otherwise stated the dead time curve is given at a count rate of 100 counts/s.

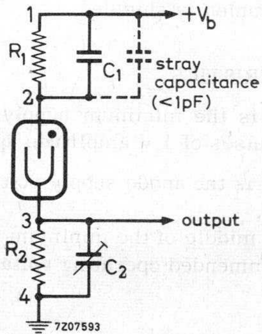
4. MEASURING CIRCUITS

4.1 Measuring circuit A



Note: The value of R_1 should not be lower than the value specified by the manufacturer.

4.2 Measuring circuit B



7Z2 8446

Notes:

1. The input resistance and the input capacitance of the measuring equipment are incorporated in R_2 and C_2 respectively.
2. R_1 should be as specified by the manufacturer and should be mounted close to the counter tube anode connector.
3. When applying a rectangular pulse at "1" with the tube inserted, but short circuited the capacitor C_2 should be adjusted so that the pulse at "3" is undistorted. Under these conditions R_1 (C_1 + stray capacitance) = R_2C_2.
4. The measuring equipment consists of a cathode follower with a pulse shaper, a limiting amplifier and a scaler.

Unless otherwise stated the measurements of a certain type are carried out in the measurement circuit given in the data sheet and with a Co^{60} source.

5. OPERATIONAL NOTES

5.1 Pulse amplitude. The pulse amplitude of the radiation counter tubes may be estimated generally at $P \geqq b\ (V_b - V_{ign})$. In this formula V_b is the applied supply voltage and V_{ign} the starting voltage of the tube. The factor b originates from the tap on the anode resistor, as indicated in the recommended circuit. The influence of the connected capacitive loss is thus minimized. The resolving time of the scaler should be smaller than the minimum dead time of the counter tube.

5.2 Scaler. For normal use and at moderate count rates an input sensitivity of approximately 0.5 V will be sufficient. At very high count rates the mean level of the anode voltage of the counter tube will drop appreciably below V_b, and the pulse amplitude will decrease accordingly so that the smallest pulses will be lost at the input of the scaler. In this case it is possible to increase the sensitivity of the measuring circuit by means of a pulse amplifier combined with pulse shaping networks.

5.3 Pulse shaper and amplifier. The circuit should have a resolving time shorter than the minimum dead time of the counter tube. The pulse amplitude should not be influenced by the pulse shaper. Pulse amplification should be sufficiently high and the rise time of the amplifier should be considerably smaller than the rise time of the pulse from the counter tube.

5.4 Load. Normally the tubes should be operated with an anode resistor having a value as indicated in the published data sheets, or a higher value. Decreasing the resistance of the anode resistor not only decreases the dead time, but also the plateau length. In general a decrease of the resistance below the indicated minimum value causes the tube to oscillate.
The anode resistor should be connected directly to the anode connector of the tube, thus preventing parasitic capacitances of leads from considerably increasing the capacitive load of the tube. An increase of the capacitive load has the tendency of increasing the pulse amplitude, the pulse duration, the dead time and the plateau slope, whereas the plateau length will be shortened appreciably. Shunt capacitances of 20 pF or more may destruct the tube.

7Z2 8447

5.5 Count rate. After every pulse the counter tube is temporarily insensitive during a period called the dead time. Consequently, the pulses that occur during this period are not counted. At a count rate of N counts/s the tube will be insensitive during $100N\tau\%$ of the time, so that approximately $100N\tau\%$ of the counts will be lost. If the counting losses may not be greater than 1%, N should be less than $1/100\tau$ counts/s. The maximum count rate is approximately $1/\tau$.

6. BF3 PROPORTIONAL COUNTERS

The range of neutron proportional counters makes use of the $B(n, \alpha)Li$ reaction to detect thermal neutrons in the flux range from 10^{-4} to 10^{5} $n/cm^2/s$. The counter tubes in this range provide effective discrimination against γ radiation. The life expectancy of the tubes is in excess of 10^{11} counts, their life being finally determined by the consumption of borontrifluoride gas in the reaction referred to, and by the effects of ionisation.

7. LIMITING VALUES

7.1 The limiting values of radiation counter tubes are given in the absolute maximum rating system.

Absolute maximum rating system (in accordance with I.E.C. publication 134)

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

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

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

7.2 Ambient temperature. The ambient temperature is the temperature of the surroundings of the tube.

8. MOUNTING

8.1 Unless otherwise stated, any mounting position is permissible.

8.2 Low-capacitance mounting of the tube is required (shortest possible connection between anode connector and load resistor and small capacitance between anode and cathode leads).

8.3 No attempt should be made to solder directly to the stainless steel cathode, as this will destroy the tube.

7Z2 8448

9. STORAGE AND HANDLING

9.1 The tube should not be stored at ambient temperatures outside the limits given under the heading "Limiting values" on the published data sheets.

9.2 In order to prevent leakage between anode and cathode the tube should be dry and well cleaned.

9.3 At a low ambient temperature care should be taken to avoid condensing of water vapour on the connectors.

9.4 Some types of radiation counter tubes have thin windows and/or thin cathode walls. In order to prevent damage, these tubes should be handled and mounted with utmost care. The mica-window types are provided with a cap to protect the window when the tube is not in operation.

10. OUTSIDE PRESSURE

10.1 Tubes provided with a window. To prevent damage to the tube, the following precautions should be observed.

10.1.1 Unless otherwise stated, the gas pressure outside the tube should be neither lower than 25 cm Hg nor higher than the atmospheric pressure.

10.1.2 Variations in pressure should be gradual.

10.2 Care should be taken when tubes having very thin envelopes are exposed to pressures higher than atmospheric.

11. OUTLINE DIMENSIONS

The outline dimensions are given in mm.

7Z2 8449

RADIATION COUNTER TUBES
LIST OF SYMBOLS

Anode supply voltage	V_b
Voltage at the beginning of the plateau	V_{b_1}
Voltage at the end of the plateau	V_{b_2}
Plateau length (= $V_{b_2} - V_{b_1}$)	V_{pl}
Starting voltage	V_{ign}
Count rate (= counts/unit of time)	N
Count rate at V_{b_1}	N_1
Count rate at V_{b_2}	N_2
Background	N_o
Plateau slope (= $\frac{N_2 - N_1}{\frac{1}{2}(N_1 + N_2)} \times \frac{1}{V_{pl}} \times 100\ \%$)	S_{pl}
Dead time	τ
Capacitance (anode to cathode)	C_{ak}
Ambient temperature	t_{amb}
Gas multiplication factor	A

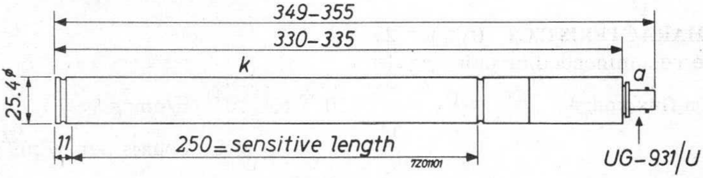
7Z2 8450

BF_3 PROPORTIONAL COUNTER TUBE

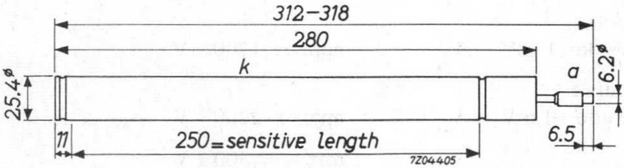
Borium-tri-fluoride filled proportional counters for thermal neutrons

QUICK REFERENCE DATA		
Thermal neutron flux range	10^{-3} to 10^4	n/cm^2s
Sensitivity	9.8	counts per n/cm^2
Background	max. 1	count/min
Operating voltage	1600 to 2400	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



ZP1000



ZP1001

CATHODE

Thickness	0.4 mm
Effective length	250 mm
Material	Oxygen-free copper

ANODE

Diameter	50 μm
Material	Tungsten

7Z2 8486

BOTTOM

Thickness	0.5 mm
Material	Fernico

FILLING — BF_3 enriched 96% B^{10}, gas pressure 70 cmHg

CAPACITANCE

Anode to cathode	ZP1000	C_{ak}	7.4 pF
	ZP1001	C_{ak}	4.4 pF

ACCESSORIES - ZP1000

Cable plug — type 56069 (MIL-UG-932/U)
With this cable plug a cable MIL-RG-59/U is recommended.

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

Thermal neutron flux range		10^{-3} to 10^{4}	n/cm^{2}s
Sensitivity		9.8	counts per n/cm^2
Operating voltage range	V_b	1600 to 2400	V
Operating voltage for pulse amplitude 1 mV	V_b	approx.1700	V
Operating voltage for pulse amplitude 10 mV	V_b	approx.2300	V
Plateau length	V_{pl}	min. 300	V
Plateau slope	S_{pl}	max. 1	% per 100 V
Background	N_o	max. 1	count/min
Pulse amplitude distribution width (see fig.2)	$\Delta P/P$	max. 14	%
Valley-to-peak ratio (see fig.2)	$\Delta N/N$	max. 2	%

7Z2 8487

TYPICAL OPERATION

Operating voltage	V_b	2100	V
Gas multiplication factor	A	13	
Source (in paraffin moderator)		100	mg RaBe
Distance between source and tube		10	cm
Accompanying γ dose rate		7	R/h
Ambient temperature	t_{amb}	25	^{o}C
Pulse amplitude	V_{pulse}	approx. 4.5	mV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2500	V
Ambient temperature	t_{amb}	min.	-80	^{o}C
		max.	+100	^{o}C

LIFE EXPECTANCY

The life of the tube is determined by consumption of the BF_3 gas, caused by the nuclear reaction B(n, α)Li, and by ionization. The experimentally verified life of the tube under the conditions specified in the section "Typical Operation" is in excess of 10^{11} counts.

In order to extend the life of the tube it is recommended to operate at low values of the gas amplification factor.

RECOMMENDED CIRCUIT

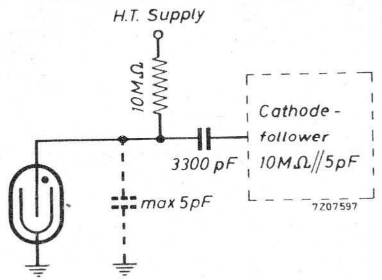


Fig.1

7Z2 8488

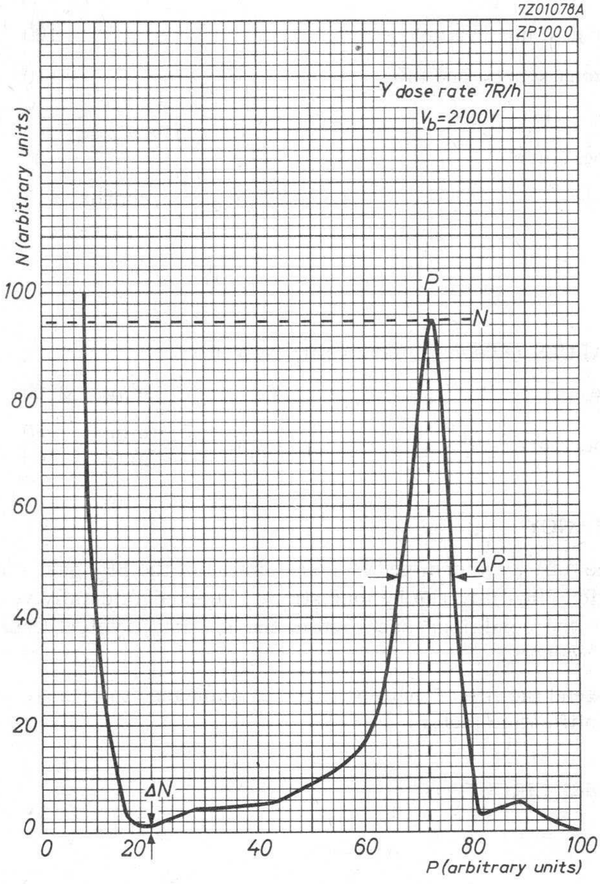


Fig. 2

Typical differential bias curve

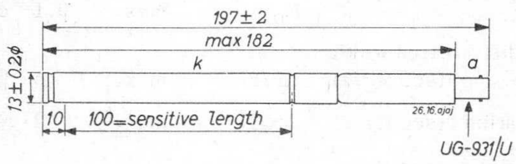
BF_3 PROPORTIONAL COUNTER TUBE

Borium-tri-fluoride filled proportional counter tube for thermal neutrons

QUICK REFERENCE DATA			
Thermal neutron flux range		10^{-2} to 10^{5}	n/cm^2s
Sensitivity		0.87	count per n/cm^2
Background	max.	0.1	count/min
Operating voltage		900 to 1900	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	0.4 mm
Effective length (outside diameter 12.7 mm)	100 mm
Material	Oxygen-free copper

ANODE

Diameter	25 μm
Material	Tungsten

BOTTOM

Thickness	0.5 mm
Material	Fernico

FILLING

BF_3 enriched 96% B^{10}
gas pressure 70 cmHg

7Z2 8489

ACCESSORIES

Cable plug — type 56069 (MIL-UG-932/U)
With this cable plug a cable MIL-RG-59/U is recommended

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in the recommended circuit, fig.1

Thermal neutron flux range			10^{-2} to 10^{5}	n/cm^2
Sensitivity			0.87	count per n/cm^2
Operating voltage range	V_b		900 to 1900	V
Operating voltage for pulse amplitude 1 mV	V_b	approx.	1050	V
Operating voltage for pulse amplitude 10 mV	V_b	approx.	1600	V
Plateau length	V_{pl}	min.	300	V
Plateau slope	S_{pl}	max.	1	% per 100 V
Background	N_o	max.	0.1	count/min
Pulse amplitude distribution width (see fig.2)	$\Delta P/P$	max.	6	%
Valley-to-peak ration (see fig.2)	$\Delta N/N$	max.	2	%

TYPICAL OPERATION

Operating voltage	V_b		1400	V
Gas multiplication factor	A		14	
Ambient temperature	t_{amb}		25	°C
Pulse amplitude	V_{pulse}	approx.	4	mV

LIMITING VALUES (Absolute max. rating system)

Supply voltage	V_b	max.	2000	V
Ambient temperature	t_{amb}	min.	-80	°C
		max.	+100	°C

LIFE EXPECTANCY

The life of the tube is determined by consumption of the BF_3 gas by the nuclear reaction B(n, α) Li and by ionisation. Tube life is expected to be 10^{11} counts.

To prolong the life of the tube it is recommended to operate at low values of gas multiplication factor.

7Z2 8490

RECOMMENDED CIRCUIT

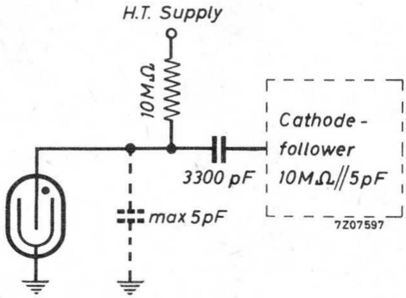


Fig.1

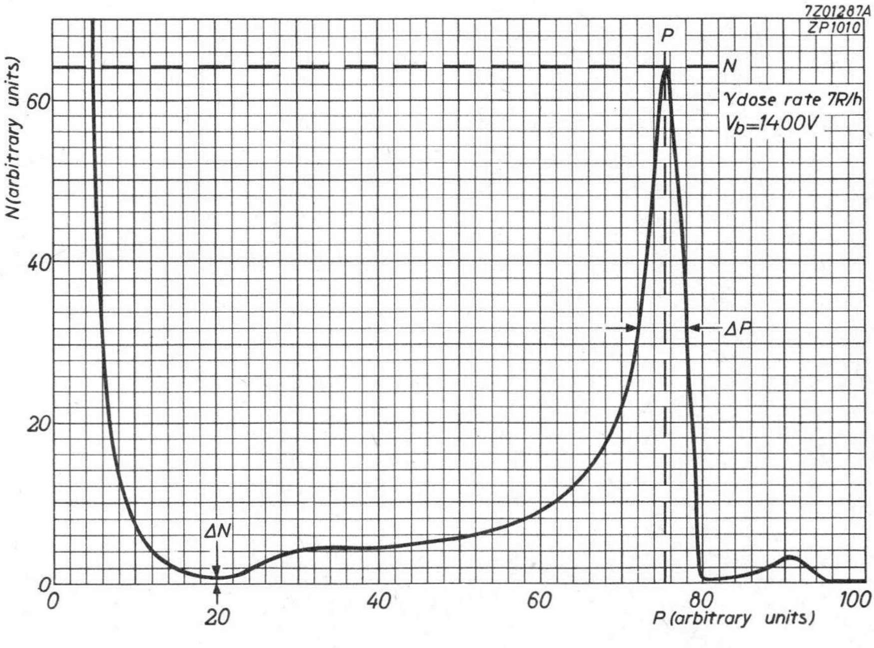


Fig.2

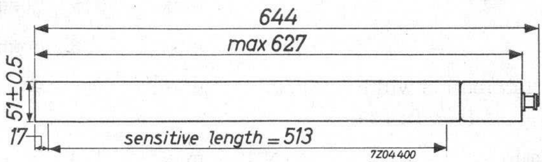
Typical differential bias curve

BF_3 PROPORTIONAL COUNTER TUBE

Borium-tri-fluoride filled proportional counter tube for thermal neutrons.

QUICK REFERENCE DATA		
Thermal neutron flux range	10^{-4} to 10^{3}	n/cm^2s
Sensitivity	75	counts per n/cm^2
Background	max. 3	counts/min
Operating voltage	2300 to 3800	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	1 mm
Effective length	513 mm
Material	Oxygen-free copper

ANODE

Diameter	100 μm
Material	Tungsten

BOTTOM

Thickness	1.5 mm
Material	Oxygen-free copper

FILLING BF_3 enriched 96% B^{10}
gas pressure 70 cmHg

7Z2 8491

ACCESSORIES

Cable plug — type 56069 (MIL-UG-932/U)
With this cable plug a cable MIL-RG-59/U is recommended.

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in the recommended circuit fig. 1

Thermal neutron flux range			10^{-4} to 10^{3}	n/cm^2s
Sensitivity			75	counts per n/cm^2
Operating voltage range	V_b		2300 to 3800	V
Operating voltage for pulse amplitude 1 mV	V_b	approx.	2700	V
Operating voltage for pulse amplitude 10 mV	V_b	approx.	3600	V
Plateau length	V_{pl}	min.	400	V
Plateau slope	S_{pl}	max.	0.5	% per 100 V
Background	N_o	max.	3	counts/min
Pulse amplitude distribution width (see fig. 2)	$\Delta P/P$	max.	25	%
Valley-to-peak ratio (see fig. 2)	$\Delta N/N$	max.	3	%

TYPICAL OPERATION

Operating voltage	V_b		3300	V
Gas multiplication factor	A		11	
Source (in paraffin moderator)			100	mg RaBe
Distance between source and tube			6	cm
Accompanying γ dose rate			< 10	R/h
Ambient temperature	t_{amb}		25	°C
Pulse amplitude	V_{pulse}	approx.	4	mV

7Z2 8492

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max.	4000	V
Ambient temperature	t_{amb}	min.	-80	°C
		max.	+100	°C

LIFE EXPECTANCY

The life of the tube is determined by consumption of the BF_3 gas by the nuclear reaction B (n, α) Li and by ionisation. The tube life is expected to be in excess of 10^{11} counts.

To prolong the life of the tube it is recommended to operate at low values of gas multiplication factor.

RECOMMENDED CIRCUIT

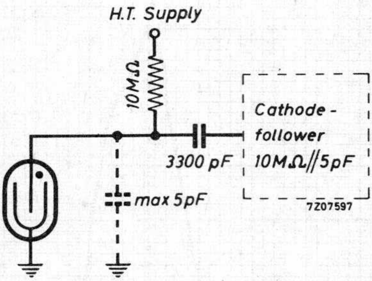


Fig.1

7Z2 8493

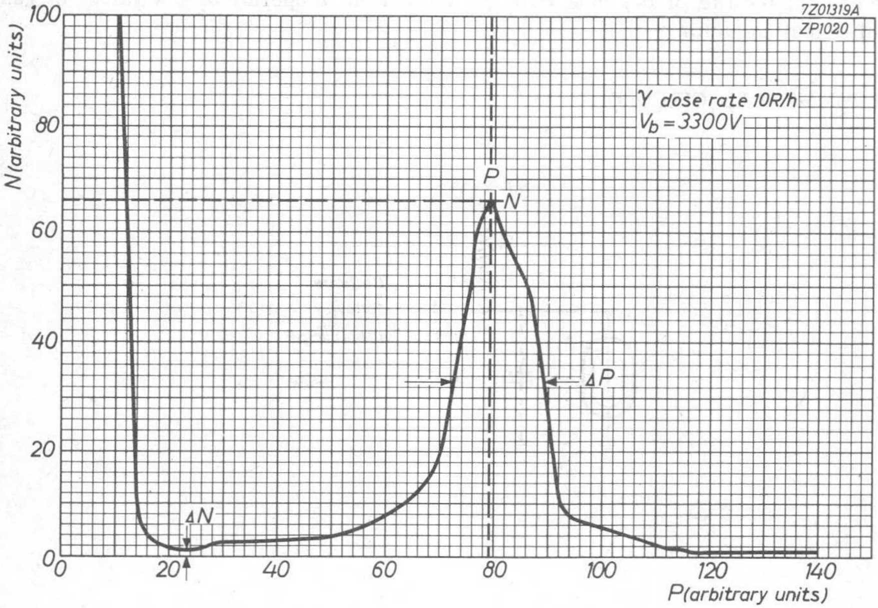


Fig.2

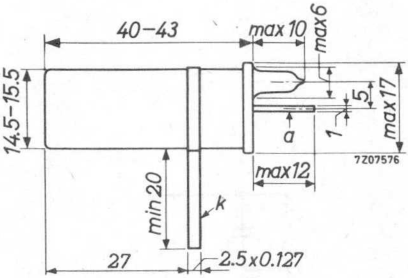
Typical differential bias curve

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-4} to 1 R/h
Operating voltage	400 to 600 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	250 mg/cm^2
Effective length	40 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 2 pF

7Z2 8452

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

Starting voltage	V_{ign}	max. 325	V 1)
Recommended operating voltage	V_b	arbitrary within plateau	
Plateau	V_{pl}	400 to 600	V
Plateau slope	S_{pl}	max. 0.03	%/V
Background, shielded with 50 mm Pb	N_o	max. 10	counts/min.
Dead time at V_b = 500 V	τ	max. 90	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 4.7	MΩ
Anode voltage	V_a	max. 600	V
Ambient temperature	t_{amb}	min. −50 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

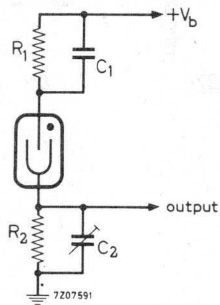
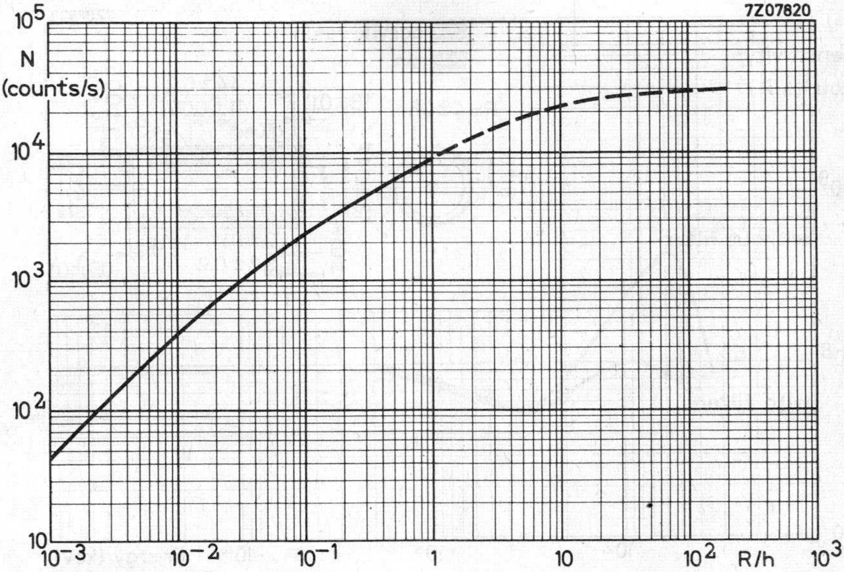


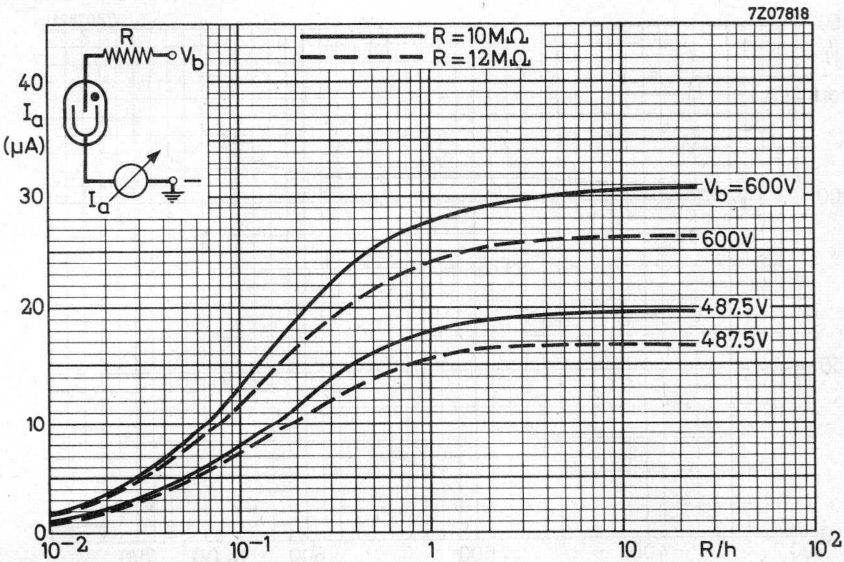
Fig.1

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

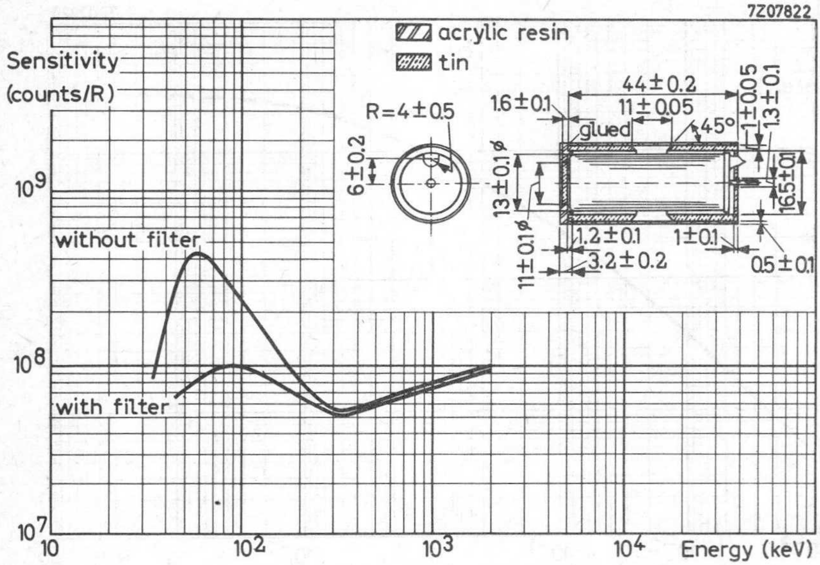
7Z2 8453



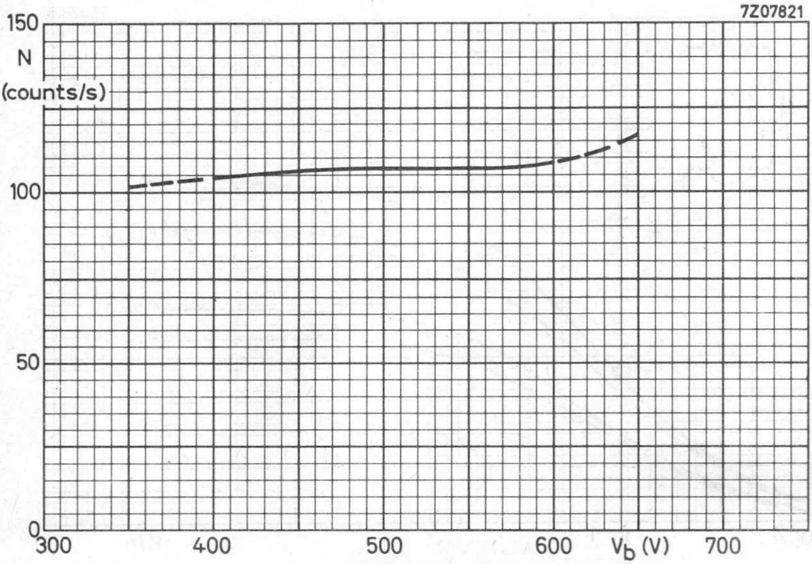
Count rate as function of dose rate



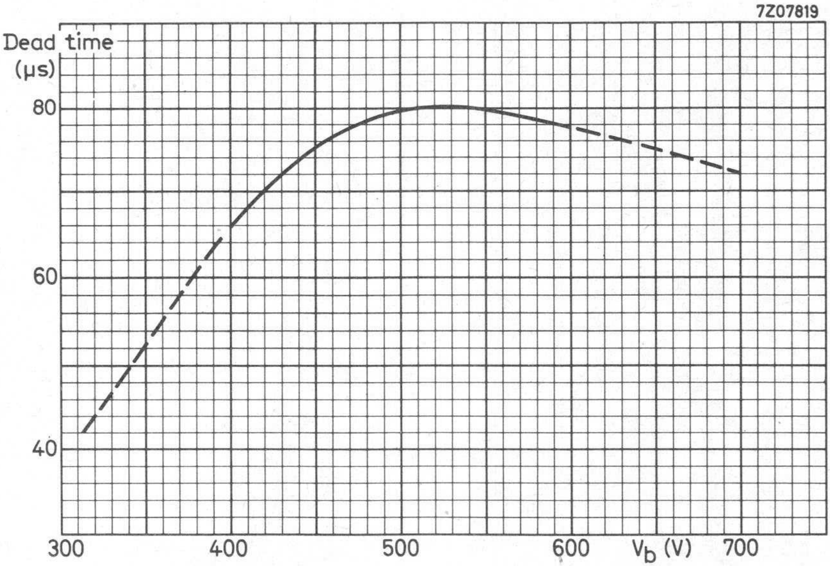
Current as function of dose rate



Energy response curve (side response)



