PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Electron tubes

Part 7 February 1974

Voltage stabilizing and reference tubes

Counter, selector and indicator tubes

Trigger tubes and switching diodes

Thyratrons

Industrial rectifying tubes

Ignitrons

High voltage rectifying tubes

Miscellaneous

ELECTRON TUBES

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Voltage stabilizing - and reference tubes

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Miscellaneous

Associated accessories

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DATA HANDBOOK SYSTEM

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

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

ELECTRON TUBES (9 parts)	**BLUE**
SEMICONDUCTORS AND INTEGRATED CIRCUITS (6 parts)	**RED**
COMPONENTS AND MATERIALS (7 parts)	**GREEN**

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically; the contents of each series are summarized on the following pages.

We have made every effort to ensure that each series is as accurate, comprehensive and up-to-date as possible, and we hope you will find it to be a valuable source of reference.

Where ratings or specifications quoted differ from those published in the preceding edition they will be pointed out by arrows.

You will understand that we can not guarantee that all products listed in any one edition of the handbook will remain available, or that their specifications will not be changed, before the next edition is published.

If you need confirmation that the published data about any of our products are the latest available, may we ask that you contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

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

Part 1a Transmitting tubes for communications **April 1973**
and Tubes for r.f. heating Types PB2/500 ÷ TBW15/125

Part 1b Transmitting tubes for communication **May 1973**
Tubes for r.f. heating
Amplifier circuit assemblies

Part 2 Microwave products **August 1973**

Communication magnetrons
Magnetrons for micro-wave heating
Klystrons
Traveling-wave tubes
Diodes
Triodes
T-R Switches
Microwave Semiconductor devices
Isolators Circulators

Part 3 Special Quality tubes; **March 1972**
Miscellaneous devices

Part 4 Receiving tubes **September 1973**

Part 5a Cathode-ray tubes **November 1973**

Part 5b Camera tubes; Image intensifier tubes **December 1973**

Part 6 Products for nuclear technology **January 1974**
Photodiodes

Photomultiplier tubes
Channel electron multipliers
Geiger-Mueller tubes
Neutron tubes
Photo diodes

Part 7 Gas-filled tubes **February 1974**

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

Part 8 T.V. Picture tubes **November 1972**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

Part 1a Rectifier diodes and thyristors — **December 1972**

Rectifier diodes
Voltage regulator diodes
Transient suppressor diodes
Thyristors, diacs, triacs
Ignistors
Rectifier stacks

Part 1b Diodes — **December 1972**

Small signal germanium diodes
Small signal silicon diodes
Special diodes
Voltage regulator diodes
Voltage reference diodes
Tuner diodes

Part 2 Low frequency and deflection transistors — **January 1973**

Part 3 High frequency and switching transistors — **February 1973**

Part 4a Special semiconductors — **March 1973**

Transmitting transistors
Microwave devices
Field effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits

Part 4b Devices for opto-electronics — **March 1973**

Photosensitive diodes and transistors
Light emitting diodes
Infra-red sensitive devices
Photocouplers
Photoconductive devices

Part 5 Linear integrated circuits — **July 1973**

Part 6 Digital integrated circuits — **March 1972**

DTL (FC family)
DTL/HNIL (FZ family)
TTL (FJ family)
TTL (GJ family)
CML (GH family)
MOS (FD family)

COMPONENTS AND MATERIALS (GREEN SERIES)

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

Part 1 **Circuit Blocks, Input/Output Devices, Electro-mechanical Components, Peripheral Devices** **January 1973**

Circuit blocks 40-Series and CSA70
Counter modules 50-Series
Norbits 60-Series, 61-Series
Circuit blocks 90-Series
Input/output devices
Electro-mechanical components
Peripheral devices

Part 2 **Resistors, Capacitors** **April 1973**

Electrolytic capacitors
Paper capacitors and film capacitors
Ceramic capacitors
Variable capacitors
Fixed resistors
Variable resistors
Non-linear resistors (VDR, LDR, NTC, PTC)

Part 3 **Radio, Audio, Television** **June 1973**

FM tuners
Loudspeakers
Television tuners, aerial input assemblies
Components for black and white TV
Components for colour television
Deflection assemblies for camera tubes

Part 4a **Soft ferrites** **October 1973**

Ferrites for radio, audio and television
Small coils
Ferroxcube potcores and square cores
Ferroxcube transformer cores

Part 4b **Piezoelectric Ceramics, Permanent magnet materials** **October 1973**

Part 5 **Ferrite core memory products** [1] **January 1974**

Ferroxcube memory cores
Matrix planes and stacks
Core memory systems

Part 6 **Electric Motors and Accessories, Timing and Control Devices** **October 1972**

Small synchronous motors
Stepper motors
D.C. motors
D.C. tachogenerators [2]
[2] Asynchronous motors
Indicators for built-in test equipment
Time indicators, timers, timing motors
Aircraft electronic clock system

Part 7 **Circuit Blocks** **September 1971**

Circuit blocks 100 kHz -Series
Circuit blocks-1-Series
Circuit blocks 10-Series
Circuit blocks for ferrite core memory drive

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[1] 4 Chapters of our former Part 5 (August 1972) are no longer included : chapter "Magnetic heads" has been withdrawn, chapters "Quartz crystal units" and "Variable mains transformers" are published as separate booklets, chapter "Microwave devices" has been transferred to the blue Handbook Series "Electron tubes" Part 2.

[2] These items have been discontinued.

Voltage stabilizing- and reference tubes

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

GENERAL OPERATIONAL RECOMMENDATIONS VOLTAGE STABILIZING AND VOLTAGE REFERENCE TUBES

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.

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.

Thc 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.

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.

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:

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

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.

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

To ensure ignition:

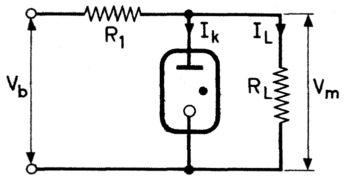
$$V_b \cdot \frac{R_1}{R_1 + R_L} > V_{ign} \max.$$

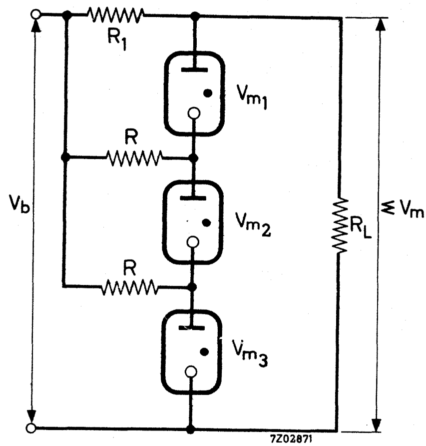
or under the most unfavourable operating conditions

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

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





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.

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.

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_{kp}	=	max.	75	mA 2)
Negative peak anode voltage	$-V_{ap}$	=	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

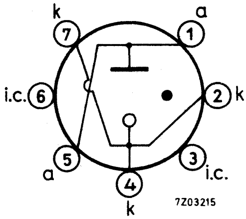
1) Thermal equilibrium is reached within 3 minutes of igniting the tube.

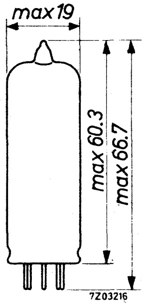
2) To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 m after passing this current.

3) This value holds good over life.

DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





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.

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

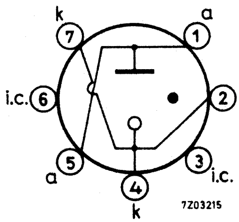
[1]) To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 min. after passing this current.

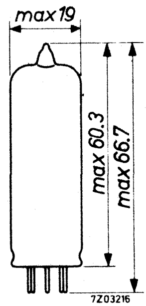
CIRCUIT DESIGN VALUES

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.

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	$-V_{ap}$	= max.	75	V
Ambient temperature	t_{amb}	= min.	−55	°C
		= max.	+90	°C

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

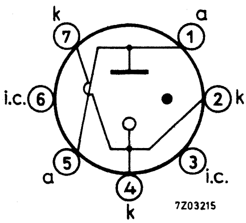
[2] To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

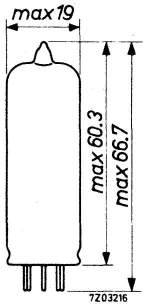
CIRCUIT DESIGN VALUES

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.

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.

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	

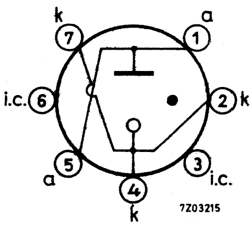
1) To be restricted for long life to approximately 10 s. Normal operation should be continued for at least 20 min. after passing this current.

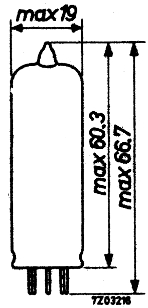
CIRCUIT DESIGN VALUES

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.

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	[3]
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.
3) The maintaining voltage after each ignition may differ from the forgoing one but remains within the limits stated. To minimize this effect the tube should be shunted by a series circuit comprising a resistor and a capacitor (approx. 1 kΩ and 330 nF).

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.

LIMITING VALUES (Absolute maximum rating system)

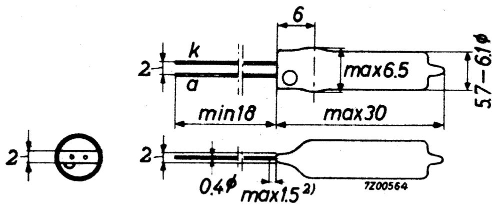
Cathode current	I_k	= max.	4.0	mA [1]
		= min.	2.0	mA
Starting current, $T_{max.}$ = 20 s	I_{kp}	= max.	20	mA
Negative peak anode voltage	$-V_{ap}$	= max.	100	V
Bulb temperature				
during operation	t_{bulb}	= min.	-55	°C
		= max.	+125	°C
during storage and stand-by	t_{bulb}	= min.	-55	°C
		= max.	+100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

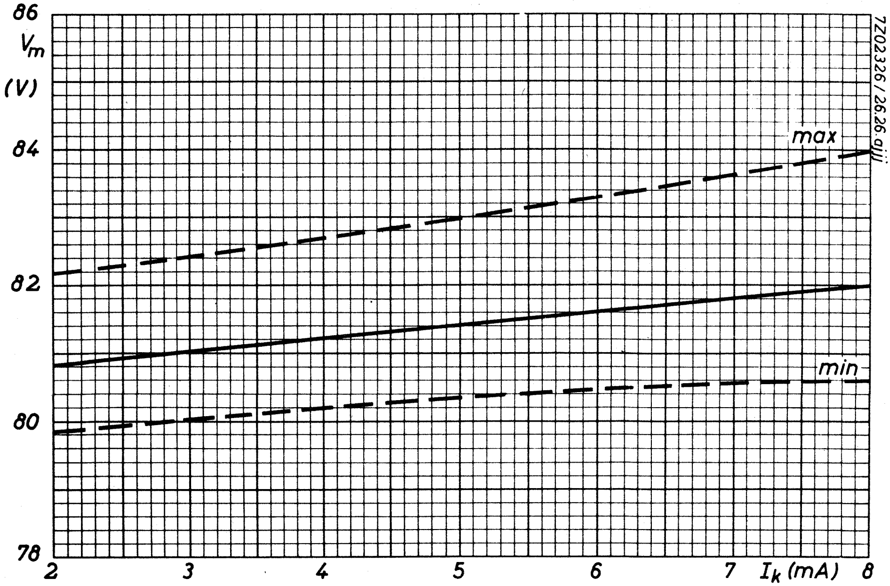
The tube may be dip-soldered at a solder temperature of max. 240 °C for a maximum of 10 seconds up to a point 5 mm from the seal.

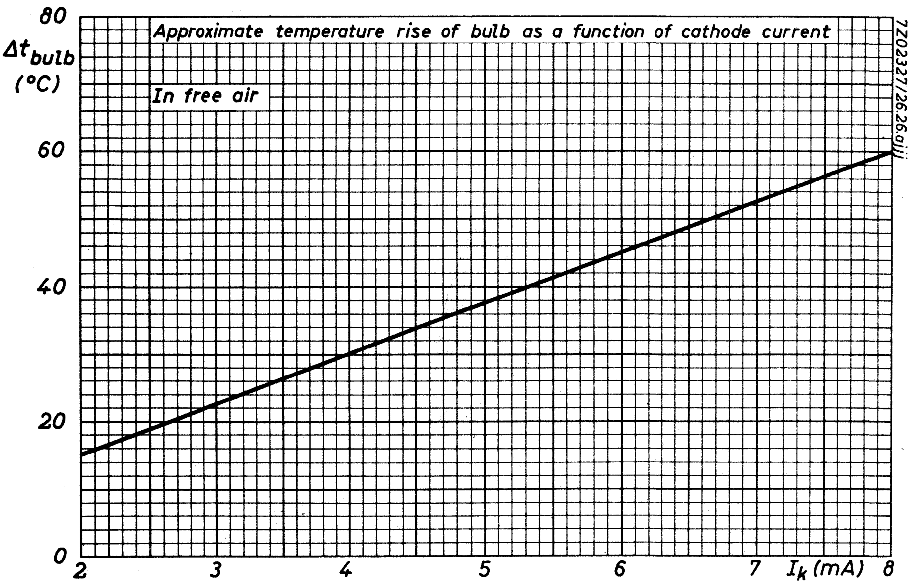
Care should be taken not to bend the leads nearer than 1.5 mm to the seal.

---

[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.


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


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.ajj

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.

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.

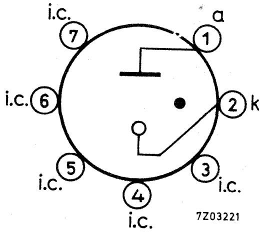
[2] Temperature rise of bulb above ambient approx. 40 °C at I_k = 30 mA and approx. 70 °C at I_k = 60 mA.
The tube will operate satisfactorily at bulb temperature up to 140 °C provided the tube is not used at either extreme of the current range.

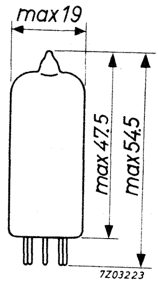
CIRCUIT DESIGN VALUES

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

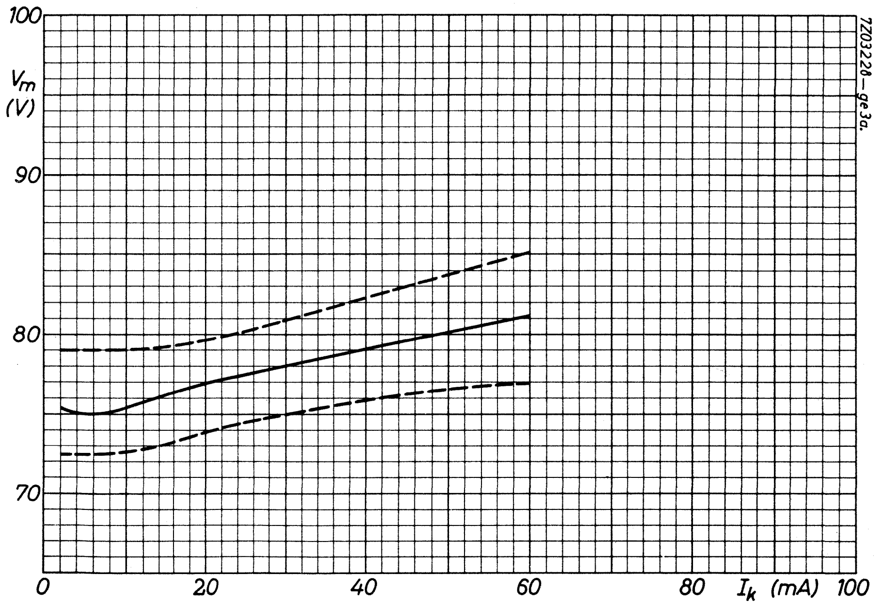
DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





[1]) This value holds good over life.


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

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.

CHARACTERISTICS AND RANGE VALUES (continued)

Life performance

Typical maximum variation in maintaining voltage

For continuous operation at preferred current

Bulb temperature		=	25	100	150	^{o}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]	^{o}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	^{o}C
		=	max.	150	^{o}C [3]
during storage and stand-by	t_{bulb}	=	min.	-55	^{o}C
		=	max.	100	^{o}C

[1]) Subsequent operation of the tube for approximately 50 hours at I_k = 4.5 mA at not more than 100 ^{o}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.

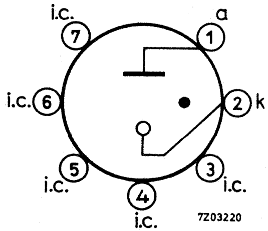
[3]) Temperature rise above ambient approx. 20 ^{o}C at I_k = 4.5 mA.

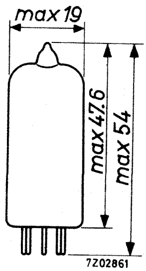
CIRCUIT DESIGN VALUES

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

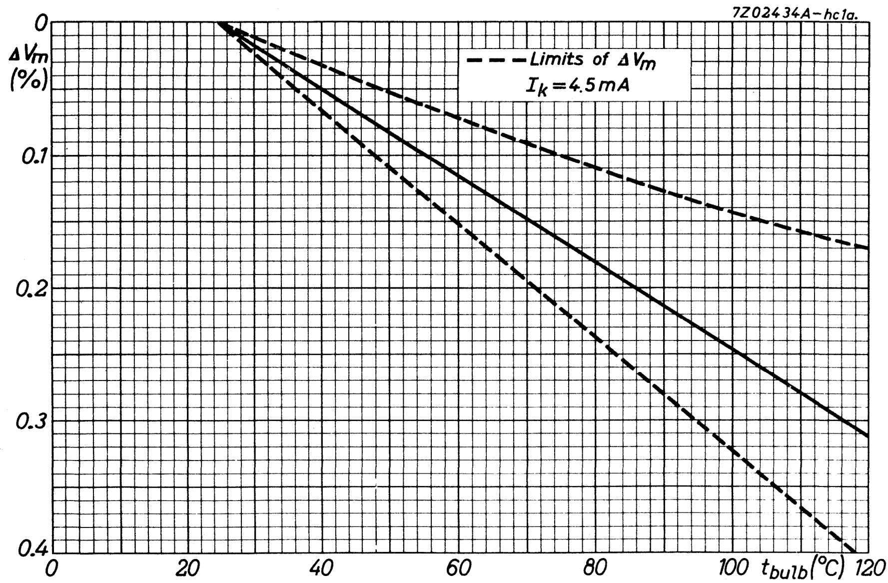
DIMENSIONS AND CONNECTIONS

Base: 7 pin miniature





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


7Z02434A-hc1a.
0
ΔVm
(%)
0.1
0.2
0.3
0.4
0
20
40
60
80
100
120
tbulb (°C)
Limits of ΔVm
Ik = 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.

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_{kp}	=	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

---

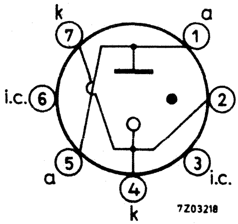
[1] To be restricted for long life to approx. 30 s once or twice in each 8 hours use.

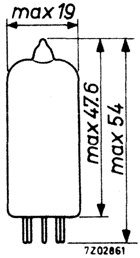
[2] Temperature rise of bulb above ambient approx. 15 °C at I_k = 5.5 mA

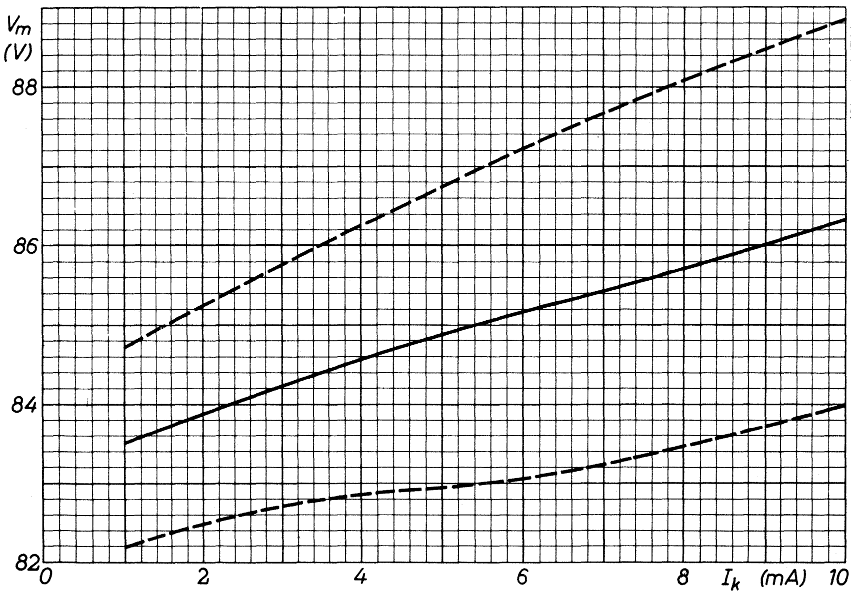
[3] This value holds good over life.

DIMENSIONS AND CONNECTIONS

Base : 7 pin miniature







V_m (V)
88
86
84
82
0
2
4
6
8
I_k (mA)
10
7Z03225-he.l.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.

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.

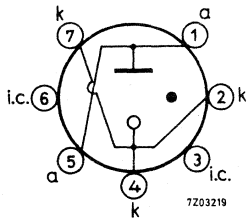
[4] Temperature rise of bulb above ambient approx. 50 °C at I_k = 40 mA.
The tube will operate satisfactorily at bulb temperatures up to 110 °C provided the tube is not used at either extreme of the current range.

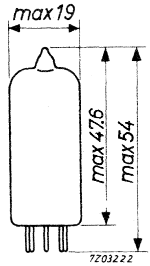
CIRCUIT DESIGN VALUES

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

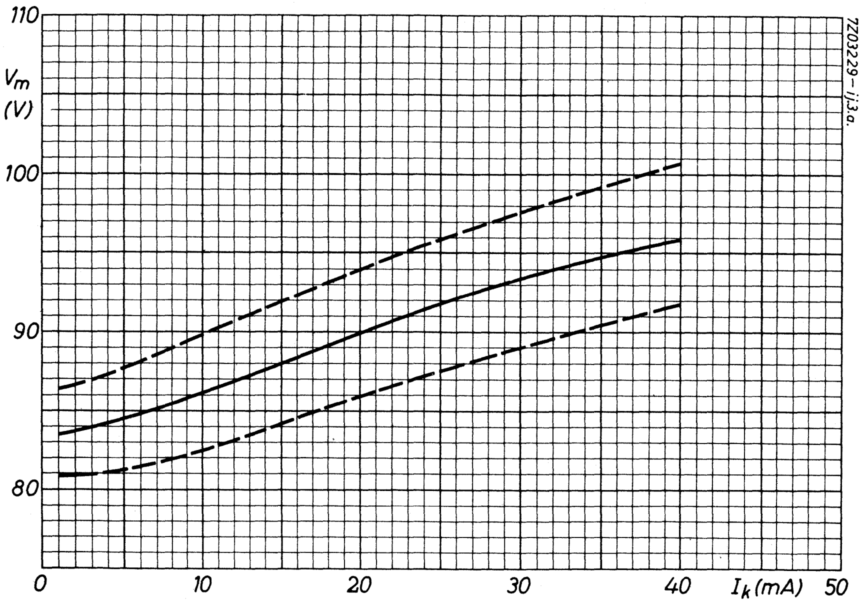
DIMENSIONS AND CONNECTIONS

Base 7 pin miniature





[1] This value holds good over life


110
V_m
(V)
100
90
80
0
10
20
30
40
I_k (mA)
50
7Z03229-ij3.a.

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.

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)

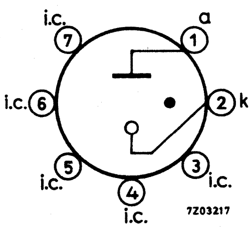
Cathode current	I_k	= min.	5	mA
		= max.	15	mA
Starting current	I_{kp}	= max.	40	mA [1]
Negative peak anode voltage	$-V_{ap}$	= max.	130	V
Bulb temperature				
during operation	t_{bulb}	= min.	-55	°C
		= max.	+110	°C [2]
during storage	t_{bulb}	= min.	-55	°C
		= max.	+70	°C

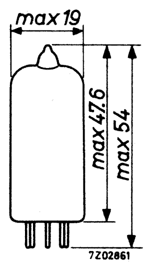
CIRCUIT DESIGN VALUES

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

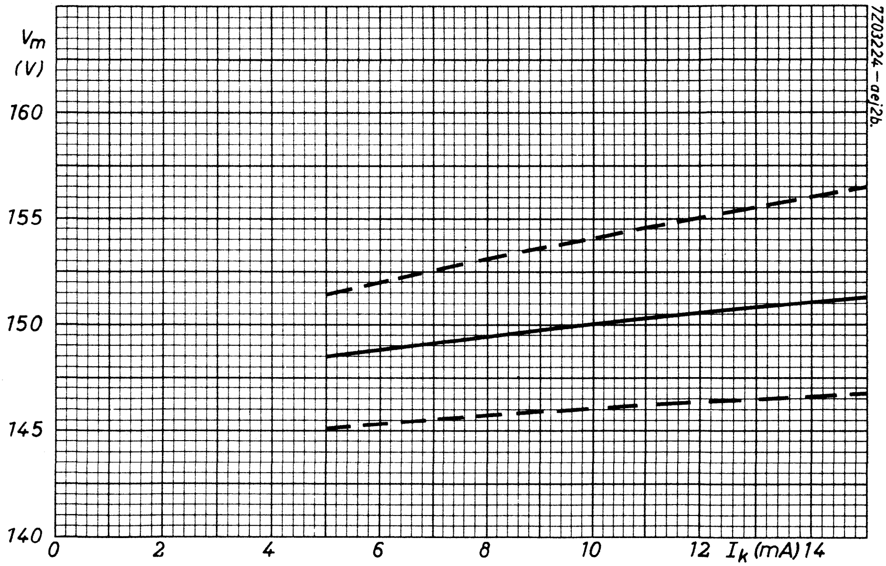




[1]) To be restricted for long life to approximately 30 s once or twice in each 8 hours use.