Plateau curve



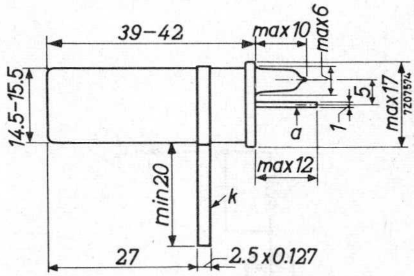
Dead time curve

BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched β and γ radiation counter tube

QUICK REFERENCE DATA		
Range (Co^{60} γ radiation)	10^{-4} to 1	R/h
Window thickness	2 to 3	mg/cm^2
Window diameter	9	mm
Operating voltage	400 to 600	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2 to 3	mg/cm^2
Effective diameter	9	mm
Material	mica	

CATHODE

Thickness	250	mg/cm^2
Effective length	39	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 2 pF

7Z2 8454

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

Starting voltage	V_{ign}	max.	325	V [1])
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	400 to 600		V
Plateau slope	S_{pl}	max.	0.03	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	10	counts/min.
Dead time at V_b = 500 V	τ	max.	90	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	4.7	MΩ
Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 220 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

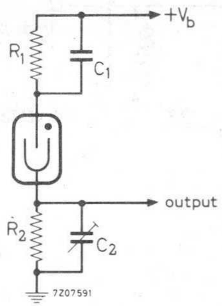
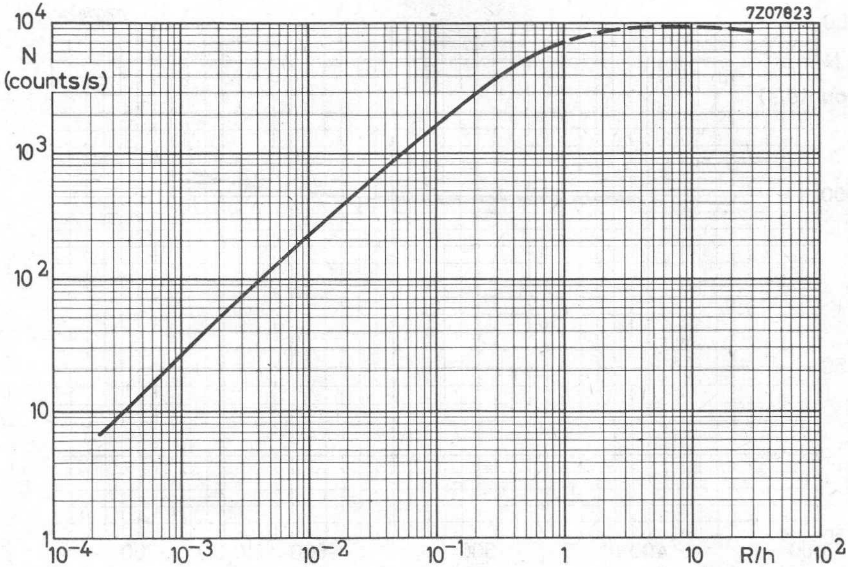


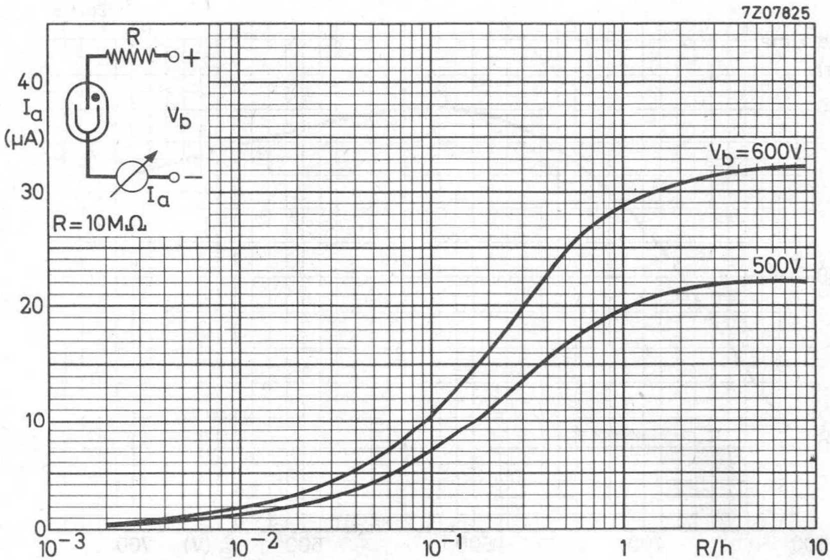
Fig.1

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

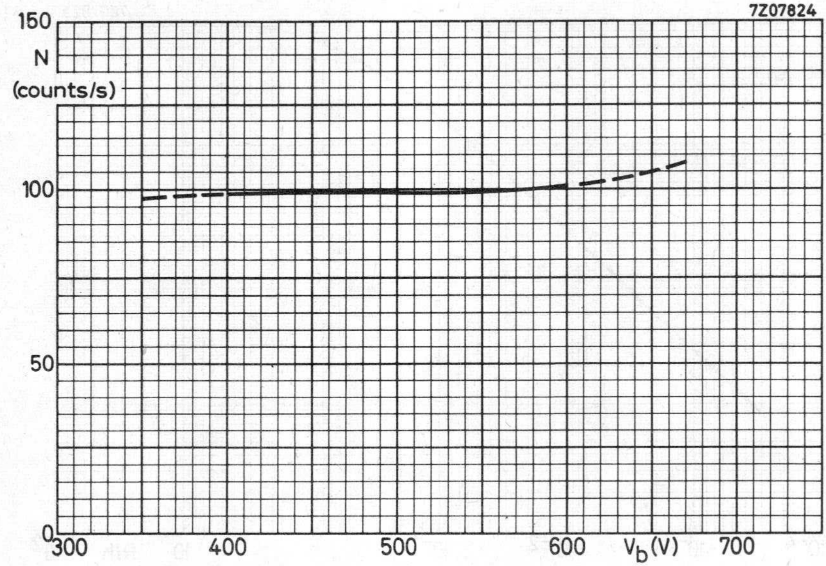
7Z2 8455



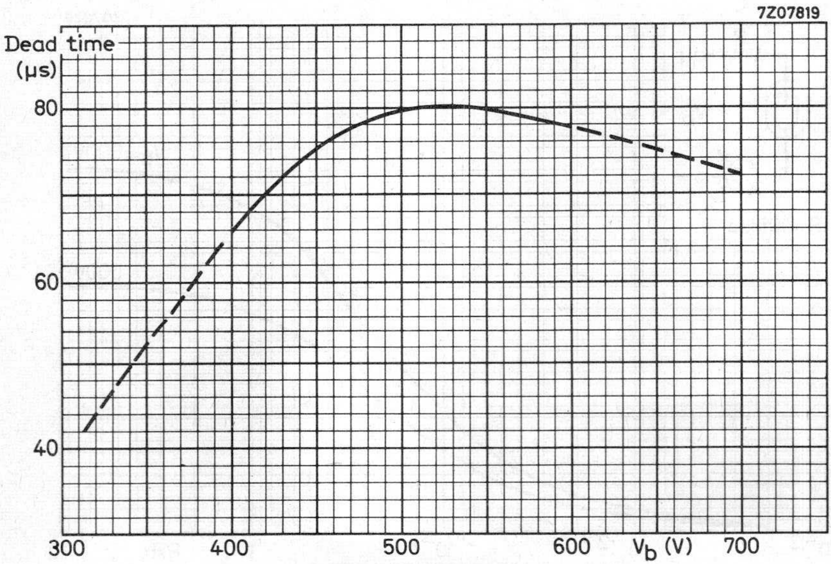
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



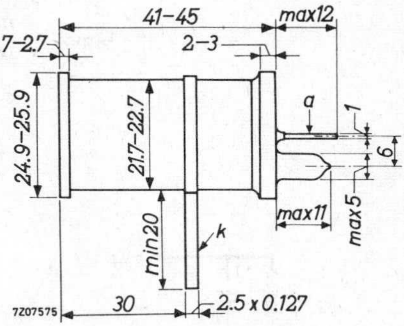
Dead time curve

ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched α, β and γ radiation counter tube

QUICK REFERENCE DATA	
Window thickness	1.5 to 2 mg/cm^2
Window diameter	19.8 mm
Operating voltage	450 to 700 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	1.5 to 2 mg/cm^2
Effective diameter	19.8 mm
Material	mica

CATHODE

Thickness	1.2 mm
Effective length	37 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 2.5 pF

7Z2 8456

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

Starting voltage	V_{ign}	max.	350	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to	700	V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	15	counts/min.
Dead time at V_b = 500 V	τ	max.	175	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	2.2	MΩ
Anode voltage	V_a	max.	700	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 470 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

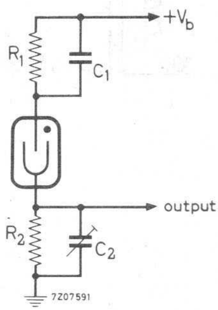
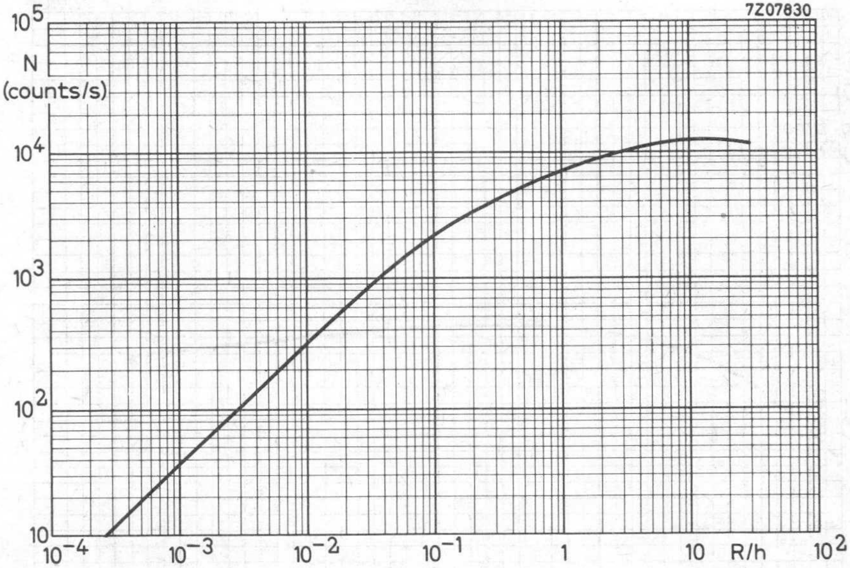
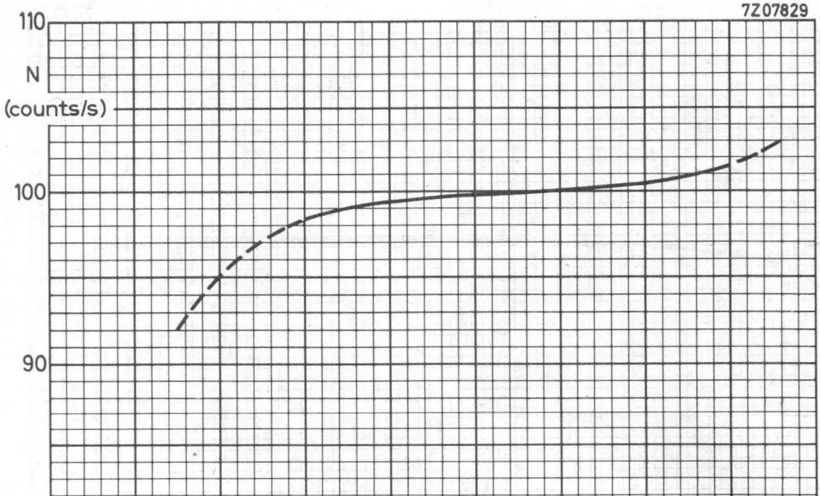


Fig.1

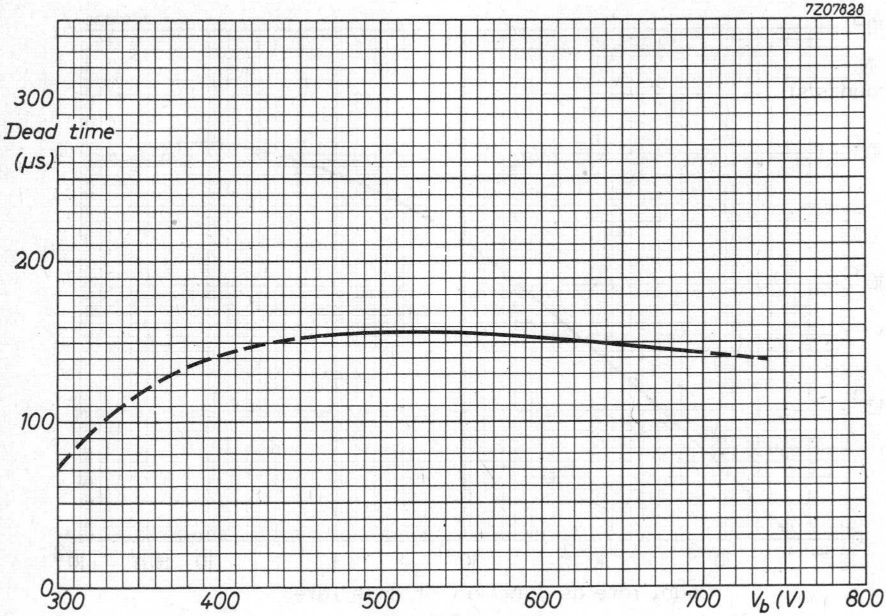
7Z2 8457



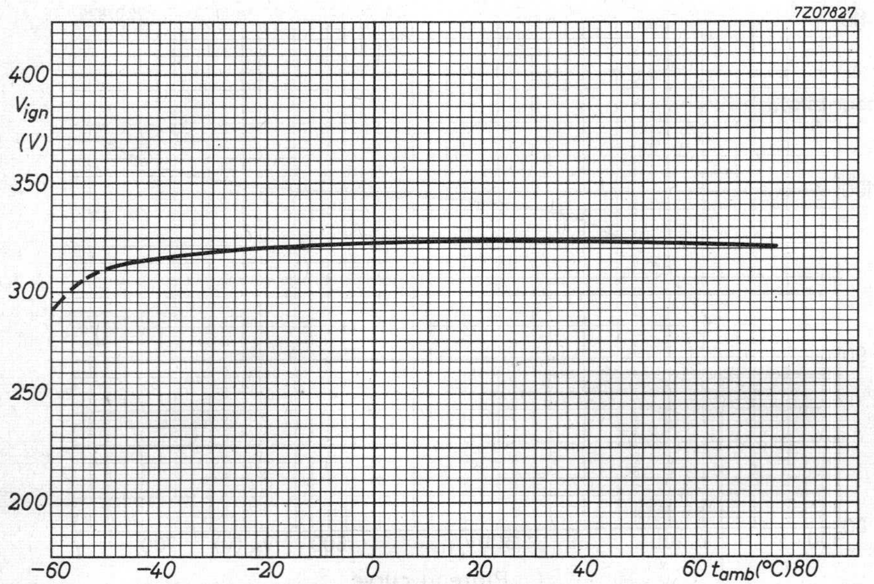
Count rate as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

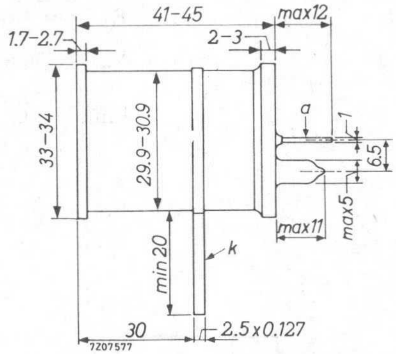
BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched β and γ radiation counter tube

QUICK REFERENCE DATA	
Window thickness	2.5 to 3.5 mg/cm^2
Window diameter	27.8 mm
Operating voltage	450 to 800 V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



WINDOW

Thickness	2.5 to 3.5 mg/cm^2
Effective diameter	27.8 mm
Material	mica

CATHODE

Thickness	1.3 mm
Effective length	37 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

7Z2 8458

CAPACITANCE

Anode to cathode	C_{ak}	3.5	pF

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

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 800		V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	25	counts/min.
Dead time at V_b = 600 V	τ		160	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R_1	min.	2.2	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 470 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

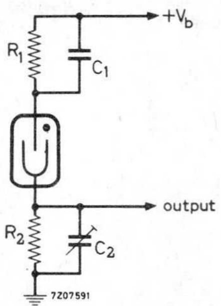
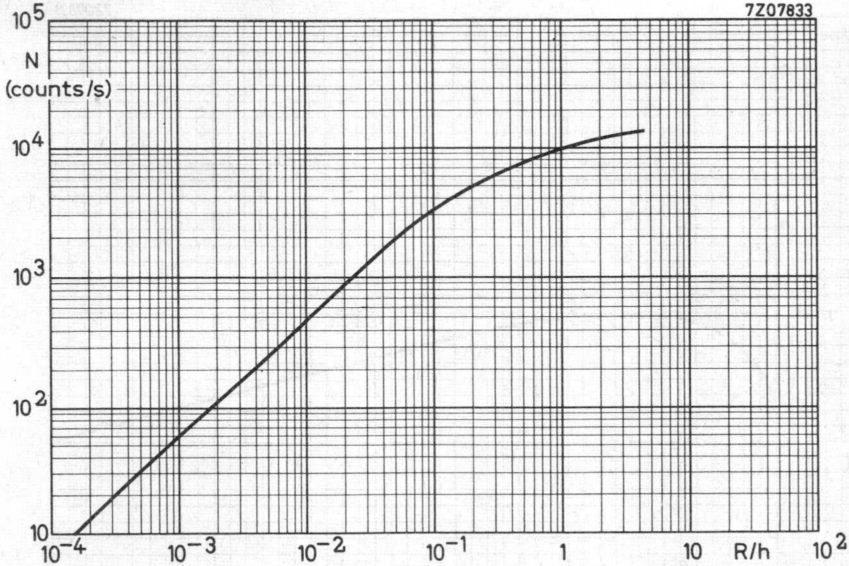
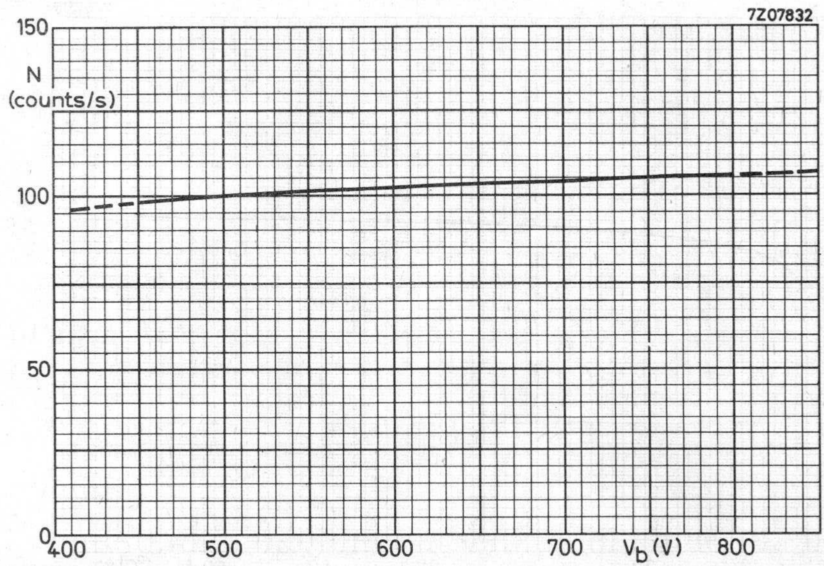


Fig.1

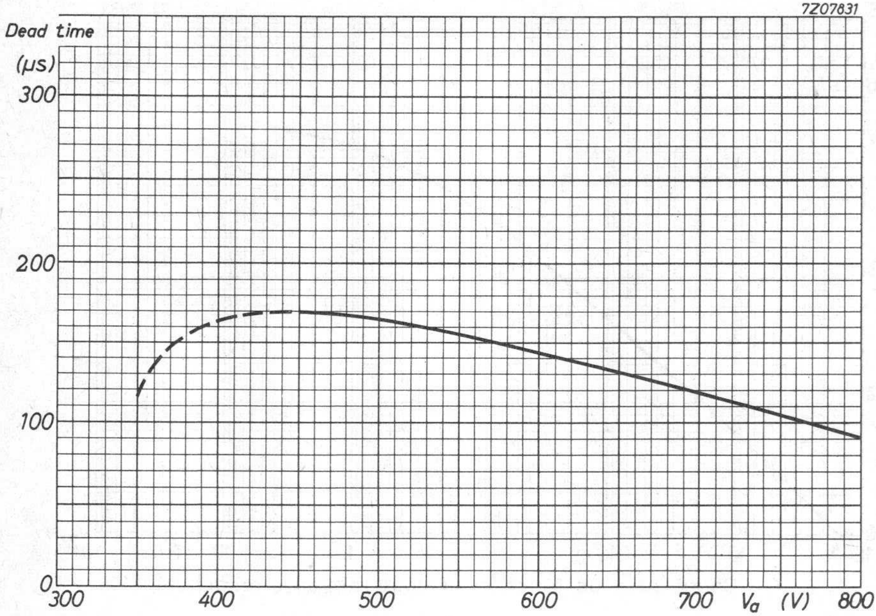
7Z2 8459



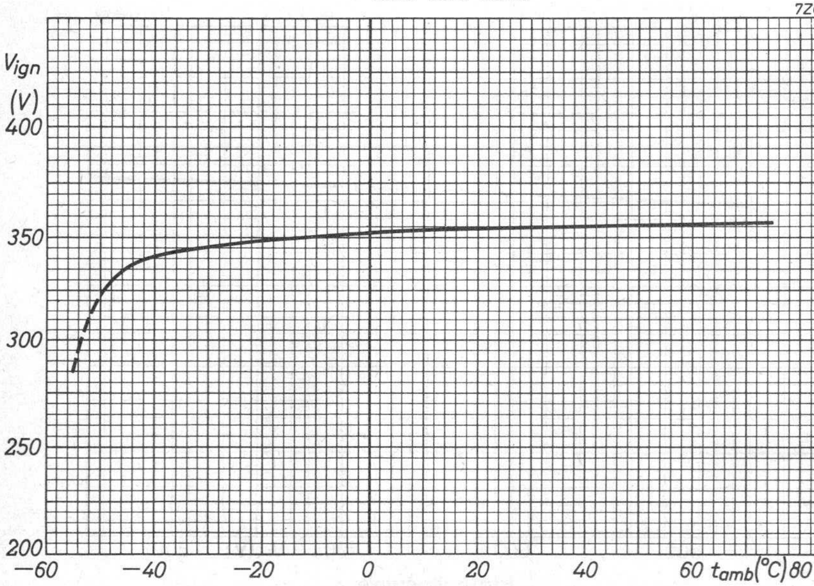
Count rate as function of dose rate (side response)



Plateau curve



Dead time curve



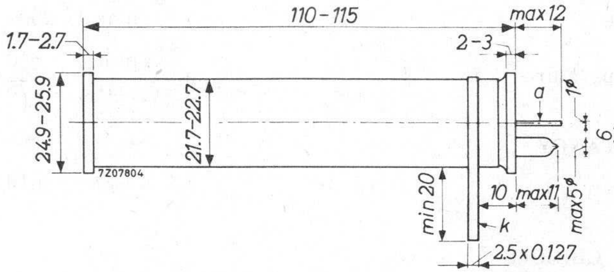
Starting voltage as function of ambient temperature

X-RAY COUNTER TUBE

End window halogen quenched X-ray counter tube.

QUICK REFERENCE DATA	
X-ray energy	2.5 to 200 keV; 0.06 to 0.3 Å
Window thickness	2.5 to 3.5 mg/cm^2
Operating voltage	1600 to 2000 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2.5 to 3.5 mg/cm^2
Effective diameter	19.8 mm
Material	mica

CATHODE

Thickness	1.2 mm
Effective length	107 mm
Material	28% Cr, 72% Fe

FILLING A, halogen

Gas pressure 60 cm Hg

CAPACITANCE

Anode to cathode C_{ak} 2.8 pF

7Z2 8494

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

Starting voltage	V_{ign}	max.	1450	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	1600 to 2000		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	25	counts/min.
Dead time at V_b = 1800 V	τ	max.	110	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	5	MΩ
Anode voltage	V_a	max.	2000	V
Ambient temperature	t_{amb}	min.	0	°C
		max.	75	°C

LIFE EXPECTANCY

Life expectancy	10^{10}	counts

MEASURING CIRCUIT

R = 5 MΩ

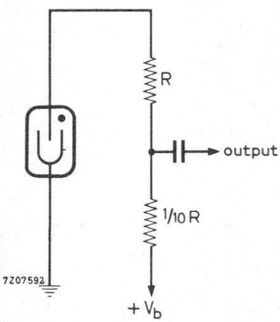
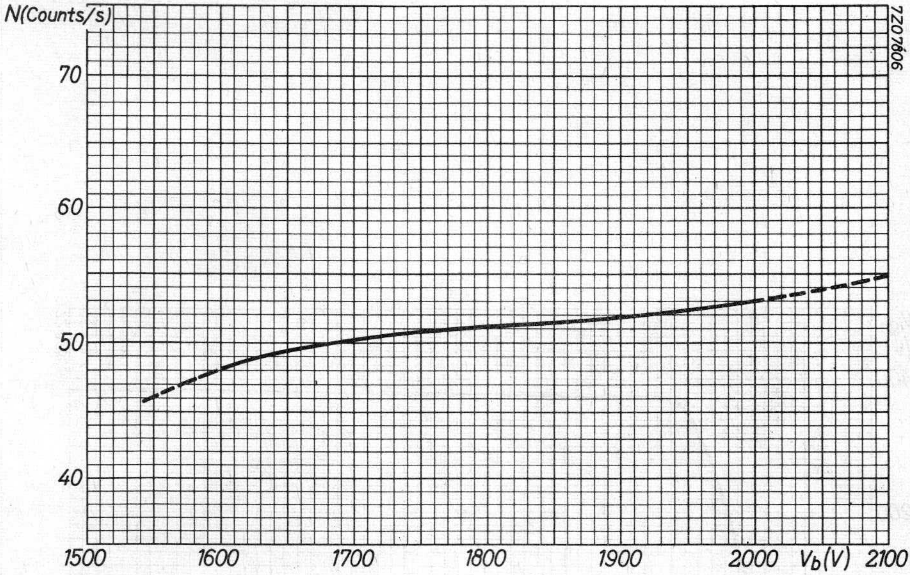
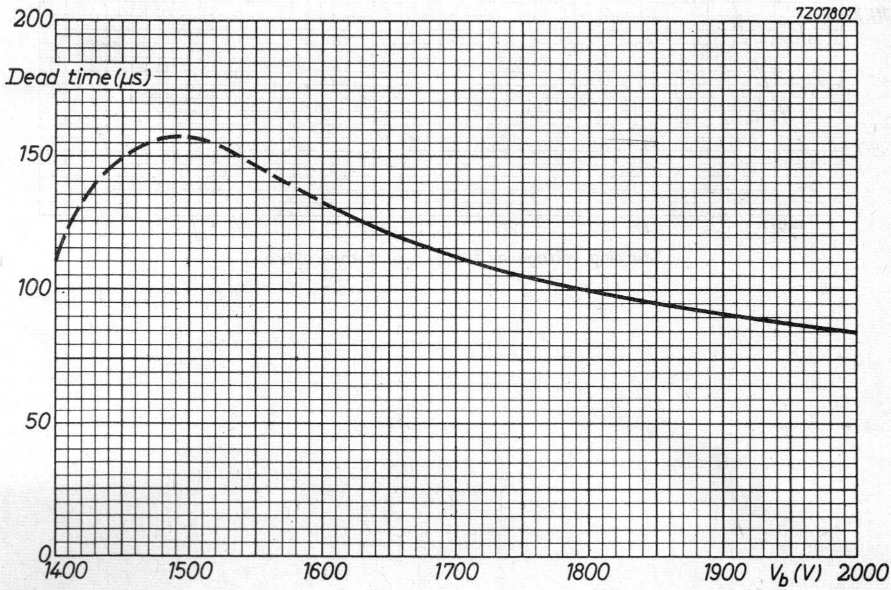


Fig.1

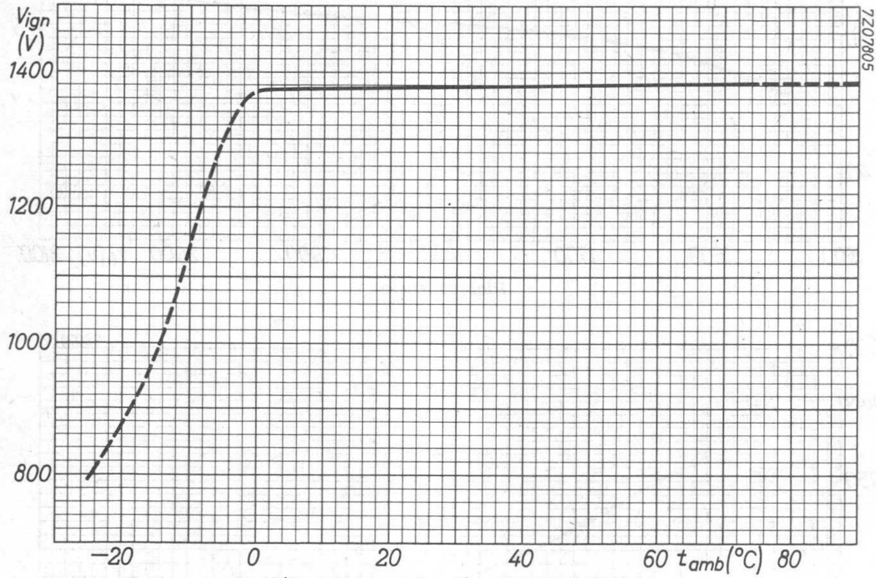
7Z2 8495



Plateau curve



Dead time curve



Starting voltage as function of temperature

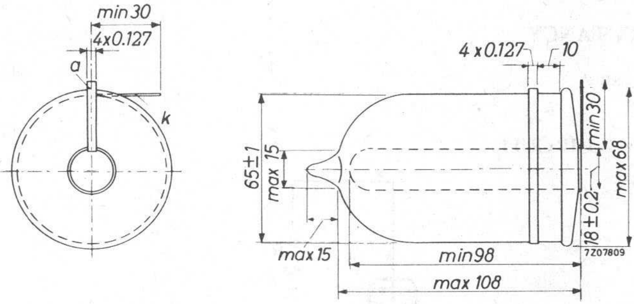
WELL TYPE GAMMA RADIATION COUNTER TUBE

Well type anode halogen quenched γ radiation counter tube for liquid or solid samples. A test glass containing the sample can be inserted in the anode of the tube.

QUICK REFERENCE DATA		
Well diameter	18	mm
Sensitivity for I^{131} (1 μC in 10 ml H_2O)	3600	counts/min
Operating voltage	800 to 1100	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE AND ANODE

Thickness	1	mm
Effective length of anode	90	mm
Material	28% Cr, 72% Fe	

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	7	pF

7Z2 8496

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

Starting voltage	V_{ign}	max.	450	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	800 to	1100	V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb	N_o	max.	100	counts/min.
Dead time at V_b = 1000 V	τ	max.	100	μs
Sensitivity for I^{131} (1 μC in 10 ml H_2O)	S		3600	counts/min.

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7	MΩ
Anode voltage	V_a	max.	1100	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 4.7 MΩ

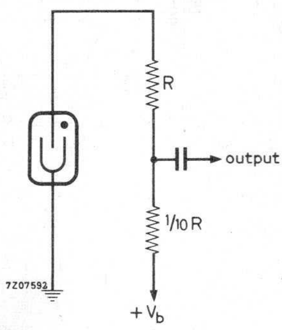


Fig.1

REMARK

To prevent contamination with radio-active materials it is recommended to use test glasses for the liquid samples.

7Z2 8497

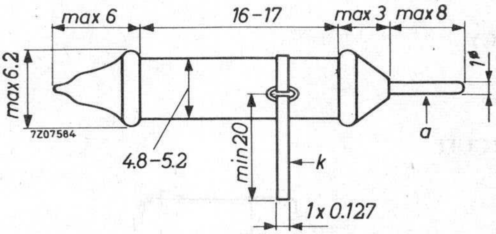
BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched radiation counter tube for the measurement of γ and high energy β (>0.5 MeV) radiation.

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-3} to 3.10^{2} R/h
Operating voltage	500 to 650 V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	80 to 100 mg/cm^2
Effective length	16 mm
Material	28% Cr, 72% Fe

FILLING He, Ne, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1 pF

7Z2 8460

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

Starting voltage	V_{ign}	max. 380 V
Recommended operating voltage	V_b	arbitrary within plateau
Plateau	V_{pl}	500 to 650 V
Plateau slope	S_{pl}	max. 0.15 %/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max. 2 counts/min.
Dead time at V_b = 600 V	τ	max. 15 µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 2.2 MΩ
Anode voltage	V_a	max. 650 V
Ambient temperature	t_{amb}	min. -40 °C max. +75 °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 56 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

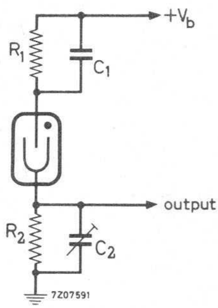
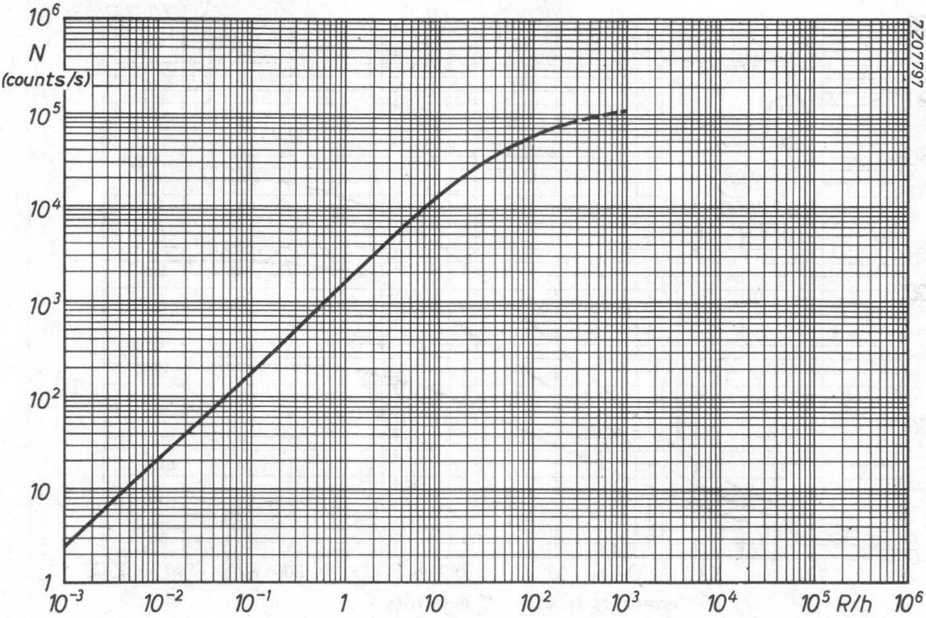
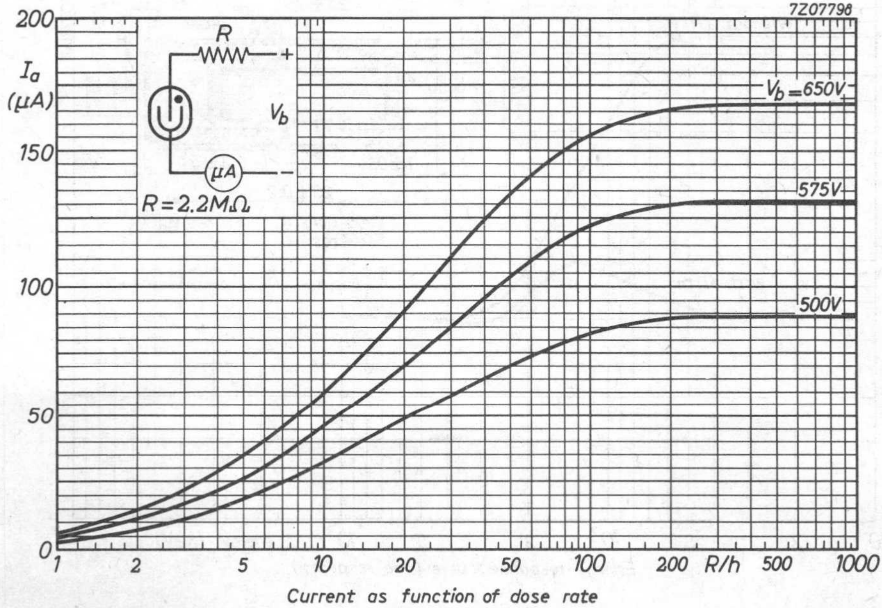


Fig. 1

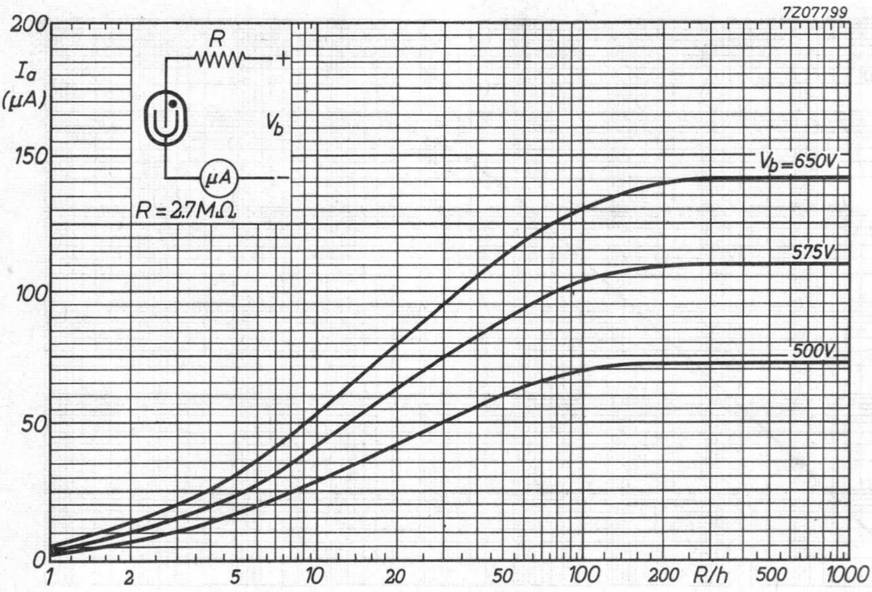
7Z2 8461



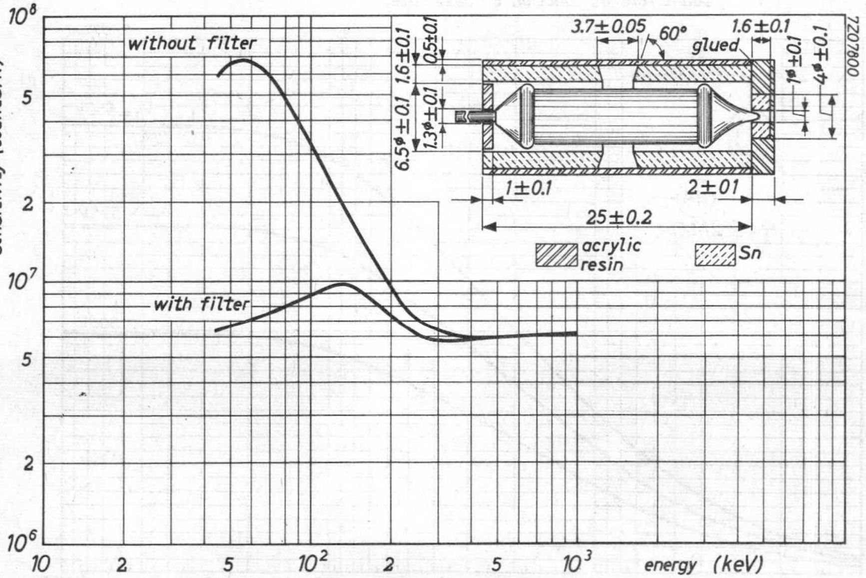
Count rate as function of dose rate



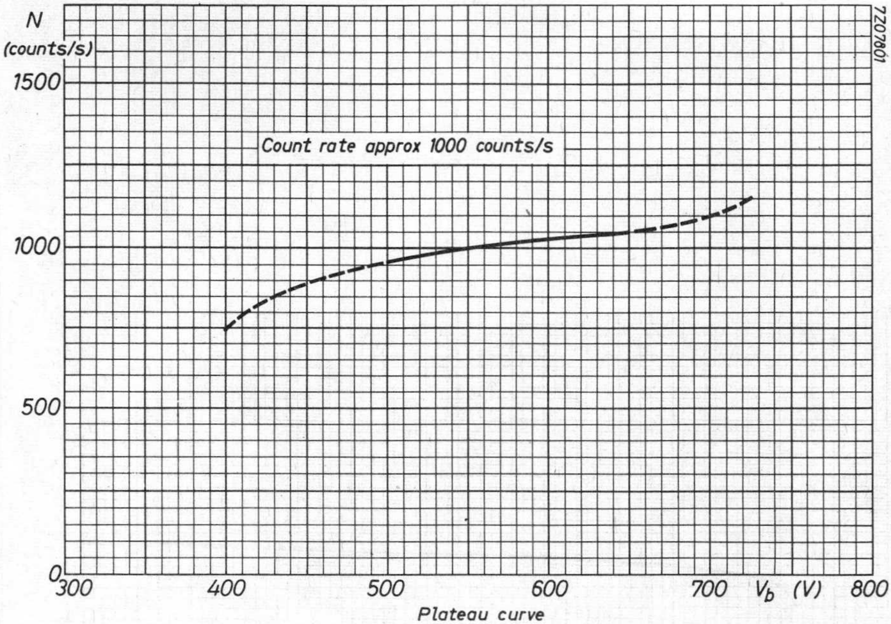
Current as function of dose rate



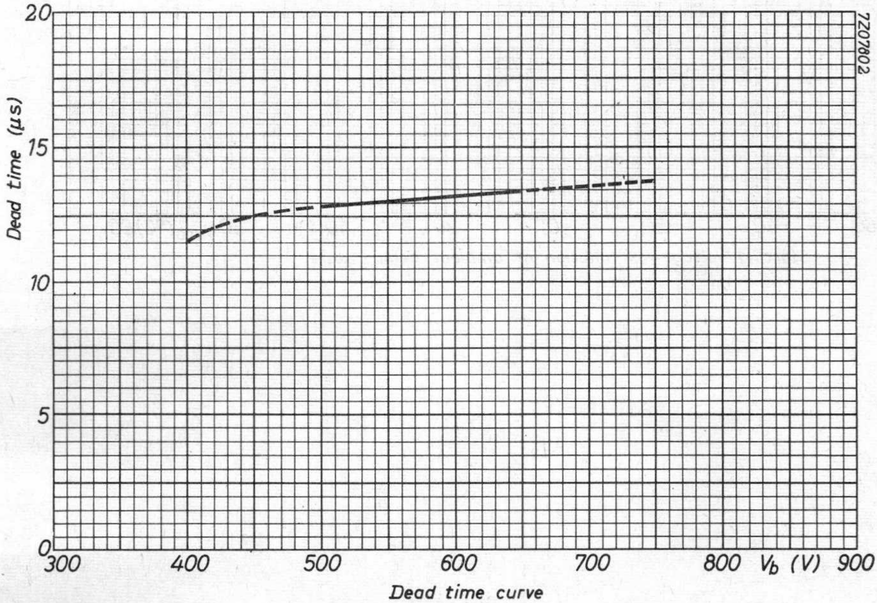
Current as function of dose rate



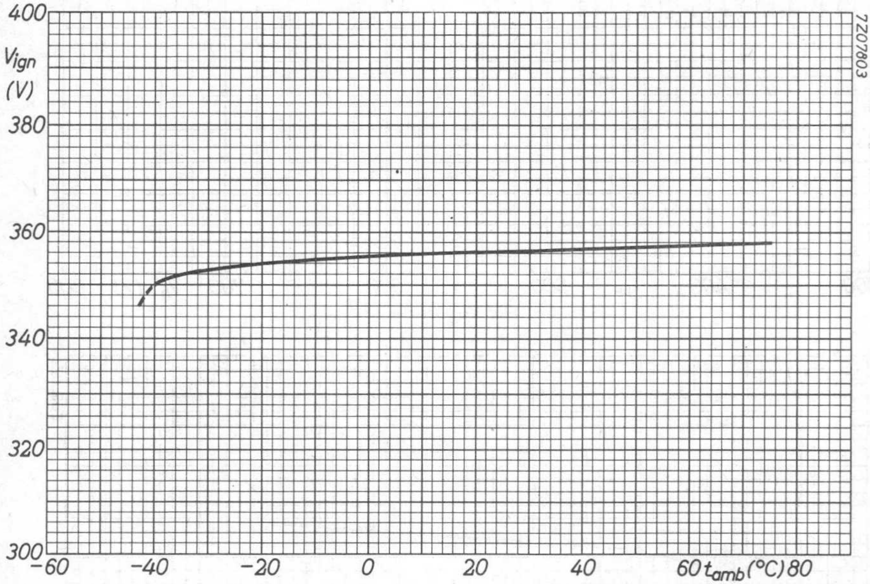
Energy response curve (side response)



Plateau curve



Dead time curve



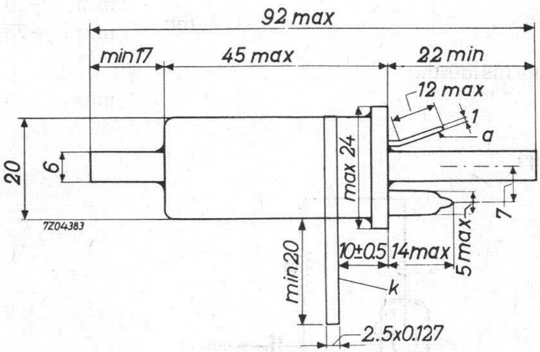
Starting voltage as function of ambient temperature

BETA RADIATION LIQUID FLOW COUNTER TUBE

Halogen quenched β radiation liquid flow counter tube.

QUICK REFERENCE DATA		
Thickness of the internal glass tubing	30	mg/cm^2
Operating voltage	500 to 650	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



INTERNAL GLASS TUBING

Thickness	30	mg/cm^2
Effective length	36	mm
Inside diameter	5.5	mm

CATHODE

Material 28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4 pF

7Z2 8498

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

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to 650		
Plateau slope	S_{pl}	max.	0.07	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	15	counts/min.
Dead time	τ	max.	125	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7	MΩ
Anode voltage	V_a	max.	650	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C
Pressure of the liquid inside the glass tubing	P	max.	120	cm Hg (abs.)

MEASURING CIRCUIT

R = 4.7 MΩ

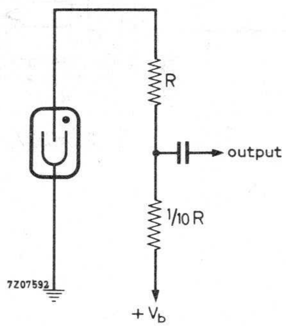


Fig.1

REMARK

The tube with its fragile thin-wall glass tubing should be handled with utmost care. Sudden changes of temperature should be avoided.

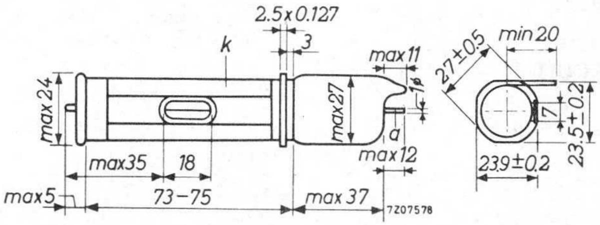
7Z2 8499

X-RAY COUNTER TUBE

Side window organic quenched X-ray counter tube

QUICK REFERENCE DATA	
X-Ray energy	2.5 to 40 keV (0.3 to 5 Å)
Window thickness	2 to 2.5 mg/cm^2
Operating voltage	1500 to 1850 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	2 to 2.5 mg/cm^2
Dimensions	7x18 mm^2
Material	mica

CATHODE

Effective length	67 mm
Material	28% Cr, 72% Fe

FILLING Xenon, organic vapour

Xenon pressure 25 cm Hg

CAPACITANCE

Anode to cathode	C_{ak}	2 pF

7Z2 8462

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

Operating voltage	V_b	1500 to 1850	V 1)
Geiger threshold		min. 1900	V
Operating voltage for pulse amplitude V_p = 1 mV	V_b	1460 to 1540	V 2)
Operating voltage for pulse amplitude V_p = 10 mV	V_b	1690 to 1770	V 2)
Energy resolution (See sheet A)	$\Delta P/P$	max. 22	% 2)3)
Integrated background for pulses 50% of the pulse amplitude P (unshielded)		15	counts/min. 2)

LIMITING VALUES (Absolute max. rating system)

Anode voltage	V_a	max. 1850	V
Ambient temperature	t_{amb}	min. -20	°C
		max. +50	°C

MEASURING CIRCUIT

R_1 = 2.2 kΩ

R_2 = 0.1 MΩ

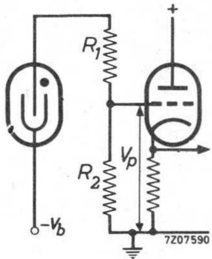
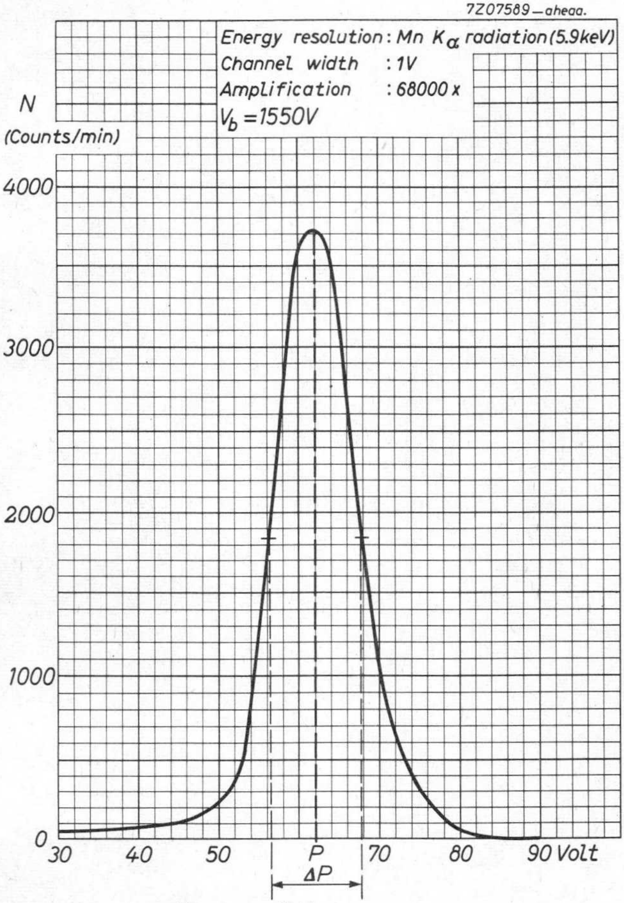


Fig.1

1) To obtain max. tube life V_b should be kept as low as possible.
2) For Mn Kα radiation (5.9 keV)
3) P= average pulse height, ΔP = width of the pulse height distribution at half of the max. value.

7Z2 8463



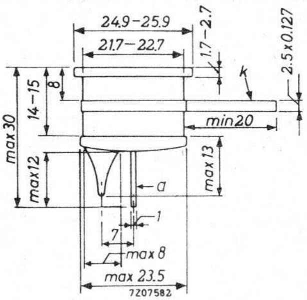
Energy resolution curve

ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube for low level measurements in combination with a guard counter (e.g. type 18517).

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	19.8	mm
Operating voltage	500 to 700	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	19.8	mm
Material	mica	

CATHODE

Thickness	1.2	mm
Effective length	13	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 1 pF

7Z2 8464

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

Starting voltage	V_{ign}	max.	350	V
Recommended operating voltage	V_b	arbitrary within plateau [1]		
Plateau	V_{pl}		500 to 700	V
Plateau slope	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	5	counts/min.
Background in anticoincidence circuit with guard counter 18517, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	1.2	counts/min.
Dead time at V_b = 600 V	τ	max.	65	μs

LIMITING VALUES (Absolute max. rating system)

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

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 470 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

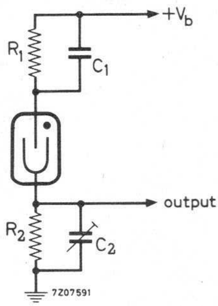


Fig.1

REMARK

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

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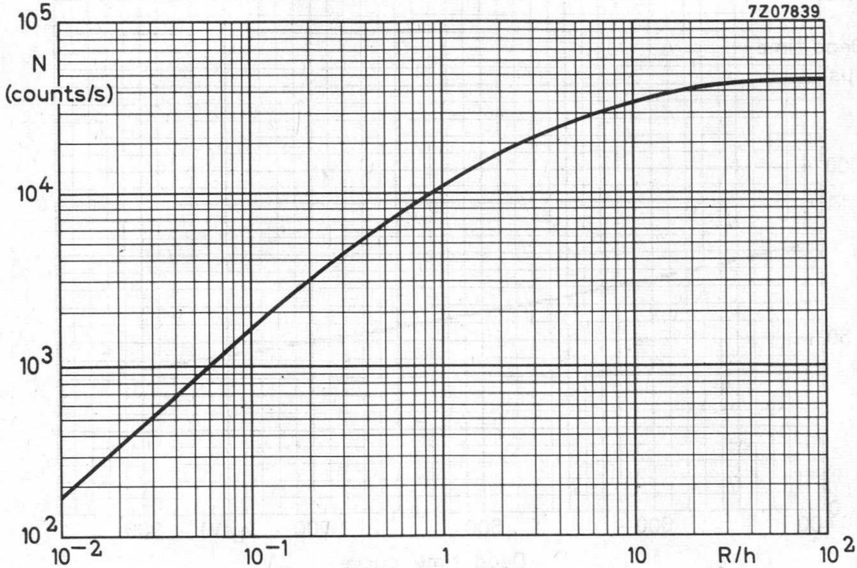
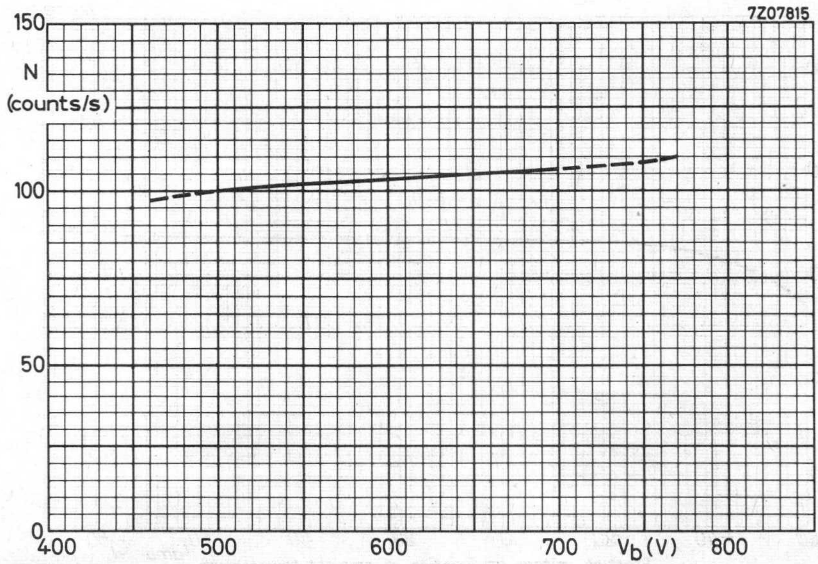
[1]) For application in anticoincidence circuits the recommended value of V_b = 600 V.