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

[3]) This value holds good over life.



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

Counter-, selector- and indicator tubes

RECOMMENDED TYPES FOR NEW EQUIPMENT

Indicator tubes

ZM1000
ZM1001
ZM1003
ZM1005
ZM1010

ZM1011
ZM1012
ZM1013
ZM1014
ZM1020

ZM1022
ZM1022p
ZM1023
ZM1040
ZM1041

ZM1042
ZM1043
ZM1075

GENERAL OPERATIONAL RECOMMENDATIONS COUNTER-AND SELECTOR TUBES

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.

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.

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.

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.

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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.

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SHOCK AND VIBRATION

An indication for the **ruggedness** of the tube is the fact that 95% of the items sampled from normal production pass the shock and vibration tests specified below without perceplible damage.
These tests are carried out on non operating tubes.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

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.

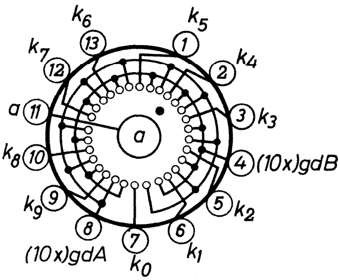
COUNTER AND SELECTOR TUBE

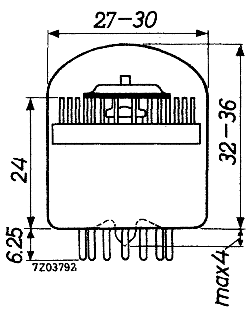
Cold cathode gas-filled bi-directional 10 output selector tube.
The Z504S gives visual indication and operates at speeds up to 5 kHz.

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_o 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	2422 505 00001
Escutcheon	type 56072

General note

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

CHARACTERISTIC AND RANGE VALUES

(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 $I_a = 340\ \mu A$, $V_{gdB} = 25$ to 50 V		See also page 6		
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

STEPPING REQUIREMENTS

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_{gd}
		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_{gd} minus	10	V 2)
	$-V_k$	max.	0	V

For notes see page 5

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 $\geq$ 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 25 000 h, but the visual read-out may be impaired after the first 15 000 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 $\pm$ 5	^{o}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.

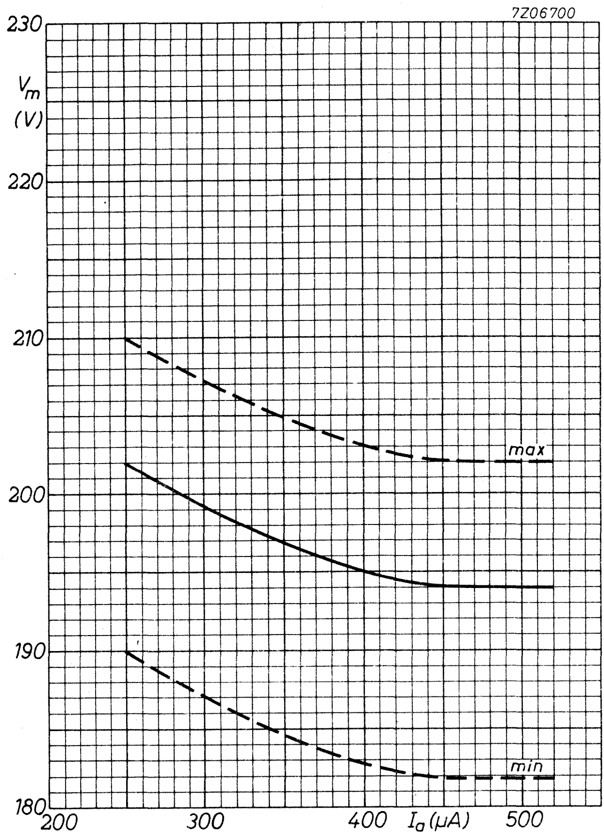
For notes see page 5

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	^{o}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.



Anode to main cathode maintaining voltage plotted against anode current

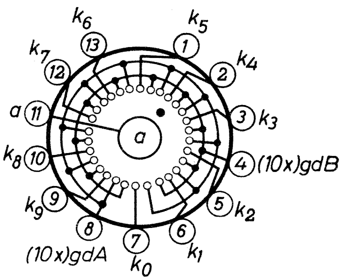
SELECTOR TUBE

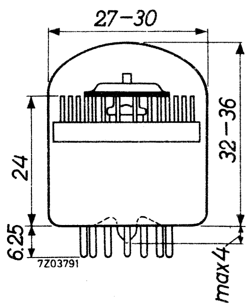
Cold cathode gas-filled bi-directional decade selector and counting tube. This tube has ten main cathodes, all of which are brought out separately. The Z505S gives visual indication and operates at speeds up to 50 kHz.

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	55072

General note

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

CHARACTERISTICS AND RANGE VALUES

(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. min.	80 30	V V

[1] [2] See page 5

CHARACTERISTICS AND RANGE VALUES

Voltage difference required between a guide and the adjacent guide in order to step the discharge	V_{gd-gd}	max.	140	V	
		min.	30	V	3)
Guide supply voltage to step the discharge from a guide to the next main cathode	V_{bgd}	max.	65	V	
		min.	40	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.	140	V	
		min.	100	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 4

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	^oC [1]

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.

---

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

INDICATOR TUBE

Long life cold cathode ten digit indicator tube for side viewing

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals			0 1 2 3 4 5 6 7 8 9	
Decimal point			to the left of the numerals	
Supply voltage	V_{b_a}	min.	170	V
Anode current, average	I_a		2.5	mA
peak	I_{a_p}	max.	12	mA

GENERAL

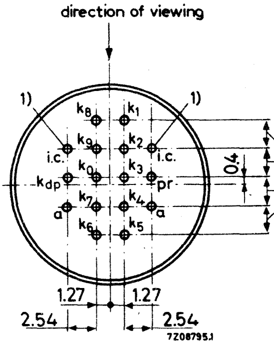
The numerals are 14 mm high and appear on the same base line allowing in-line read out.

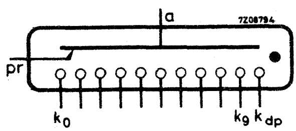
PRINCIPLE OF OPERATION

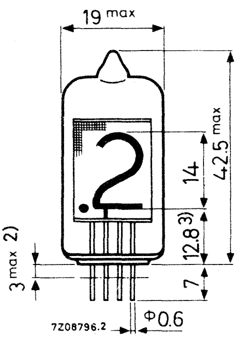
The tube contains ten cathodes in the form of ten numerals and one in the form of a decimal point; a primer, and one common anode. By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral or the decimal point will be covered by a red neon glow.
The primer allows ionization without delay in strobe type or blanking applications.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Length of i.c. pins max. 2.8 mm.
2) Not tinned.
3) Standard deviation 0.13 mm

The deviations of the axis of the pins with respect to the true geometrical position cover an area of max. 0.3 mm diameter. The pin configuration is compatible with the reference grid for printed wiring according to IEC Publication 97 (0.1 in).

Mounting position: Any

Soldering

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

Natural frequency

The natural frequencies of the numeral cathodes lie within the range from 300 Hz to 800 Hz.

ACCESSORIES

55701 Printed wiring mounting board (19 x 100 mm) on which the ZM1000 can be soldered; afterwards the combination can be mounted on a vertical printed wiring board carrying, e.g., the drive circuit. Can also be used with the snap-fit tube holder 55703.

55702 Tube socket (for 0.1 in grid). Phenolic. Tinned contacts.

55703 Snap-fit tube holder.

55704 Set of one left-hand and one right-hand end piece to complete the snap-fit indicator tube assembly.

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see page 4		
Anode current for coverage	I_a	min.	1.5	mA
(with or without decimal point and	I_a	max.	4.5	mA
$V_{kk} = V_{kk_{min}} - V_{fl}$, see page 5)				
Cathode selecting voltage	V_{kk}	see page 5		
Cathode resistor, decimal point	R_{dp}		100	kΩ ± 10% [1])
Primer resistor	R_{pr}		10	MΩ ± 10%
Extinction voltage	V_{ext}	min.	118	V

[1]) Lower values of this resistor are permitted. The anode current should be increased by the increase of decimal point current resulting from the decrease of this resistor.

Typical operation over full temperature range 0 °C to +70 °C.

D.C. operation see pages 4, 5, 6 and 7.

Pulse operation

Peak currents up to 12 mA can be allowed provided the average current value does not exceed 2.5 mA.
To avoid excessive glow on "off" cathodes, the cathode selecting voltage should exceed 65 V. Minimum pulse duration 100 μs.
For further information consult the manufacturer.

LIFE EXPECTANCY at I_a = 2.5 mA

This tube is manufactured on the same physical principles as other tubes in this category and it is expected that the life will be comparable, viz:

sequentially changing the display from one digit to the others every 1000 h or less		100 000	h
Mean time between failures	min.	200 000	h

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.	1.5	mA	
average (T_{av} = 20 ms)	I_a	max.	4.5	mA	
peak	I_{a_p}	max.	12	mA	
Cathode selecting voltage	V_{kk}	see page 5			
Bias voltage between anode and "off" cathodes	V_{bias}	max.	$V_{floating}$		
Ambient temperature	t_{amb}	min.	−50	°C	[1])
	t_{amb}	max.	+70	°C	

SHOCK AND VIBRATION

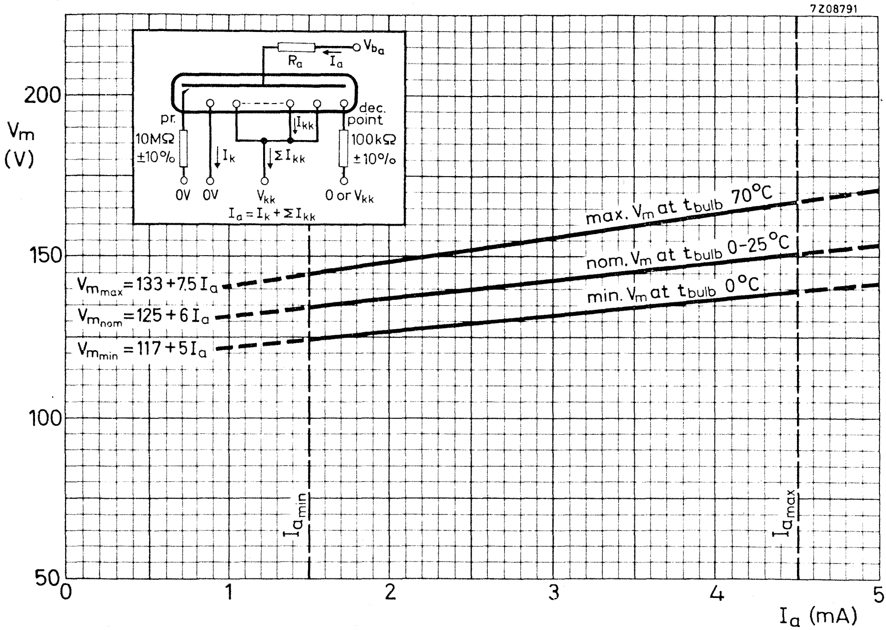
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

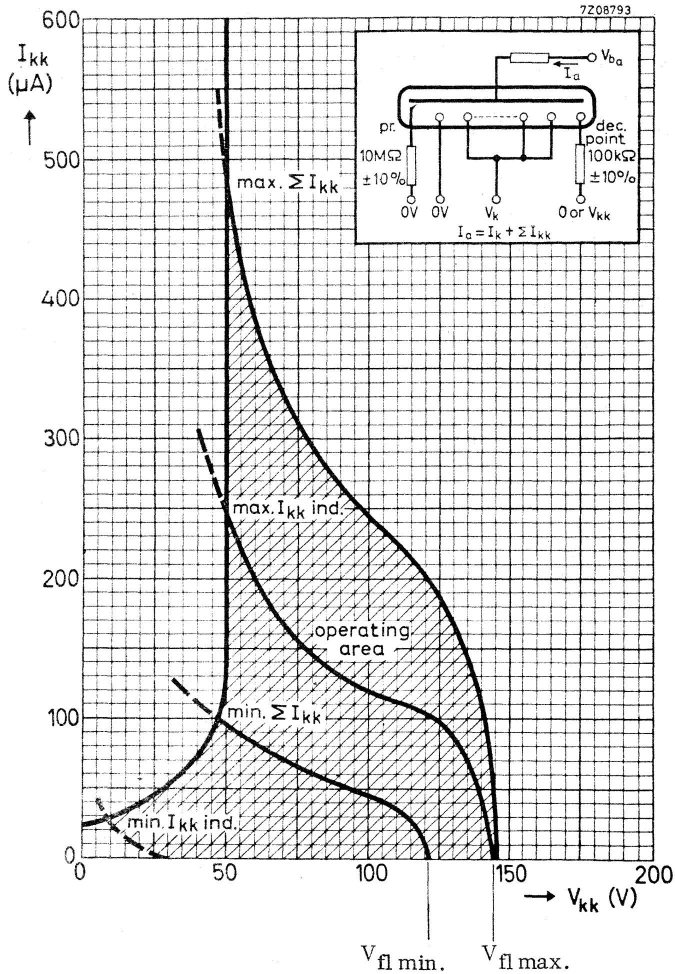
Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

---

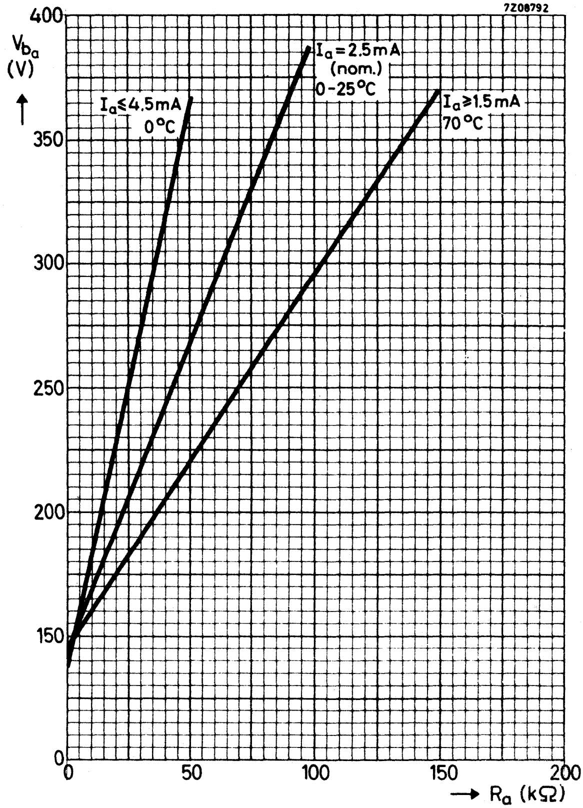
[1]) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics (see page 4).
For equipment to be used over a wide temperature range, "constant current operation" (high supply voltage with a high anode series resistor) is recommended.


7Z08791
V_{b_a}
R_a
I_a
pr.
dec. point
$10 M\Omega$ $\pm 10\%$
I_k
I_{kk}
ΣI_{kk}
$100 k\Omega$ $\pm 10\%$
0V 0V
V_{kk}
0 or V_{kk}
$I_a = I_k + \Sigma I_{kk}$
V_m (V)
max. V_m at t_{bulb} 70 °C
nom. V_m at t_{bulb} 0-25 °C
min. V_m at t_{bulb} 0 °C
$V_{m_{max}} = 133 + 7.5\,I_a$
$V_{m_{nom}} = 125 + 6\,I_a$
$V_{m_{min}} = 117 + 5\,I_a$
$I_{a_{min}}$
$I_{a_{max}}$
I_a (mA)

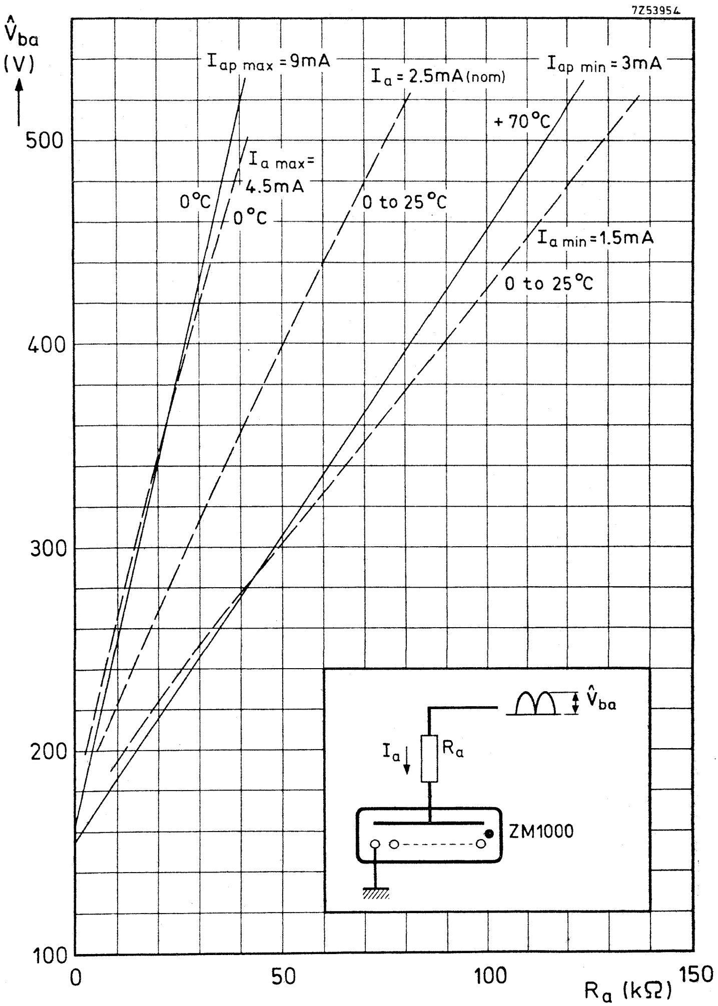


I_{kk} individual and ΣI_{kk} versus cathode selecting voltage V_{kk} at I_a = 2.5 mA.
I_{kk} and ΣI_{kk} are proportional to the anode current within the operating range of I_a and with V_{kk} = 0 V to 100 V.

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



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


7Z53954
$\hat{V}_{ba}$ (V)
500
400
300
200
100
0
50
100
150
R_a (kΩ)
$I_{ap\ max}$ = 9mA
I_a = 2.5mA (nom)
$I_{ap\ min}$ = 3mA
+70 °C
$I_{a\ max}$ = 4.5mA
0 °C
0 °C
0 to 25 °C
$I_{a\ min}$ = 1.5mA
0 to 25 °C
$\hat{V}_{ba}$
I_a
R_a
ZM1000

INDICATOR TUBE

Long-life cold-cathode character indicator tube for side viewing.

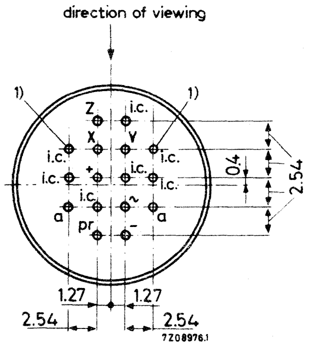
QUICK REFERENCE DATA				
Character height		approx.	10 to 14	mm
Characters	+, –, ~, X, Y, Z			
Supply voltage	V_{b_a}	min.	170	V
Anode current	I_a		2.5	mA

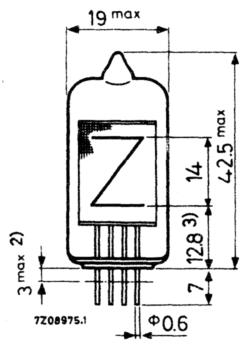
GENERAL

Character indicator tube to be used in conjunction with ZM1000 numerical indicator tube for in-line read-out in e.g. digital instruments or numerical control applications.

DIMENSIONS AND CONNECTIONS

Dimensions in mm





Mounting and Accessories: see ZM1000

CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

These are essential the same as of type ZM1000

1) Length of these i.c. pins max. 2.8 mm
2) Not tinned
3) Standard deviation 0.13 mm

INDICATOR TUBE

Long-life cold-cathode character indicator tube for side viewing.

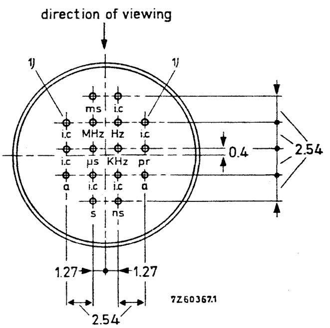
QUICK REFERENCE DATA				
Character height		approx. 9 to	13	mm
Characters		ns, μs, ms, s, Hz, kHz,	MHz	
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		4	mA

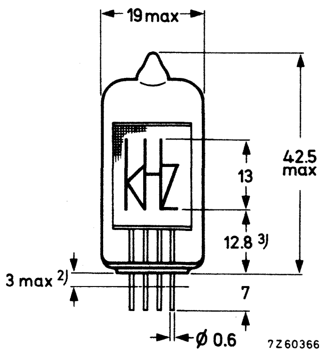
GENERAL

Character indicator tube to be used in conjunction with ZM1000 numerical indicator tube for in-line read-out in e.g. digital instruments such as frequency and time interval measuring apparatus.

DIMENSIONS AND CONNECTIONS

Dimensions in mm





Mounting and Accessories: see ZM1000

1) Length of these i.c. pins max. 2.8 mm
2) Not tinned
3) Standard deviation 0.13 mm

Data based on pre-production tubes

INDICATOR TUBE

Long-life cold-cathode ten-digit indicator tube for side viewing.
The tube is designed for time-sharing (pulse) applications.

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals	0 1 2 3 4 5 6 7 8 9			
Decimal point	to the left of the numerals			
Supply voltage	V_{ba}(pulse)	min.	170	V
Anode current, peak	I_{a_p}	min.	6	mA
	I_{a_p}	max.	20	mA
average	I_a	max.	2.5	mA

GENERAL

The numerals are 14 mm high and appear on the same base line allowing in-line read-out.

PRINCIPLE OF OPERATION

The tube contains ten cathodes in the form of ten numerals and one in the form of a decimal point; a primer, and one common anode. By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral or the decimal point will be covered by a red neon glow.
The primer allows ionization without delay in strobe type or blanking applications.

SHOCK AND VIBRATION

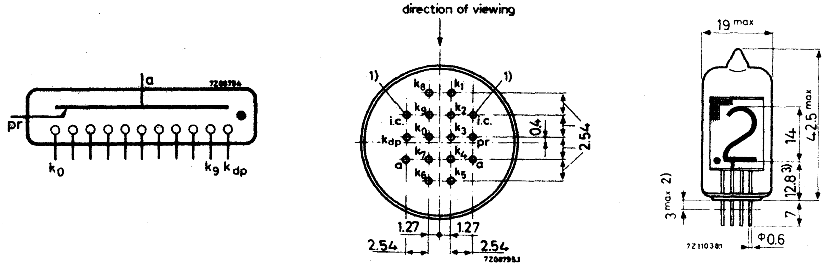
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

DIMENSIONS AND CONNECTIONS

Dimensions in mm



The deviation of the axes of the pins with respect to the true geometrical position cover an area of 0.3 mm diameter. The pin configuration is compatible with the reference grid for printed wiring according to IEC Publication 97 (0.1 in).

Mounting position: any

Soldering

The pins may be dip-soldered at a solder temperature of max. 240 °C for maximum 10 seconds up to a point 3 mm from the seals.

Natural frequency

The natural frequencies of the numeral cathodes lie within the range from 300 Hz to 800 Hz.

ACCESSORIES

55702 Tube socket (for 0.1 in grid). Phenolic. Tinned contacts.

55703 Snap-fit tube holder.

55704 Set of one left-hand and one right-hand end piece to complete the snap-fit indicator tube assembly.

---

1) i.c. pins max. length 2.8 mm
2) Not tinned
3) Standard deviation 0.13 mm

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see page 4		
Anode current, average (T_{av} = max. 20 ms)	I_a	max.	2.5	mA
peak	I_{ap}	min.	6	mA
(with or without decimal point)	I_{ap}	max.	20	mA
Pulse duration	T_{imp}	min.	50	µs [1]
Cathode selecting voltage (see also page 4)	V_{kk}	min.	70	V [2]
	V_{kk}	max.	115	V
Cathode resistor, decimal point	R_{dp}		10	kΩ±10% [3]
Primer resistor (anode to primer supply voltage min. 170 V)	R_{pr}		10	MΩ±10%
Extinguishing voltage	V_{ext}	min.	118	V

LIFE EXPECTANCY at I_a = 2 mA

The life expectancy is dependent on the instantaneous and average values of anode current:

sequentially changing the display from one digit to the others every 100 h or less, I_{ap} = 10 mA	100 000	h
I_{ap} = 20 mA	20 000	h
Mean time between failures	min. 200 000	h

LIMITING VALUES (Absolute max. rating system)

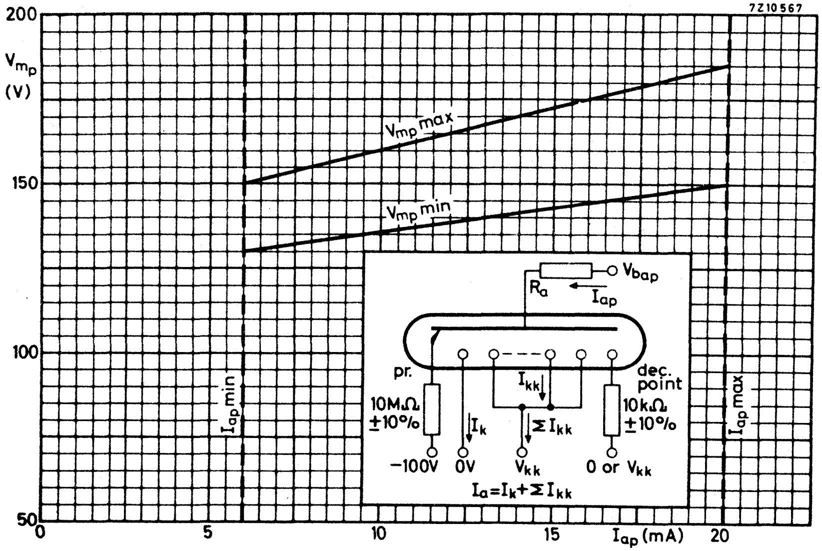
Anode voltage necessary for ignition, pulse	V_{ap}	min.	170	V
Anode current, average (T_{av} = 20 ms)	I_a	max.	2.5	mA
peak	I_{ap}	min.	6	mA
	I_{ap}	max.	20	mA
Pulse duration	T_{imp}	min.	10	µs
Cathode selecting voltage	V_{kk}	min.	70	V
	V_{kk}	max.	115	V
"Off" anode voltage	$V_{a\text{"off"}}$	max.	115	V
Ambient temperature	t_{amb}	min.	−50	°C [4]
	t_{amb}	max.	+70	°C

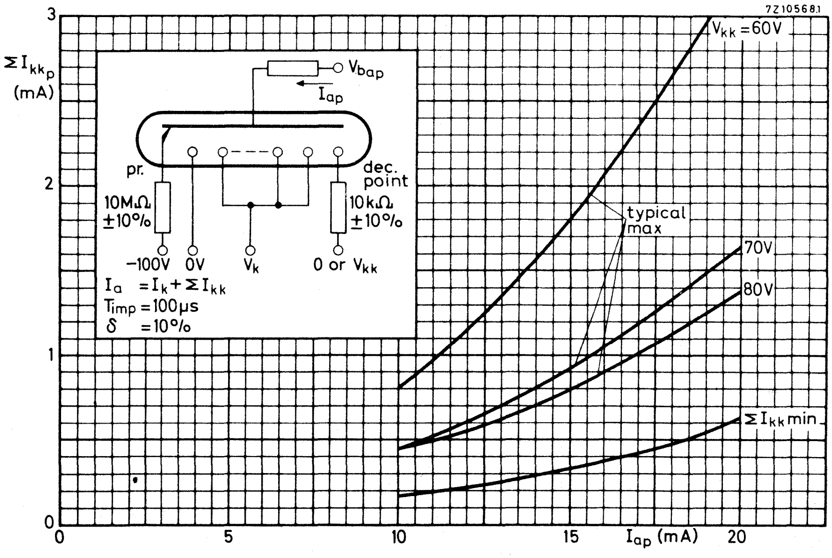
[1]) Pulse durations down to 10 µs are allowed provided the minimum peak anode current is not less than 10 mA.

[2]) Lower values of V_{kk} result in increasing background glow impairing readability.

[3]) The decimal point cathode may not be operated without extra current limiting resistor unless a numeral cathode is operated simultaneously.

[4]) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics.
For equipment to be used over a wide temperature range, "constant current operation" is recommended.


7Z10567
200
V_{m_p}
(V)
150
100
50
0
5
10
15
20
I_{ap} (mA)
V_{mp} max
V_{mp} min
I_{ap} min
I_{ap} max
R_a
V_{bap}
I_{ap}
pr.
dec. point
I_{kk}
10MΩ ±10%
10kΩ ±10%
I_k
ΣI_{kk}
−100V
0V
V_{kk}
0 or V_{kk}
$I_a = I_k + \Sigma I_{kk}$


7Z10568.1
3
ΣI_{kk_p}
(mA)
2
1
0
5
10
15
20
I_{ap} (mA)
V_{kk} = 60V
70V
80V
typical max
ΣI_{kk} min
V_{bap}
I_{ap}
pr.
dec. point
10MΩ ±10%
10kΩ ±10%
−100V
0V
V_k
0 or V_{kk}
$I_a = I_k + \Sigma I_{kk}$
T_{imp} = 100µs
δ = 10%

INDICATOR TUBE

Long life cold-cathode ten-digit indicator tube for side-viewing.

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals		0 1 2 3 4 5 6 7 8 9		
Decimal point		to the left of the numerals		
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		2,5	mA

GENERAL

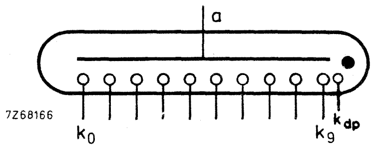
The numerals are 14 mm high and appear on the same base line allowing in-line read out.

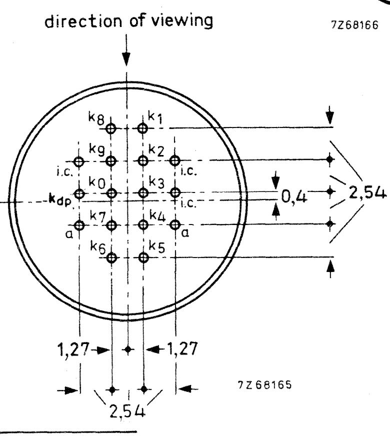
PRINCIPLE OF OPERATION

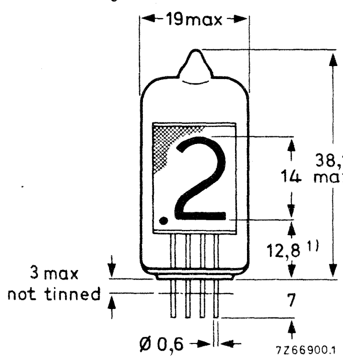
By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral or the decimal point will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Standard deviation 0,13 mm

The deviations of the axis of the pins with respect to the true geometrical position cover an area of max. 0,3 mm diameter. The pin configuration is compatible with the reference grid for printed wiring according to IEC Publication 97 (0,1 in).

Mounting position: Any

Soldering:

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

ACCESSORIES

55701 Printed wiring mounting board (19 x 100 mm) on which the tube can be soldered; afterwards the combination can be mounted on a vertical printed wiring board carrying, e.g., the drive circuit.

55702 Tube socket compatible with IEC reference grid for printed wiring (0,1 in). Phenolic. Tinned pins.

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see page	4	
Anode current for coverage	I_a	max.	3,5	mA
		min.	1,5	mA
Cathode selecting voltage	V_{kk}	see page	4	
Extinction voltage	V_{ext}	min.	118	V

LIFE EXPECTANCY at I_a = 2,5 mA

The tube is manufactured on the same physical principles as other tubes in this category and it is expected that the life will be comparable, viz:

Sequentially changing the display from one digit to the others every 1000 h or less		100 000	h
Mean time between failures	min.	200 000	h

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition	V_a	min.	170	V
Anode current	I_a	max.	3,5	mA
		min.	1,5	mA
Cathode selecting voltage	V_{kk}	max.	100	V
		min.	60	V
Ambient temperature	t_{amb}	max.	+70	°C
		min.	-50	°C

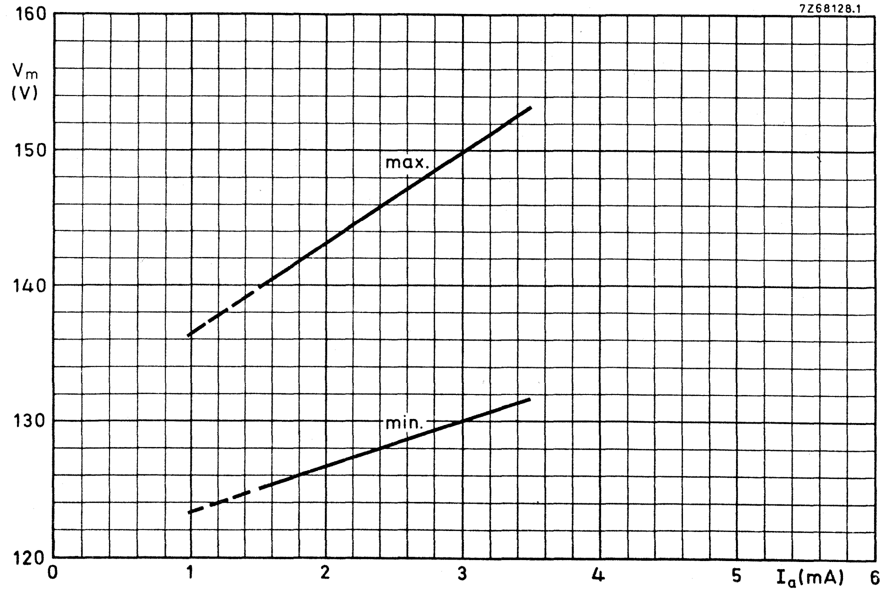
Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics.

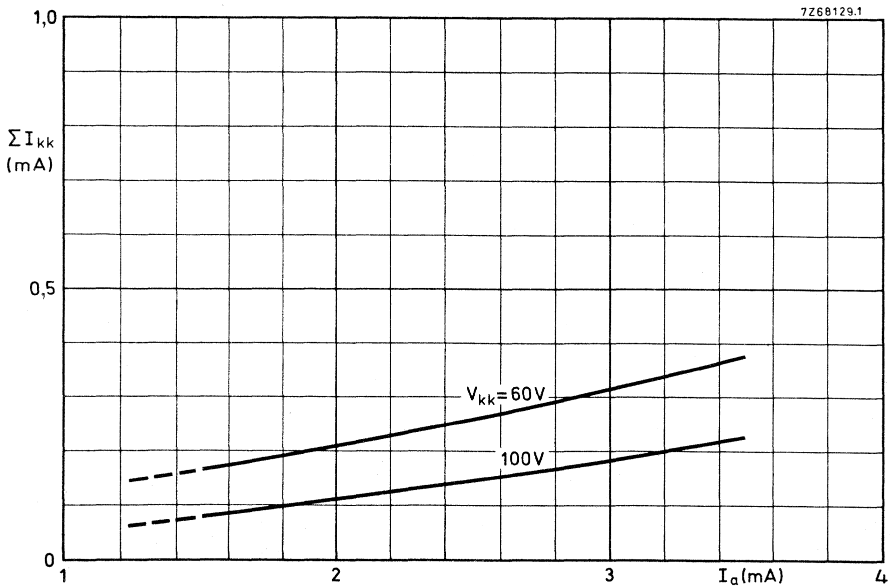
SHOCK AND VIBRATION

An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration test specified below without perceptible damage.

Shock 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration 2,5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.


7Z68128.1
160
Vm
(V)
150
max.
140
130
min.
120
0
1
2
3
4
5
Ia(mA)
6


7Z68129.1
1,0
ΣIkk
(mA)
0,5
Vkk=60V
100V
0
1
2
3
Ia(mA)
4

INDICATOR TUBE

Long life cold-cathode nine digit indicator tube for side-viewing.

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals		0 1 2 3 4 5 6 7 8		
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		2,5	mA

GENERAL

The numerals are 14 mm high and appear on the same base line allowing in-line read out.

PRINCIPLE OF OPERATION

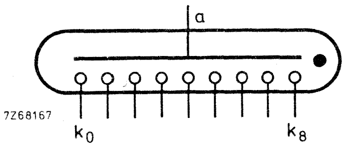
By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral will be covered by a red neon glow.

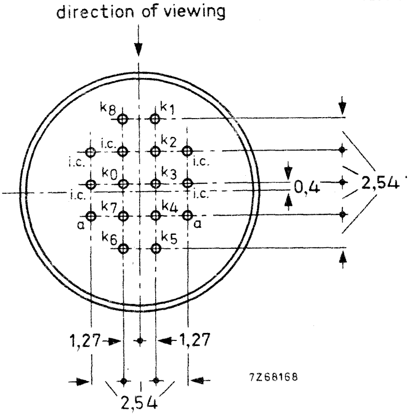
CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

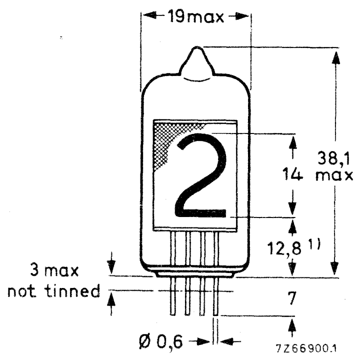
These are essentially the same as of type ZM1010.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Standard deviation 0,13 mm

INDICATOR TUBE

Long life cold-cathode eight-digit indicator tube for side-viewing.

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals		1 2 3 4 5 6 7 8		
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		2,5	mA

GENERAL

The numerals are 14 mm high and appear on the same base line allowing in-line read out.

PRINCIPLE OF OPERATION

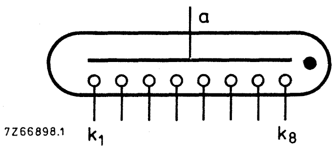
By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral will be covered by a red neon glow.

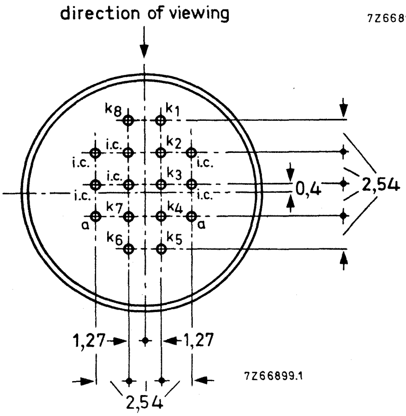
CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

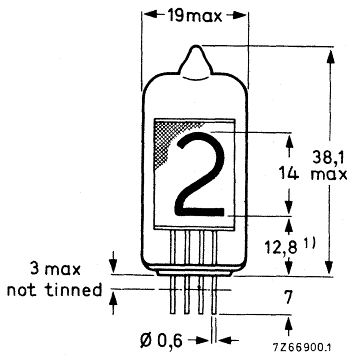
These are essentially the same as of type ZM1010.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Standard deviation 0,13 mm

INDICATOR TUBE

Long life cold-cathode seven-digit indicator tube for side-viewing.

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals		0 1 2 3 4 5 6		
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		2, 5	mA

GENERAL

The numerals are 14 mm high and appear on the same base line allowing in-line read out.

PRINCIPLE OF OPERATION

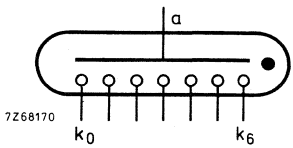
By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral will be covered by a red neon glow.

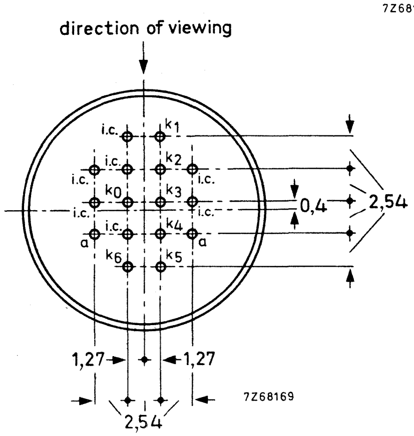
CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

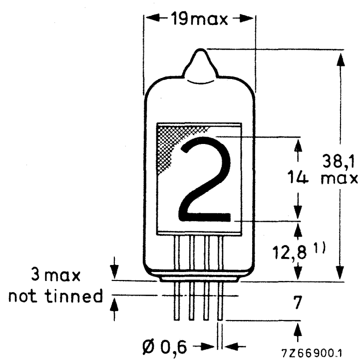
These are essentially the same as of type ZM1010.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Standard deviation 0, 13 mm

INDICATOR TUBE

Long life cold-cathode six-digit indicator tube for side-viewing

QUICK REFERENCE DATA				
Numeral height		approx.	14	mm
Numerals		1 2 3 4 5 6		
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		2,5	mA

GENERAL

The numerals are 14 mm high and appear on the same base line allowing in-line read out.

PRINCIPLE OF OPERATION

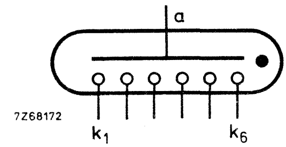
By applying a suitable voltage between the anode and one of the cathodes the corresponding numeral will be covered by a red neon glow.

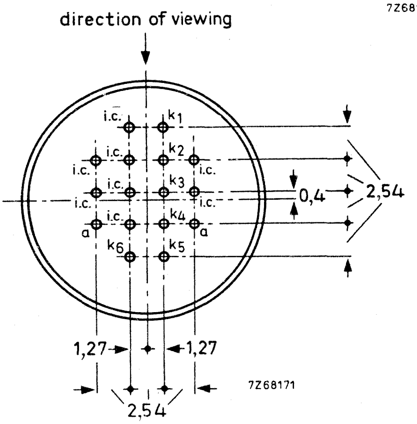
CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

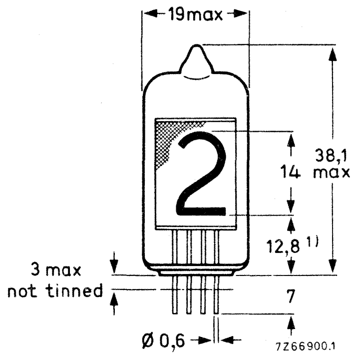
These are essentially the same as of type ZM1010.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Standard deviation 0,13 mm

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.
The ZM1020/01 is identical with the ZM1020 but has tinned pins.

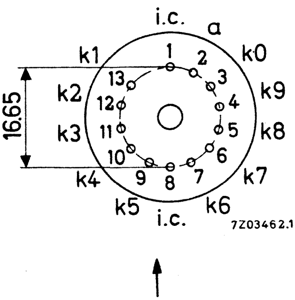
PRINCIPLE OF OPERATION

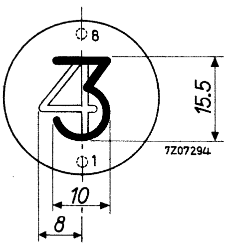
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding numeral will be covered by a red neon glow.

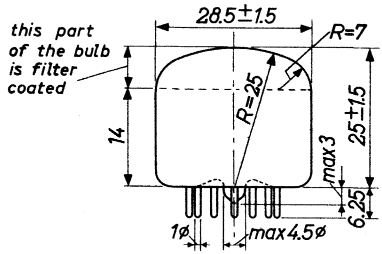
DIMENSIONS AND CONNECTIONS

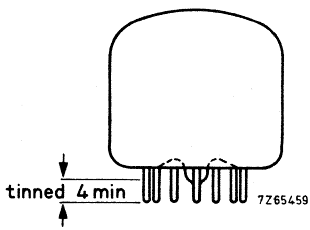
Dimensions in mm

Base: B13B









ZM1020/01

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.	170	V
Maintaining voltage	V_m	see sheet 4		
Anode current for coverage,				
averaged during any conduction period	I_a	min.	1	mA
Anode current,				
average (T_{av} = max. 20 ms)	I_a	max.	3	mA
peak	I_{ap}	max.	6	mA
Cathode selecting voltage	V_{kk}	see sheet 5		
Extinguishing voltage	V_{ext}	min.	118	V

Typical operation [1])

D.C. operation

See sheets 5 and 6

A.C. operation

See sheets 5 and 7

[1]) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics (see sheet 4).
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.

LIFE EXPECTANCY AND RELIABILITY (at I_a = 2 mA)

Sequentially changing the display from one digit to the others every 1000 h. or less	100.000 h

The reliability has been assessed in a life test programme totalling 4.5 x 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.	170	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 5		
Bias voltage between anode and "off" cathodes (see sheet 5)	V_{bias}	max.	$V_{floating}$	
Ambient temperature	t_{amb}	min.	-50	°C
		max.	+70	°C

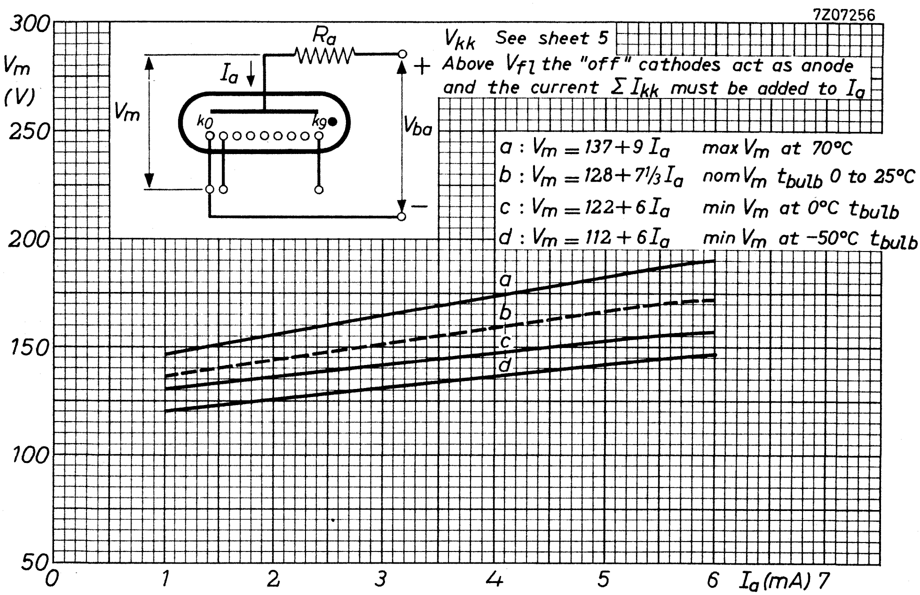
SHOCK AND VIBRATION

An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

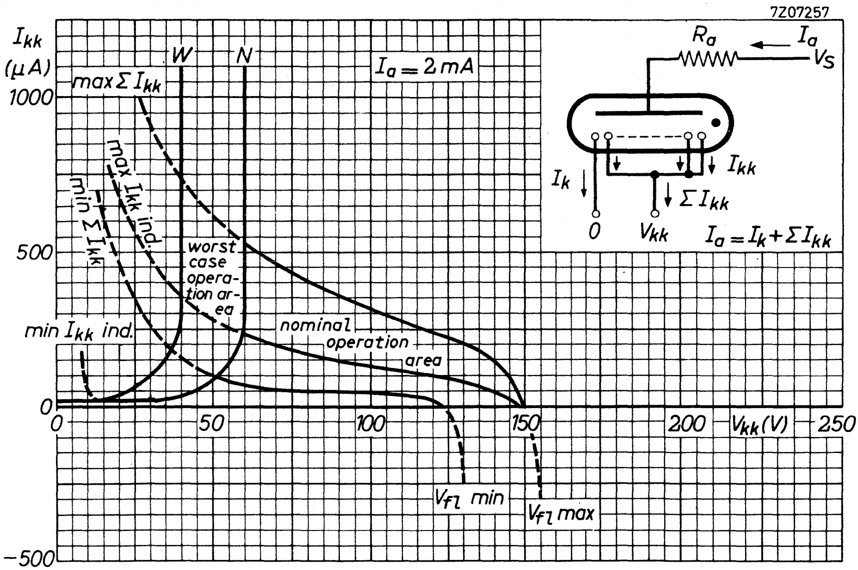
1) Above I_a = 6 mA the connecting wires and eyelets may be covered by the glow.


7Z07256
Vkk See sheet 5
Above Vfl the "off" cathodes act as anode
and the current Σ Ikk must be added to Ia
a : Vm = 137 + 9 Ia max Vm at 70°C
b : Vm = 128 + 7⅓ Ia nom Vm tbulb 0 to 25°C
c : Vm = 122 + 6 Ia min Vm at 0°C tbulb
d : Vm = 112 + 6 Ia min Vm at -50°C tbulb
Ra
Ia
Vm
Vba
k0
k9
+
−
Vm
(V)
300
250
200
150
100
50
0
1
2
3
4
5
6
Ia (mA) 7
a
b
c
d

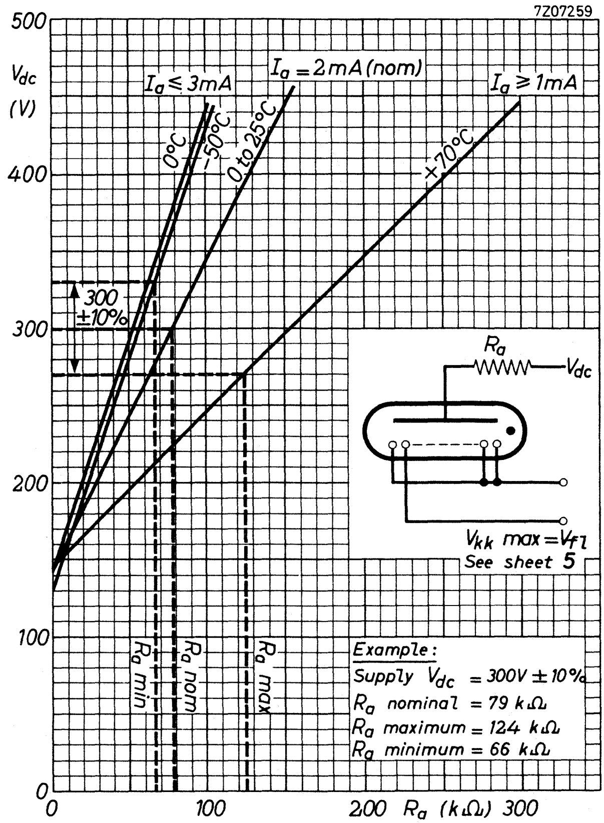
I_{kk} individual and ΣI_{kk} versus cathode selecting voltage V_{kk} at I_a = 2 mA.
I_{kk} and ΣI_{kk} are proportional to anode current in the range V_{kk} = 0 to 100 V.

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

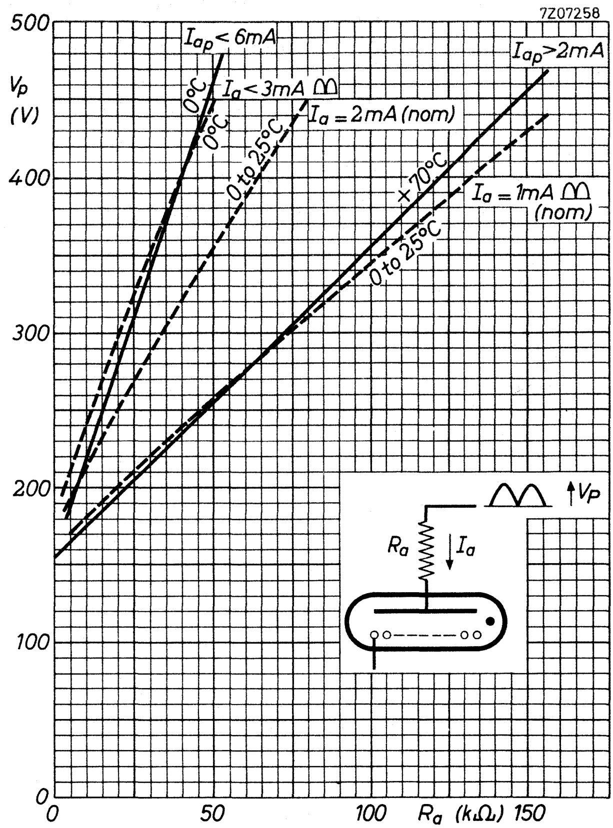
The curves are valid for instantaneous and for average values of anode current.