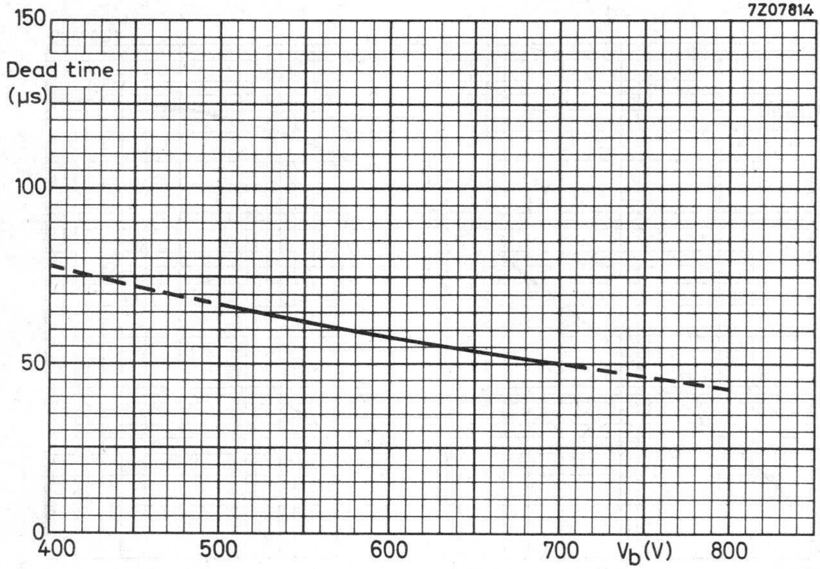
7Z2 8465



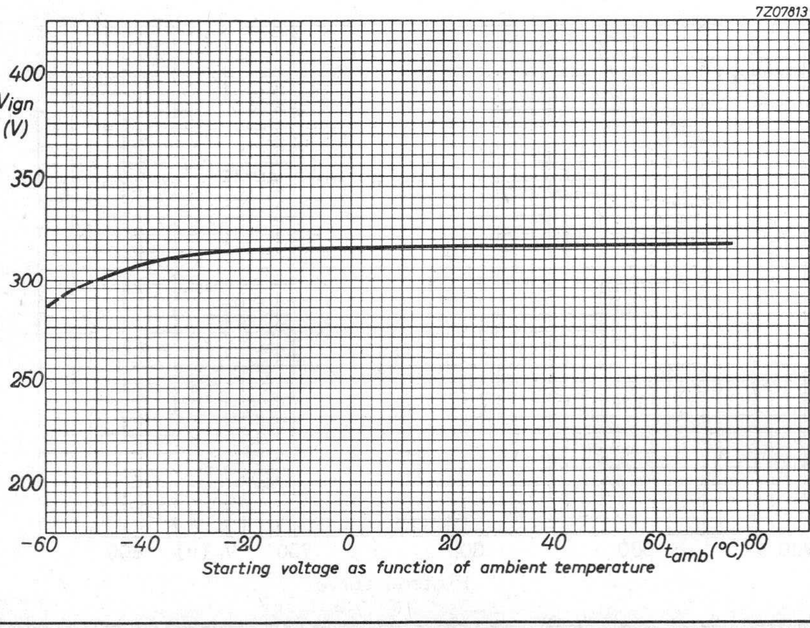
Count rate as function of dose rate



Plateau curve



Dead time curve



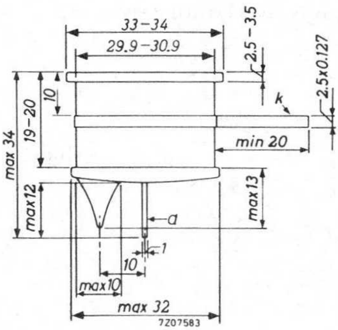
Starting voltage as function of ambient temperature

BETA RADIATION COUNTER TUBE

End window halogen quenched β radiation counter tube for low level measurements in combination with a guard counter (e.g. type 18518)

QUICK REFERENCE DATA		
Window thickness	10	mg/cm^2
Window diameter	27.8	mm
Operating voltage	500 to 750	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	10	mg/cm^2
Effective diameter	27.8	mm
Material	CrFe	

CATHODE

Thickness	1.3	mm
Effective length	18	mm
Material	28% Cr, 72% Fe	

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.3	pF

7Z2 8466

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

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau [1])		
Plateau	V_{pl}		500 to 750	V
Plateau slope	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	9	counts/min.
Background in anticoincidence circuit with guard counter 18518, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	1.3	counts/min.
Dead time at V_b = 600 V	τ	max.	70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 10 MΩ

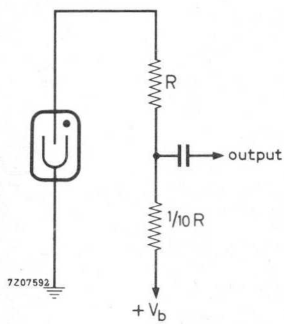


Fig.1

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

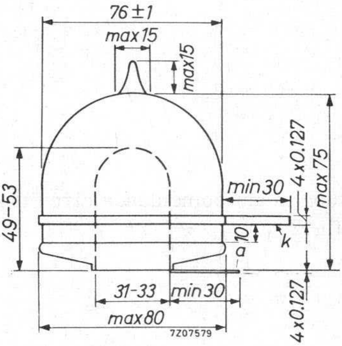
7Z2 8467

COSMIC RAY GUARD COUNTER TUBE

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

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

DIMENSIONS AND CONNECTIONS Dimensions in mm



Connectors
0.127 mm thick

CATHODE AND ANODE

Thockness	1 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 5.5 pF

7Z2 8468

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

Starting voltage	V_{ign}	max.	650	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau (at 50 counts/s)	V_b	800 to 1200		V
Plateau slope (at 50 counts/s)	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	75	counts/min.
Dead time (at 50 counts/s)	τ	max.	1	ms

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	10	MΩ
Anode voltage	V_a	max.	1200	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

CIRCUITS

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

R = 10 MΩ

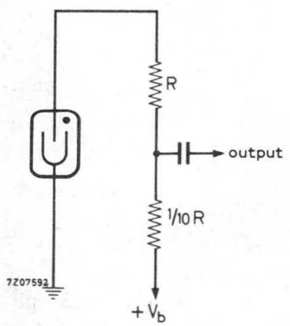


Fig.1

R_1 = 10 MΩ

R_2 = 10 MΩ

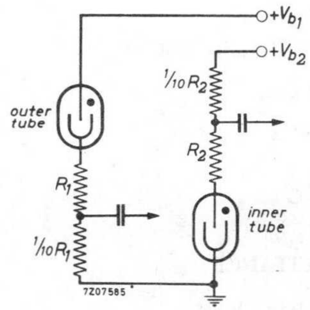


Fig.2

7Z2 8469

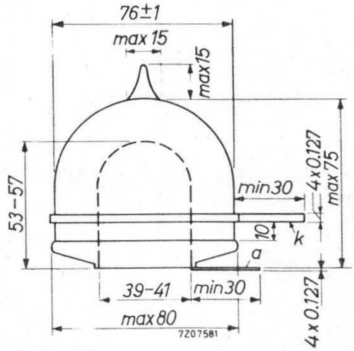
COSMIC RAY GUARD COUNTER TUBE

Halogen quenched cosmic ray guard counter tube for low background measurements in combination with β counter (e.g. type 18516 or 18536) in an anticoincidence circuit. It can also be used in combination with a gas-flow counter.

QUICK REFERENCE DATA		
Hollow anode diameter	40	mm
Operating voltage	800 to 1200	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE AND ANODE

Thickness	1 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	8 pF

7Z2 8470

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

Starting voltage	V_{ign}	max.	650	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau (at 50 counts/s)	V_{pl}	800 to 1200		V
Plateau slope (at 50 counts/s)	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	70	counts/min.
Dead time (at 50 counts/s)	τ	max.	1	ms

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	10	MΩ
Anode voltage	V_a	max.	1200	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

For use as guard counter tube in anticoincidence circuits in combination with 18516 or 18536: recommended circuit see fig.2.

R = 10 MΩ

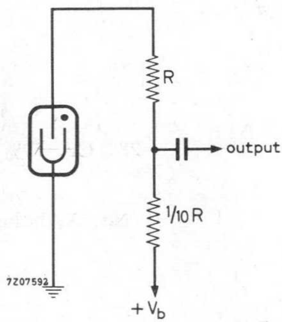


Fig.1

R_1 = 10 MΩ

R_2 = 10 MΩ

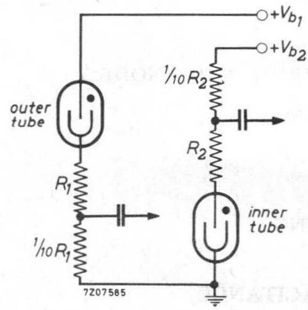
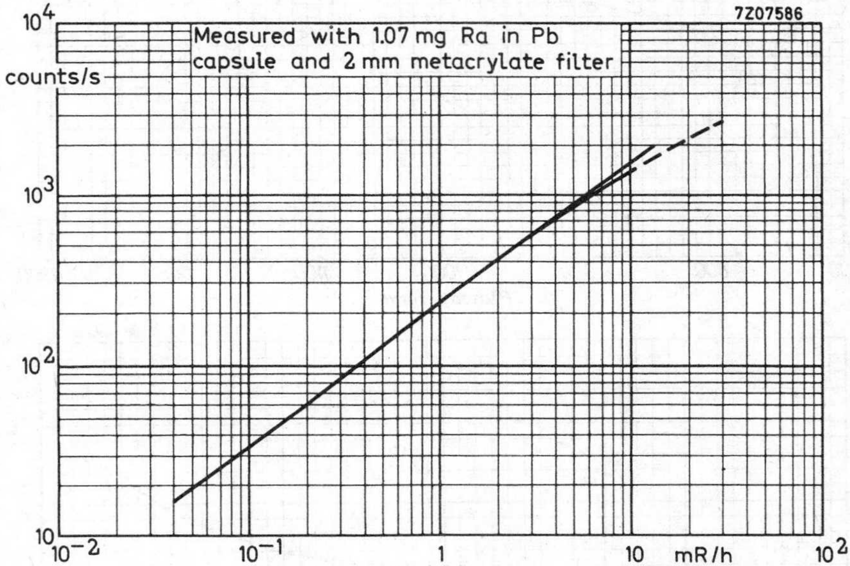
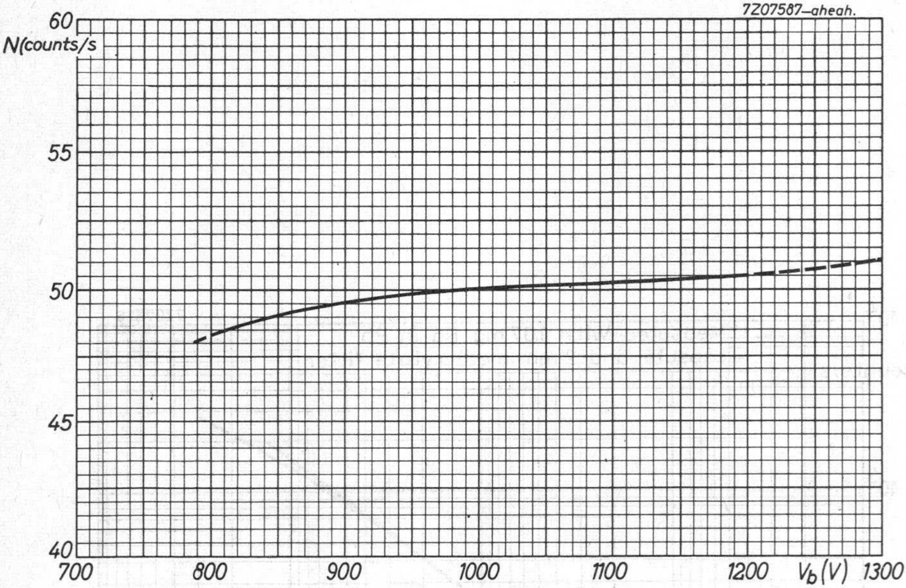


Fig.2

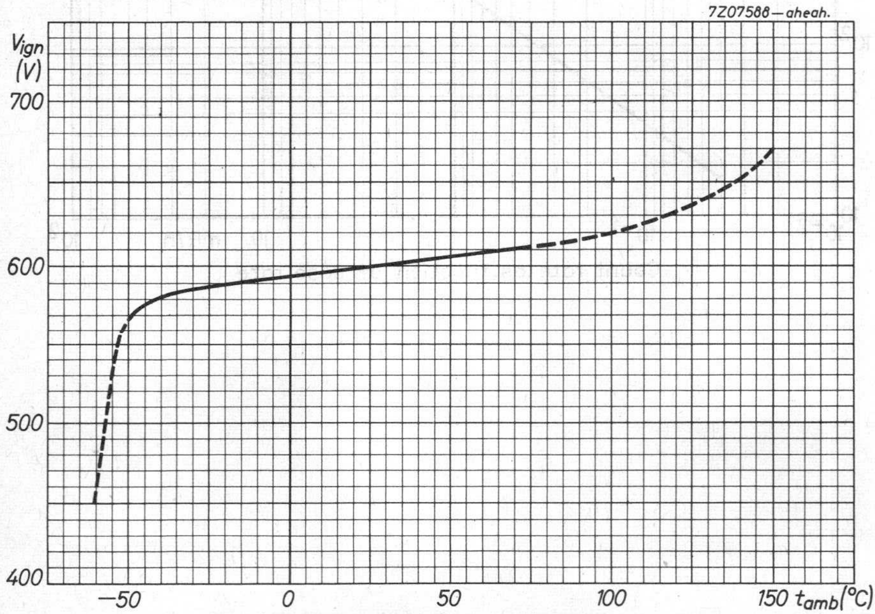
7Z2 8471



Count rate as function of dose rate



Plateau curve



Starting voltage as function of temperature

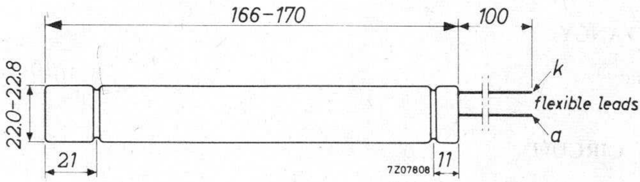
GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube.

QUICK REFERENCE DATA		
Range (Co 60 γ radiation)	5.10^{-4} to 2.10^{-1}	R/h
Operating voltage	375 to 475	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	0.7 mm
Effective length	140 mm
Material	27% Cr, 73% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4.5 pF

7Z2 8472

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

Starting voltage	V_{ign}	max.	360	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	375 to 475		V
Plateau slope	S_{pl}	max.	0.15	%/V
Background, shielded with 50 mm Pb	N_o		40	counts/min.
Dead time at V_b = 450 V	τ	max.	220	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2	MΩ
Anode voltage	V_a	max.	475	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.7 MΩ

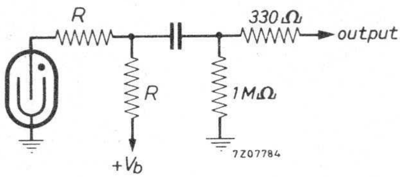
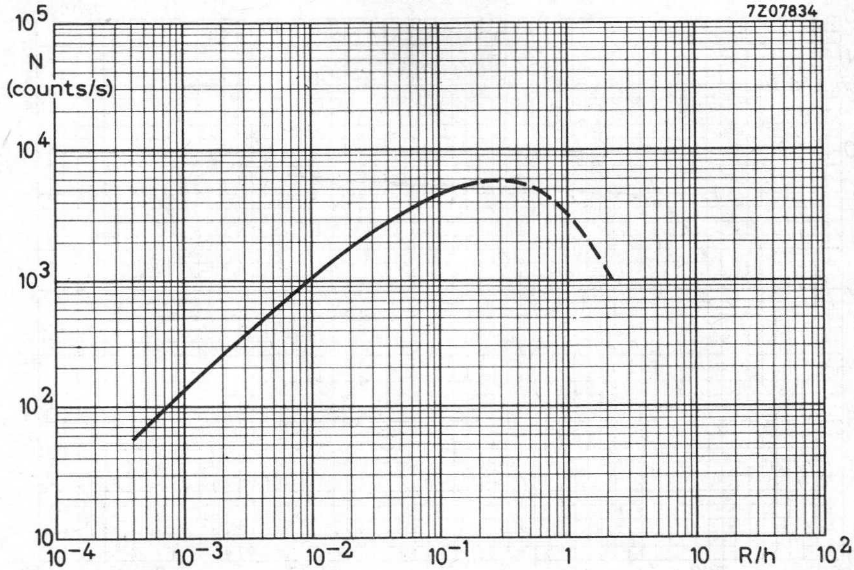
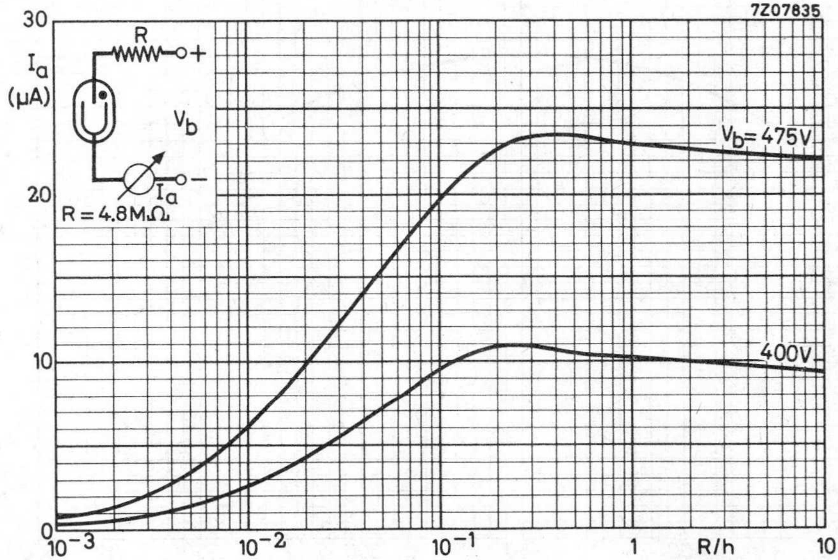


Fig.1

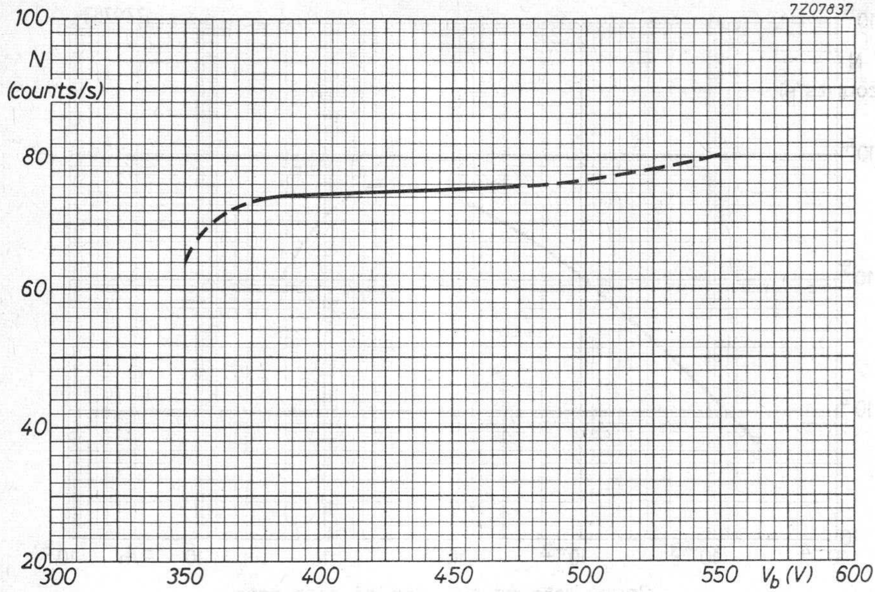
7Z2 8473



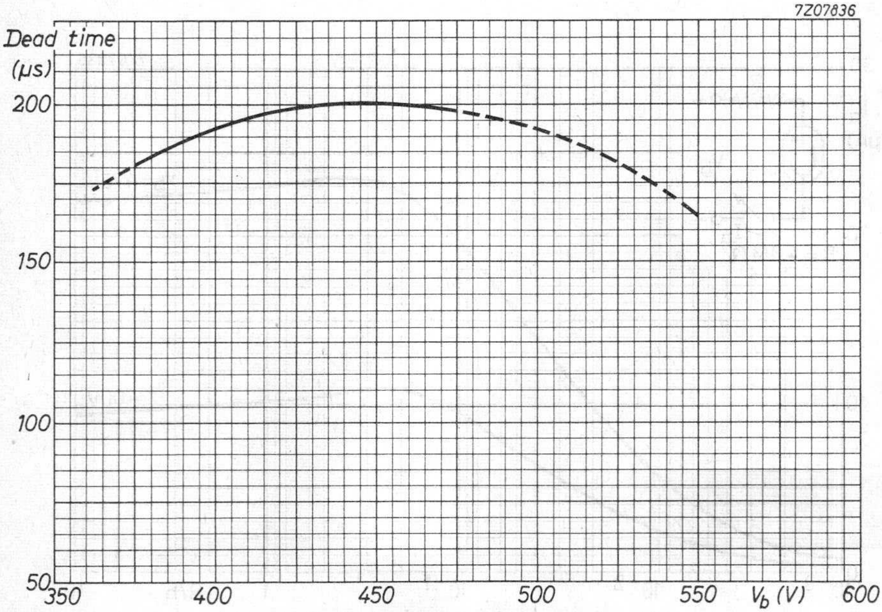
Count rate as function of dose rate



Current as function of dose rate



Plateau curve



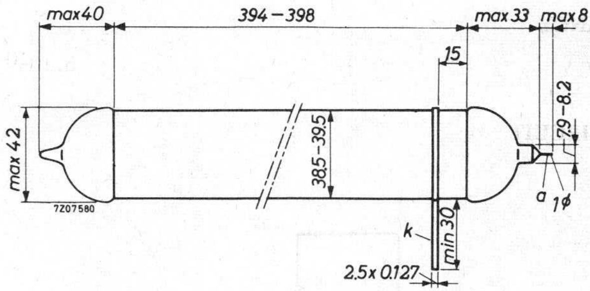
Dead time curve

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube.

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

DIMENSIONS AND CONNECTIONS Dimensions in mm



Cathode connector: 0.127 mm thick

CATHODE

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

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 15 pF

7Z2 8474

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

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

LIMITING VALUES (Absolute max. rating system)

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

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 10 MΩ

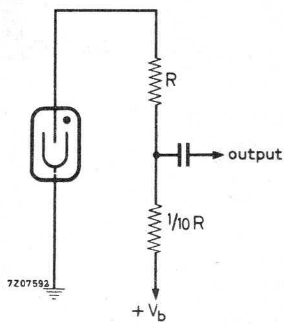


Fig.1

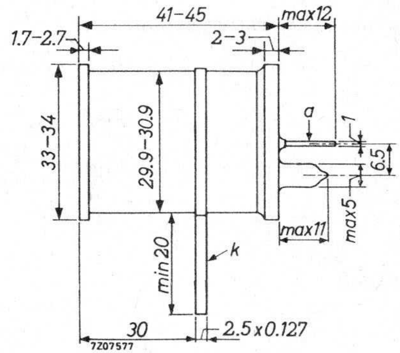
7Z2 8475

ALPHA, BETA AND GAMMA RADIATION COUNTER TUBE

End window halogen quenched α, β and γ radiation counter tube.

QUICK REFERENCE DATA		
Window thickness	1.5 to 2	mg/cm^2
Window diameter	27.8	mm
Operating voltage	450 to 750	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



Cathode connector
0.127 mm thick

WINDOW

Thickness	1.5 to 2 mg/cm^2
Effective diameter	27.8 mm
Material	mica

CATHODE

Thickness	1.3 mm
Effective length	37 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

7Z2 8476

CAPACITANCE

Anode to cathode	C_{ak}		3.5 pF

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	375	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	450 to 750		V
Plateau slope	S_{pl}	max.	0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	25	counts/min.
Dead time at V_b = 600 V	τ	max.	160	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	750	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 10 MΩ

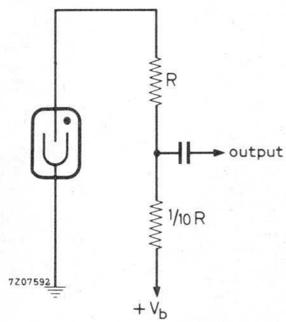
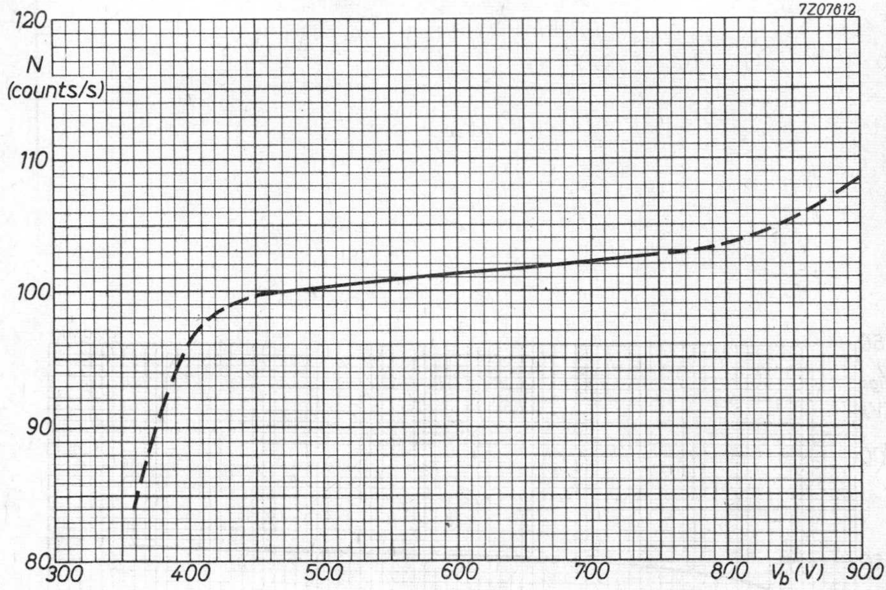
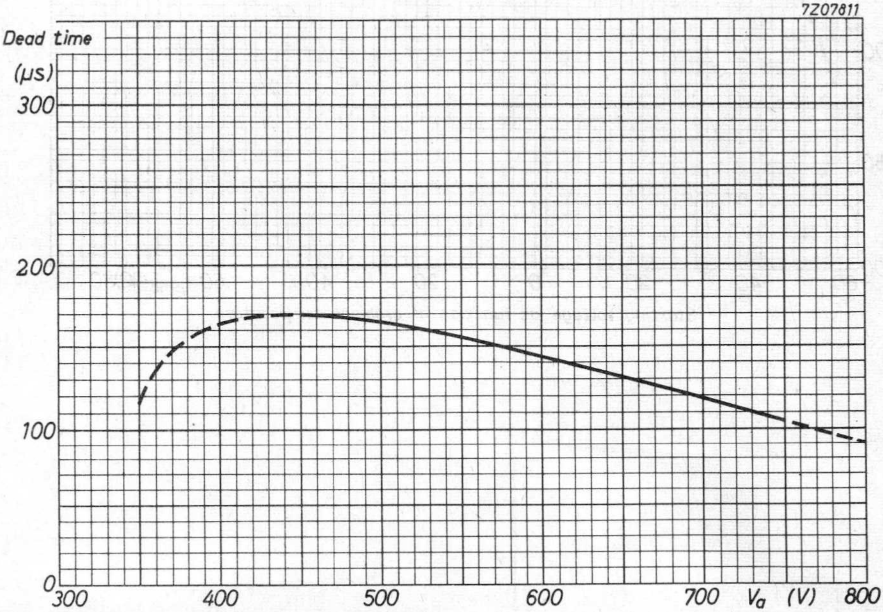


Fig.1

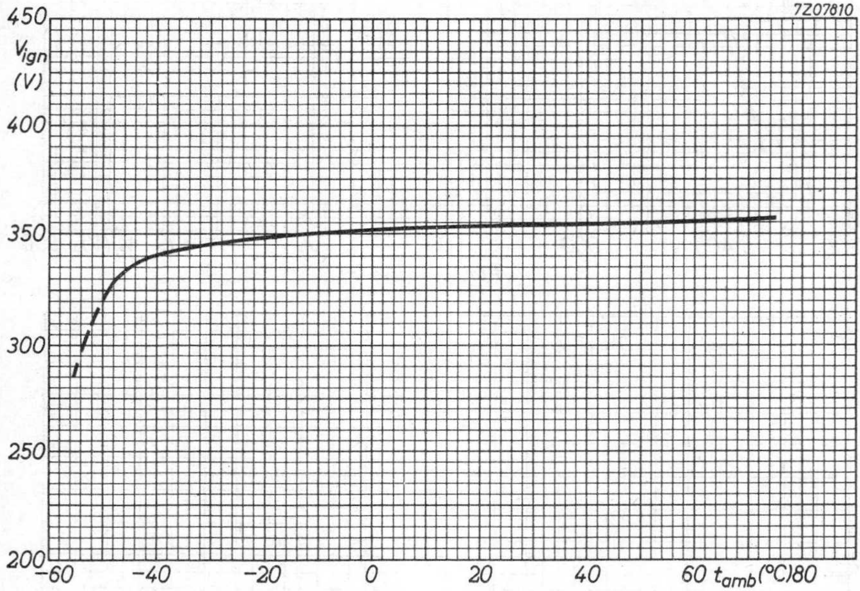
7Z2 8477



Plateau curve



Dead time curve



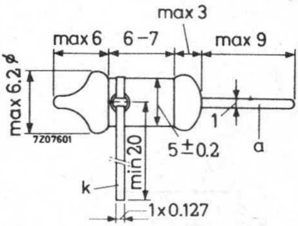
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched radiation counter tube for the measurement of γ and high energy β (> 0.5 Me V) radiation.

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-2} to 2.10^{3} R/h
Operating voltage	500 to 600 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	80 to 100 mg/cm^2
Effective length	8 mm
Material	28% Cr, 72% Fe

FILLING He, Ne, halogen

CAPACITANCE

Anode to cathode	C_{ak}	0.7 pF

7Z2 8478

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}		500 to 600	V
Plateau slope	S_{pl}	max.	0.3	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	1	count/min.
Dead time at V_b = 550 V	τ	max.	11	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	600	V
Ambient temperature	t_{amb}	min.	-40	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 2.2 MΩ

R_2 = 47 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

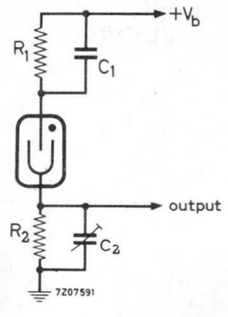
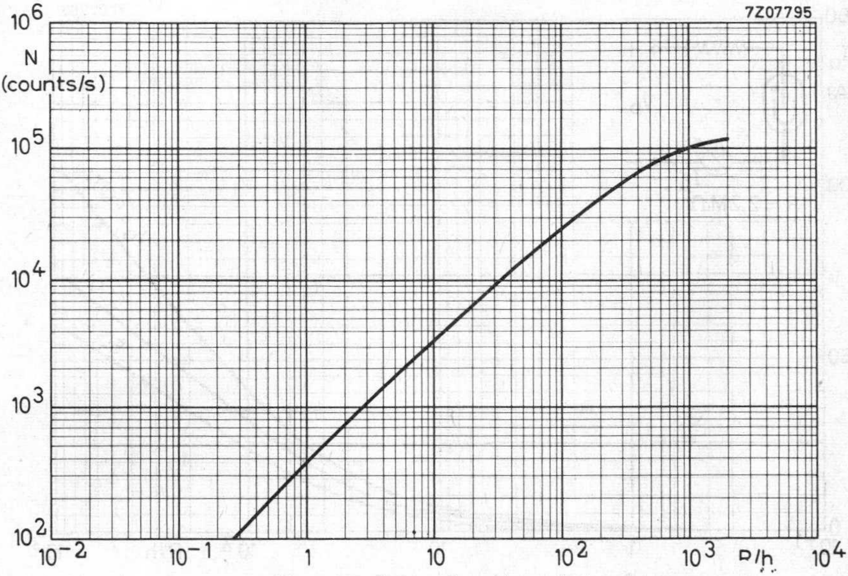
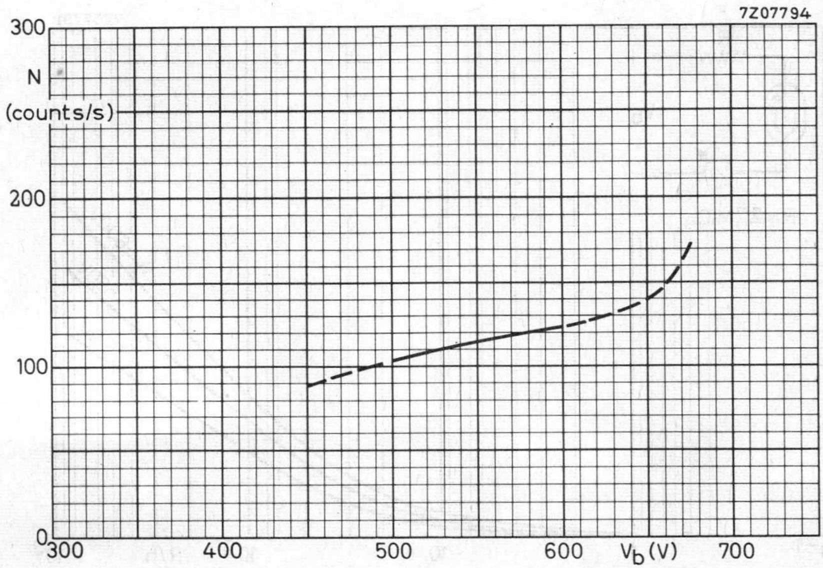


Fig.1

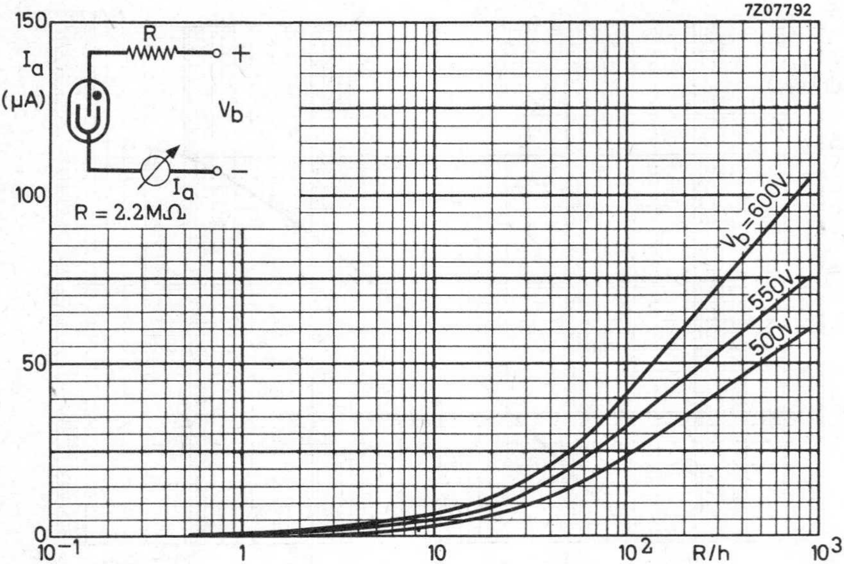
7Z2 8479



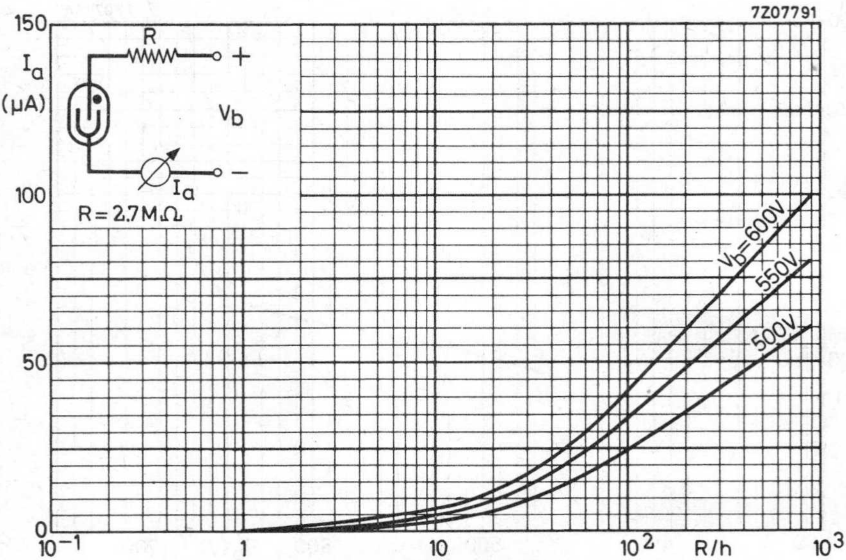
Count rate as function of dose rate



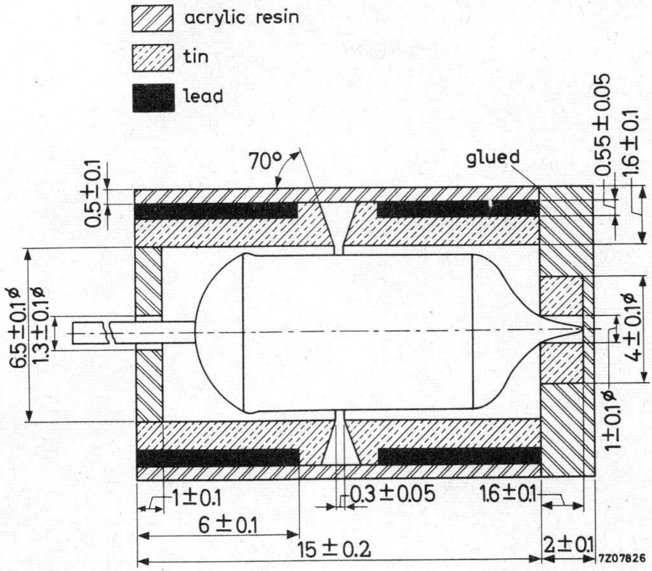
Plateau curve

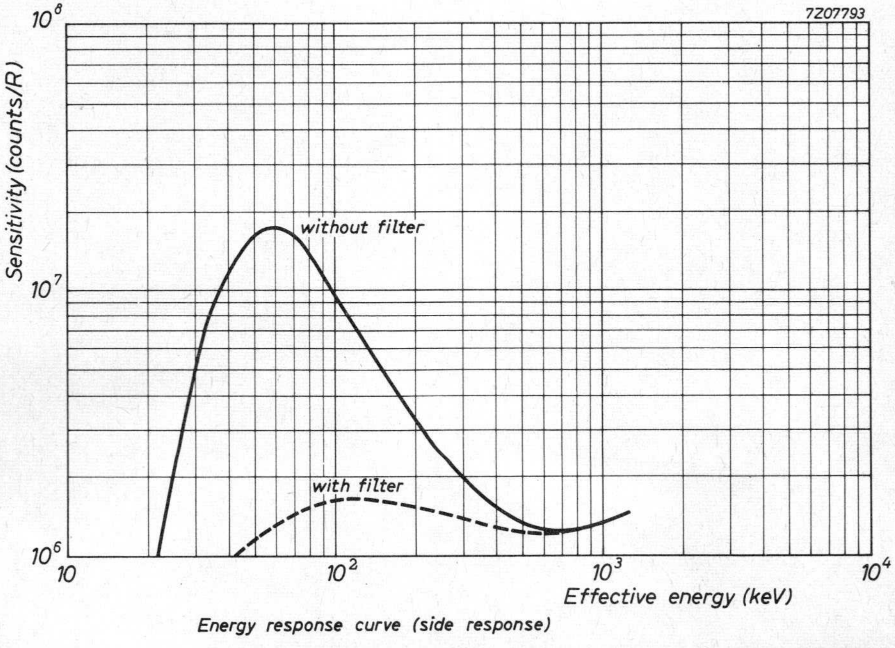


Current as function of dose rate



Current as function of dose rate





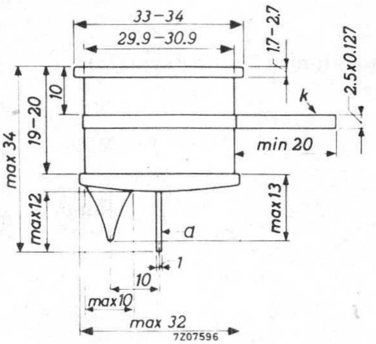
Energy response curve (side response)

ALPHA AND BETA RADIATION COUNTER TUBE

End window halogen quenched α and β radiation counter tube, for low level measurements in combination with a guard counter (e.g. type 18518)

QUICK REFERENCE DATA	
Window thickness	1.5 to 2 mg/cm^2
Window diameter	27.8 mm
Operating voltage	500 to 750 V

DIMENSIONS AND CONNECTIONS — Dimensions in mm



WINDOW

Thickness	1.5 to 2 mg/cm^2
Effective diameter	27.8 mm
Material	mica

CATHODE

Thickness	1.3 mm
Effective length	18 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.4 pF

7Z2 8480

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	375 V
Recommended operating voltage	V_b	arbitrary within plateau [1]	
Plateau	V_{pl}		500 to 750 V
Plateau slope	S_{pl}	max.	0.04 %/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	9 counts/min.
Background in anticoincidence circuit with guard counter 18518, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	2 counts/min.
Dead time at V_b = 600 V	τ	max.	60 μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	4.7 MΩ
Anode voltage	V_a	max.	750 V
Ambient temperature	t_{amb}	min.	-50 °C
		max.	+75 °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 10 MΩ

R_2 = 470 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

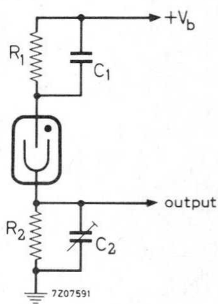
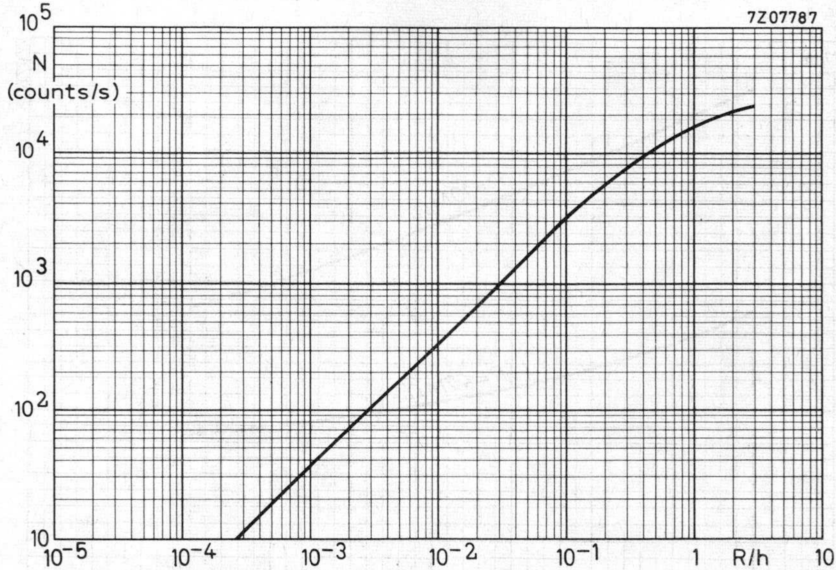


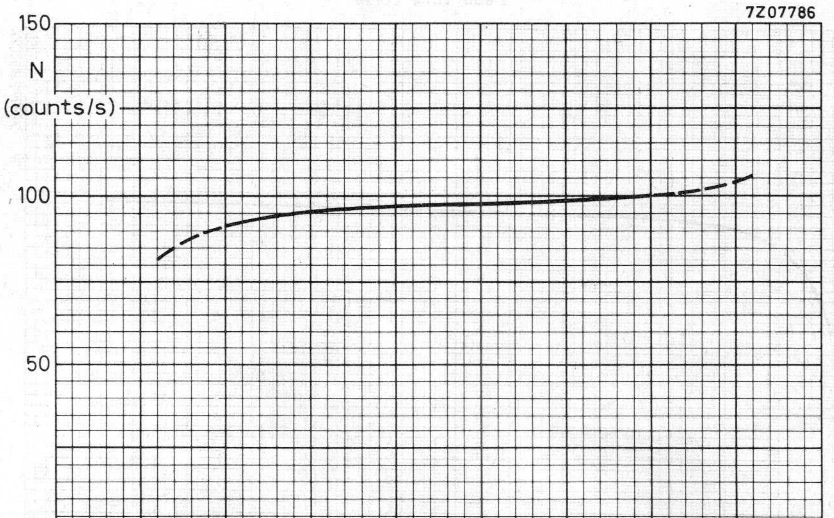
Fig.1

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

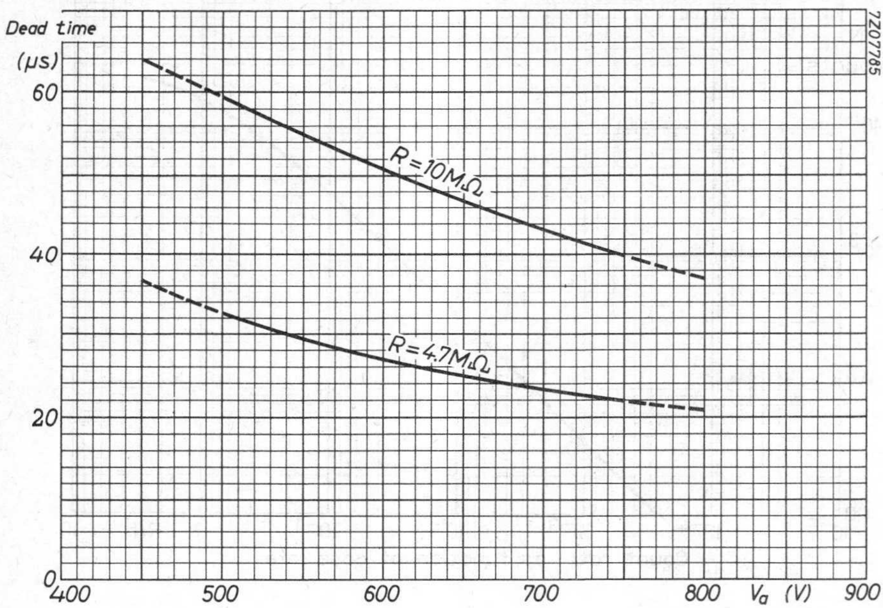
7Z2 8481



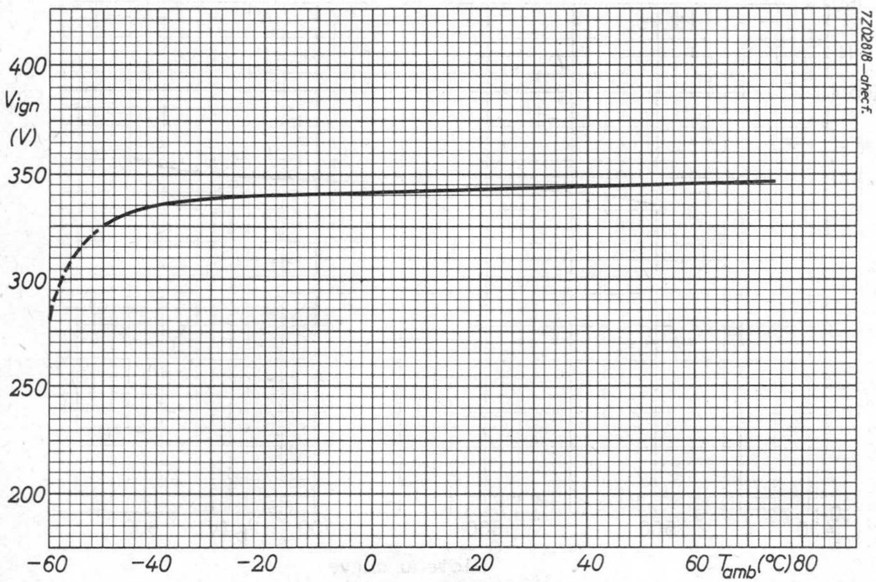
Count rate as function of dose rate



Plateau curve



Dead time curve



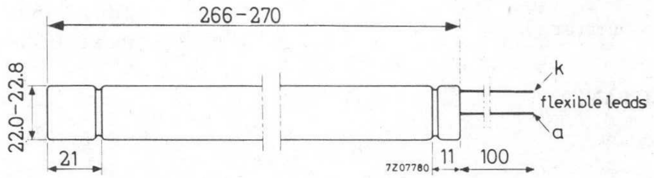
Starting voltage as function of ambient temperature

GAMMA RADIATION COUNTER TUBE

Halogen quenched γ radiation counter tube

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-4} to 10^{-1} R/h
Operating voltage	380 to 480 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Thickness	525 mg/cm^2
Effective length	240 mm
Material	27% Cr, 73% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 10 pF

7Z2 8500

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

Starting voltage	V_{ign}	max.	360	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	380 to 480		V
Plateau slope	S_{pl}	max.	0.10	%/V
Background, shielded with 50 mm Pb and 6 mm Al	N_o	max.	75	counts/min.
Dead time at V_b = 420 V	τ	max.	200	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.7	MΩ
Anode voltage	V_a	max.	480	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.7 MΩ

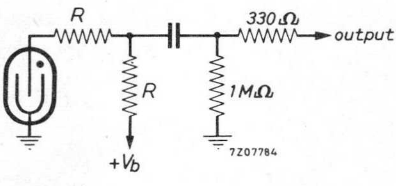
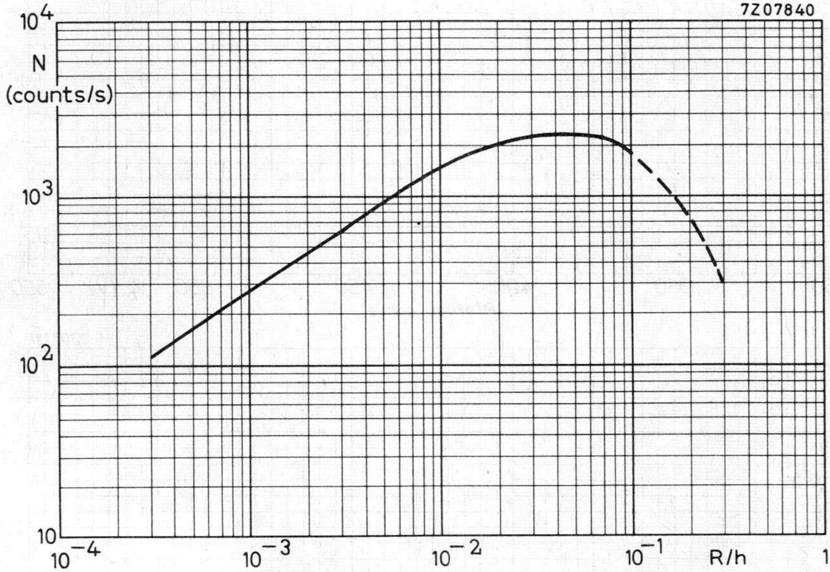
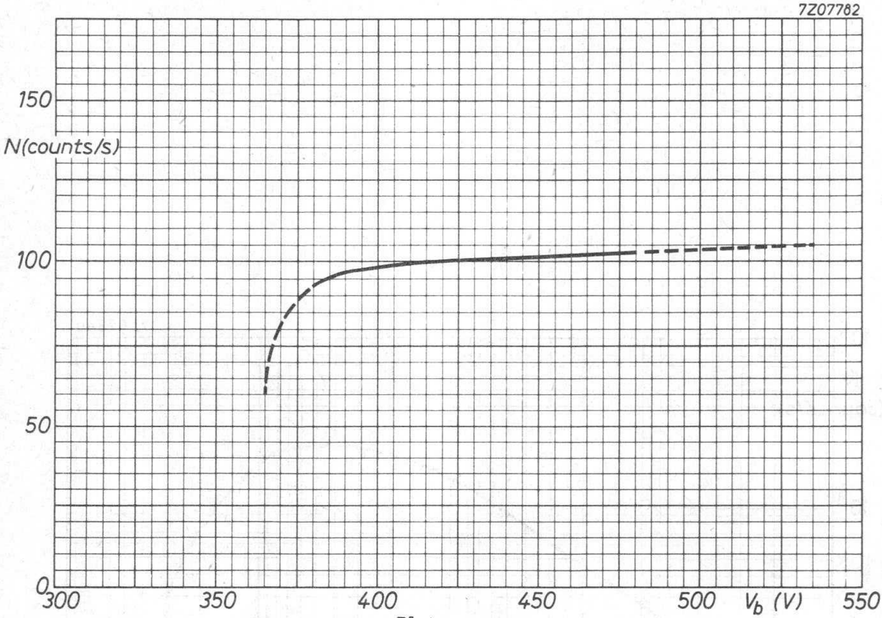


Fig.1

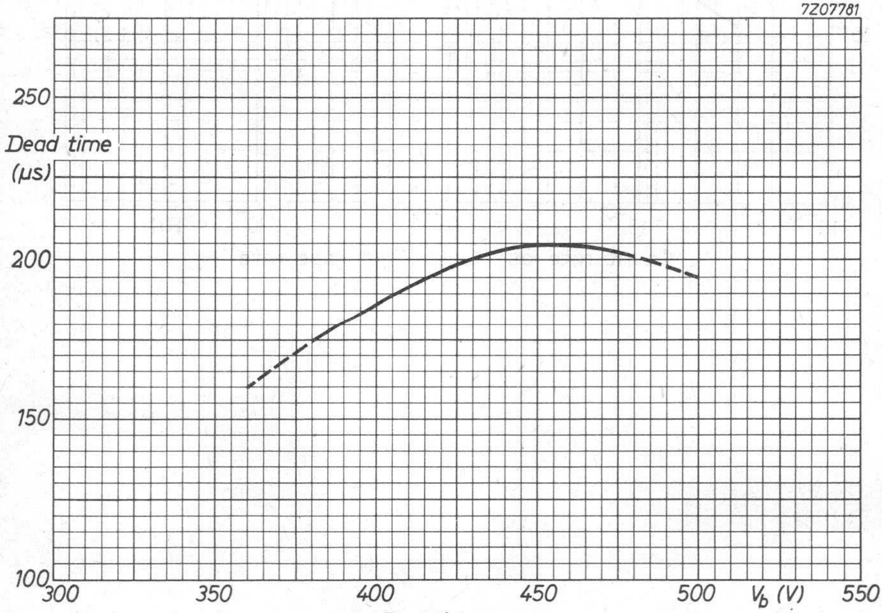
7Z2 8501



Count rate as function of dose rate



Plateau curve



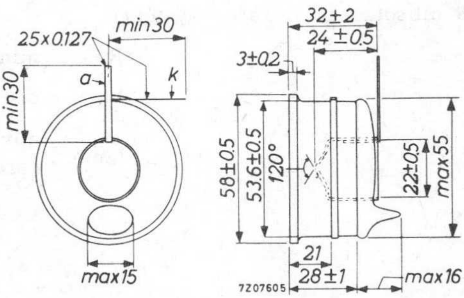
Dead time curve

BETA RADIATION COUNTER TUBE

End window halogen quenched β radiation counter tube for low level measurements in combination with a guard counter (e.g. type 18548).

QUICK REFERENCE DATA	
Window thickness	3.5 to 4 mg/cm^2
Window diameter	51 mm
Operating voltage	700 to 1100 V

DIMENSIONS AND CONNECTIONS Dimensions in mm



WINDOW

Thickness	3.5 to 4 mg/cm^2
Effective diameter	51 mm
Material	mica

CATHODE

Thickness	1.25 mm
Effective length	25 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	5 pF

7Z2 8482

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	700 to 1100		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	30	counts/min.
Background in anticoincidence circuit with guard counter 18548, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	9	counts/min.
Dead time at V_b = 900 V	τ	max.	45	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	3.9	MΩ
Anode voltage	V_a	max.	1100	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 4.7 MΩ

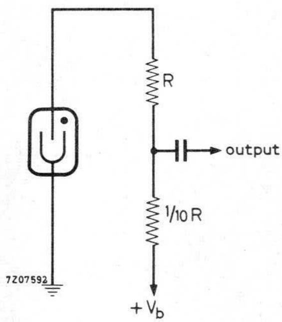
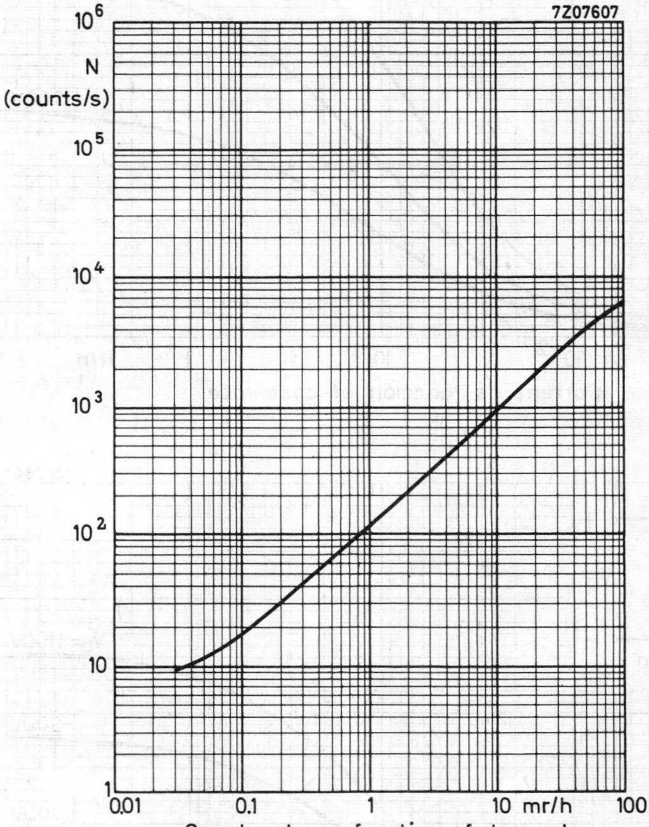
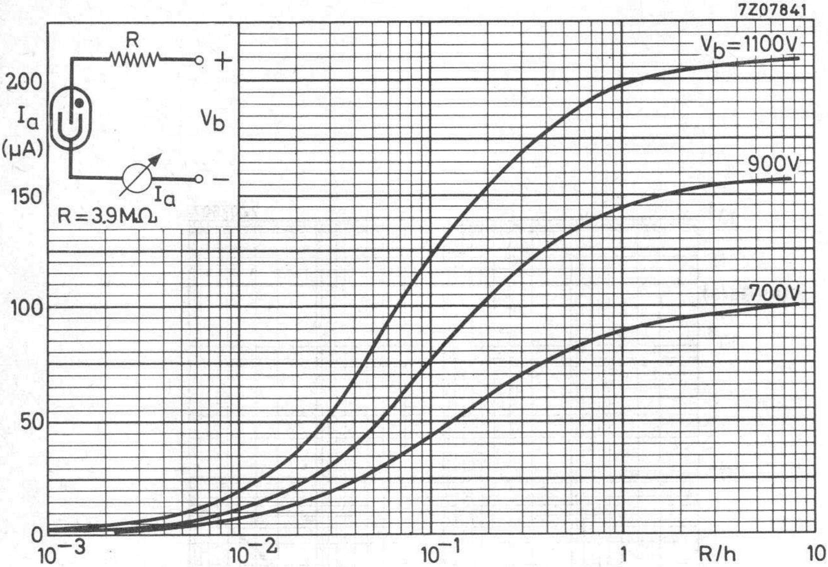


Fig.1

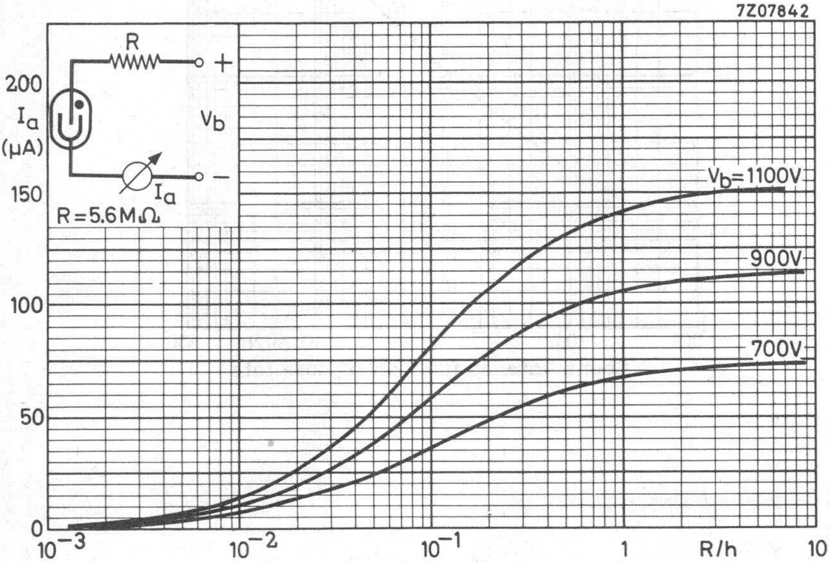
7Z2 8483



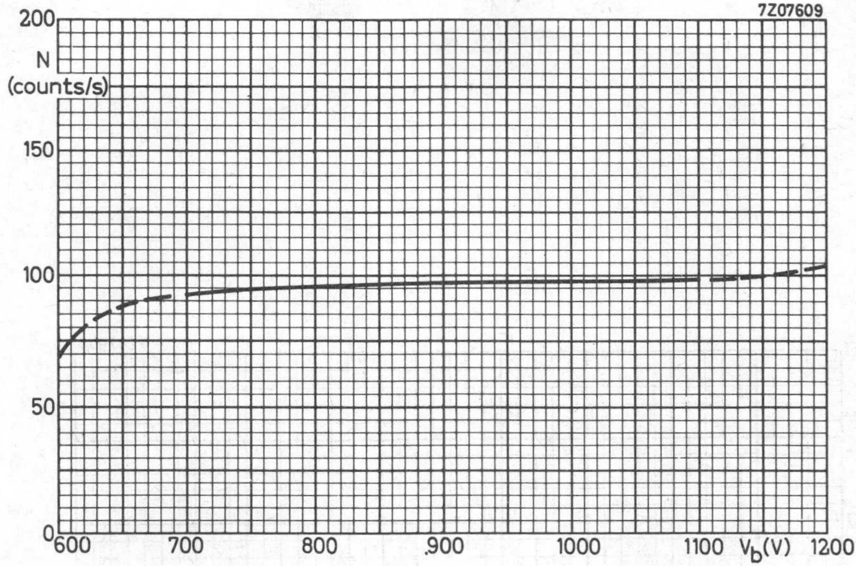
Count rate as function of dose rate



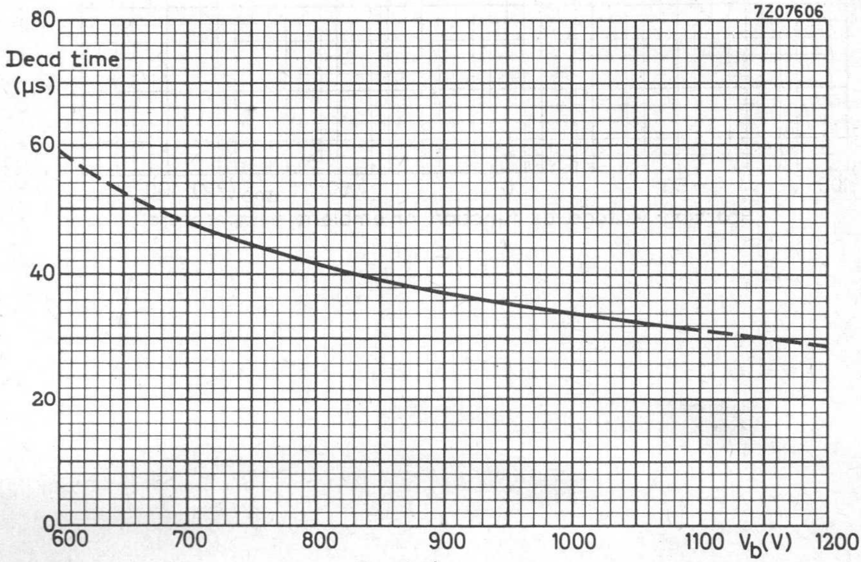
Current as function of dose rate



Current as function of dose rate



Plateau curve



Dead time curve

Starting voltage as function of ambient temperature

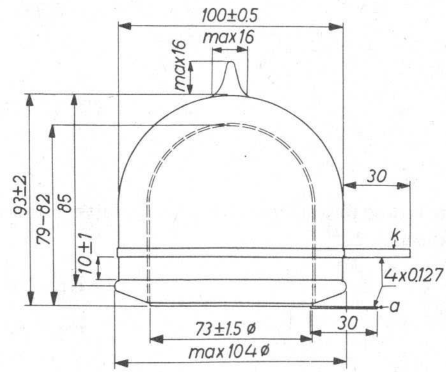
COSMIC RAY GUARD COUNTER TUBE

Halogen quenched cosmic ray guard counter tube for low background measurements in combination with a β counter tube (e.g. type 18546). It can also be used in combination with a gas flow counter.