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

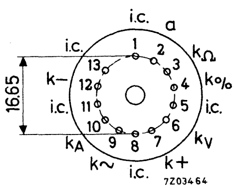
Cold cathode character indicator tube for top viewing.

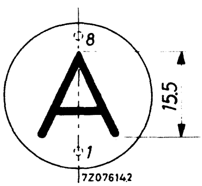
QUICK REFERENCE DATA			
Character height		15	mm
Characters	A, V, Ω, %, , +, -, ~		
Supply voltage	min.	170	V
Anode current		2	mA

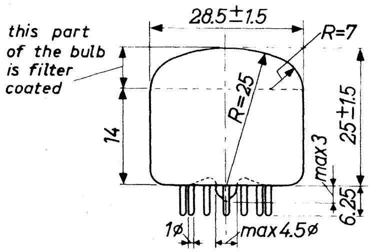
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B







CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

These are essential the same as of type ZM1020.

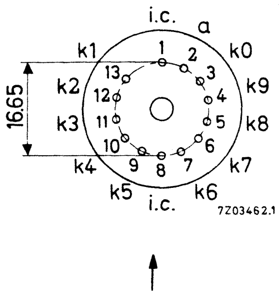
INDICATOR TUBE

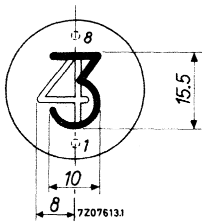
The type ZM1022 is electrically identical with type ZM1020 but has no filter coating.
The use of a separate blue absorbing e.g. cicular polarized amber filter is recommended.

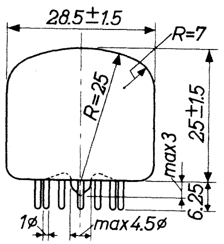
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B







INDICATOR TUBE

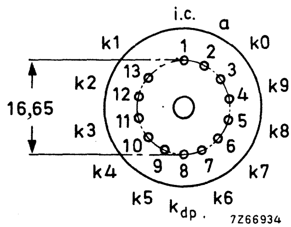
Cold cathode numerical indicator tube for top viewing, electrically identical to type ZM1022 but provided with a decimal point to the left of the numerals.
The use of a separate blue absorbing, e.g. circular polarized, amber filter is recommended.

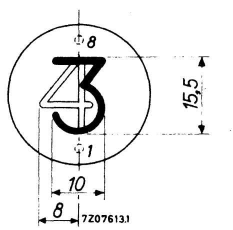
QUICK REFERENCE DATA			
Numeral height		15	mm
Numerals	1 2 3 4 5 6 7 8 9 0		
Decimal point	to the left of the numerals		
Supply voltage	min.	170	V
Anode current, numerals		2	mA
decimal point		0, 25	mA

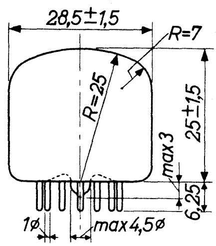
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B







CHARACTERISTICS, OPERATING CONDITIONS, AND LIMITING VALUES

For the numerals, these are the same as for type ZM1020.

LIMITING VALUES decimal point (Absolute max. rating system)

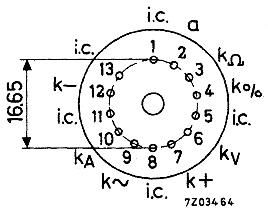
Anode current, decimal point	max.	0, 5	mA
	min.	0, 1	mA

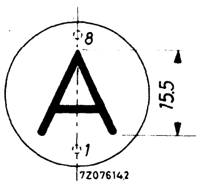
INDICATOR TUBE

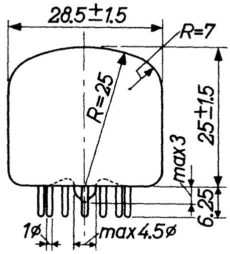
The type ZM1023 is electrically identical with type ZM1021 but has no filter coating.
The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B







INDICATOR TUBE

Cold cathode character indicator tube for top viewing

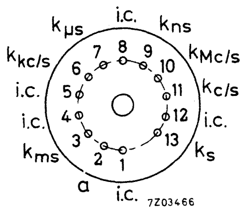
QUICK REFERENCE DATA	
Characters	c/s, Kc/s, Mc/s, μs, ms, ns, s

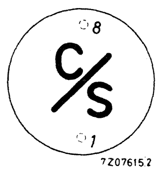
This tube is mechanically compatible with type ZM1020

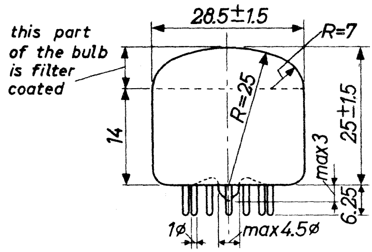
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B







CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

These are essential the same as of type ZM1020.

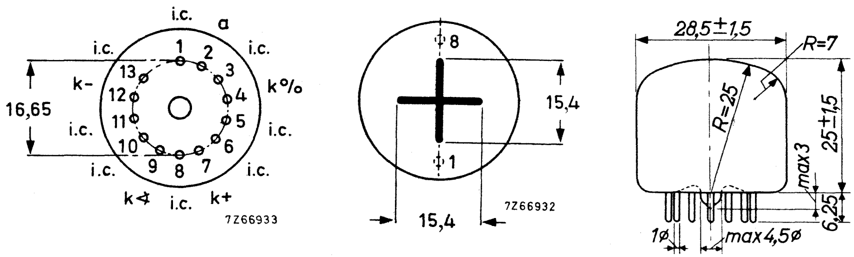
INDICATOR TUBE

Cold cathode sign indicator tube.
The use of a separate blue absorbing, e.g. circular polarized, amber filter is recommended.

QUICK REFERENCE DATA		
Sign height	15	mm
Signs	∢ % + -	
Supply voltage	min. 170	V
Anode current	2	mA

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: B13B



CHARACTERISTICS, OPERATING CONDITIONS, AND LIMITING VALUES

These are essentially the same as for type ZM1020.

INDICATOR TUBE

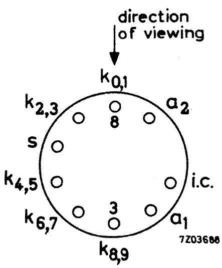
Cold-cathode gas-filled biquinary numerical indicator tube for side viewing.

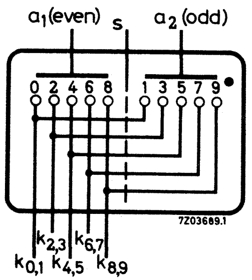
QUICK REFERENCE DATA				
Numerical height			15,5	mm
Numerals		0 1 2 3 4 5 6 7 8 9		
Supply voltage	V_{b_a}	min.	170	V
Anode current	I_a		4	mA
Cathode selecting voltage	V_{kk}		50	V
Extinction voltage	V_{ext}		110	V
Screen supply voltage	V_{b_s}		50	V
"Off" anode supply voltage	V_{b_a}"off"		100	V

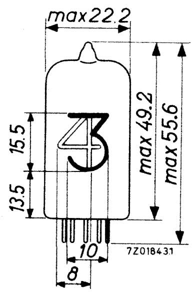
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval







CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Anode current for coverage, average during any conduction period	I_a	min.	3	mA
Anode current, average (T_{av} = 20 ms)	I_a	max.	5	mA
peak, 50 to 60 pps	I_{a_p}	max.	12	mA
Cathode selecting voltage	V_{kk}	min.	40	V
		max.	110	V
"Off" anode supply voltage	V_{b_a}"off"	min.	85	V
		max.	115	V
Extinction voltage	V_{ext}	min.	110	V

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.	3	mA
average (T_{av} = 20 ms)	I_a	max.	5	mA
peak	I_{a_p}	max.	12	mA
Cathode selecting voltage	V_{kk}	min.	40	V
		max.	110	V
"Off" anode supply voltage	V_{b_a}"off"	min.	85	V
		max.	115	V
Screen voltage	V_s	min.	40	V
		max.	80	V
Bulb temperature, storage	t_{bulb}	max.	+70	^{o}C
		min.	-55	^{o}C
operation	t_{bulb}	max.	+70	^{o}C
		min.	+15	^{o}C

INDICATOR TUBE

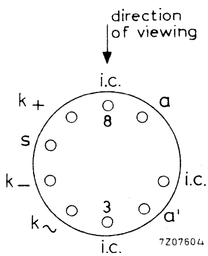
Cold cathode sign indicator tube for side viewing.

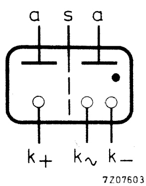
QUICK REFERENCE DATA				
Sign height			15	mm
Signs			+ -	
Supply voltage	V_{ba}	min.	170	V
Anode current	I_a		3	mA

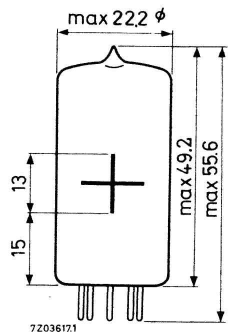
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval







CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage at I_a = 3 mA	V_m		140	V
Anode current,				
average during any conduction period for coverage	I_a	min.	2	mA
average, T_{av} = 20 ms	I_a	max.	4	mA
peak	I_{ap}	max.	10	mA
Incremental resistance	r_a		4,5	kΩ

LIMITING VALUES (Absolute max. rating system)

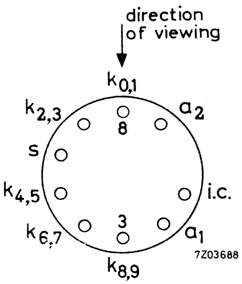
Anode voltage necessary for ignition	V_a	min.	170	V
Anode current,				
average during any conduction period	I_a	min.	2	mA
average (T_{av} = 20 ms)	I_a	max.	4	mA
peak	I_{a_p}	max.	10	mA
Bulb temperature	t_{bulb}	min.	-55	^oC
		max.	+70	^oC

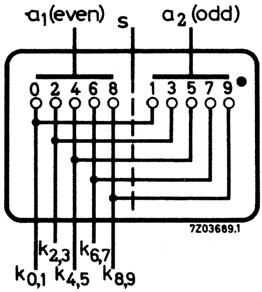
INDICATOR TUBE

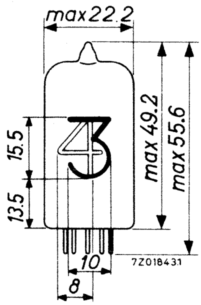
The type ZM1032 is electrically identical with type ZM1030 but has no filter coating. The use of a separate blue absorbing e.g. circular polarized amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: Noval







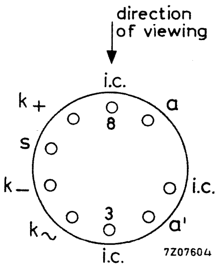
INDICATOR TUBE

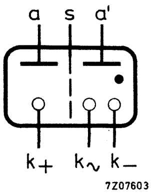
The type ZM1033/01 is electrically identical with type ZM1031/01 but has no filter coating.
The use of a separate bleu absorbing e.g. circular polarized amber filter is recommended.

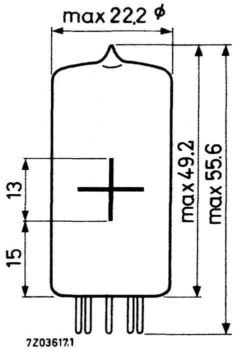
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval







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.

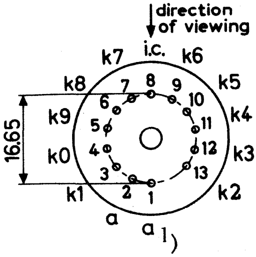
PRINCIPLE OF OPERATION

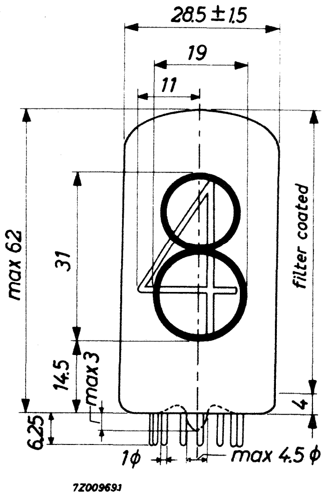
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding numeral will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: B13B





1) Pins 1 and 2 to be interconnected externally.

Mounting position: any

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

Accessories

Socket	type	2422 505 00001 or 2422 505 00002

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see sheet 5		
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 6		
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 5 and 6)

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 5)

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.

LIFE EXPECTANCY at I_k = 4.5 mA

Sequentially changing the display from one digit to the others every 1000 hours or less	100 000 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	°C °C [1]

SHOCK AND VIBRATION

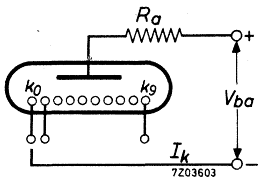
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

[1]) Bulb temperatures below 0 °C result in a reduced life expectancy and changes in characteristics (see sheet 7)
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.

Fig.1



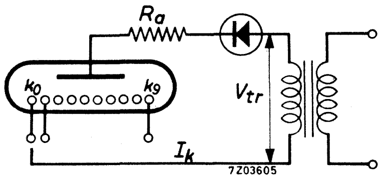


Fig.2

Fig.3

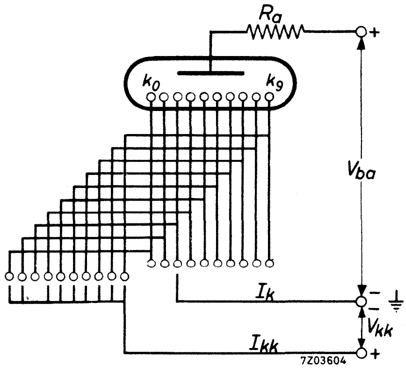
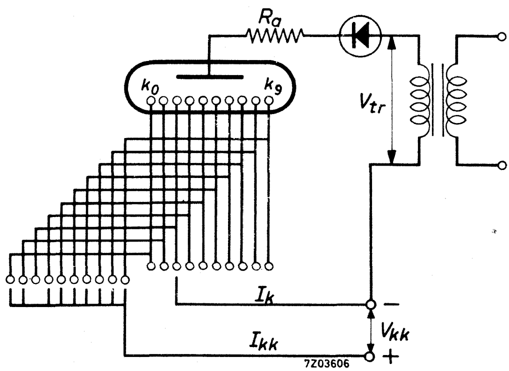
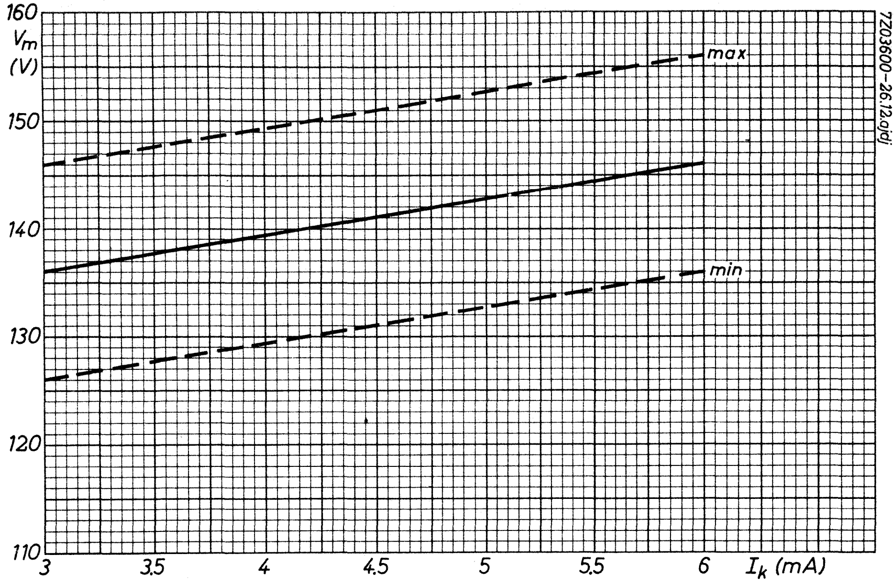
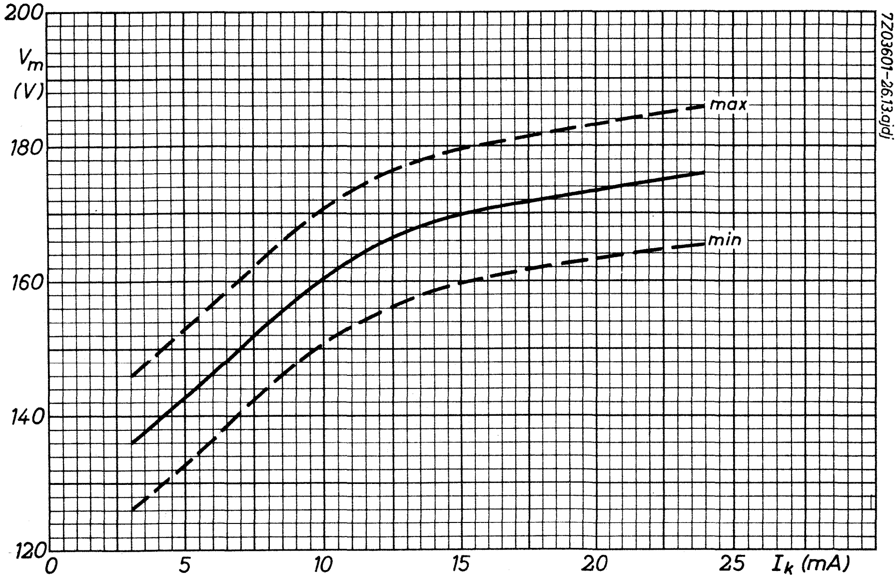
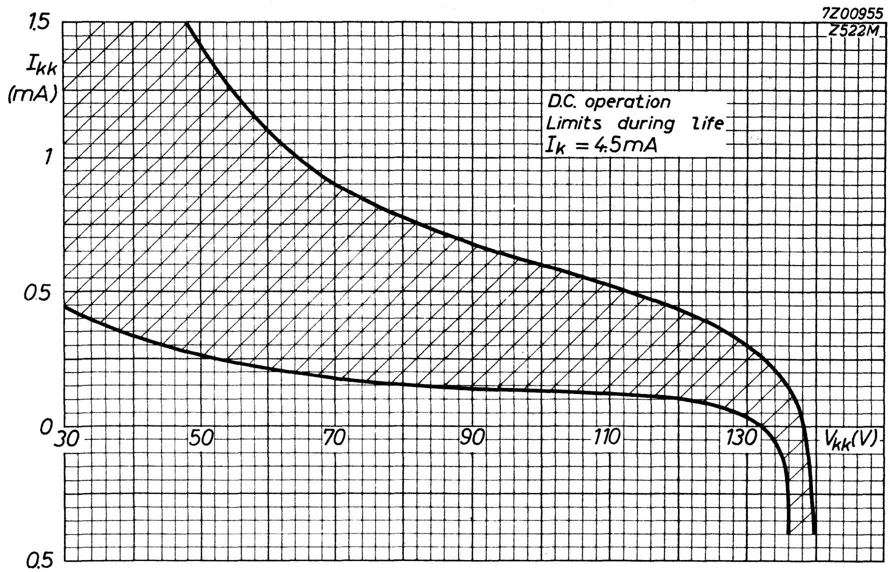


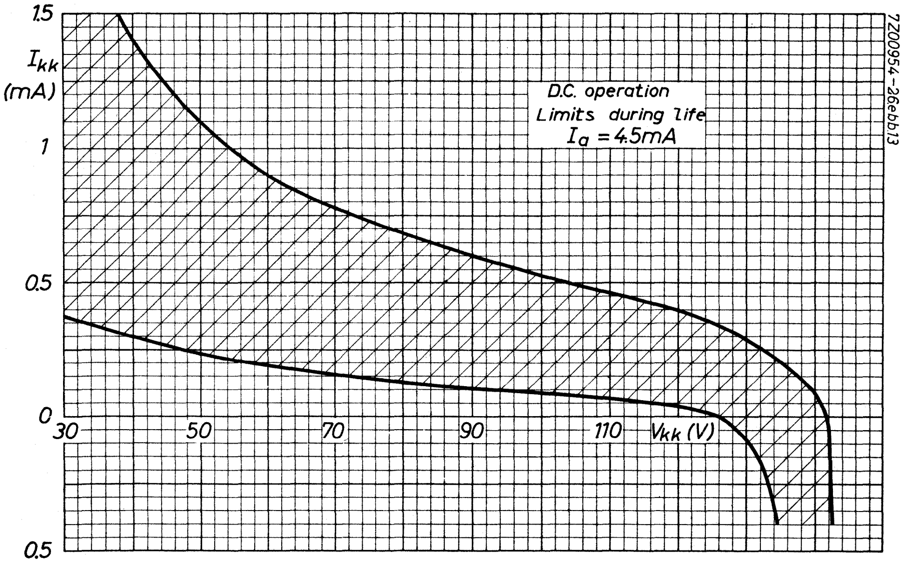
Fig.4

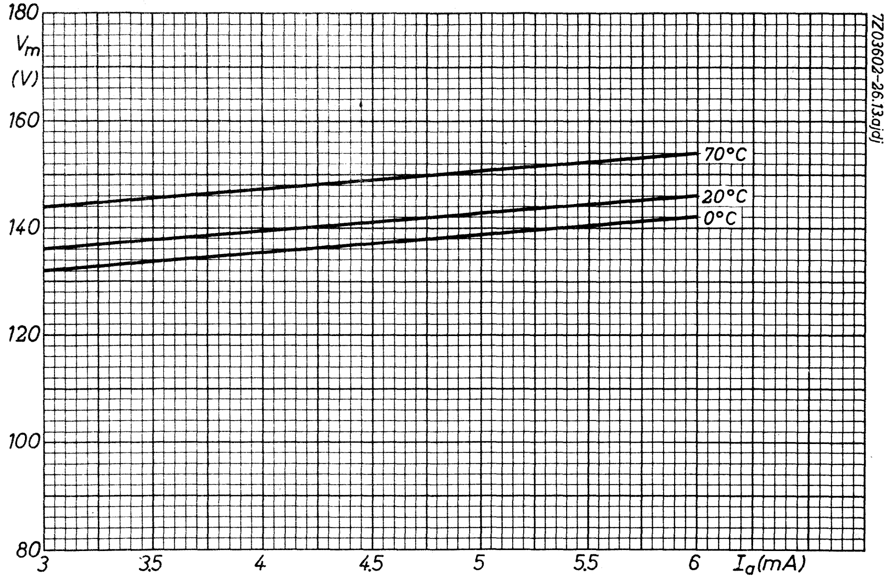



160
V_m
(V)
150
140
130
120
110
3
3.5
4
4.5
5
5.5
6
I_k (mA)
max
min
7Z03600-26.12.ajdj


200
V_m
(V)
180
160
140
120
0
5
10
15
20
25
I_k (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


7Z00954-26eb13
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
7Z03602-26.13.a/dj

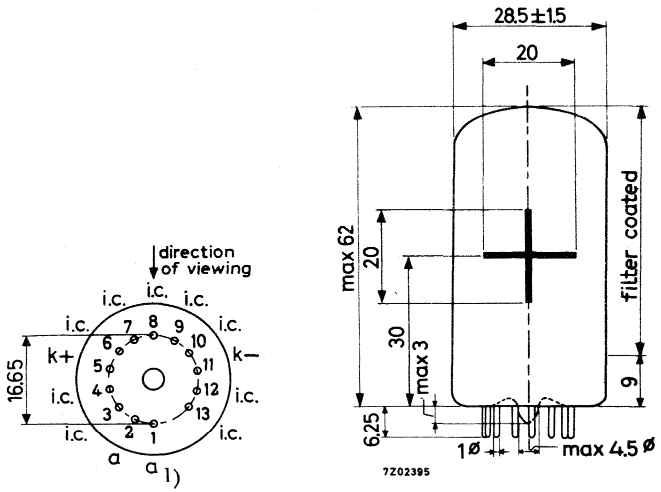
INDICATOR TUBE

Cold cathode sign indicator tube for side viewing.

QUICK REFERENCE DATA		
Sign height	20	mm
Signs	+ -	
Supply voltage	170	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.

1) Pins 1 and 2 to be interconnected externally.

CHARACTERISTICS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see sheets 3 and 4		
Extinguishing voltage	V_{ext}	min.	120	V
"Off" cathode probe current characteristic		see sheet 4		

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 or 2422 505 00002

MOUNTING POSITION

Any
The signs are vieuwed through the side of the envelope.