QUICK REFERENCE DATA		
Hollow anode diameter	73	mm
Operating voltage	800 to 1200	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	1 mm
Material	28% Cr, 72% Fe

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	20 pF

7Z2 8429

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	700	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	800 to 1200		V
Plateau slope	S_{pl}	max.	0.03	%/V
Background, shielded with 100 mm Fe and 30 mm Pb, Fe outside	N_o	max.	90	counts/min.
Dead time at V_b = 1000 V	τ	max.	850	µs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	6.8	MΩ
Anode voltage	V_a	max.	1200	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

CIRCUITS

For use as guard counter tube in anticoincidence circuits in combination with 18546: recommended circuit see fig.2.

R = 10 MΩ

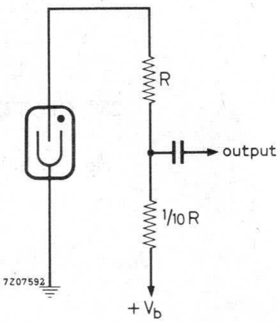


Fig.1

R_1 = 10 MΩ

R_2 = 10 MΩ

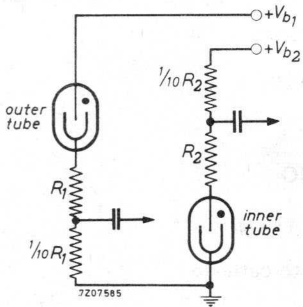


Fig.2

7Z2 8428

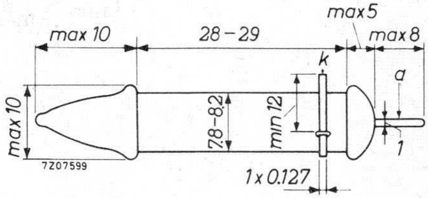
BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (>0.25 MeV) and γ radiation counter tube.

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-3} to 10^{2} R/h
Cathode wall thickness	32 to 40 mg/cm^2
Operating voltage	500 to 650 V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Thickness	32 to 40 mg/cm^2
Effective length	28 mm
Material	28% Cr, 72% Fe

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode	C_{ak}	1.1 pF

7Z2 8430

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max.	380	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}	500 to 650		V
Plateau slope	S_{pl}	max.	0.04	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max.	4	counts/min.
Dead time at V_b = 600 V	τ	max.	45	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	2.2	MΩ
Anode voltage	V_a	max.	650	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R_1 = 4.7 MΩ

R_2 = 100 kΩ

C_1 = 1 pF

$R_1C_1 = R_2C_2$

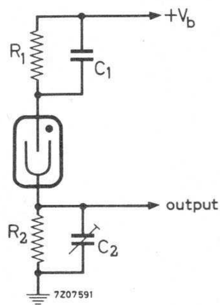
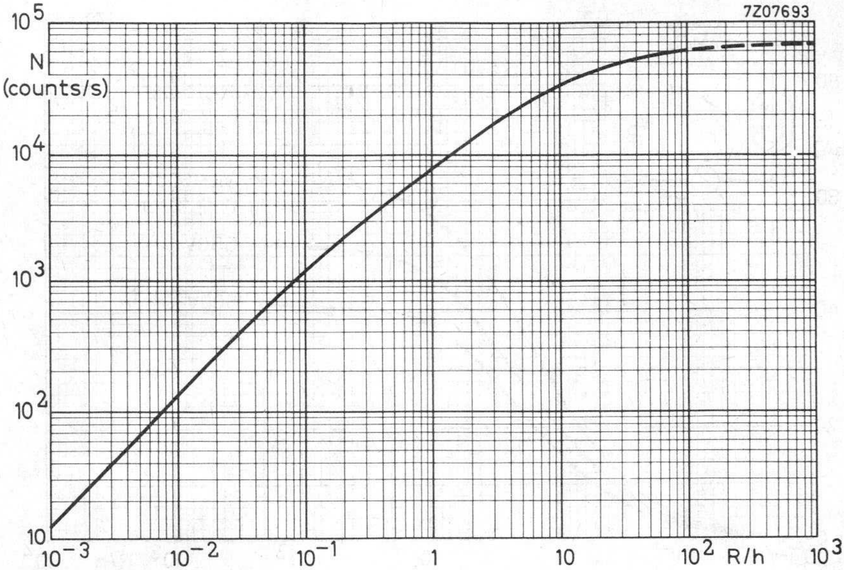
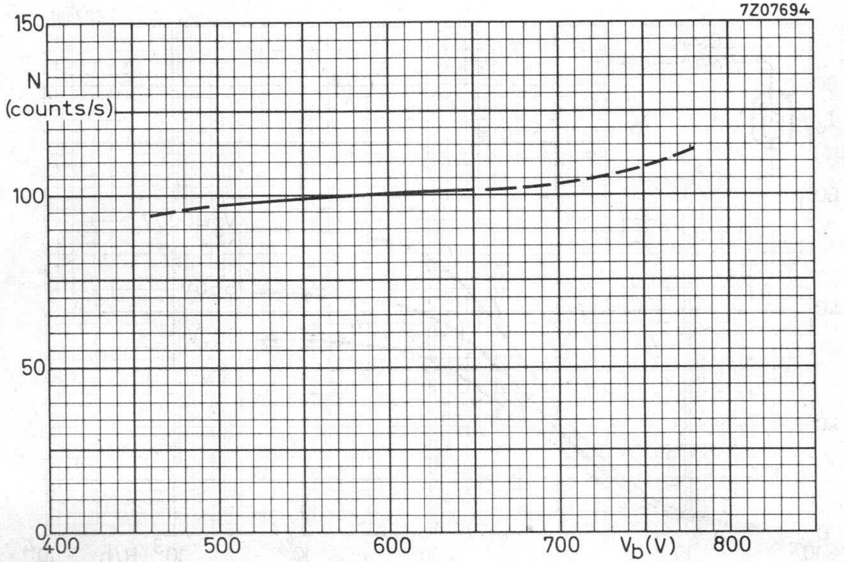


Fig.1

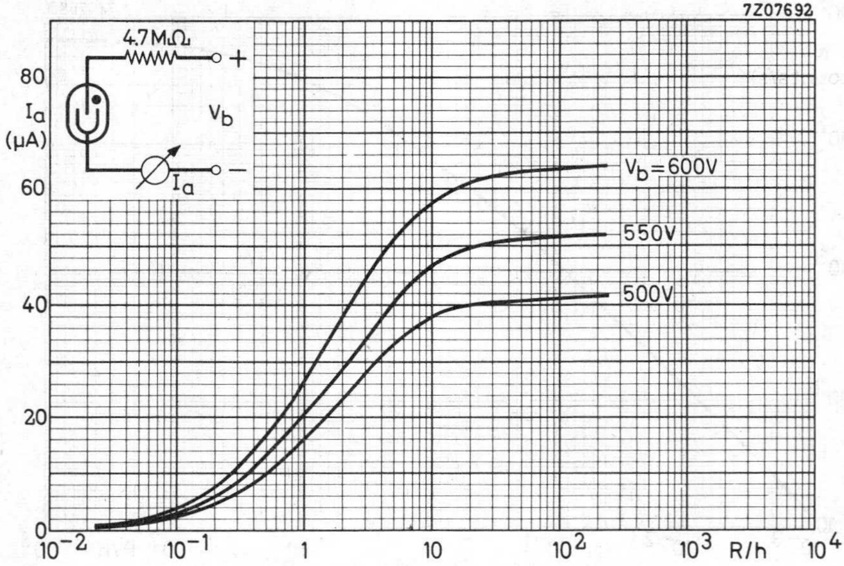
7Z2 8431



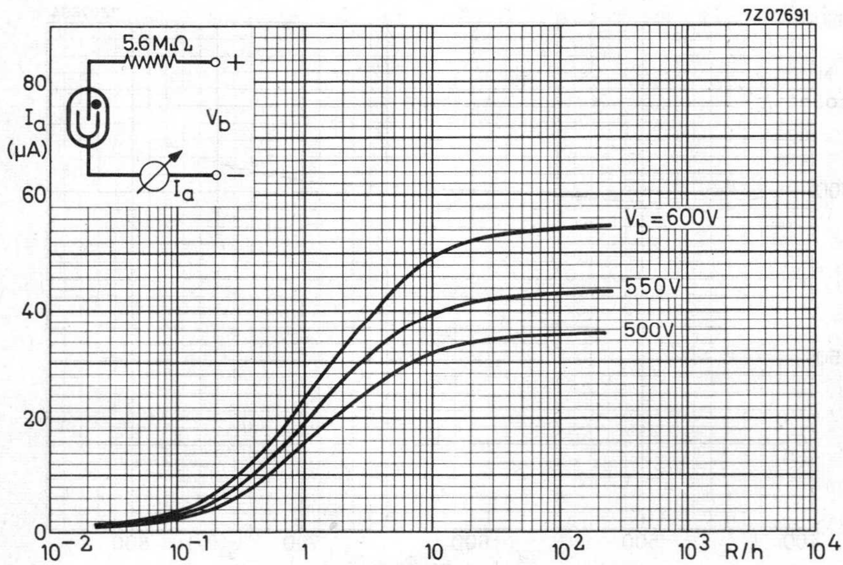
Count rate as function of dose rate



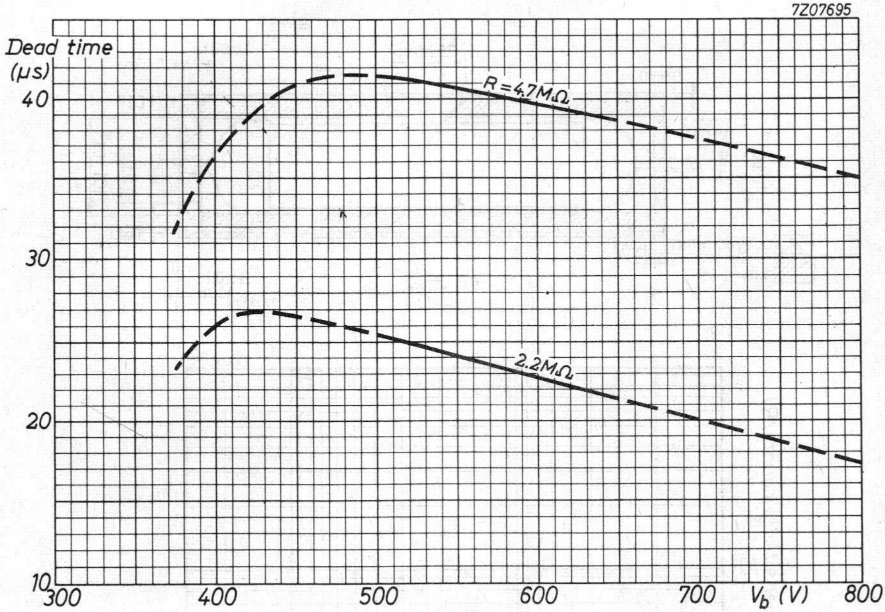
Plateau curve



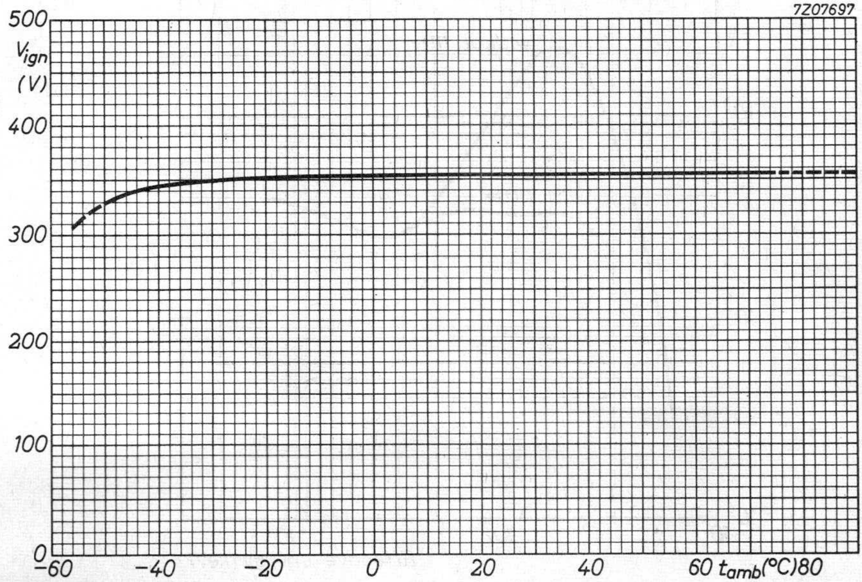
Current as function of dose rate



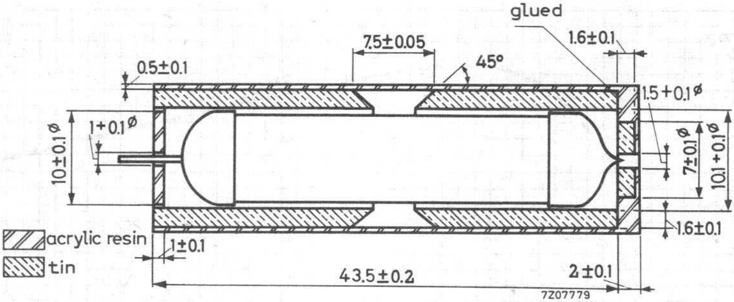
Current as function of dose rate

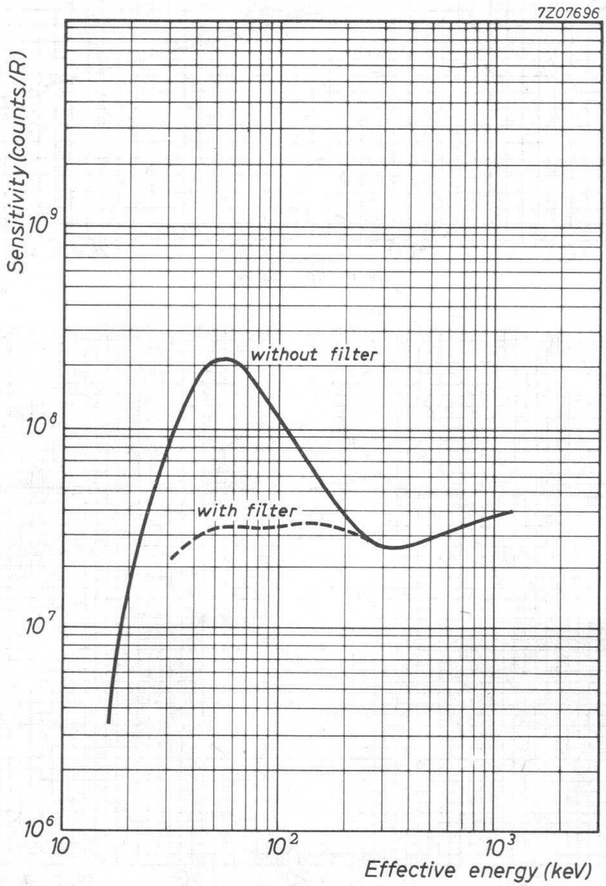


Dead time curve



Starting voltage as function of ambient temperature





Energy response curve (side response)

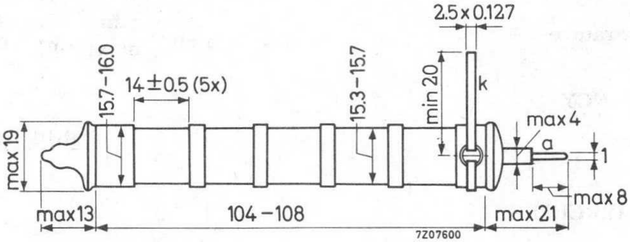
BETA AND GAMMA RADIATION COUNTER TUBE

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

QUICK REFERENCE DATA		
Range (Co 60 γ radiation)	10^{-3} to 10	R/h
Cathode wall thickness between the strengthening rings	40 to 60	mg/cm^2
Operating voltage	450 to 800	V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Construction	cylindrical wall with strengthening rings
Thickness between the strengthening rings	40 to 60 mg/cm^2
Total effective length	75 mm
Material	28% Cr, 72% Fe

FILLING

Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4 pF

7Z2 8371

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max. 400	V
Recommended operating voltage	V_b	arbitrary within plateau	
Plateau	V_{pl}	450 to 800	V
Plateau slope	S_{pl}	max. 0.02	%/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max. 30	counts/min.
Dead time at V_b = 600 V	τ	max. 70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 1	MΩ
Anode voltage	V_a	max. 800	V
Ambient temperature	t_{amb}	min. -50 max. +75	°C °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

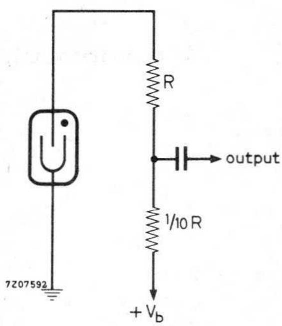
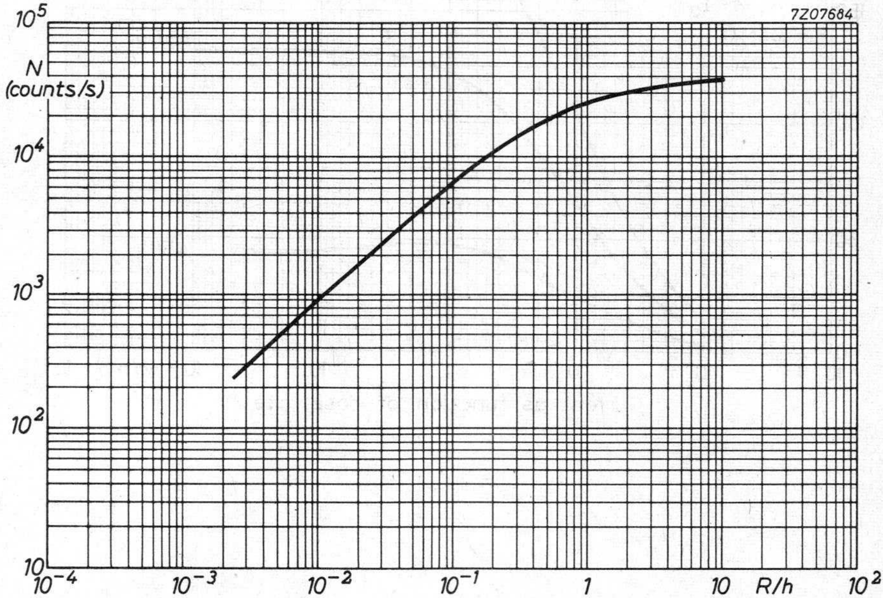
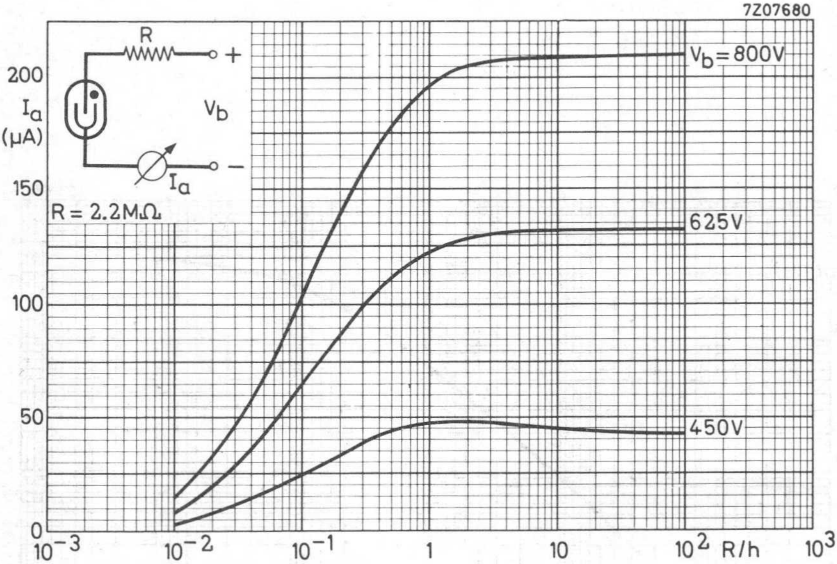


Fig.1

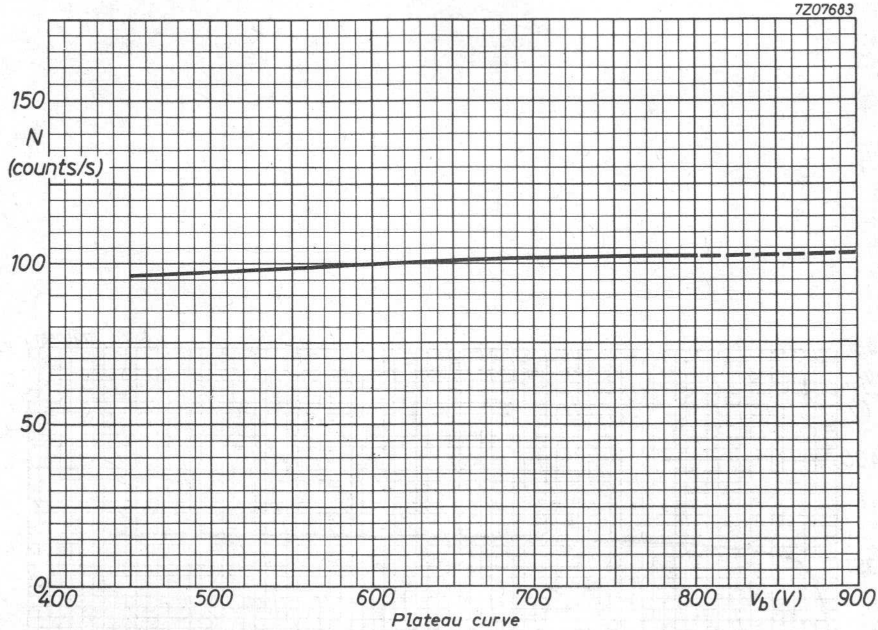
7Z2 8372



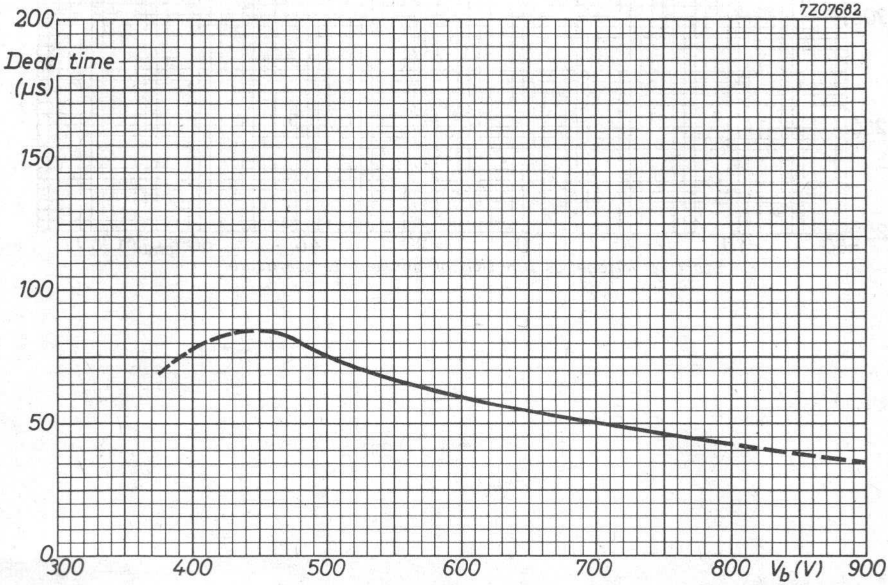
Count rate as function of dose rate



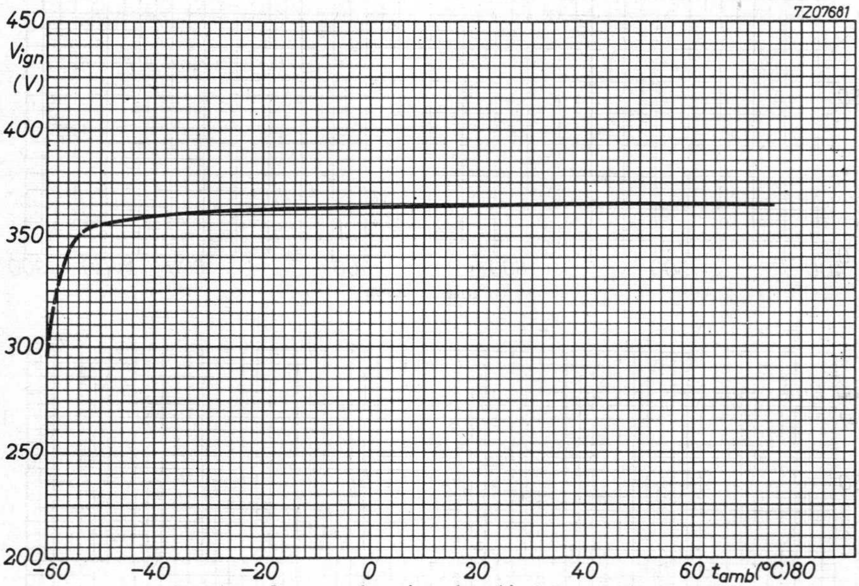
Current as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

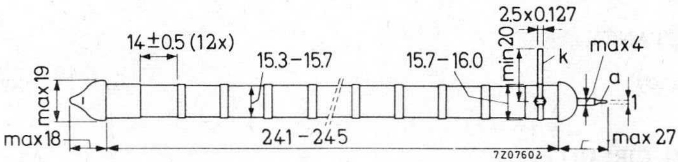
BETA AND GAMMA RADIATION COUNTER TUBE

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

QUICK REFERENCE DATA	
Range (Co 60 γ radiation)	10^{-4} to 1 R/h
Cathode wall thickness between the strengthening rings	40 to 60 mg/cm^2
Operating voltage	450 to 800 V

DIMENSIONS AND CONNECTIONS

Dimensions in mm



CATHODE

Construction	cylindrical wall with strengthening rings
Thickness between the ribbons	40 to 60 mg/cm^2
Total effective length between the strengthening rings	185 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 10 pF

7Z2 8432

OPERATING CHARACTERISTICS (t_{amb} = 25 °C)

Measured in circuit of fig.1

Starting voltage	V_{ign}	max. 400 V
Recommended operating voltage	V_b	arbitrary within plateau
Plateau	V_{pl}	450 to 800 V
Plateau slope	S_{pl}	max. 0.02 %/V
Background, shielded with 50 mm Pb and 3 mm Al	N_o	max. 60 counts/min.
Dead time at V_b = 600 V	τ	max. 100 μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min. 2.2 MΩ
Anode voltage	V_a	max. 800 V
Ambient temperature	t_{amb}	min. −50 °C max. +75 °C