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_{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

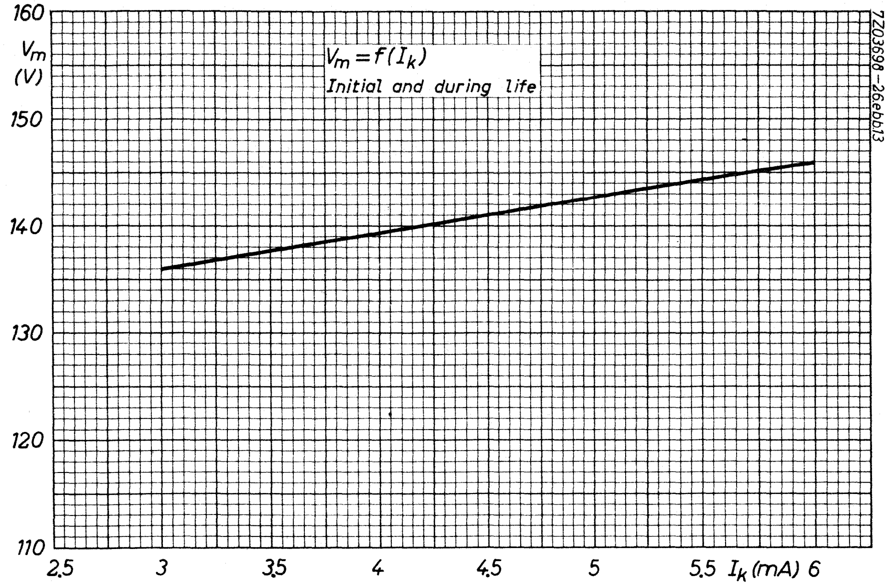
SHOCK AND VIBRATION

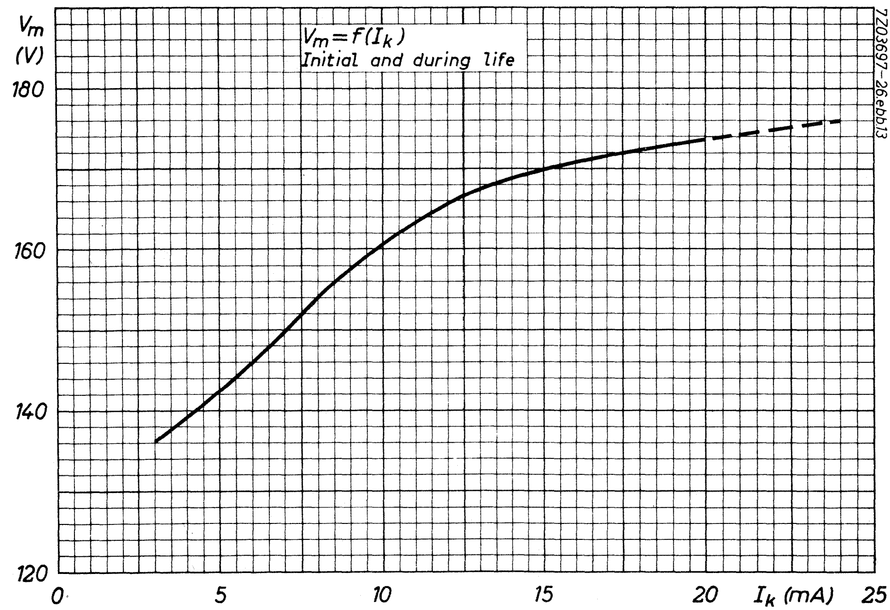
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

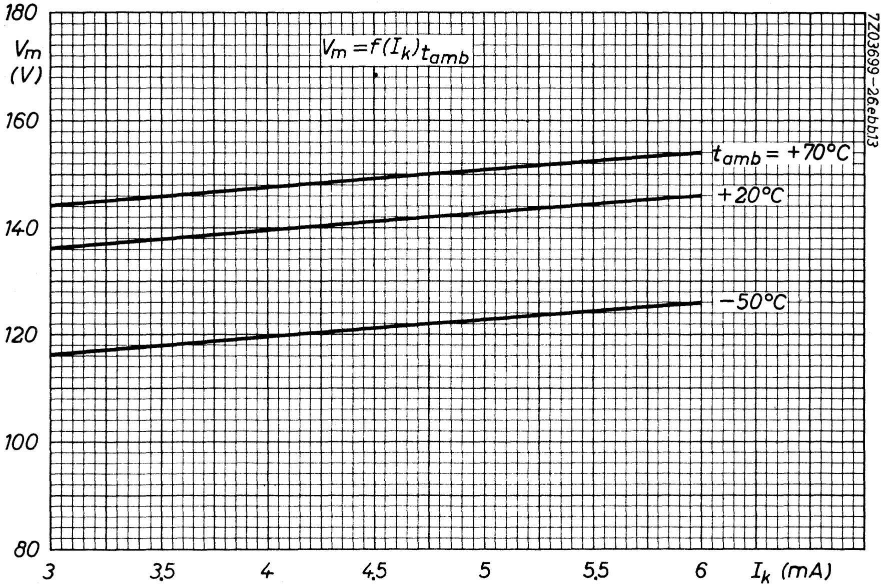
Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

[1]) Bulb temperatures below 10 °C result in a reduced life expectanxy and changes in characteristics (see sheet 4).
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.


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


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

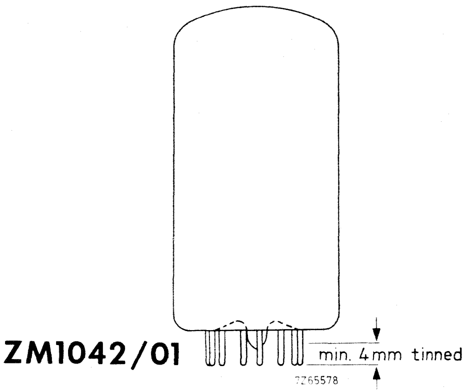


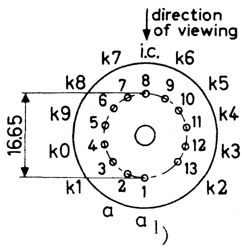
180
160
140
120
100
80
V_m
(V)
$V_m = f(I_k)t_{amb}$
$t_{amb} = +70°C$
+20°C
−50°C
3
3.5
4
4.5
5
5.5
6
I_k (mA)
7Z03699−26ebb13

INDICATOR TUBE

Cold cathode ten digit numeral indicator tube for side viewing.
The types ZM1042 and ZM1042/01 are identical with type ZM1040 but have no filter coating. ; the ZM1042/01 has tinned pins .
The use of a separate blue absorbing, e.g. circular polarized, amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm



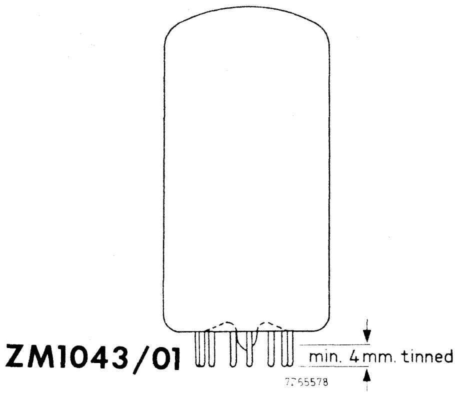


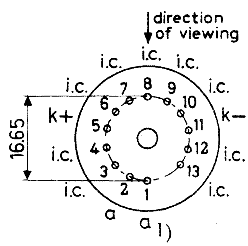
1) Pins 1 and 2 to be connected externally.

INDICATOR TUBE

Cold cathode sign indicator tube for side viewing.
The types ZM1043 and ZM1043/01 are identical with type ZM1041 but have no filter coating; the ZM1043/01 has tinned pins.
The use of a separate blue absorbing, e.g. circular polarized, amber filter is recommended.

DIMENSIONS AND CONNECTIONS Dimensions in mm





1) Pins 1 and 2 to be connected externally.

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

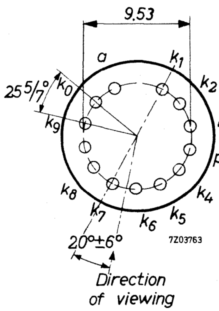
The numerals are 13 mm high and appear on the same base line allowing in-line read out. The ZM1080 is identical to the ZM1082 but is provided with a red contrast filter.

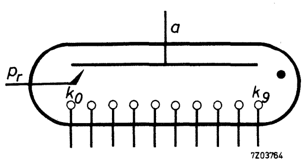
PRINCIPLE OF OPERATION

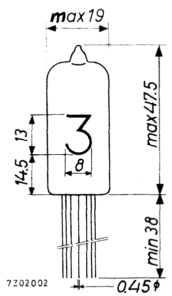
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding figure will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

CHARACTERISTICS AND RANGE VALUES

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 3	

Conduction

D.C. operation

Cathode current	I_k		< 3,5	mA
Cathode current for coverage	I_k		> 1,5	mA
Maintaining voltage at I_k = 2 mA (see also page 3)	V_m		140	V
Probe current to individual non-conducting cathodes	I_{kk}		See page 4	

Pulse operation

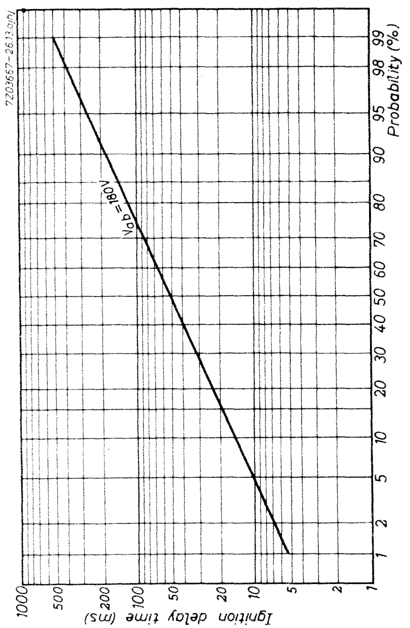
Cathode current, peak	I_{kp}		< 12	mA
average, T_{av} = 20 ms	I_k		< 2,5	mA
Average cathode current for satisfactorily display	I_k		> 0,8	mA
Pulse duration	T_{imp}		< 20	ms
			> 100	µs
Maintaining voltage	V_m		See page 3	
Probe current to individual non-conducting cathodes	I_{kk}		See pages 4	

Extinction

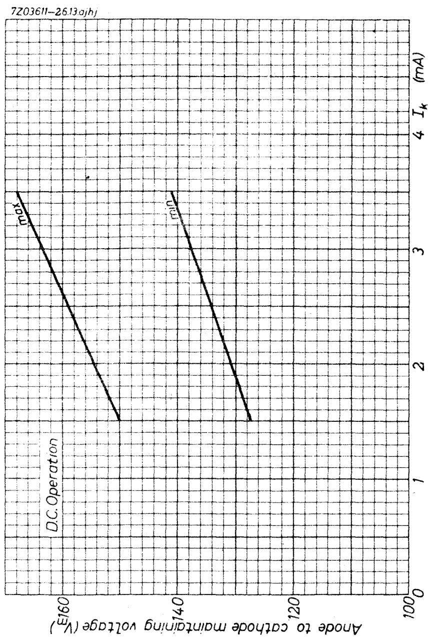
Anode voltage to ensure extinction	V_a		< 115	V

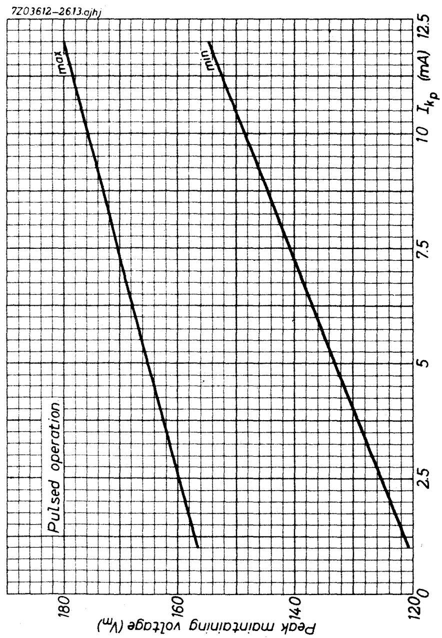
LIMITING VALUES (Absolute max. rating system)

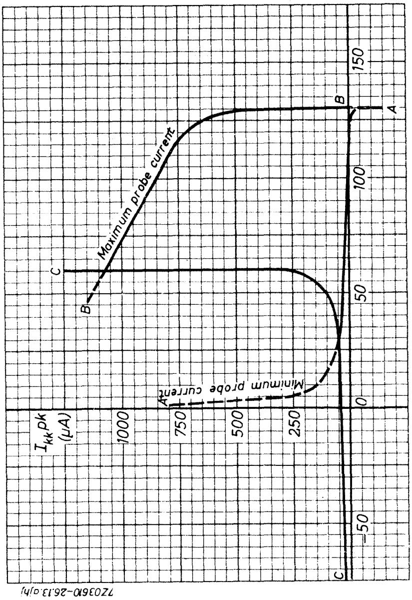
Cathode current (each digit)				
average, T_{av} = max. 20 ms	I_k	max.	3,5	mA
peak	I_{kp}	max.	12	mA
average during any conduction period	I_k	min.	1,5	mA
Bulb temperature	t_{bulb}	max.	+70	°C
		min.	-50	°C
Anode voltage necessary for ignition	V_a	min.	170	V



Cumulative distribution of ignition delay time

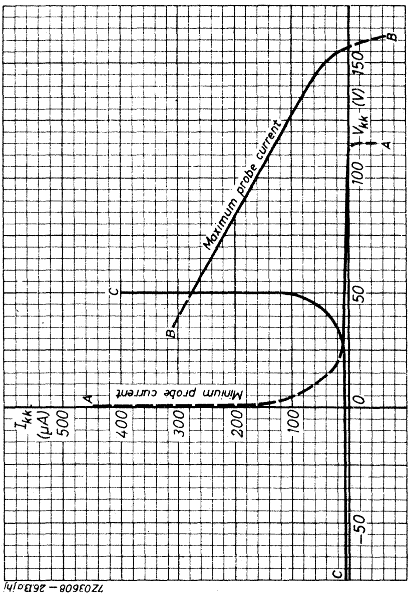




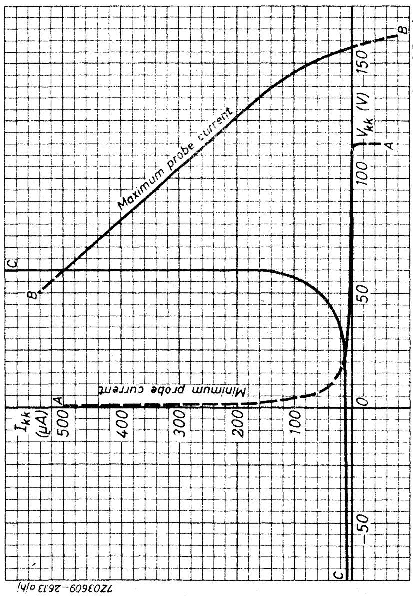


Peak probe currents to individual cathodes. Pulsed anode current 10mA Duty factor 0.1

Probe current curves



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



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

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

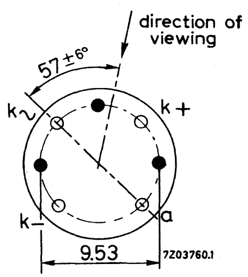
The ZM1081 is identical to the ZM1083 but is provided with a red contrast filter.

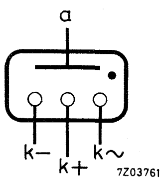
PRINCIPLE OF OPERATION

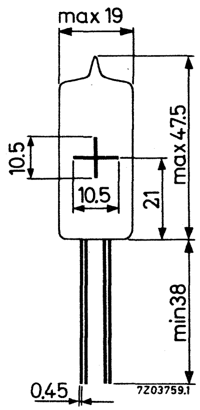
The tube contains 3 cathodes in the form of the characters –, + and ~ and one common anode.
By applying a suitable voltage between the anode and one of the three cathodes the corresponding character will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

The characters are viewed through the side of the envelope.
The characters will appear upright (within $\pm 2^{o}$) 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 ^{o}C for a maximum of 10 seconds.

CHARACTERISTICS, OPERATING CONDITIONS AND LIMITING VALUES

These are essential the same as of type ZM1082.

INDICATOR TUBE

Long life cold cathode ten digit numeral indicator tube for top viewing.
The rectangular envelope allows for close tube-to-tube spacing, both in the horizontal and vertical axes.

QUICK REFERENCE DATA				
Numeral height			15.5	mm
Numerals	1 2 3 4 5 6 7 8 9 0			
Supply voltage	V_{ba}	min.	170	V
Cathode current	I_k		2.5	mA
Distance between mounting centres		min.	20	mm
Viewing angle			90	o

GENERAL

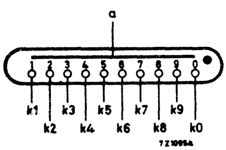
The numerals are 15.5 mm high and appear on the same base line allowing in-line read out.

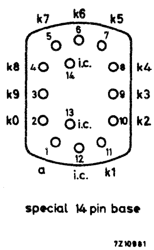
PRINCIPLE OF OPERATING

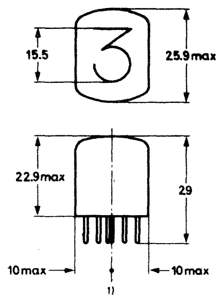
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding figure will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







1) Centre line through pins 6 and 12 (Note: distance between centre lines of adjacent tubes must be at least 20 mm)

Mounting position: any

The numerals are viewed through the top of the envelope. The numerals will appear upright (within $\pm 3^0$) when the tube is mounted with the line through pins 6 and 12 vertical, pin 6 uppermost.

Accessory

Socket	type	55705

CHARACTERISTICS AND OPERATING CONDITIONS (at 20 °C to 50 °C)

Ignition voltage	V_{ign}	min.	170	V
Ignition delay		see page 3		
Maintaining voltage		see page 4		
Cathode current, recommended	I_k		2.5	mA
Cathode current for coverage average during any conduction period	I_k	min.	1.5	mA
D.C. operation		see pages 5 to 9		
Extinguishing voltage	V_{ext}		118	V

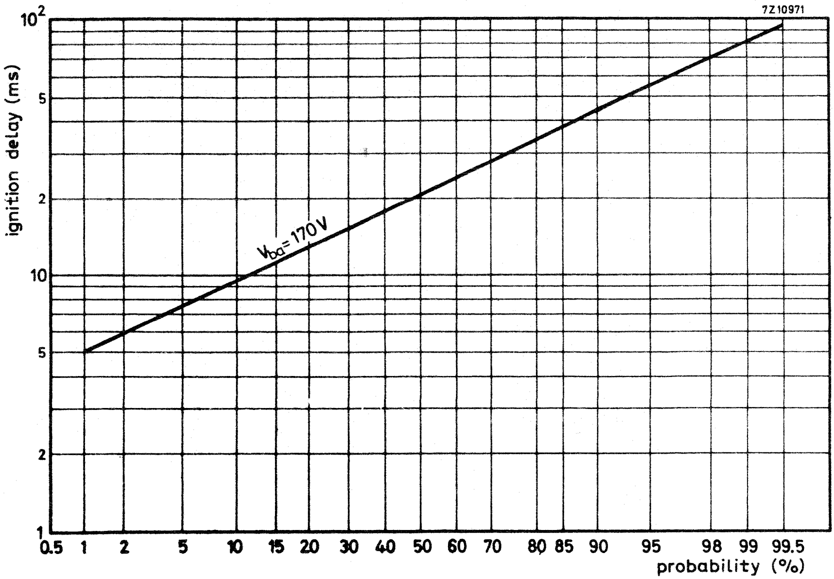
LIFE EXPECTANCY at I_k = 2.5 mA and room temperature 1)

Continuous display of one numeral	>	5 000	h
Sequentially changing the display from one numeral to another, every 100 hrs or less	>	30 000	h

LIMITING VALUES (Absolute max. rating system)

Cathode current (each digit),				
average, T_{av} = max. 20 ms	I_k	max.	3.0	mA
peak	I_{kp}	max.	3.5	mA
average during any conduction period	I_k	min.	1.5	mA
Anode voltage necessary for ignition	V_a	min.	170	V
Bulb temperature	t_{bulb}	max.	+70	°C
	t_{bulb}	min.	-10	°C 1)

1) For bulb temperatures below +10 °C the life expectancy of the tube is substantially reduced.



CUMULATIVE DISTRIBUTION OF IGNITION DELAY

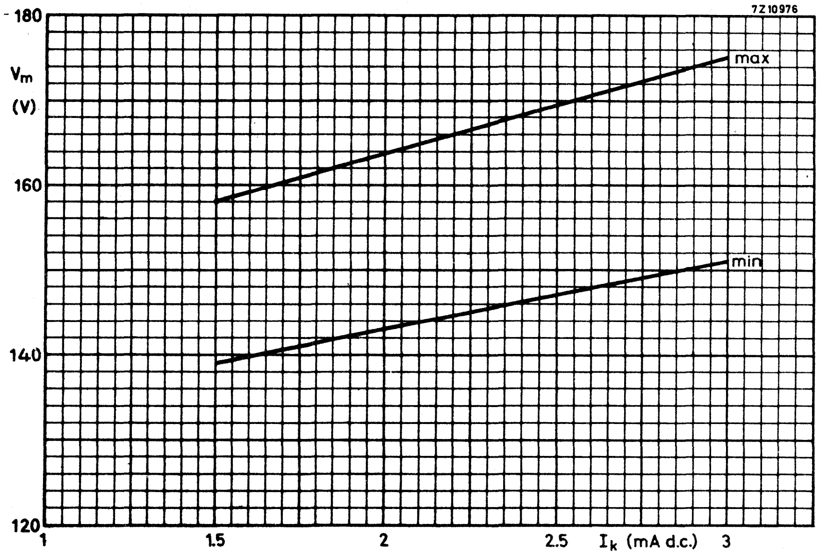
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few seconds. The ignition delay will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage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

SHOCK AND VIBRATION

An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

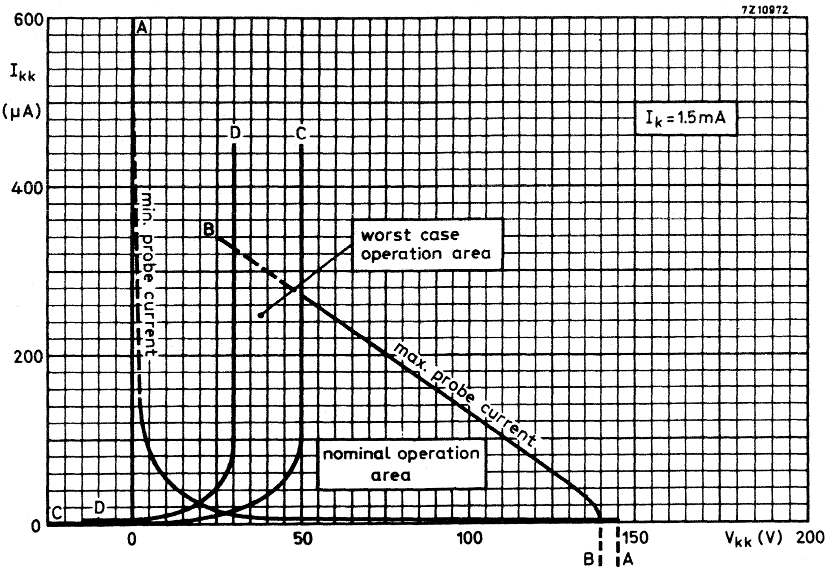


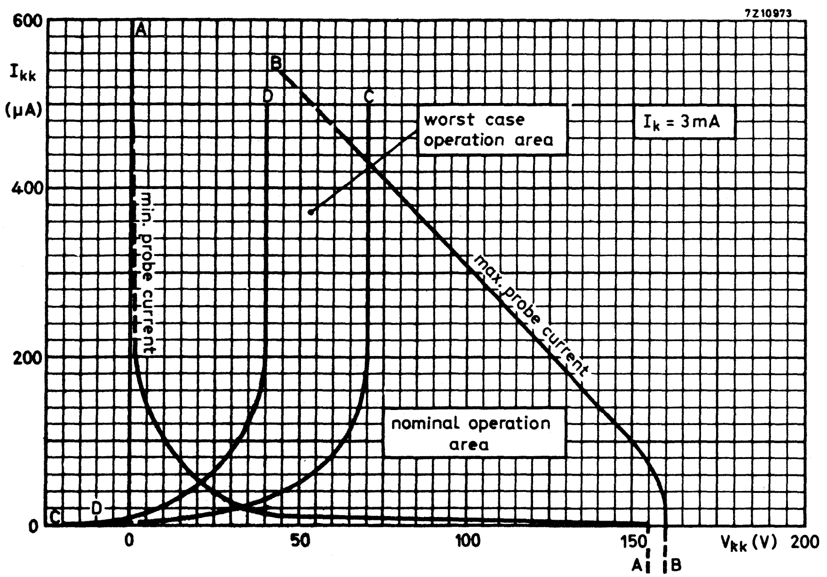
ANODE-TO-CATHODE MAINTAINING VOLTAGE
AS A FUNCTION OF CATHODE CURRENT

NOTE

PROBE CURRENT CURVES

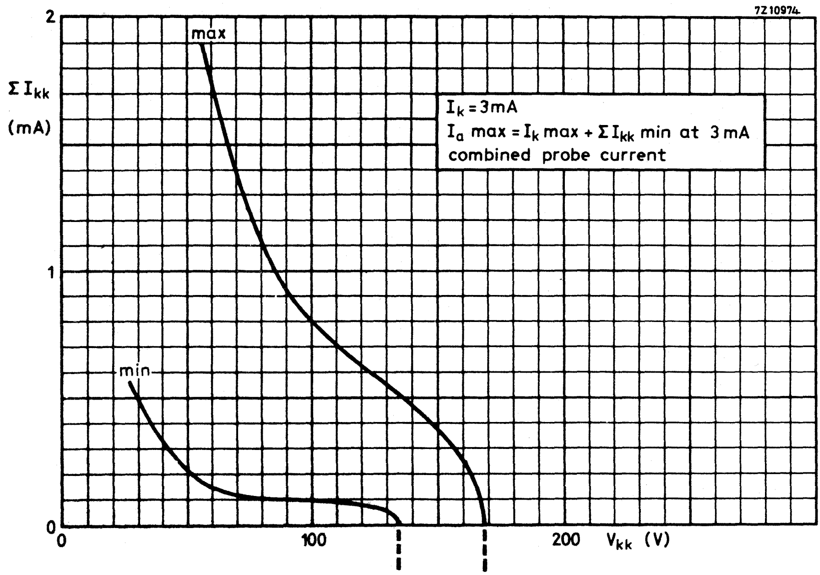
For low cathode selecting voltages (V_{kk}) the current I_{kk} to the non-conducting cathode will increase, and the readability of the conducting cathode will be affected.
It is therefore recommended to use a nominal operating point to the right of line C-C. Under the worst operating conditions the operating point should never reach the area left of the line D-D.

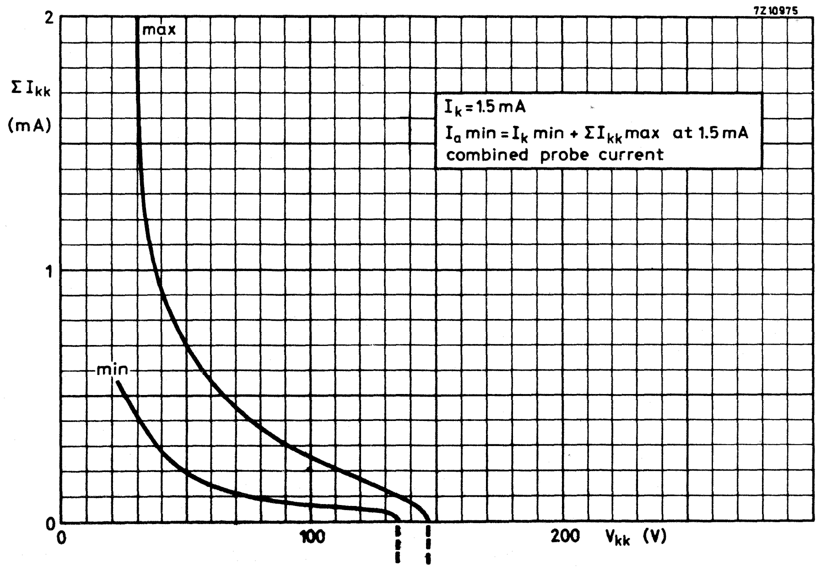




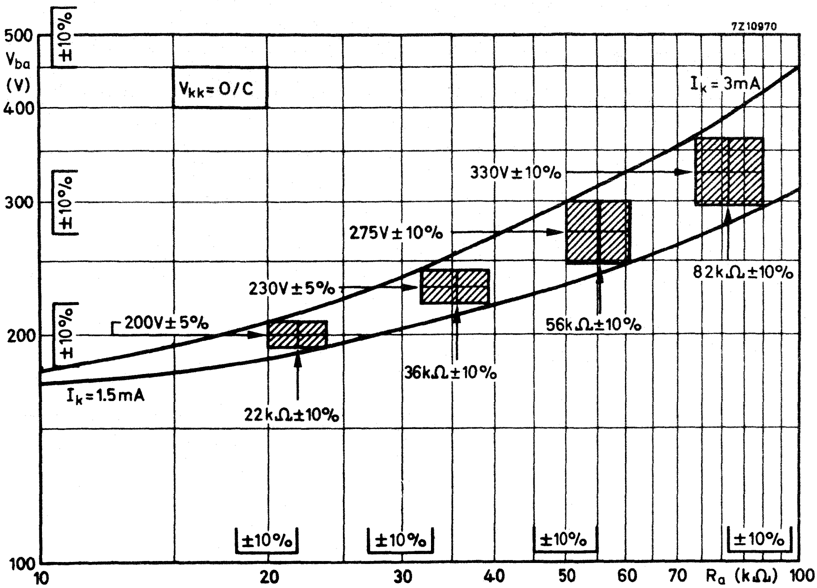
PROBE CURRENTS TO INDIVIDUAL NON-CONDUCTING CATHODES

See note page 4





COMBINED PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

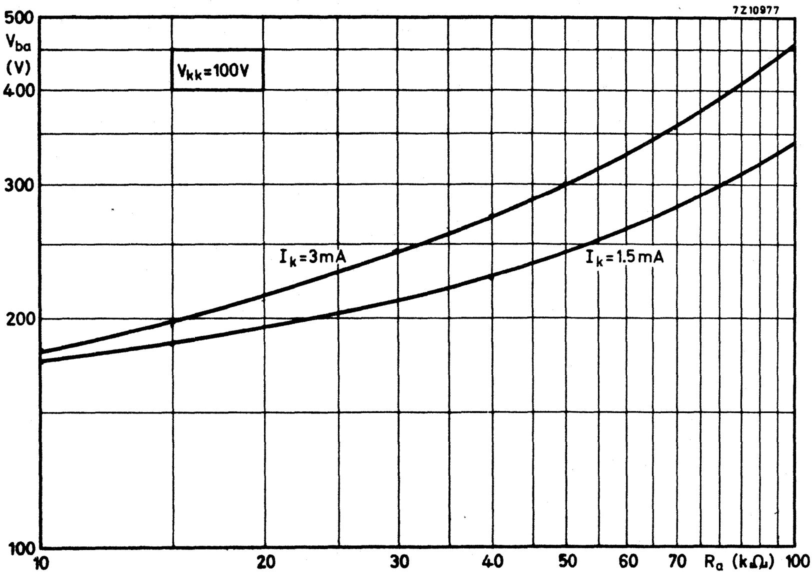


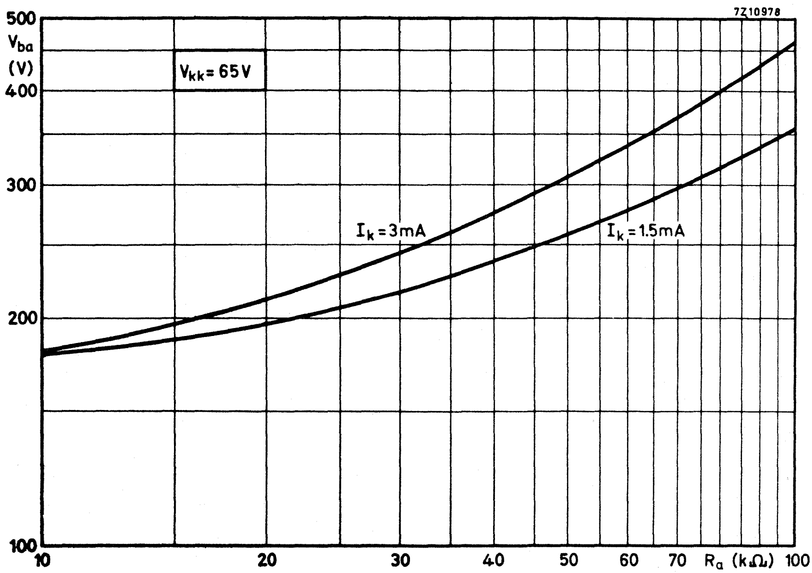
D.C. SUPPLY VOLTAGE AS A FUNCTION OF ANODE LOAD RESISTOR:

NON-CONDUCTING CATHODES OPEN CIRCUIT

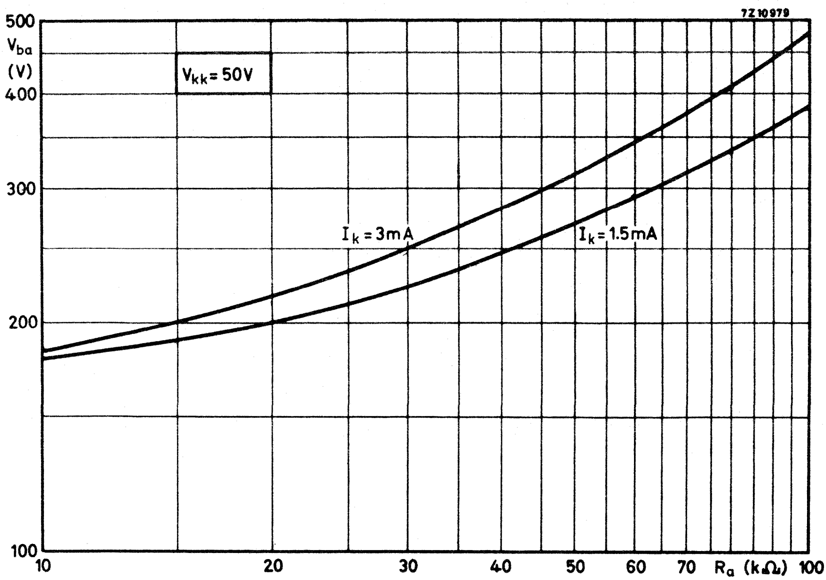
NOTE - SUPPLY VOLTAGE/LOAD RESISTOR

The graphs on pages 7 to 9 give the relationship between the d.c. anode supply voltage and the required anode load resistor for fixed values of V_{kk} (voltage difference between conducting and non-conducting cathodes).
Each graph is plotted on log-log graph paper; therefore a given tolerance expressed as a percentage can be represented as a fixed length at any point on the x and y axis. This is shown on the graph above by taking points on each axis with a fixed tolerance. Examples are shown on the graph above of the supply voltages and load resistors with tolerances expressed as a percentage so as to remain within the recommended operating region.
On page 9 details are given of the method of calculating corresponding values of supply voltage and anode load resistor, for fixed values of V_{kk}.





D.C. SUPPLY VOLTAGE AS A FUNCTION OF ANODE LOAD RESISTOR



D.C. SUPPLY VOLTAGE AS A FUNCTION OF ANODE LOAD RESISTOR

NOTE - The supply voltage/load resistor curves are derived from:

$$V_{ba} = I_a . R_a + V_m \text{ (General formula)}$$

$$V_{ba} = \left[I_k + \Sigma I_{kk}\right] R_a + V_m$$

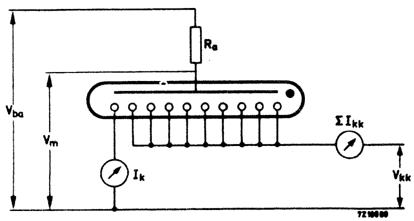
The value of I_{kk} will depend on the bias voltage V_{kk}.

Supply voltage required to work above the minimum value of I_k:

$$V_{ba} = \left[1.5 \text{ mA} + \Sigma I_{kk} \text{ max. at } I_k = 1.5 \text{ mA}\right] R_a + 158 \text{ V}$$

Supply voltage required to work below the maximum value of I_k:

$$V_{ba} = \left[3.0 \text{ mA} + \Sigma I_{kk} \text{ min. at } I_k = 3.0 \text{ mA}\right] R_a + 151 \text{ V}$$



INDICATOR TUBE

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

QUICK REFERENCE DATA

Numeral height		15.5	mm
Numerals	0 1 2 3 4 5 6 7 8 9		
Decimal point	see "General"		
Supply voltage	min.	170	V
Numeral cathode current		2.5	mA
Decimal point cathode current		0.5	mA
Distance between mounting centres	min.	19	mm

GENERAL

The numerals are 15.5 mm high and appear on the same base line allowing in-line read out. The four types are electrically identical but differ in the position of the decimal point and the inclusion of a red contrast filter.

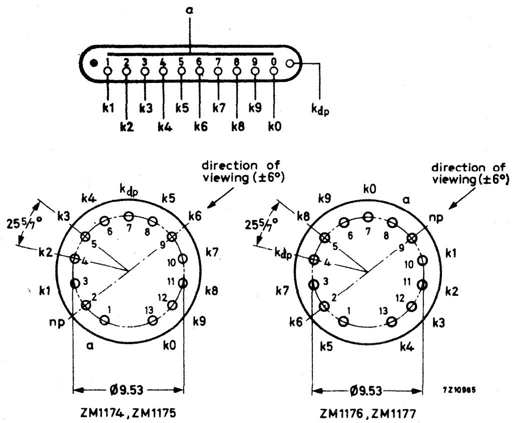
ZM1174 Decimal point on the left hand side. Red contrast filter. **Obsolescent type**
ZM1175 Decimal point on the left hand side. No filter.
ZM1176 Decimal point on the right hand side. Red contrast filter. **Obsolescent type**
ZM1177 Decimal point on the right hand side. No filter. **Obsolescent type**

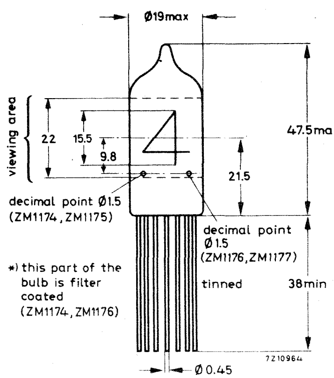
PRINCIPLE OF OPERATION

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm





Mounting position: any

The numerals and the decimal point are viewed through the side of the envelope. The numerals will appear upright (within ± 3°) when the tube is mounted vertically, base down.

Soldering

The tube may be soldered directly into the circuit, but heat conduction 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 for a maximum of 10 s.

Note

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

CHARACTERISTICS AND OPERATING CONDITIONS (at 20 °C to 50 °C)

Ignition voltage	V_{ign}	max.	170	V	
Mainting voltage	V_m	see page 3			
Numeral cathode current,					
recommended average	I_k		2.5	mA	
average (T_{av} = 10 ms)	I_k	max.	3.5	mA	
average, averaged over any conduction period	I_k	min.	1.5	mA	1)
peak	I_{kp}	max.	12	mA	
Decimal point cathode current					
recommended average	I_{kdp}		0.5	mA	
average, averaged over any conduction period	I_{kdp}	min.	0.05	mA	2)
peak	I_{kdpp}	max.	2.5	mA	
Extinguishing voltage	V_{ext}		115	V	

LIFE EXPECTANCY at I_k = 2.5 mA and room temperature. 3)

Continuous display of one numeral	>	5000	h
Sequentially changing the display from one numeral to another, every 100 h or less	>	30 000	h

LIMITING VALUES (Absolute max. rating system)

Numeral cathode current					
average, T_{av} = 10 ms	I_k	max.	3.5	mA	
peak	I_{kp}	max.	12	mA	
average during any conduction period	I_k	min.	1.5	mA	
Pulse duration	T_{imp}	min.	100	μs	
Bulb temperature	t_{bulb}	max.	+70	°C	
	t_{bulb}	min.	-50	°C	3)

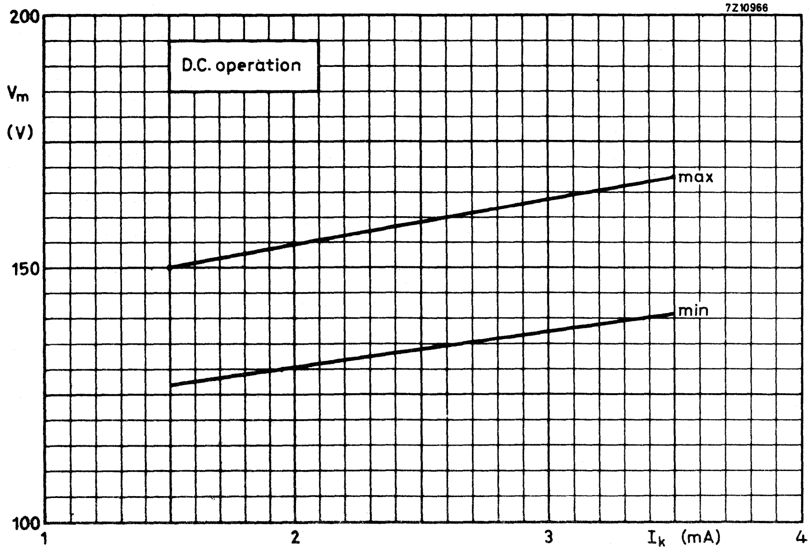
1) This value applies, irrespective of wether the decimal point is running or not.
2) These conditions are automatically satisfied when the decimal point is directly connected to the numeral cathode carrying the main discharge. When the decimal point is connected in this way the max. decimal point current is 0.15 mA at a numeral cathode current of 1.5 mA.
3) For bulb temperatures below 0 °C the life expectancy of the tube is substantially reduced.

SHOCK AND VIBRATION

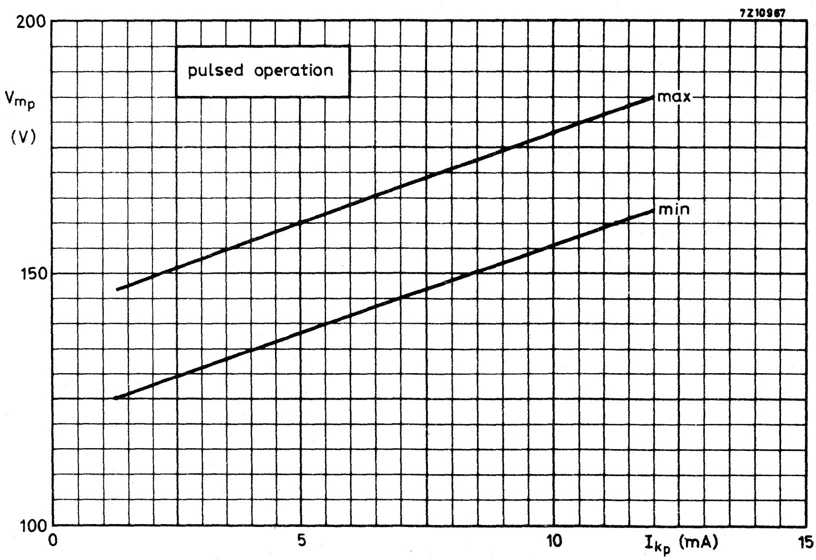
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.



ANODE-TO-CATHODE MAINTAINING VOLTAGE
AS A FUNCTION OF CATHODE CURRENT



PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE
AS A FUNCTION OF PEAK CATHODE CURRENT

PANDICON* INDICATOR TUBE

Long-life, multiple cold-cathode, gas-filled indicator tube for in-line numerical display applications requiring a large number of digits (up to 14) to be displayed on a minimum of space, e.g. in electronic desk-top calculators. To facilitate the reading of large numbers, punctuation marks can be made to appear at suitable places.

QUICK REFERENCE DATA			
Numeral height		10	mm
Numerals		0 1 2 3 4 5 6 7 8 9	
Number of decades		ZM1200:14;ZM1202:12;ZM1204:10;ZM1206:8	
Decimal points		to the lower right of the numerals	
Punctuation marks		to the upper right of the numerals	
Decade pitch		10	mm
Supply voltage, peak	V_{bap}	190	V
Anode current, peak	I_{ap}	9	mA

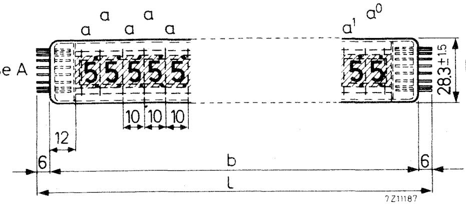
GENERAL

The numerals are 10 mm high and appear on the same base-line allowing in-line read-out.

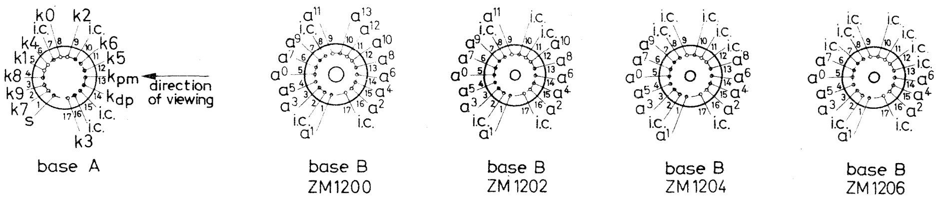
DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base : 17 pin all-glass; pitch circle 18,3 mm ϕ; pin length 6 mm; pin diameter 0,9 mm
Socket: type number 55708 or type number 55709 (printed wiring).



	b	l_{max}
ZM1200	166,5	180
ZM1202	146,5	160
ZM1204	126,5	140
ZM1206	106,5	120



No undue stress should be placed on the base pins.
Pumping stem: length max. 4,7 mm, diameter max. 5,0 mm.

* Registered Trade Mark for multiple indicator tubes.

CHARACTERISTICS

Ignition voltage	V_{ign}	<	170	V
Ignition delay, first ignition	T_d typ.	<	0,5	s
subsequent ignitions	$T_{d(numerals)}$		10	μs
at V_{ba} = 200 V	$T_{d(d.p.\ or\ p.m.)}$		15	μs
Anode current, peak with or without decimal point and/or punctuation mark at T_{imp} = 50 μs	I_{ap}	>	6	mA
at T_{imp} = 150 μs	I_{ap}	>	5	mA
at T_{imp} = 1000 μs	I_{ap}	>	4	mA
	I_{ap}	<	12	mA
Recommended anode current, peak	I_{ap}		9	mA
Recommended pulse duration	T_{imp}		150 to 500	μs
Maintaining voltage	V_m		see page 4	
Cathode selecting voltage	V_{kk}	>	70	V [1]
		<	100	V
"Off" anode voltage	$V_{a_{off}}$	>	85	V
		<	115	V
Recommended "off" anode voltage	$V_{a_{off}}$		110	V
Recommended shield voltage	V_s		10 V below $V_{a_{off}}$	
Recommended shield supply resistance	R_s		10	kΩ
Decimal point resistor [2]	$R_{d.p.}$		10 kΩ ± 10	%
Punctuation mark resistor [2]	$R_{p.m.}$		10 kΩ ± 10	%
Recommended $V_{a_{off}}$ supply resistance	R		10	kΩ
Extinguishing voltage	V_{ext}	>	115	V

1) At lower values of V_{kk} the contrast of the display will be reduced to glow on adjacent numerals. This will not affect the life of the tube.
After switching the bias should be restored within 20 μs.

2) The decimal point and/or punctuation mark cathode(s) may not be operated without extra current limiting resistor.

LIMITING VALUES (Absolute max. rating system)

Anode supply voltage	V_{ba}	min.	170	V
		max.	220	V
Anode current, peak each anode with or without decimal point and/or punctuation mark at T_{imp} = 50 μs	I_{a_p}	min.	6	mA
at T_{imp} = 100 μs		min.	5	mA
at T_{imp} = 1500 μs		min.	4	mA
	I_{a_p}	max.	12	mA
average (T_{av} = 1 s)	I_a	max.	1,5	mA
Anode current, peak: decimal point or punctuation mark only [2]	I_{a_p}	min.	0,5	mA
		max.	2	mA
average (T_{av} = 1 s)	I_a	max.	0,25	mA
Pulse duration	T_{imp}	min.	50	μs
Cathode selecting voltage	V_{kk}	max.	100	V
"Off" anode voltage	$V_{a_{off}}$	min.	85	V
		max.	115	V
Shield voltage	V_s	min.	70	V
		max.	100	V
Voltage between any pair of electrodes (operating anode excluded)	V	max.	120	V
Ambient temperature	t_{amb}	min.	−50	°C [1]
		max.	+70	°C

SHOCK AND VIBRATION

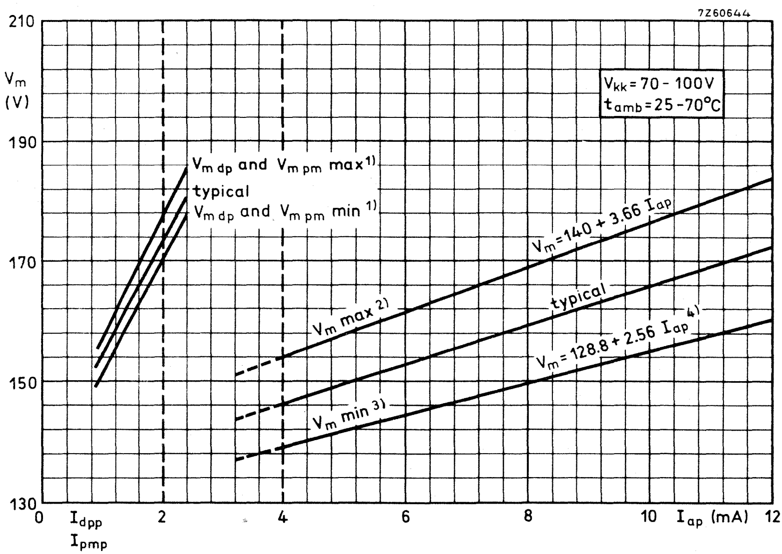
An indication for the ruggedness of the tube is the fact that 95 % of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}. 1000 shocks in one of the three positions of the tube.

Vibration: 2,5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

[1]) Bulb temperatures below 10 °C result in a reduced life expectancy and changes in characteristics.

[2]) See page 2.



1) The decimal point maintaining voltage V_{mdp} and the punctuation mark maintaining voltage V_{mpm} include the voltage drop at the 10 kΩ series resistor.

2) V_m max. pertains to the maximum operating temperature and assumes the decimal point or punctuation mark not operating.

3) V_m min. pertains to the maximum operating temperature and assumes the decimal point or punctuation mark operating.

4) The maintaining voltage can be considered as the sum of a constant voltage and a current dependent voltage (V/mA).

ZM1230 OBSOLESCENT TYPE

INDICATOR TUBE

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

QUICK REFERENCE DATA				
Numeral height			15.5	mm
Numerals	1 2 3 4 5 6 7 8 9 0			
Supply voltage	V_{ba}	min.	170	V
Cathode current	I_k		2.5	mA
Distance between mounting centres		min.	19	mm

GENERAL

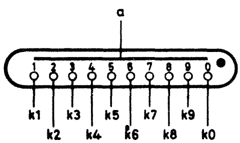
The numerals are 15.5 mm high and appear on the same base line allowing in-line read out. The ZM1230 is identical to the ZM1232 but is provided with a red contrast filter.

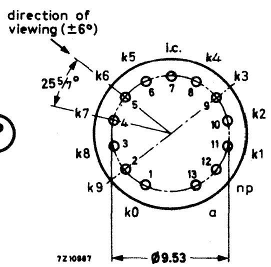
PRINCIPLE OF OPERATION

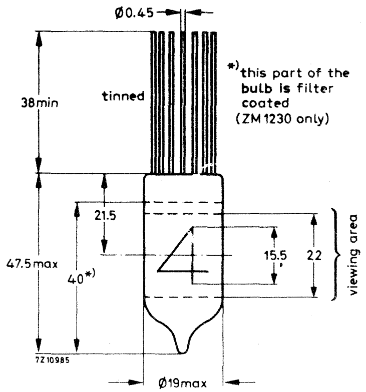
The tube contains ten cathodes in the form of ten figures and one common anode. By applying a suitable voltage between the anode and one of the ten cathodes the corresponding figure will be covered by a red neon glow.