LIFE EXPECTANCY

Life expectancy 5.10^{10} counts

MEASURING CIRCUIT

R = 2.2 MΩ

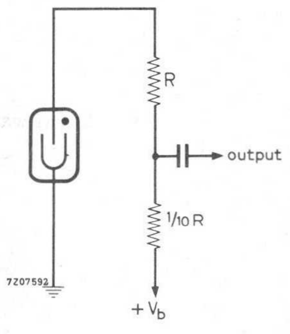
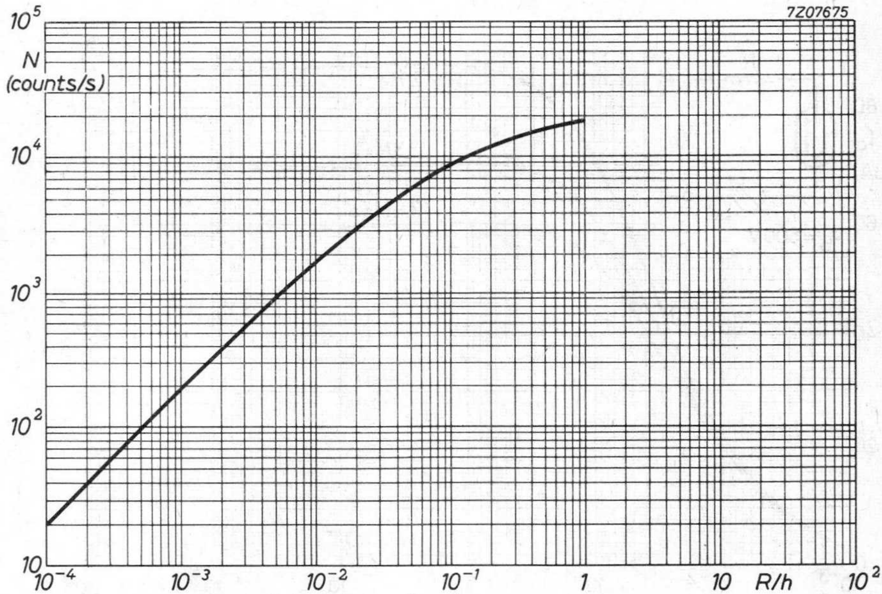
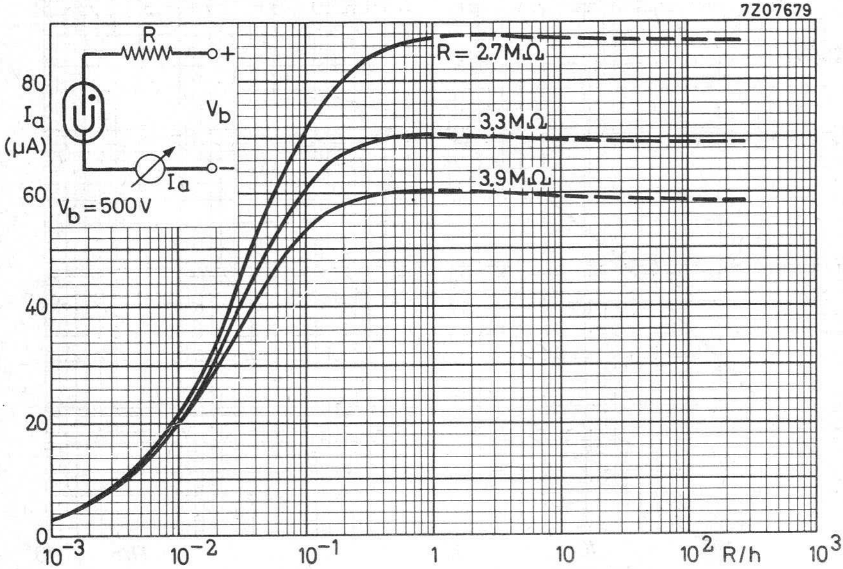


Fig.1

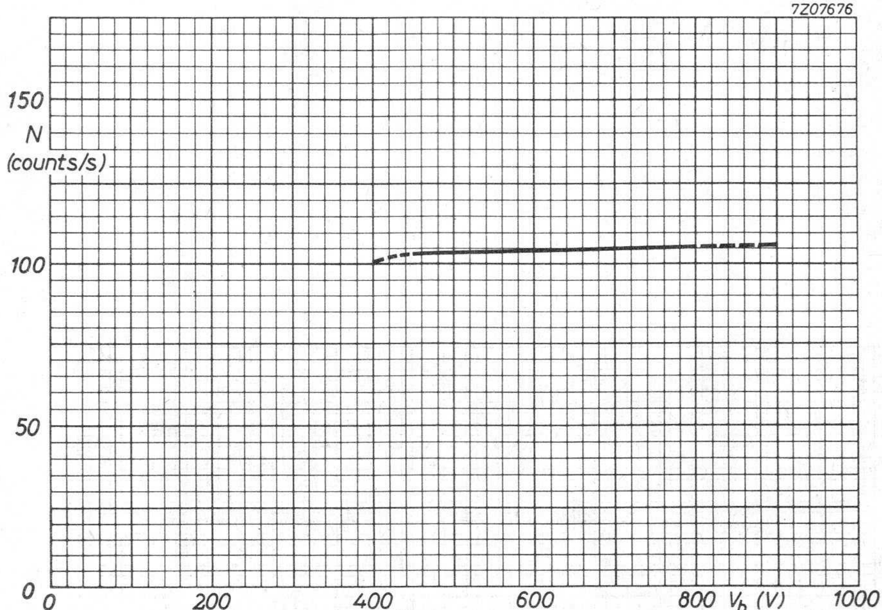
7Z2 8433



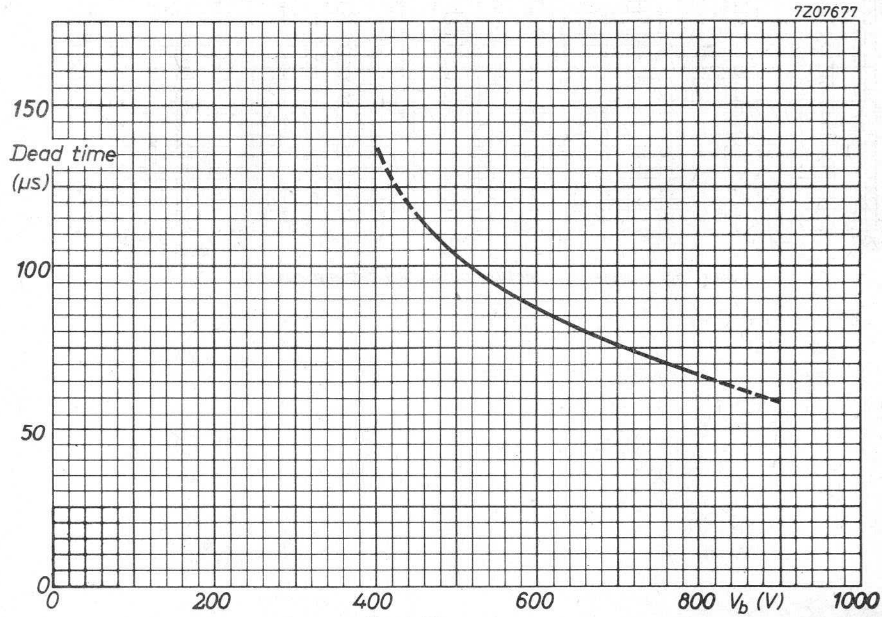
Count rate as function of dose rate



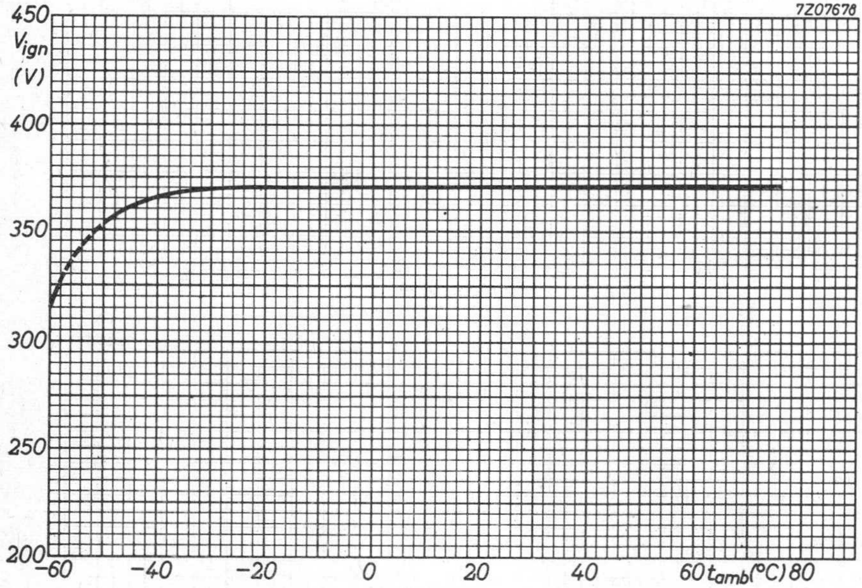
Current as function of dose rate



Plateau curve



Dead time curve



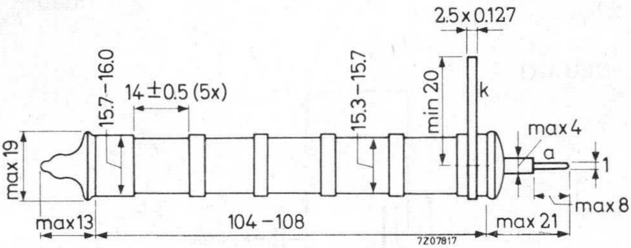
Starting voltage as function of ambient temperature

BETA AND GAMMA RADIATION COUNTER TUBE

Halogen quenched β (> 0.3 MeV) and γ radiation counter tube suitable for use in damp and/or saline atmosphere.

QUICK REFERENCE DATA		
Range (Co^{60} γ radiation)	10^{-3} to 10	R/h
Cathode wall thickness between the strengthening rings	40 to 60	mg/cm^2
Operating voltage	450 to 800	V

DIMENSIONS AND CONNECTIONS Dimensions in mm



CATHODE

Construction	cylindrical wall with strengthening rings
Thickness between the strengthening rings	40 to 60 mg/cm^2
Total effective length	75 mm
Material	28% Cr, 72% Fe

FILLING Ne, A, halogen

CAPACITANCE

Anode to cathode C_{ak} 4 pF

7Z2 8484

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

Starting voltage	V_{ign}	max.	400	V
Recommended operating voltage	V_b	arbitrary within plateau		
Plateau	V_{pl}		450 to 800	V
Plateau slope	S_{pl}	max.	0.02	%/V
Background shielded with 50 mm Pb	N_o	max.	30	counts/min.
Dead time	τ	max.	70	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	R	min.	1	MΩ
Anode voltage	V_a	max.	800	V
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+75	°C

LIFE EXPECTANCY

Life expectancy	5.10^{10}	counts

MEASURING CIRCUIT

R = 2.2 MΩ

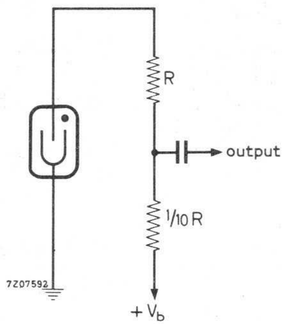
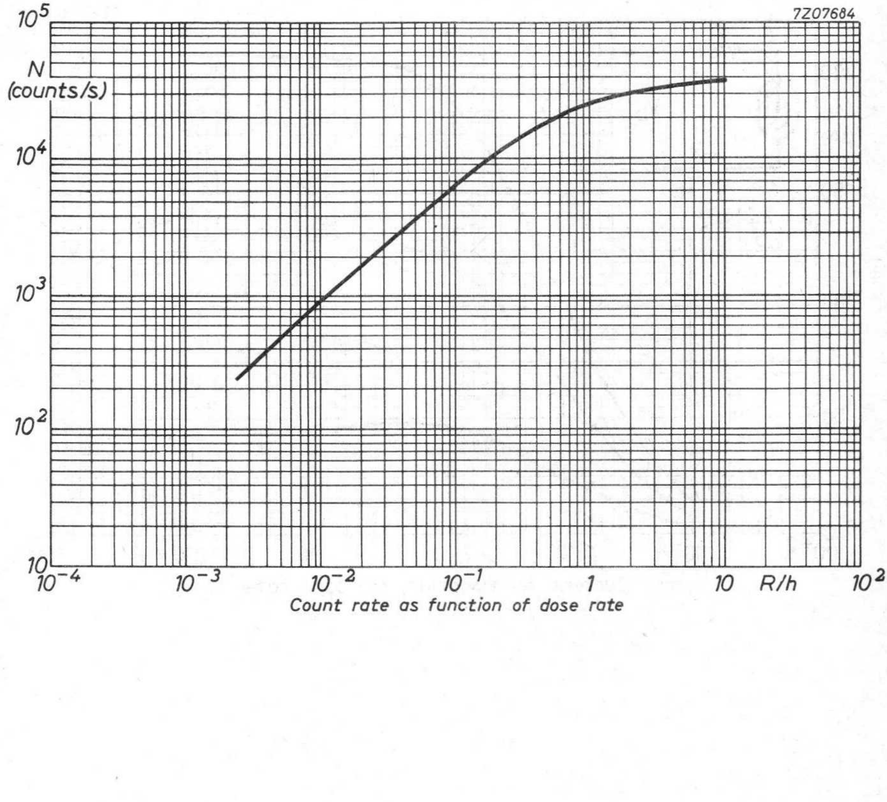


Fig.1

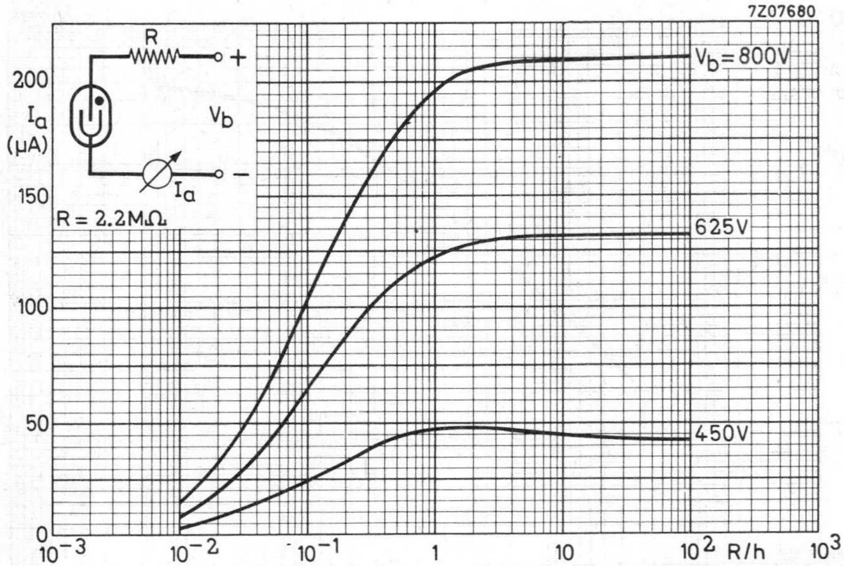
REMARK

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

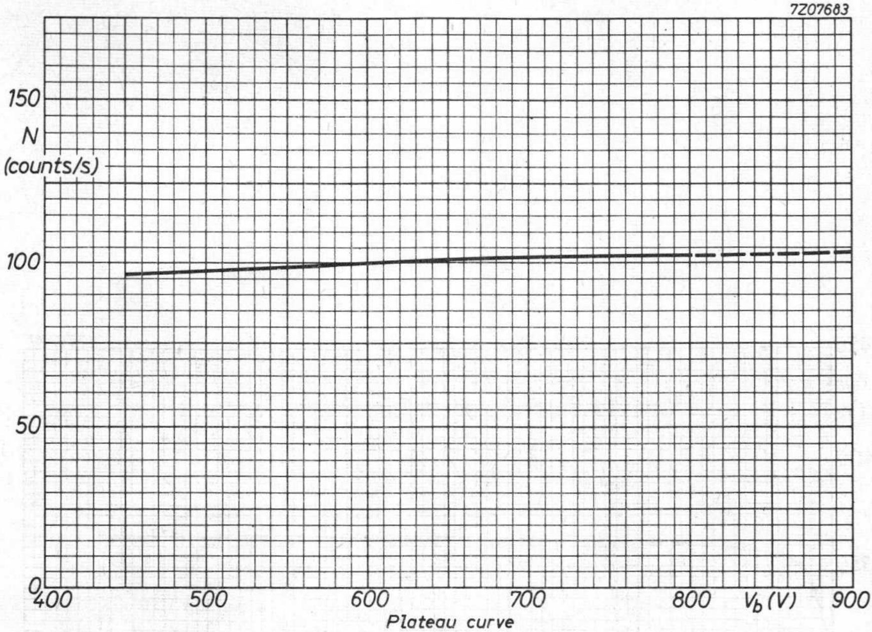
7Z2 8485



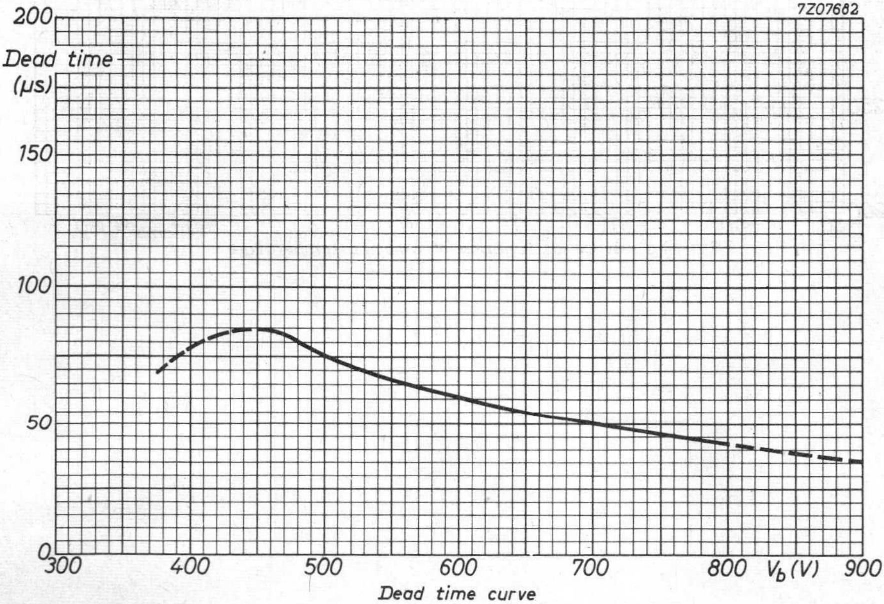
Count rate as function of dose rate



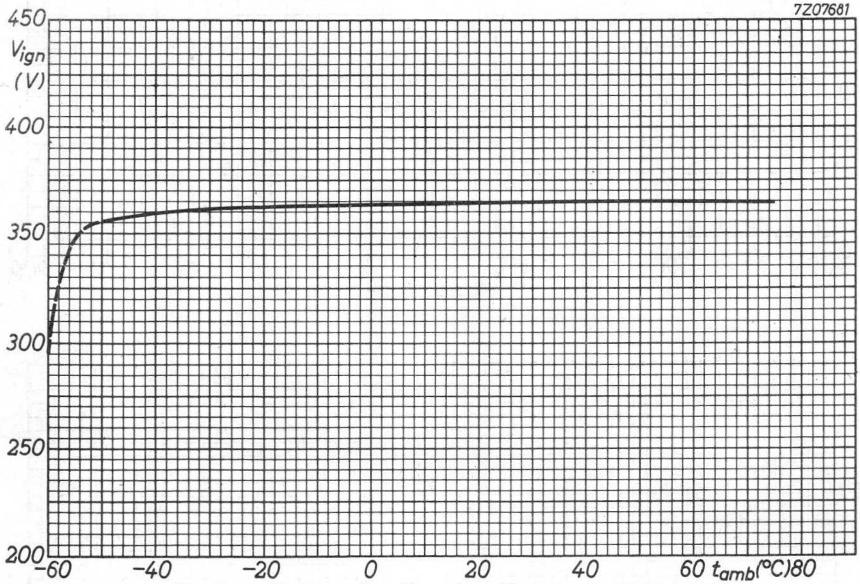
Current as function of dose rate



Plateau curve



Dead time curve



Starting voltage as function of ambient temperature

Miscellaneous Nuclear Devices

NEUTRON GENERATOR TUBE

The 18600 is a compact and sturdy type of sealed-off accelerating tube that makes use of the $T^3(d,n)He^4$ reaction to generate 14-MeV neutrons, thus forming a mono-energetic continuous or pulsed neutron source without accompanying γ radiation.

The tube contains a Penning ion source which operates at the same gas pressure as the accelerating system at a voltage of 2 kV.

The gas filling is a mixture of deuterium and tritium, the pressure of which is controlled by a replenisher.

The beam of accelerated ions strikes a self-replenishing titanium target, so that a tube life is ensured that is unlimited by the life of the target.

APPLICATIONS

The tube is intended for use in applications such as:

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

  labelling of items for tracer work;
  moisture control of foundry sand;
  inventory of large stockpiles of coal and grain.

The tube operates at a high voltage of −125 kV and, with a beam of about 100 μA, it produces more than 10^8 n per second. Its expected life is one thousand hours under conditions specified in the section "Typical Operation".

7Z2 8593

MECHANICAL DATA

Dimensions in mm

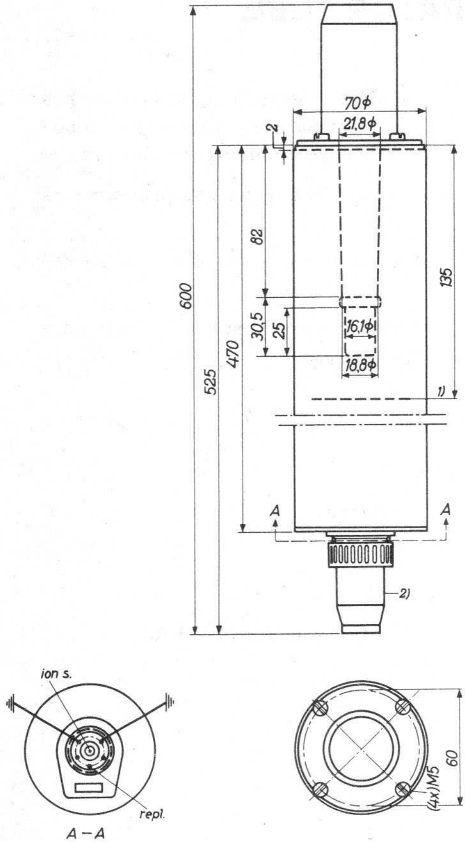


Fig. 1

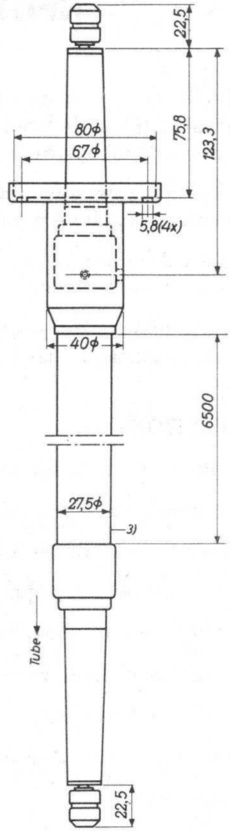


Fig. 2. High-tension cable
(type No. 56066)

	Tube	HT cable
Weight		
Net weight	4 kg	6.2 kg
Shipping weight	10 kg	approx. 8 kg
Mounting position	dependent on application	

1) Position of the target indicated by a groove.
2) Connector, type No. W4 063 45.
3) 150 kV cable.

7Z2 8594

MECHANICAL DATA (continued)

Accessories supplied with the tube

a. contact spring for HT connector
b. container filled with silicon paste for HT connector (Philips No. X02078, Dow Corning 41 or an equivalent)
c. 6-pins female connector plug (type No. W4 063 45, see Fig.1)
d. HT cable with connector [1]) (type No. 56066, see Fig.2)

CHARACTERISTICS

Neutron yield (at target voltage = −125 kV)	min. 10^6	n/sec/μA
Neutron yield = f (target voltage)	Fig.4	
Target current = f (target voltage)	Fig.5	
Capacitance target to envelope	40	pF

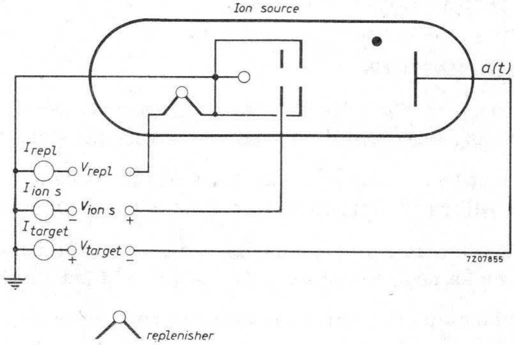


Fig.3. Circuit symbol

TYPICAL OPERATION
(reference point for all voltages is the metal envelope)

Ion-source voltage	2000	V d.c.
Ion-source current	0.3	mA d.c.
Replenisher voltage	1.5	V
Replenisher current	3.5	A
Target voltage	−125	kV d.c.
Target current	100	μA d.c.
Neutron yield	min. 10^8	n/sec

[1]) Optional at extra cost.

7Z2 8595

LIMITING VALUES (Absolute ratings)

Ion-source voltage	min.	1500	V
	max.	2500	V
Ion-source current	max.	0.6	mA
Replenisher voltage	max.	3	V [1])
Replenisher current	max.	5	A
Target voltage	max.	-130	kV [2])
Target current	max.	125	μA
Ambient temperature	min.	-25	°C
	max.	+55	°C [3])

TUBE LIFE

The life of the tube is expected to be one thousand operating hours under the conditions specified in the section "Typical Operation".

OPERATIONAL CONSIDERATIONS

For satisfactory operation of the tube the recommendations given in the pamphlet "Installation and Operating Instruction" packed with each tube should be observed.

Although the most attractive feature of this tube is that it can yield a continuous neutron flux for hours without interruption, it can be adapted to pulsed operation.

If the ion-source voltage is pulsed, it is possible to get neutron pulses with a pulse duration down to 5 μs and a neutron output of 10^7 n/sec at a duty cycle of 3%.

Warning: 1. The tube contains 9.5 curie titanium-bounded tritium.

2. It is necessary to protect the user against the neutron radiation and the secondary γ radiation.

1) Measured directly on the tube.

2) Breakdown in the HT supply apparatus should be carefully avoided, as accompanying oscillations in the secondary LC circuit might cause a breakdown in the tube and destroy it. For protection of the tube it is recommended to use a current-limiting resistor of 3 MΩ in the target supply line.

3) This temperature is determined by the HT cable.

7Z2 8596

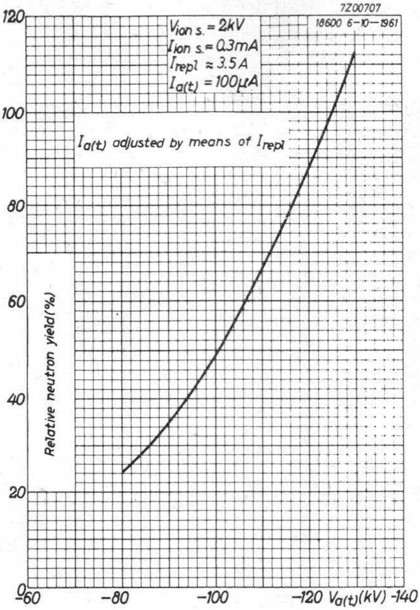


Fig.4. Relative neutron yield as a function of the target voltage

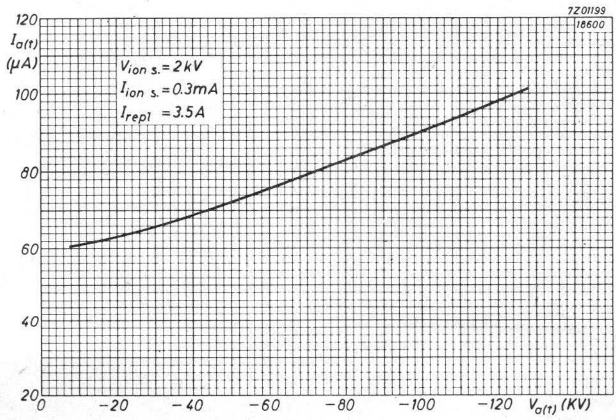
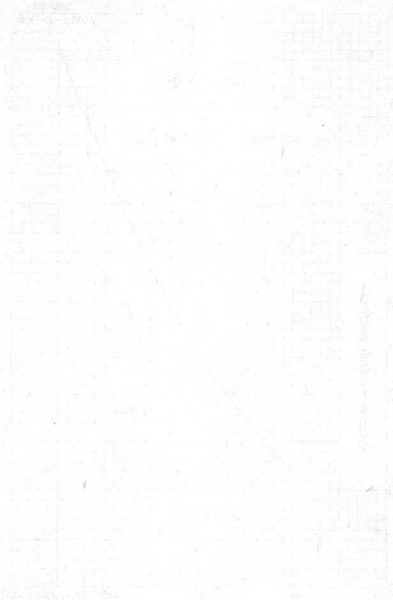
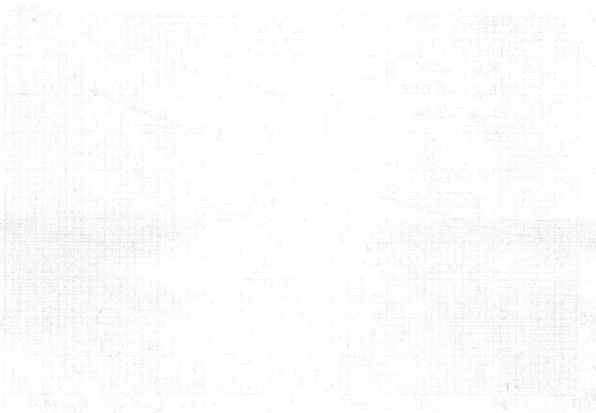


Fig.5. Target current as a function of the target voltage



[illegible]



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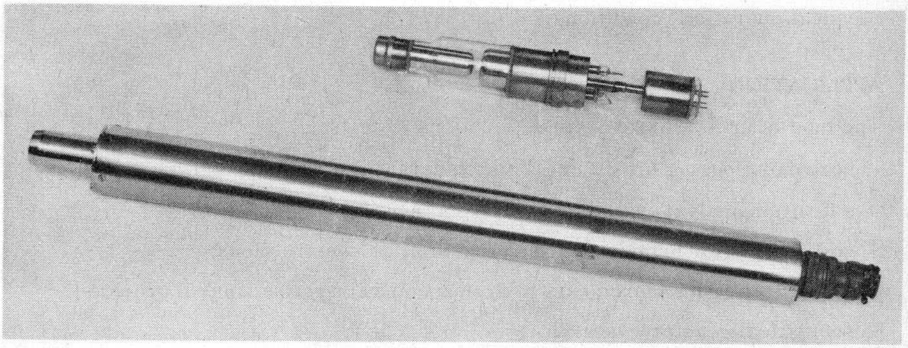
NEUTRON GENERATOR TUBE

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



7Z2 8556

DESCRIPTION

The 18601 is a compact and sturdy type of sealed-off accelerating tube that makes use of the T^3 (d, n) He^4 reaction to generate 14 MeV neutrons, thus forming a mono-energetic continuous or pulsed neutron source without accompanying γ radiation. The tube operates at a high voltage of −125 kV. It produces in continuous operation over 10^8 neutrons per second, in pulsed operation up to 2.10^{11} neutrons per second (typical) during the pulse.
The tube contains a Penning ion source, which operates at the same pressure as the accelerating system.
The gas filling is a mixture of deuterium and tritium the pressure of which is controlled by a replenisher and can be measured by a built-in ionization gauge.
The beam of accelerated deuterium-and tritium ions strikes and replenishes the titanium-tritium target ensuring a tube life that is not limited by the tritium content of the target. The life expectancy of the tube is more than 1000 h under "Typical operation" conditions.