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

The numerals will appear upright (within ± 3°) when the tube is mounted vertically, base up.

Soldering

The tube may be soldered directly into the circuit, but heat conduction 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 for a maximum of 10 s.

Note

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

CHARACTERISTICS AND OPERATING CONDITIONS (at 20 °C to 50 °C)

Ignition voltage	V_{ign}	min.	170	V
Ignition delay	see page 3			
Maintaining voltage	see page 4			
Cathode current, recommended	I_k		2.5	mA
Cathode current for coverage, average during any conduction period	I_k	min.	1.5	mA
D.C. operation	see pages 4 to 9			
Pulse operation	see pages 4, 10, 11 and 12			
Extinguishing voltage	V_{ext}		115	V

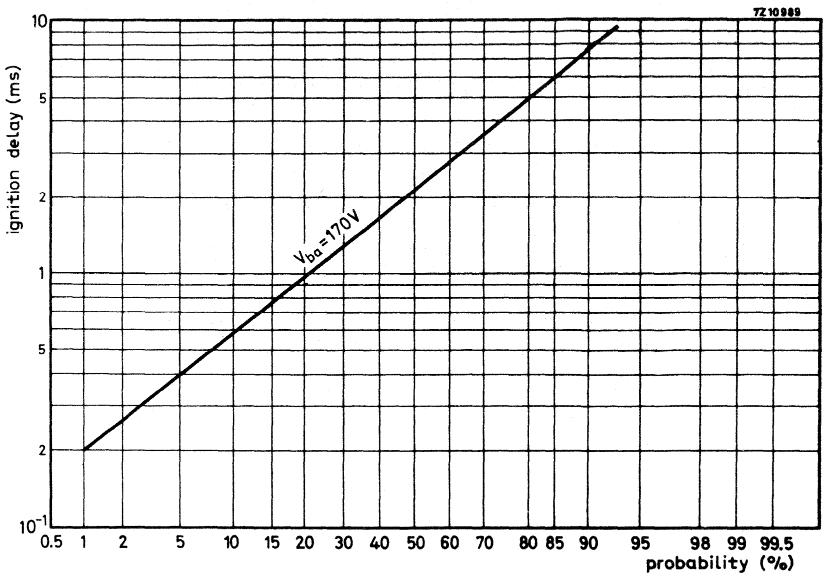
LIFE EXPECTANCY at I_k = 2.5 mA and room temperature [1])

Continuous display of one numeral	>	5 000	h
Sepuentially changing the display from one numeral to another, every 100 hrs or less	>	30 000	h

LIMITING VALUES (Absolute max. rating system)

Cathode current (each digit),				
average, T_{av} = max. 10 ms	I_k	max.	3.5	mA
peak	I_{kp}	max.	12	mA
average during any conduction period	I_k	min.	1.5	mA
Anode voltage necessary for ignition	V_a	min.	170	V
Pulse duration	T_{imp}	min.	100	μs
Bulb temperature	t_{bulb}	max.	+70	°C
	t_{bulb}	min.	−50	°C [1])

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



CUMULATIVE DISTRIBUTION OF IGNITION DELAY

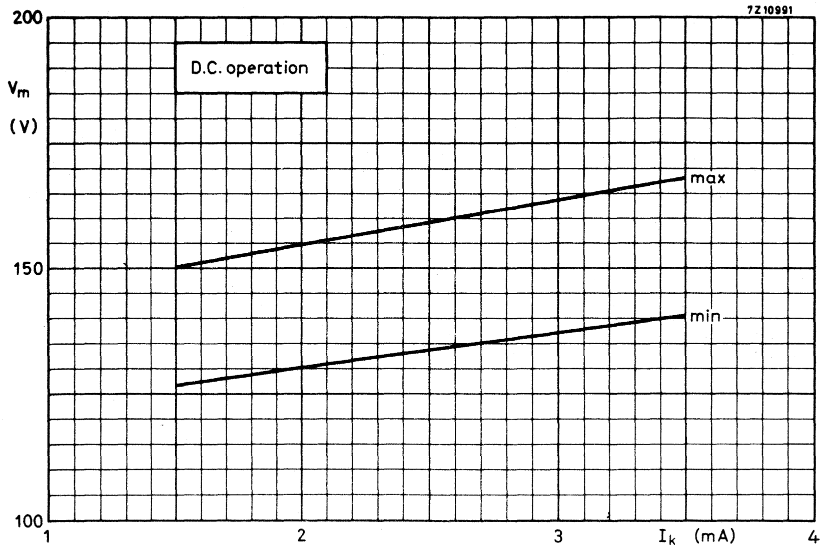
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few periods. The ignition delay will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage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

SHOCK AND VIBRATION

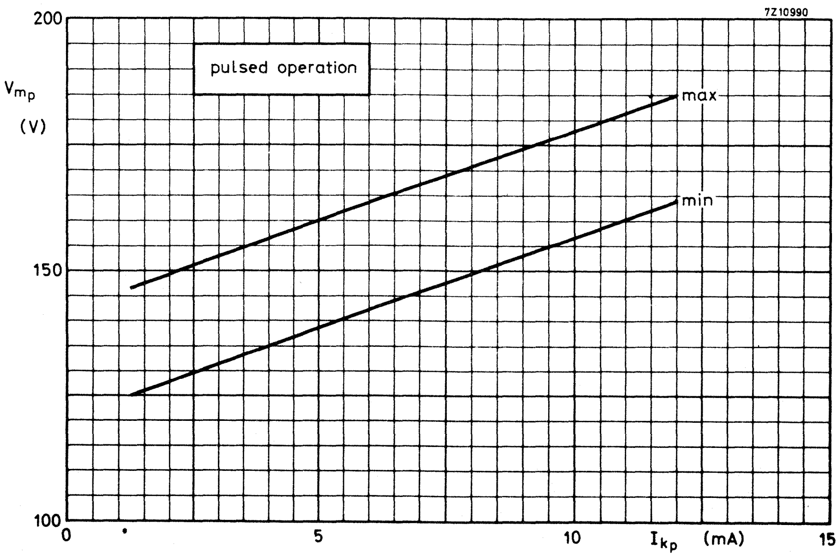
An indication for the ruggedness of the tube is the fact that 95% of the items sampled from the normal production line pass the shock and vibration tests specified below without perceptible damage.

Shock: 25 g_{peak}, 1000 shocks in one of the three positions of the tube.

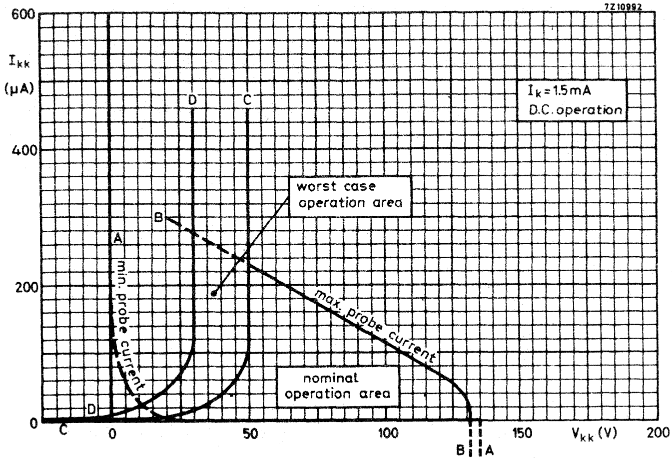
Vibration: 2.5 g_{peak}, 50 Hz, during 32 hours in each of the three positions of the tube.

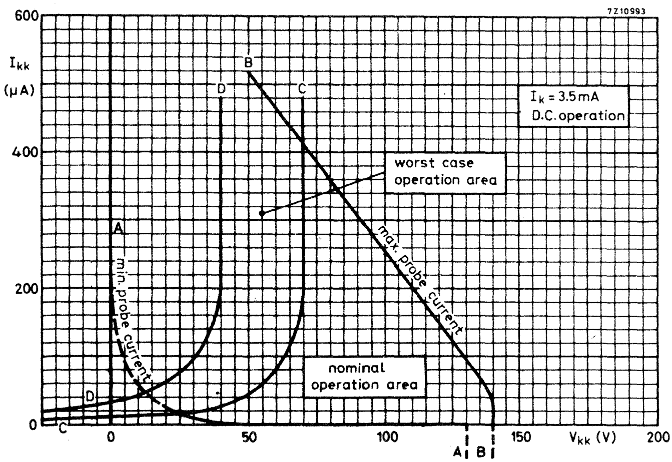


ANODE-TO-CATHODE MAINTAINING VOLTAGE
AS A FUNCTION OF CATHODE CURRENT



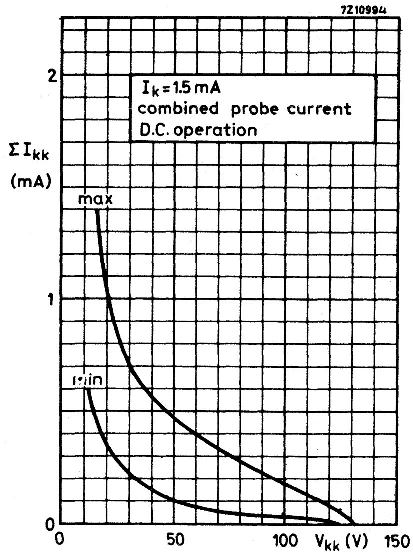
PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE
AS A FUNCTION OF PEAK CATHODE CURRENT

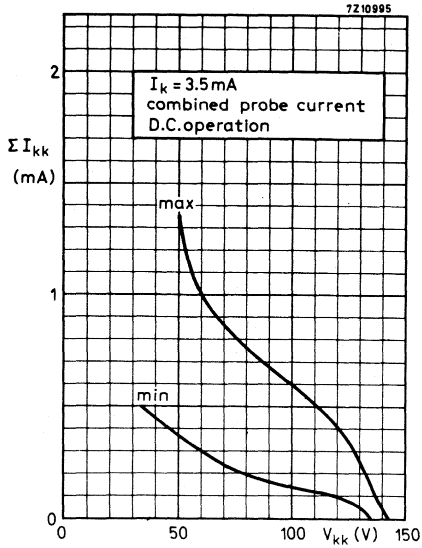




PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

The boundaries A-A and B-B of the graphs represent, for the shown cathode current range, the range of probe current (I_{kk}) to individual non-conducting cathodes plotted against the voltage difference between the non-conducting cathodes and the conducting cathode (V_{kk}).
For low cathode selecting voltages (V_{kk}) the current I_{kk} to the non-conducting cathode will increase, and the readability conducting cathode will be affected.
It is therefore recommended to use a nominal operating point to the right of line C-C.
Under the worst operating conditions the operating point should never reach the area left of the line D-D.





COMBINED PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

Sum of the probe currents to the non-conducting cathodes (I_{kk}) plotted against the voltage difference between the non-conducting cathodes and the conducting cathode (V_{kk}), showing the minimum and maximum values of probe current for a particular cathode current (I_k).

SUPPLY VOLTAGE/LOAD RESISTOR

The graphs on pages 8, 9 and 12 give the relationship between the anode supply voltage and the required anode load resistor for fixed values of V_{kk} (voltage difference between conducting cathode and non-conducting cathodes).

Each graph is plotted on log-log graph paper; therefore a given tolerance expressed as a percentage can be represented as a fixed length at any point on the x and y axes. This is shown on the first graph by taking points on each axis with a fixed tolerance.

Examples are shown on the first graph of the supply voltages and load resistors with tolerance expressed as a percentage so as to remain within the recommended operating region.

The curves are derived from:-

$$V_{ba} = I_a \cdot R_a + V_m$$

$$I_a = I_k + \Sigma I_{kk}$$

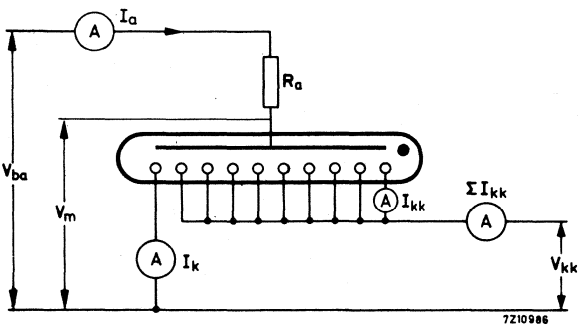
$$V_{ba} = (I_k + \Sigma I_{kk})\, R_a + V_m$$

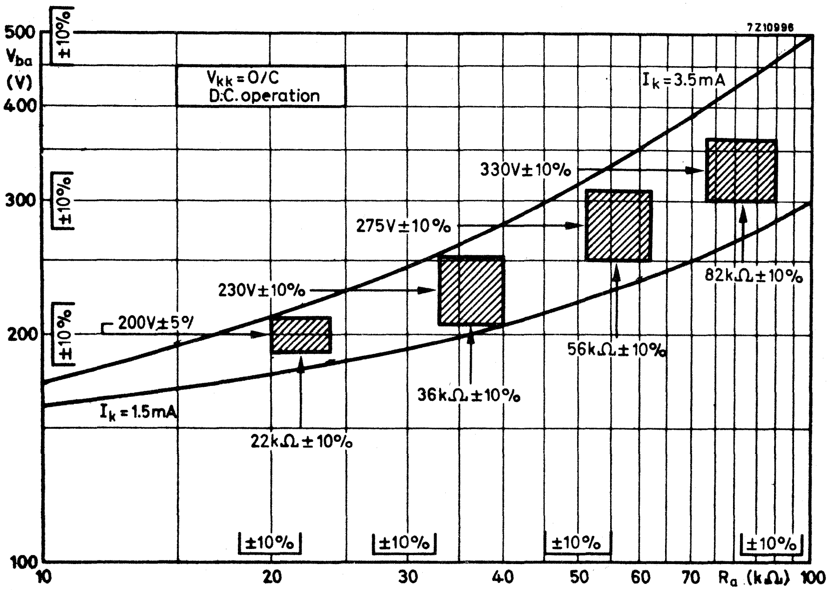
For a given value of R_a, the minimum supply voltage limit to ensure that the cathode current exceeds I_k min. is given by:

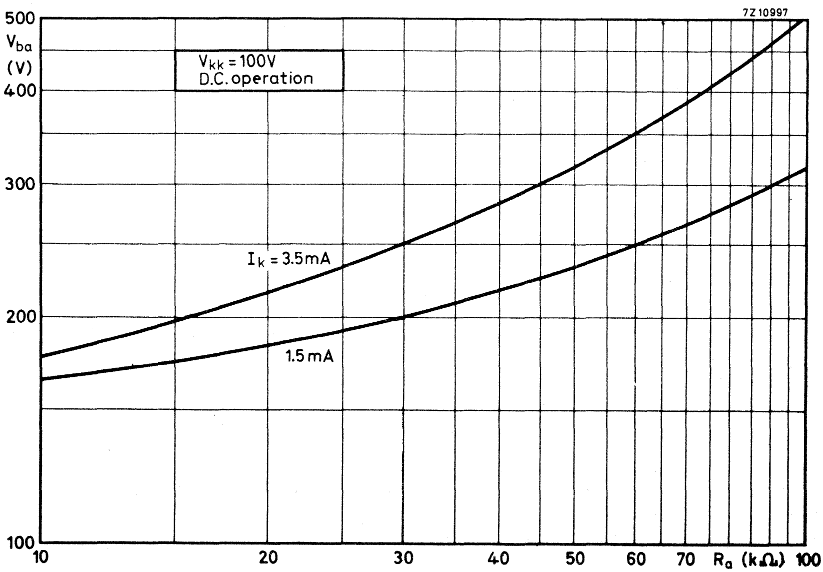
$$V_{ba}\ \text{min.} = \left[I_k\ \text{min.} + \Sigma I_{kk}\ \text{max. (at } I_k\ \text{min.)}\right] R_a + V_m\ \text{max. (at } I_k\ \text{min.)}$$

For the same value of R_a, the maximum supply voltage limit to ensure that the cathode current does not exceed I_k max. is given by:

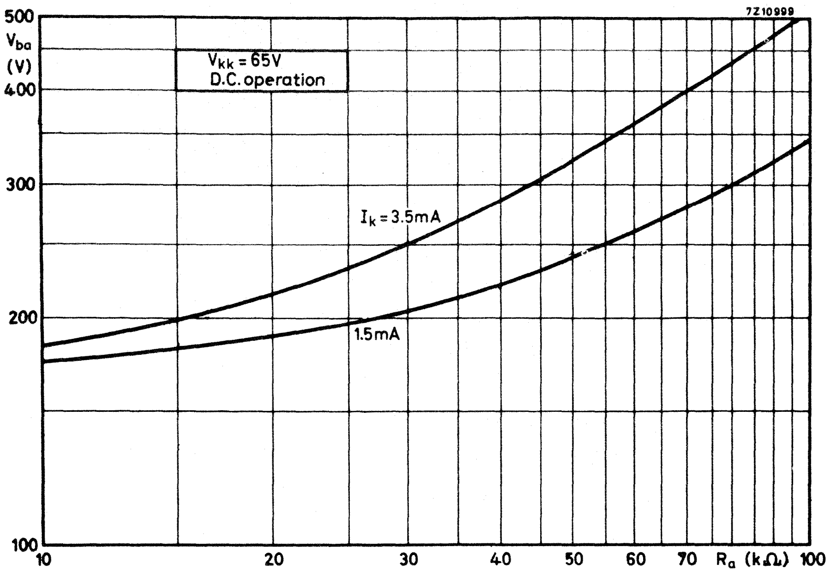
$$V_{ba}\ \text{max.} = \left[I_k\ \text{max.} + \Sigma I_{kk}\ \text{min. (at } I_k\ \text{max.)}\right] R_a + V_m\ \text{min. (at } I_k\ \text{max.)}$$

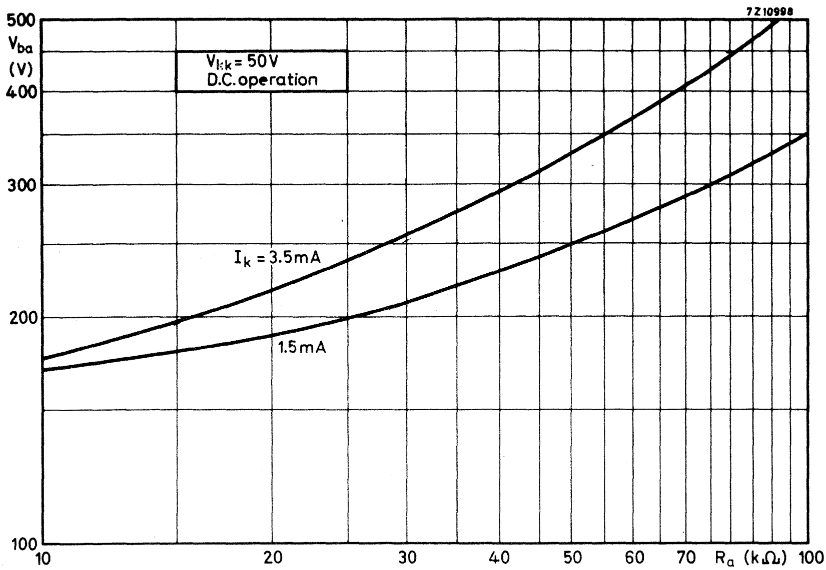




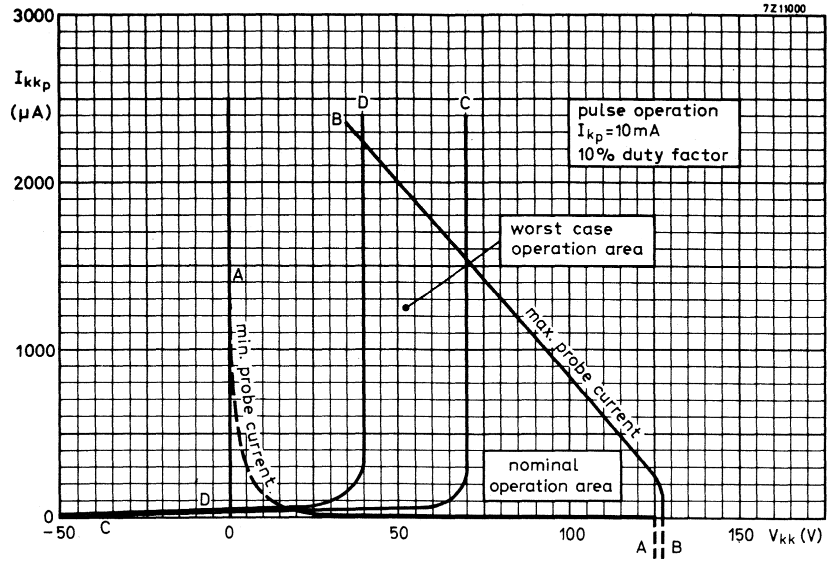


D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR



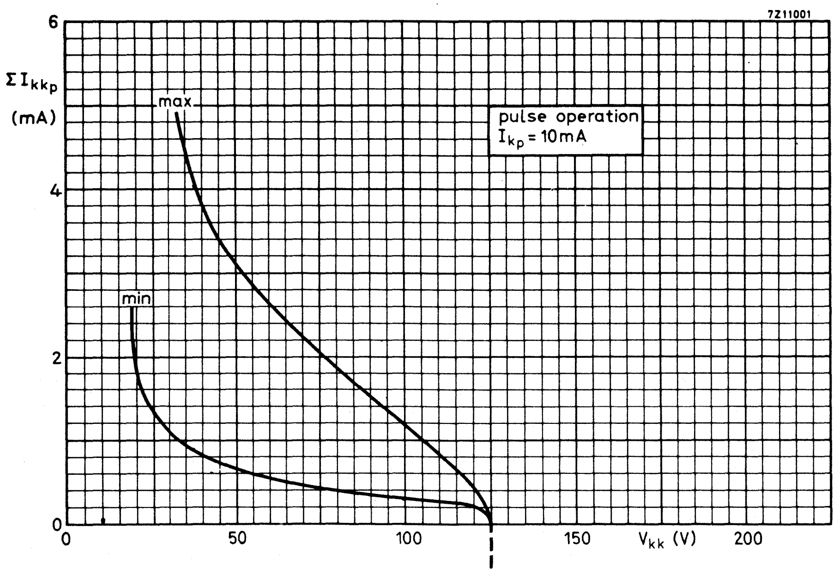


D.C. SUPPLY VOLTAGE AS A FUNCTION OF ANODE LOAD RESISTOR



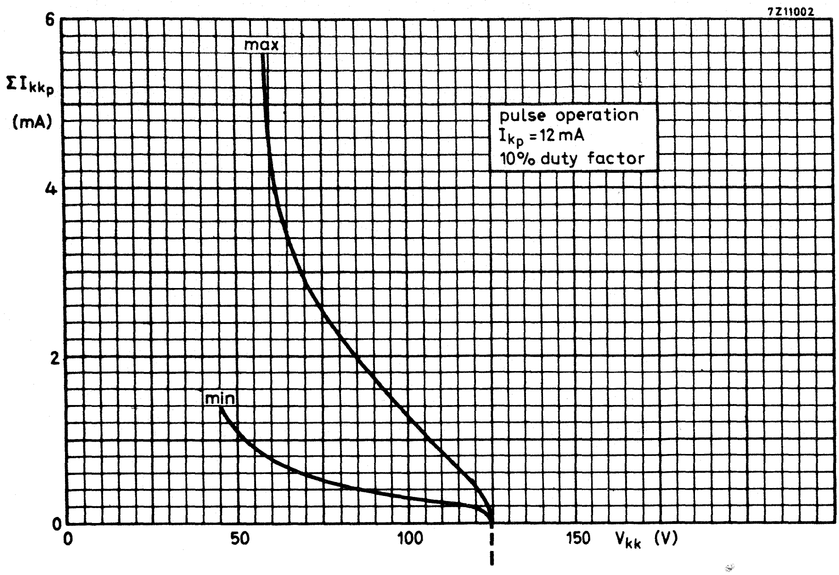
PEAK PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

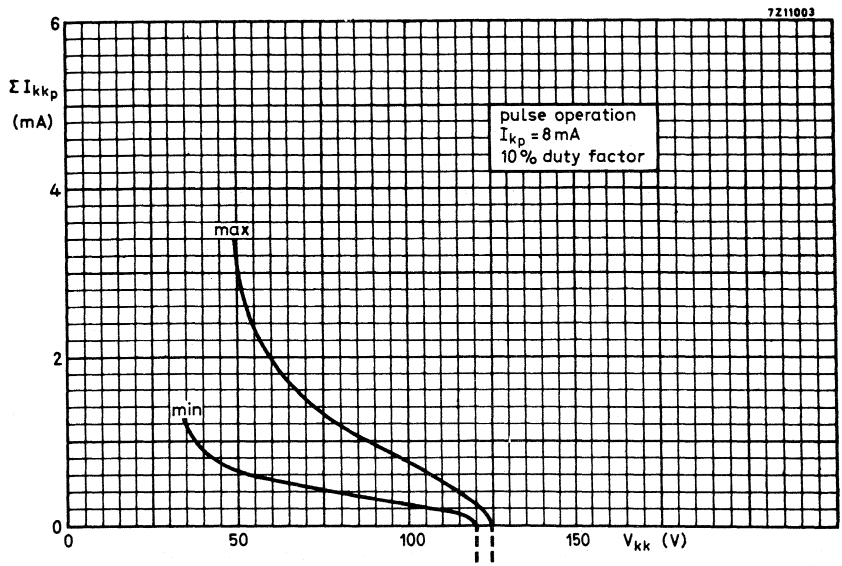
See also page 5



COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

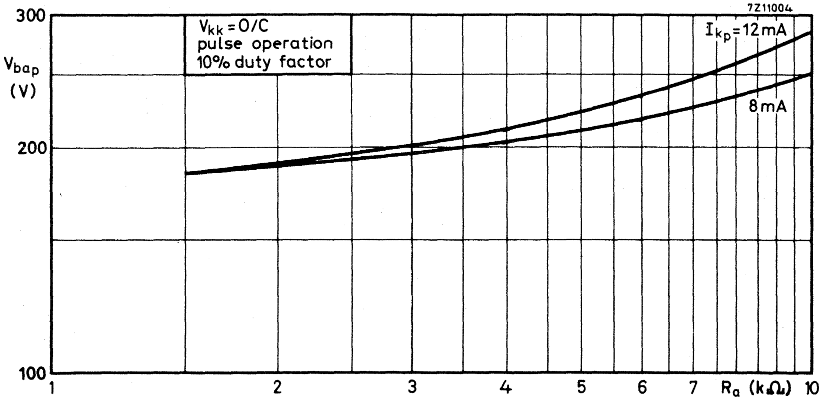
See also page 6

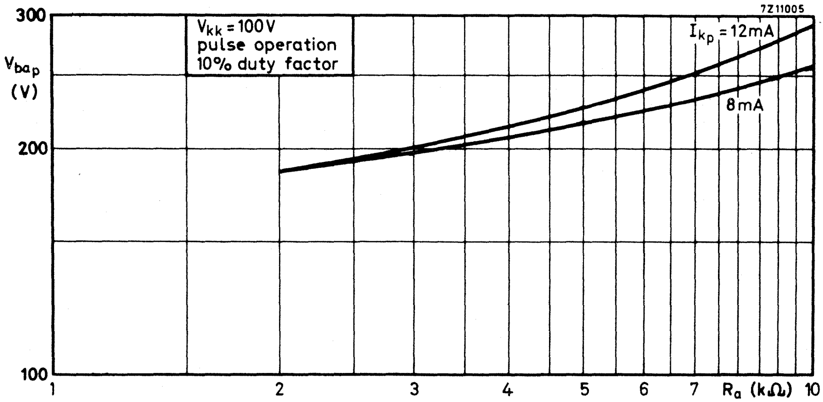


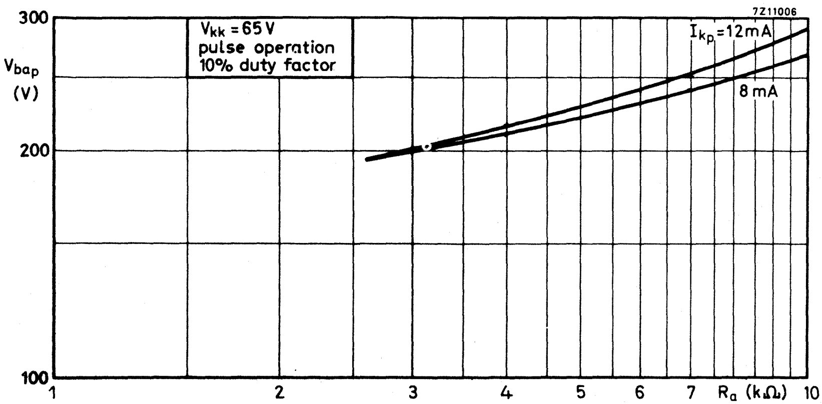


COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

See also page 6







PEAK SUPPLY VOLTAGE AS A FUNCTION OF ANODE LOAD RESISTOR

INDICATOR TUBE

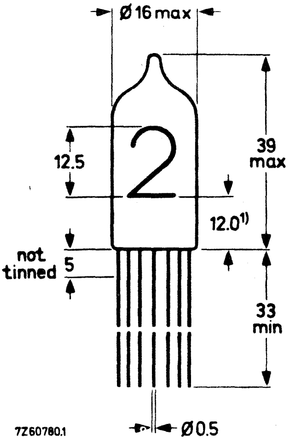
Long-life cold-cathode ten-digit indicator tube for side viewing.
The tube is designed for time-sharing (pulse) applications.