APPLICATION

The tube is intended for use in applications such as:

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

  labelling of items for tracer work;

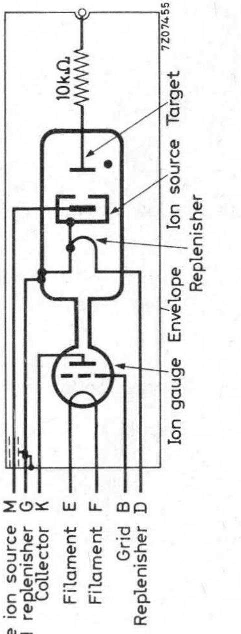
  moisture control of foundry sand;

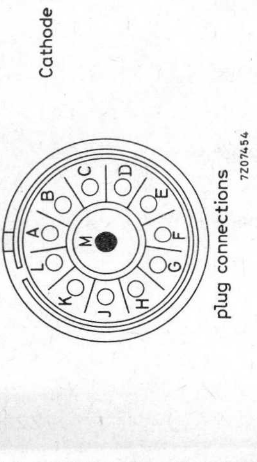
  inventory of large stockpiles of coal and grain.

7Z2 8557

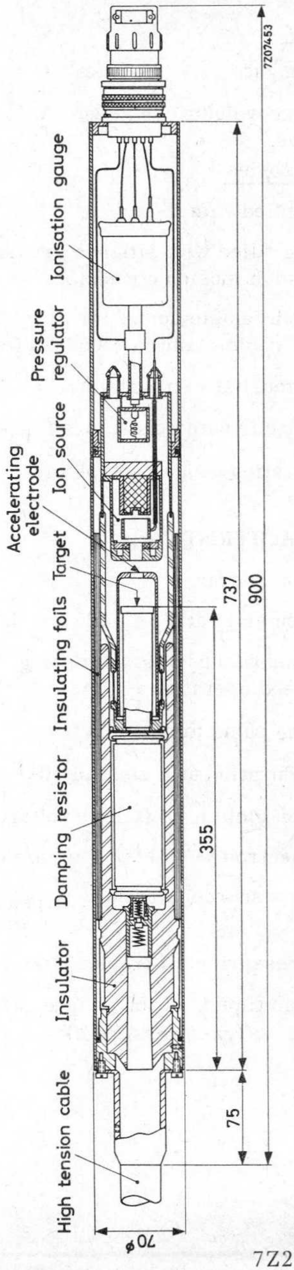
MECHANICAL DATA

Dimensions in mm





plug connections



7Z2 8558

Mounting position: any

Weight

Net weight 6 kg

Shipping weight 11.5 kg

Accessories

a) Supplied with the tube:

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

b) Optional at extra costs:

- HT cable with connectors (length 6.5 m) type 56066
- Ionization gauge control unit type WPS-3-NL/NG

CHARACTERISTICS

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

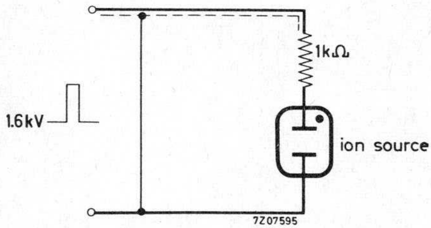
7Z2 8559

TYPICAL OPERATION

	Continuous operation	Pulsed operation	
Neutron output	2.10^{8}	2.10^{11}	n/s
Pulse duration	–	5 to 1000	µs [1])
Target voltage	-125	-125	kV
Target current	100	mean value 100	µA
Ion source supply voltage	2	1.6	kV
Ion source current	10^{-4}	peak value 1	A
Replenisher current	3	4.2	A
Gas pressure	3.10^{-5}	8.10^{-3}	mmHg
Ambient temperature	25	25	°C

Ionization gauge:

emission current	10	µA
collector voltage	5	V
cathode voltage	33	V
grid voltage	178	V
filament voltage	approx. 2	V



Ion source circuit

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

7Z2 8560

LIMITING VALUES (Absolute max. rating system)

Target voltage	max.	-130	kV
Target dissipation (T_{av} = max. 1 s)	max.	15	W
Ion source supply voltage	max.	3	kV
Replenisher current	max.	5	A
Gas pressure	max.	10^{-2}	mmHg
Ambient temperature	min.	-25	^{o}C
	max.	70	^{o}C

LIFE EXPECTANCY

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

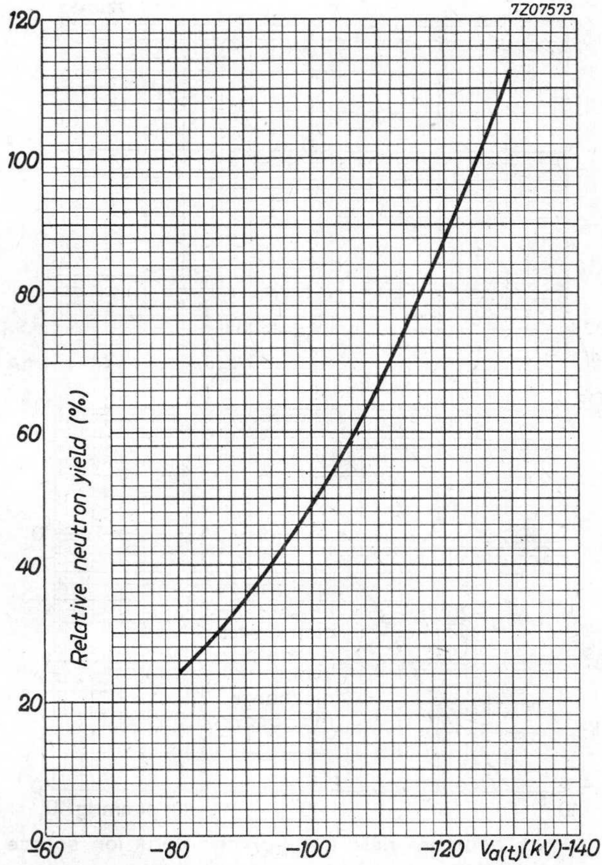
WARNINGS

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

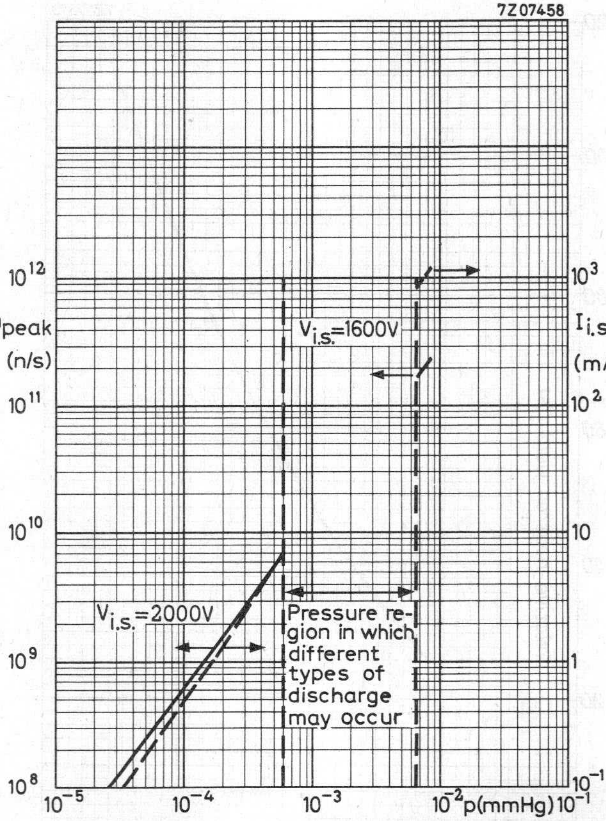
OPERATIONAL CONSIDERATION

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

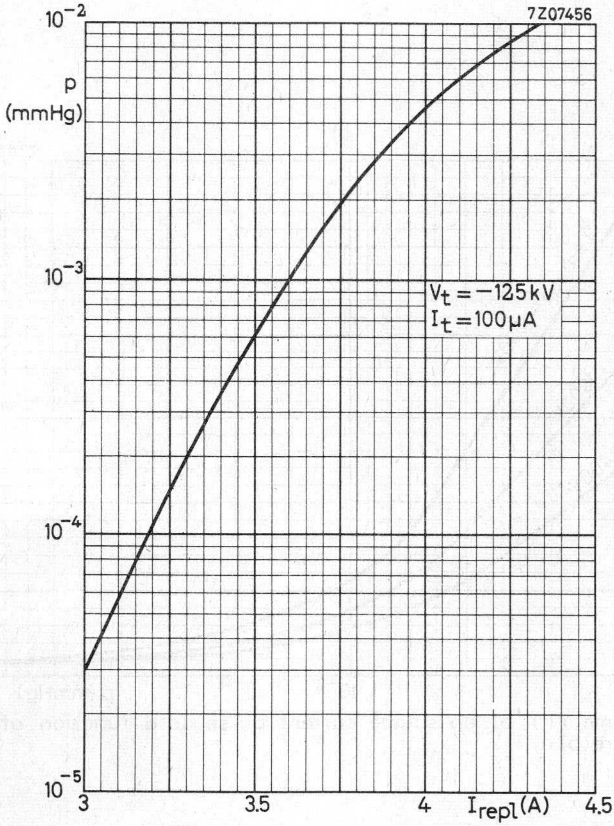
7Z2 8561



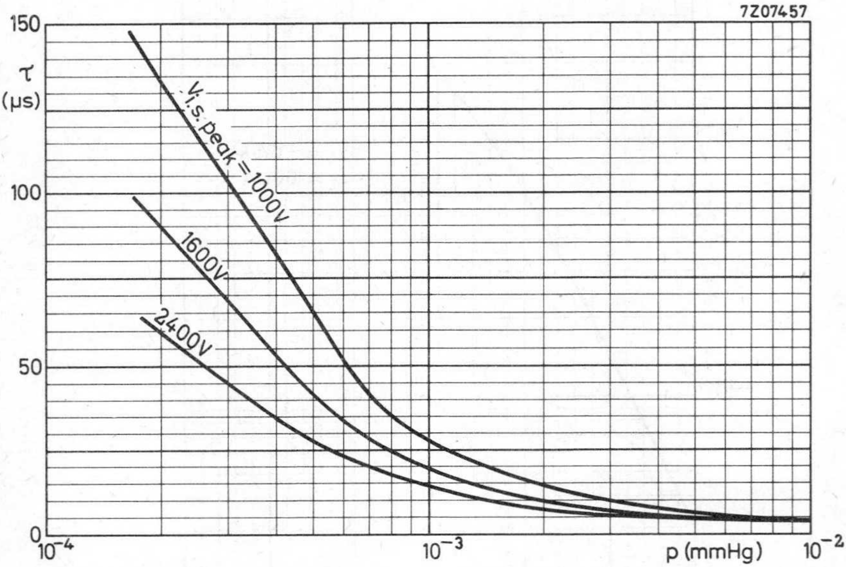
Neutron yield (n) = f (target voltage V_t)



Peak neutron yield (n_{peak}) and peak ion source current ($I_{i.s.peak}$) as a function of gas pressure (p)
Target dissipation = 12.5 W



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



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

THERMOLUMINESCENT DOSIMETER

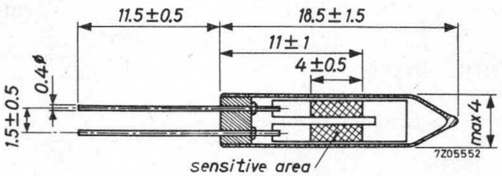
Thermoluminescent dosimeter for therapeutic and diagnostic practice and health physics applications. Its small dimensions make this dosimeter particularly suitable for intra cavitary use and measurements of isodose curves of X-ray machines.

QUICK REFERENCE DATA

Range	100 mR to 10^6 R
Energy independent within ± 25% with correction filter	from 25 KeV to 1.3 MeV

The number of dose measurements with the dosimeter is practically unlimited.

DIMENSIONS AND CONNECTIONS — Dimensions in mm



Any bending of the leads must be at least 2 mm from the glass.

GENERAL

Sensitive material	Mn activated CaF2
Wavelength of the emitted light (mean value)	480 nm
Sensitive area	8 mm^2

HEATING

Heater current A.C. or D.C.	I_f	1.80 to 1.84 A [1])
Resistance of heater	R_f	approx. 0.4 Ω
Read-out time } See also page A		13 ± 1 sec
Heating time } See also page A		24 sec

[1]) Required stability of heater current chosen within this range: 1%. 7Z2 6785

CHARACTERISTICS at t_{amb} = 25 °C

Range	measured with filter	100 mR to 10^6 R
Linear response		up to 10^5 R
Absolute sensitivity		2.10^6 photons/R
Energy dependency		See page B
Longitudinal polar response		See pages C and D
Transverse polar response		See pages E and F
Glow curve		See page A
Fading		See page G [1]
Residual dose up to 10^5 R		< 4 ‰ [2]
Daylight sensitivity equivalent to 1 mR		approx. 1000 lux h

LIMITING VALUES (Absolute max. rating system)

Heater current	I_f	max.	2.0	A
Heating time		max.	30	sec
Ambient temperature, operating	t_{amb}	min.	-40	°C
		max.	+70	°C
storage		max.	100	°C

LIFE EXPECTANCY

Total dose	> 10^6 R
Number of dose measurements	> 1000

REMARK

Exposure to direct sunlight should be avoided.

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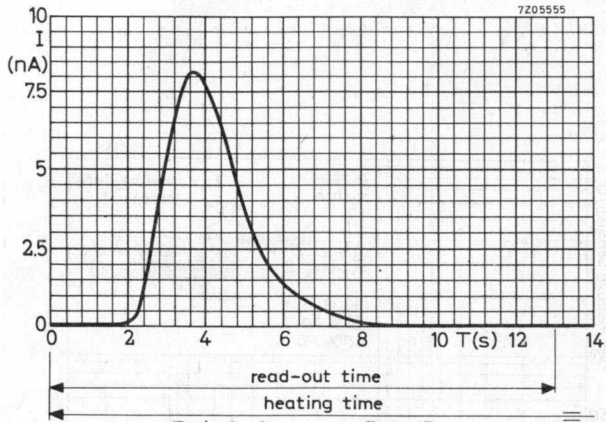
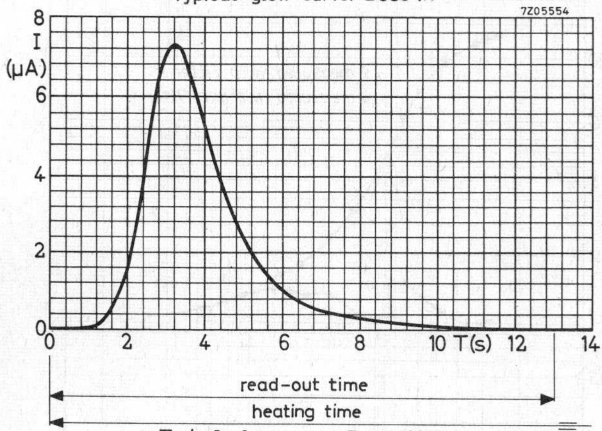
[1]) Dosimeter stored in darkness. When stored in daylight and/or higher temperature a higher fading must be taken into account.

[2]) In order to reduce the residual dose to < 1‰ it is necessary to repeat the read-out cycle 4 times.
The period between two readings should be minimum 1 minute.

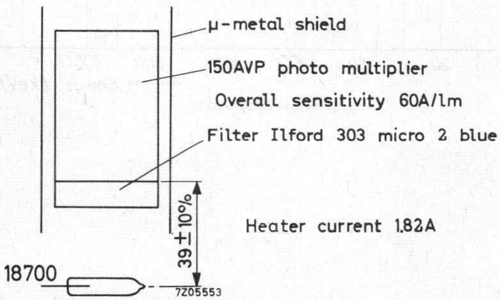
7Z2 6786

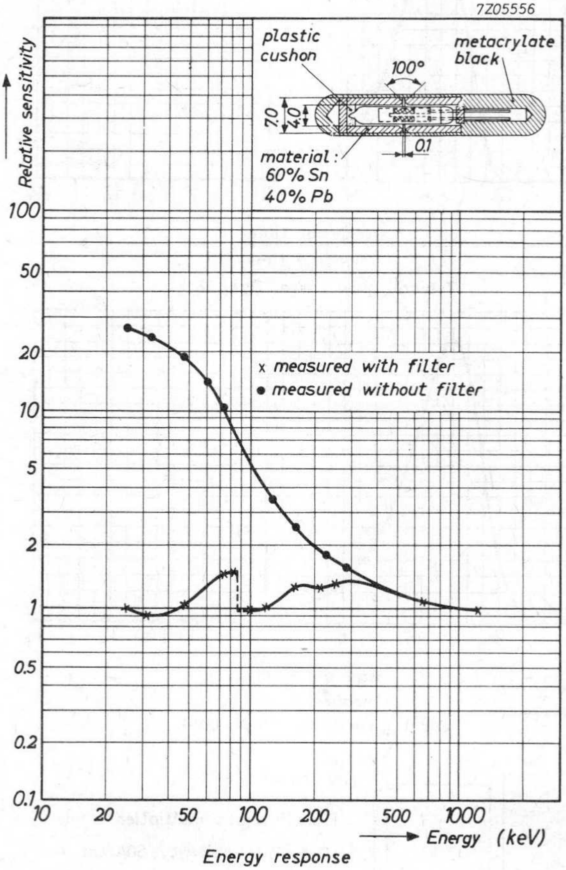


Typical glow curve. Dose 1R



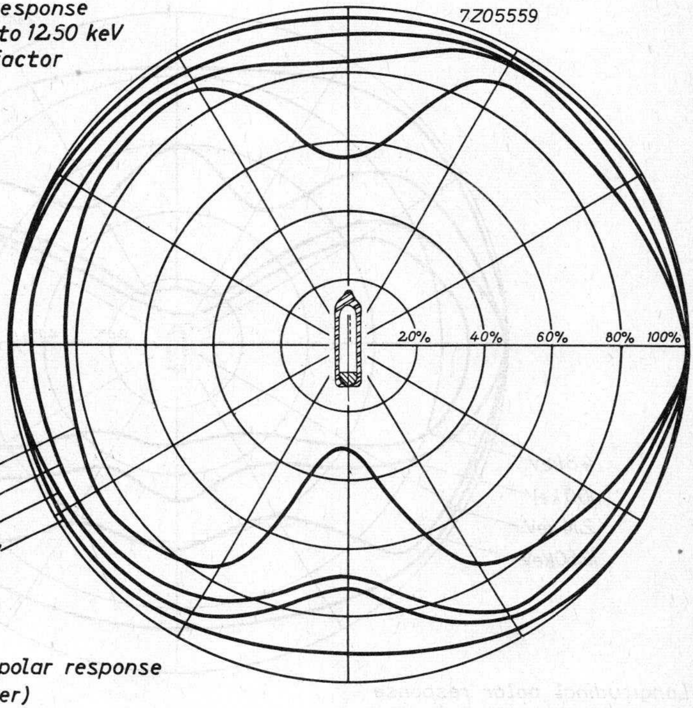
Typical glow curve. Dose 1000R



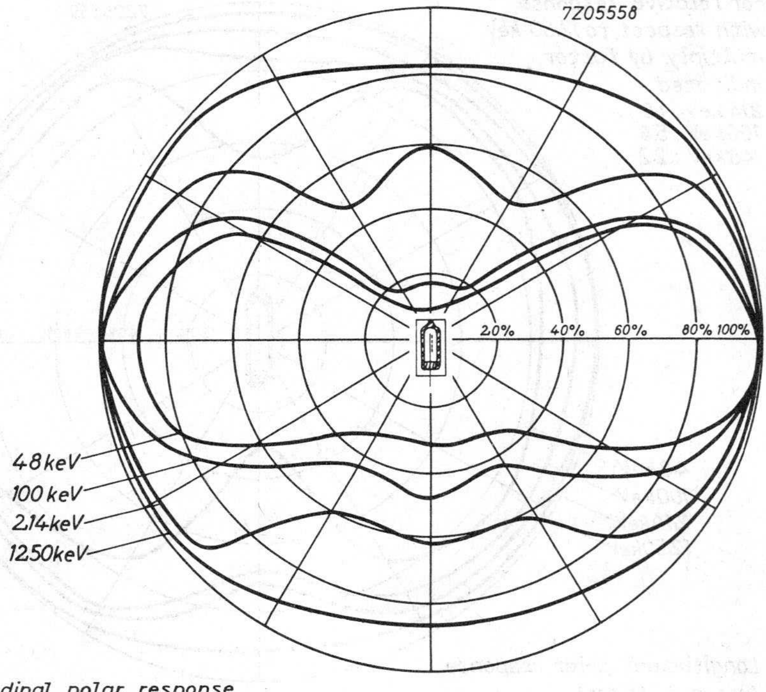


Energy response

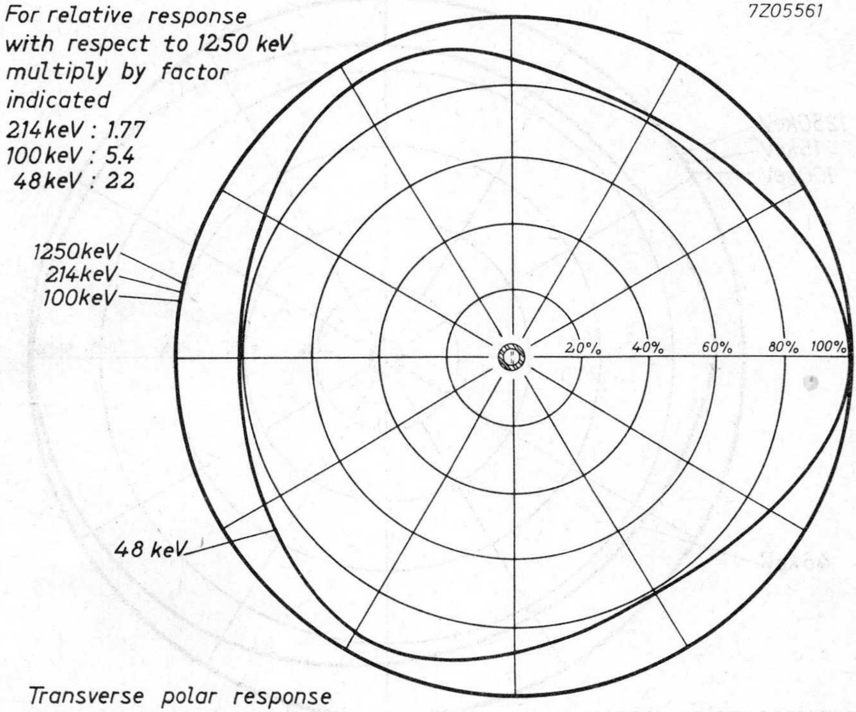
For relative response
with respect to 12.50 keV
multiply by factor
indicated
2.14 keV : 1.8
100 keV : 5.4
48 keV : 2.2



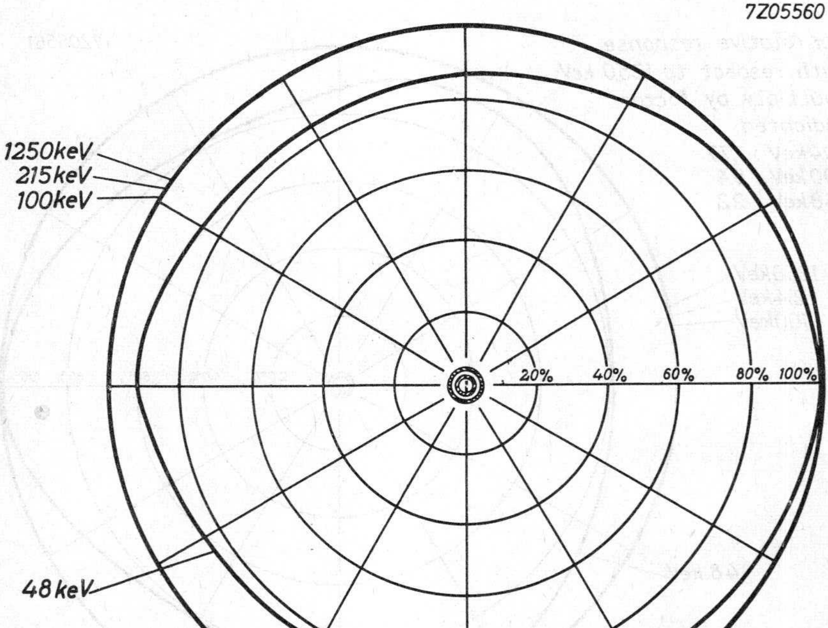
Longitudinal polar response
(without filter)



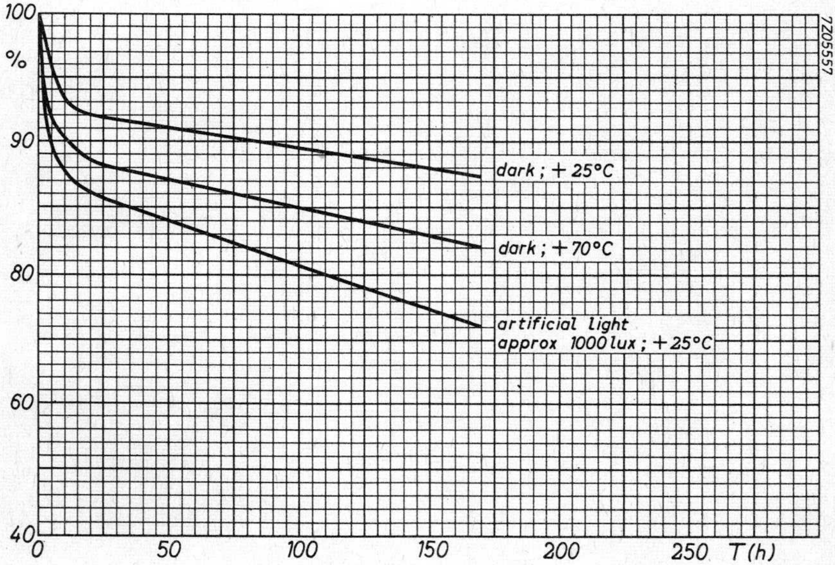
Longitudinal polar response (with filter)



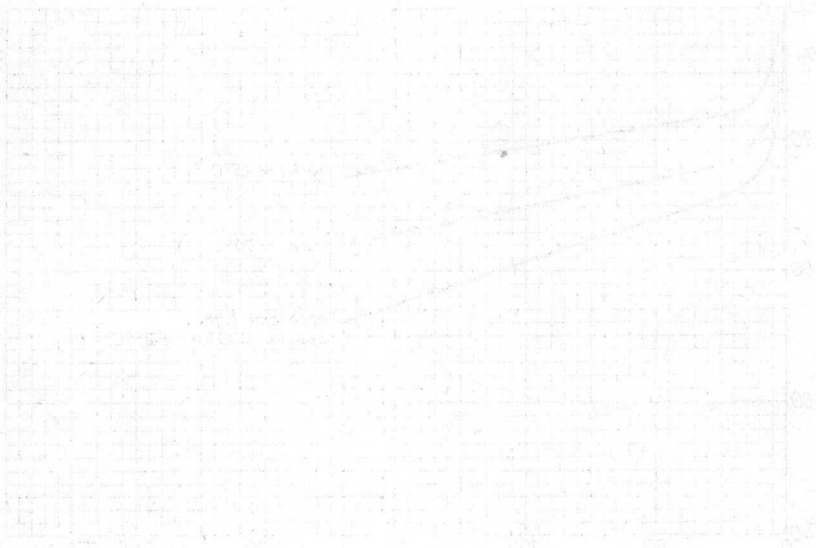
Transverse polar response
(without filter)



Transverse polar response (with filter)



Fading curve



INDEX OF TYPENUMBERS

CSIT = Counter-, selector and indicator tubes
Ign = Ignitrons
IRT = Industrial rectifying tubes
MND = Miscellaneous nuclear devices
RCT = Radiation counter tubes
Thyr = Thyratrons
Tr T = Trigger tubes and switching diodes
VSRT = Voltage stabilizing and reference tubes

7Z2 8554

Type No.	Section	Type No.	Section	Type No.	Section
367	IRT	18504	RCT		
451	IRT	18505	RCT		
1010	IRT	18506	RCT		
1037	IRT	18507	RCT		
1039	IRT	18508	RCT		
1049	IRT	18509	RCT		
1054	IRT	18510	RCT		
1069A	IRT	18511	RCT		
1110	IRT	18515	RCT		
1119	IRT	18516	RCT		
1138	IRT	18517	RCT		
1163	IRT	18518	RCT		
1164	IRT	18520	RCT		
1173	IRT	18522	RCT		
1174	IRT	18526	RCT		
1176	IRT	18529	RCT		
1177	IRT	18536	RCT		
1710	IRT	18545	RCT		
1725A	IRT	18546	RCT		
1738	IRT	18548	RCT		
1749A	IRT	18550	RCT		
1788	IRT	18552	RCT		
1838	IRT	18553	RCT		
1849	IRT	18555	RCT		
1859	IRT	18600	MND		
4662	CSIT	18601	MND		
5643	Thyr	19700	MND		
5696	Thyr				
5949	Thyr				
18503	RCT				

CSIT = Counter-, selector and indicator tubes
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7Z2 8555

ELECTRON TUBES
PART 6

Voltage stabilizing- and reference tubes

Counter-, Selector- and indicator tubes

Trigger tubes and switching diodes

Thyratrons

Industrial rectifying tubes

Ignitrons

Radiation counter tubes

Miscellaneous nuclear devices

August, 1967

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