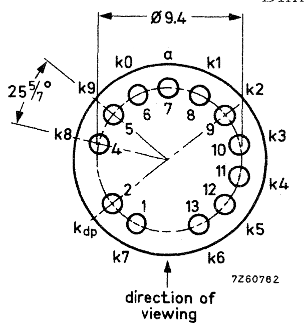
QUICK REFERENCE DATA

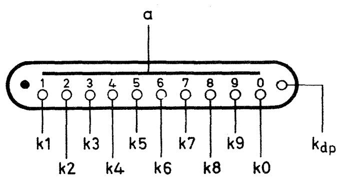
Numeral height		approx.	12,5	mm
Numerals		0 1 2 3 4 5 6 7 8 9		
Decimal point		to the right of the numerals		
Supply voltage	V_{ba}(pulse)	min.	190	V
Cathode current, peak	I_{kp}	min.	2	mA
	I_{kp}	max.	8	mA
average	I_k	max.	0,5	mA

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

Soldering
The leads may be dip-soldered at a solder temperature of max. 240 °C for maximum 10 s up to a point 5 mm from the seals.

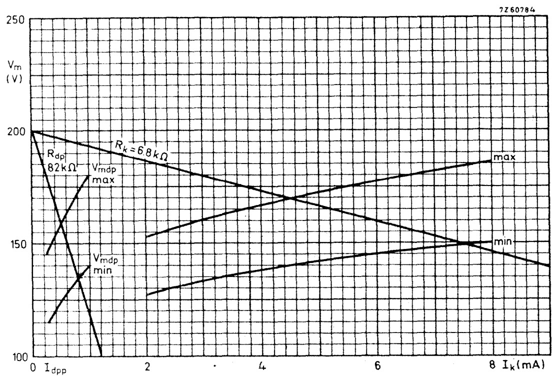
1) Standard deviation 0,13 mm

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	190	V
Maintaining voltage	V_m	see below		
Cathode current, average (T_{av}= max. 20 ms)	I_k	max.	0,5	mA
peak	I_{k_p}	min.	2	mA
(with or without decimal point)	I_{k_p}	max.	8	mA
Pulse duration	T_{imp}	min.	100	μs
	T_{imp}	max.	500	μs
Cathode selecting voltage	V_{kk}	min.	60	V
	V_{kk}	max.	100	V
Cathode resistor, decimal point	R_{dp}		82	kΩ 10%
Extinguishing voltage	V_{ext}	min.	110	V

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition, pulse	V_{a_p}	min.	190	V
Cathode current, average (T_{av}= 20 ms)	I_k	max.	0,5	mA
peak	I_{k_p}	min.	2	mA
	I_{k_p}	max.	8	mA
Pulse duration	T_{imp}	min.	100	μs
Cathode selecting voltage	V_{kk}	min.	60	V
	V_{kk}	max.	100	V
"Off" anode voltage	$V_{a"off"}$	max.	110	V
Ambient temperature	t_{amb}	min.	0	°C
	t_{amb}	max.	+50	°C



INDICATOR TUBE

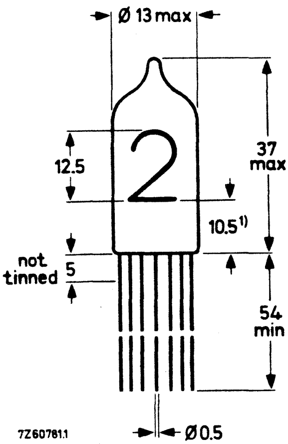
Long-life cold-cathode ten-digit indicator tube for side viewing.
The tube is designed for time-sharing (pulse) applications.

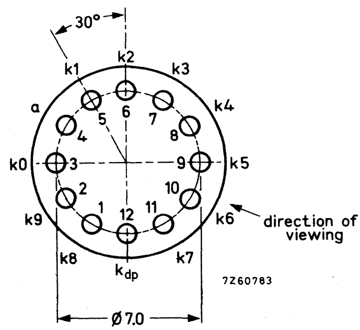
QUICK REFERENCE DATA

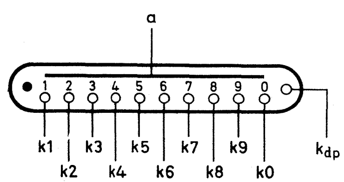
Numeral height		approx.	12, 5	mm
Numerals		0 1 2 3 4 5 6 7 8 9		
Decimal point		to the right of the numerals		
Supply voltage	$V_{ba(pulse)}$	min.	170	V
Cathode current, peak	I_{kp}	min.	7	mA
	I_{kp}	max.	19	mA
average	I_k	max.	1, 7	mA

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

Soldering

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

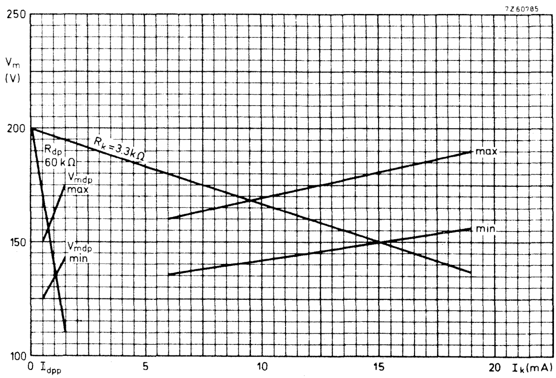
1) Standard deviation 0, 13 mm

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see below		
Cathode current, average (T_{av} = max. 20 ms)	I_k	max.	1,7	mA
peak	I_{kp}	min.	7	mA
(with or without decimal point)	I_{kp}	max.	19	mA
Pulse duration	T_{imp}	min.	35	µs
	T_{imp}	max.	500	µs
Cathode selecting voltage	V_{kk}	min.	60	V
	V_{kk}	max.	80	V
Cathode resistor, decimal point	R_{dp}		60	kΩ±10%
Extinguishing voltage	V_{ext}	min.	110	V

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition, pulse	V_{ap}	min.	170	V
Cathode current, average (T_{av} = 20 ms)	I_k	max.	1,7	mA
peak	I_{kp}	min.	7	mA
	I_{kp}	max.	19	mA
Pulse duration	T_{imp}	min.	35	µs
Cathode selecting voltage	V_{kk}	min.	60	V
	V_{kk}	max.	80	V
"Off" anode voltage	$V_{a"off"}$	max.	110	V
Ambient temperature	t_{amb}	min.	0	°C
	t_{amb}	max.	+50	°C



OBSOLESCENT TYPE

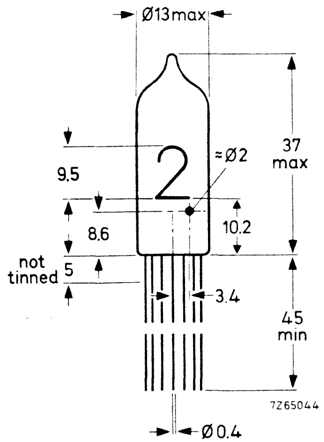
INDICATOR TUBE

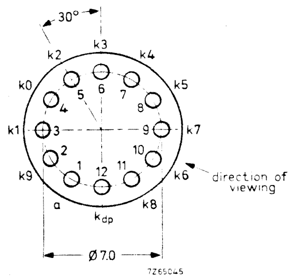
Long-life cold cathode ten-digit indicator tube for side viewing.

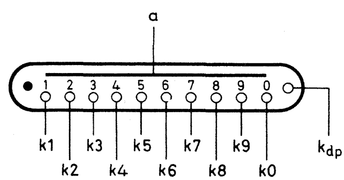
QUICK REFERENCE DATA				
Numeral height		approx.	9,5	mm
Numerals		1 2 3 4 5 6 7 8 9 0		
Decimal point		to the right of the numerals		
Supply voltage	$V_{ba(pulse)}$	max.	170	V
Cathode current, peak	I_{kp}	max.	11	mA
average	I_k	max.	1,1	mA

DIMENSIONS AND CONNECTIONS

Dimensions in mm







Mounting position: any

Soldering

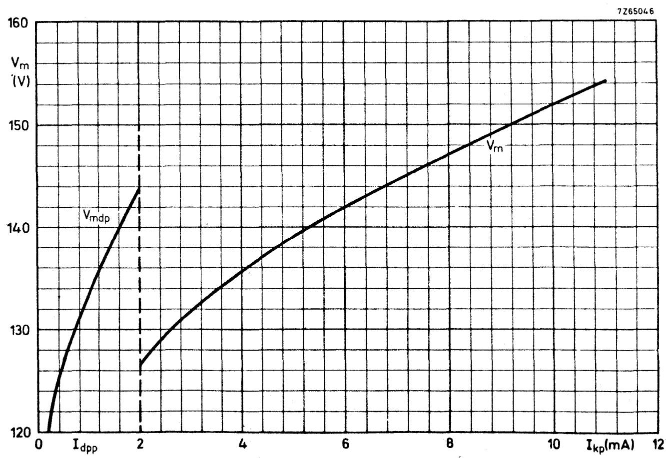
The leads may be dip-soldered at a solder temperature of max. 240 °C for maximum 10 s up to a point 5 mm from the seals.

CHARACTERISTICS AND OPERATING CONDITIONS

Ignition voltage	V_{ign}	max.	170	V
Maintaining voltage	V_m	see below		
Cathode current, average (T_{av} = max. 20 ms)	I_k	max.	1, 1	mA
peak (with or without decimal point)	I_{kp}	max.	11	mA
Pulse duration	T_{imp}	min.	15	µs
	T_{imp}	max.	500	µs
Cathode selecting voltage	V_{kk}	min	60	V
	V_{kk}	max.	100	V
Cathode resistor, decimal point	R_{dp}		10	kΩ±10%

LIMITING VALUES (Absolute max. rating system)

Anode voltage necessary for ignition, pulse	V_{ap}	min	170	V
Cathode current, average (T_{av} = max. 20 ms)	I_k	max.	1, 1	mA
peak	I_{kp}	max.	11	mA
Pulse duration	T_{imp}	min.	15	µs
	T_{imp}	max.	500	µs
Cathode selecting voltage	V_{kk}	min.	60	V
	V_{kk}	max.	100	V
Ambient temperature	t_{amb}	min.	0	°C
	t_{amb}	max.	+50	°C



Trigger tubes and switching diodes

RECOMMENDED TYPES FOR NEW EQUIPMENT

Switching and light diodes

ZA1002
ZA1004
ZA1006

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.

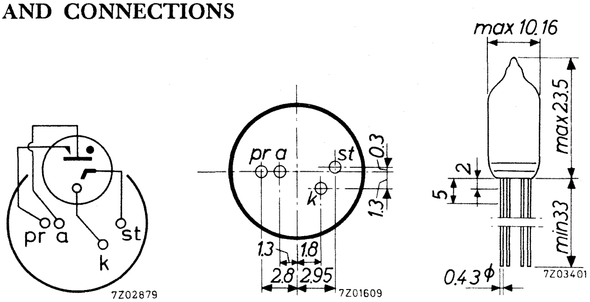
5065

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.

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, $I_{st} \leq 0.5$ μA) See also sheet 10	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 12		
Starter to cathode voltage to ensure non ignition				
positive, at V_{ba} = 300 V, see also sheet 7	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 10		
negative		=	0	μA
Starter to cathode maintaining voltage (I_{st} = 30 μA, I_a = 0 mA, see also sheet 10)				
typical minimum	V_{mst}	= min.	105	V

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 7)					
initially	$V_{st_{ign}}$	= min.	153	V	
typical over life	$V_{st_{ign}}$	= min.	155	V	[7]
Typical max. change over life	$\Delta V_{st_{ign}}$	=	$\pm$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 7)	C_{st}	= min.	100	pF	[8]
Starter to cathode maintaining voltage (I_{st} = 30 μA, I_a = 0 mA, See also sheet 10)					
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 11			
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

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 8)	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 12)	I_{k_p}	= max.	200	mA	
Starter current		See sheet 11			
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	

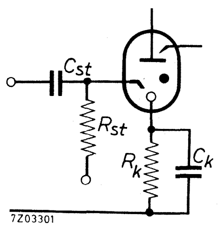
Extinction

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

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.

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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.

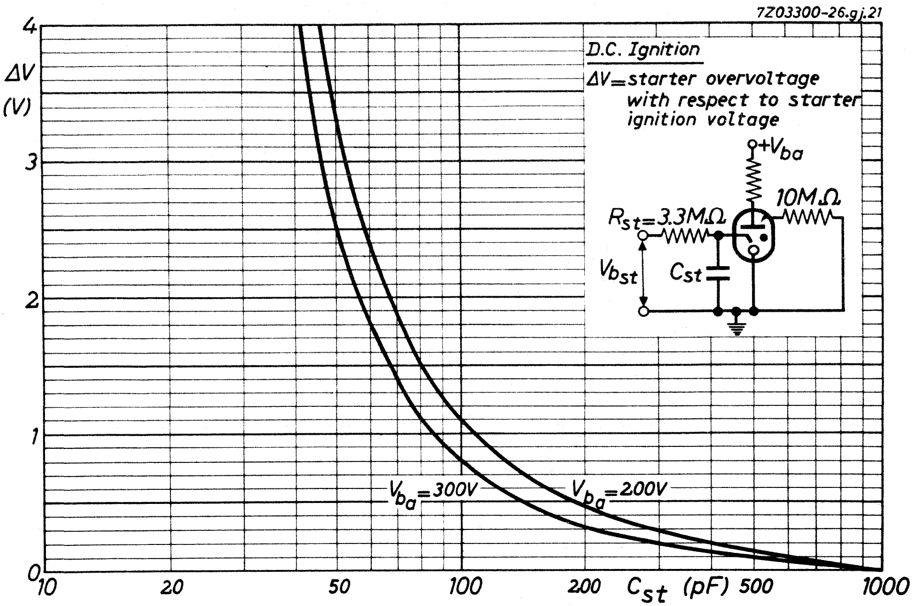
LIMITING VALUES (Absolute max. rating system)

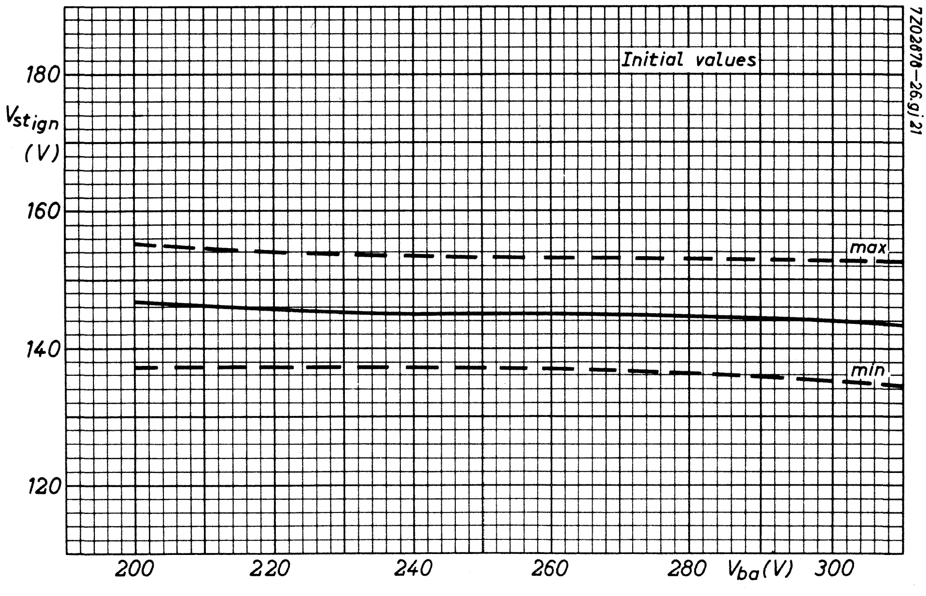
Anode voltage				
negative (V_{st} = −50 to +100 V, I_{st} = 0 μA)	$-V_a$	= max.	50	V
($I_{st} > 0$ μA)	$-V_a$	= max.	0	V
Starter voltage				
negative at V_{ba} = 300 V	$-V_{st}$	= max.	30	V
at V_{ba} = 200 V	$-V_{st}$	= max.	50	V
Cathode current, average during conduction period	I_k	= min.	2	mA
average ($T_{av\ max.}$ = 5 s)	I_k	= max.	5	mA
peak (See also sheet 12)	I_{kp}	= max.	200	mA
Starter current				
positive average ($T_{av\ max.}$ = 5 s)	I_{st}	= max.	3	mA
peak	I_{stp}	= 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

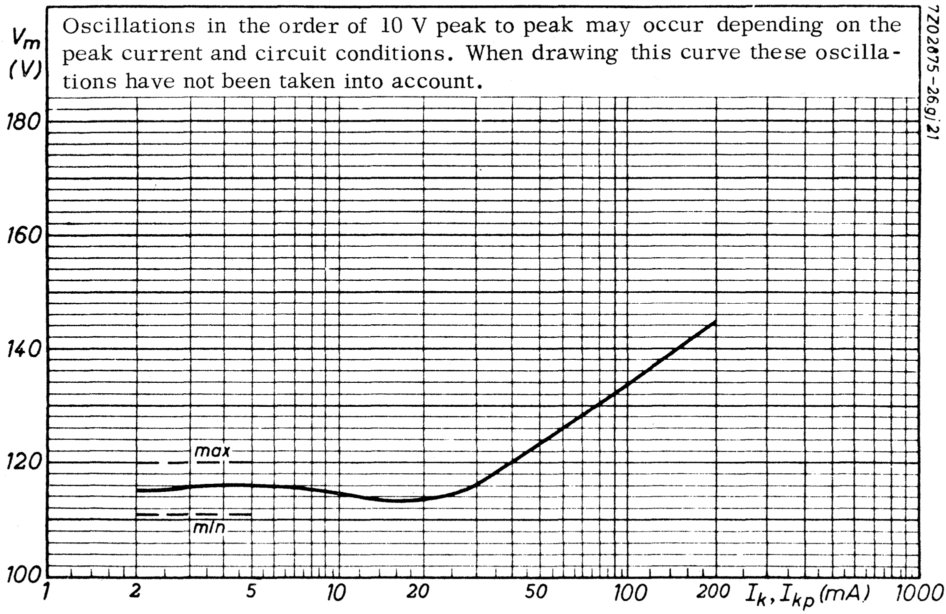
LIMITING VALUES (Absolute max. rating system) for reduced life expectancy (4000 operating hours)

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

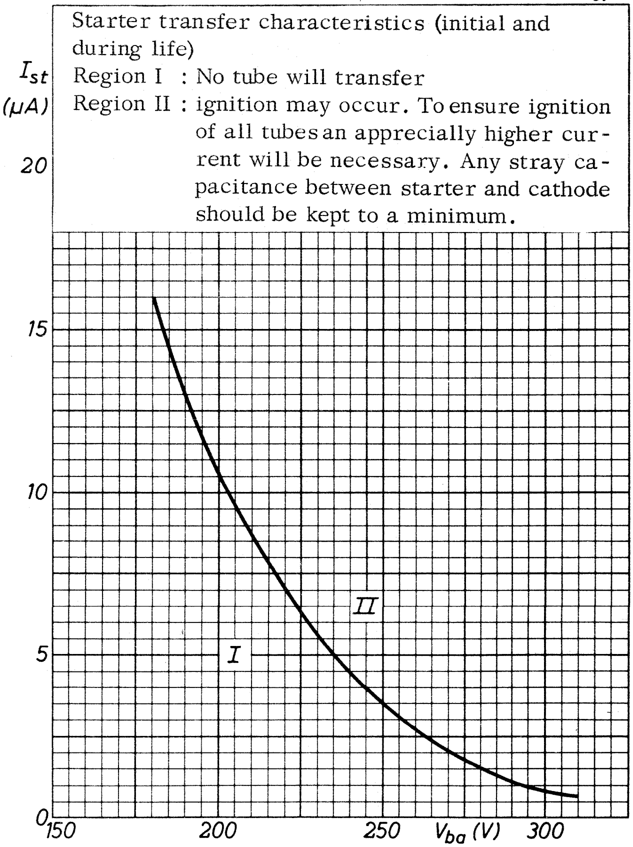
Cathode current				
d.c.	I_k	= max.	20	mA
half-wave rectified a.c., average	I_k	= max.	8	mA
peak ($T_{max.}$ = 20 ms)	I_{kp}	= max.	32	mA
Envelope temperature	t_{bulb}	= max.	200	°C [10]

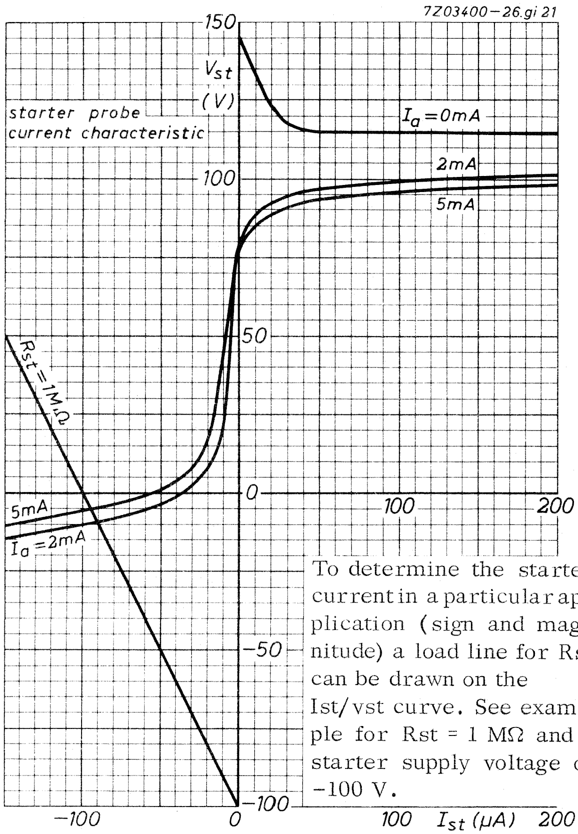

7Z03300-26.gj.21
D.C. Ignition
ΔV=starter overvoltage with respect to starter ignition voltage
+Vba
10MΩ
Rst=3.3MΩ
Vbst
Cst
ΔV (V)
Vba=300V
Vba=200V
Cst (pF)
0
1
2
3
4
10
20
50
100
200
500
1000


7Z02878-26.gj.21
Initial values
max
min
Vstign (V)
120
140
160
180
200
220
240
260
280
300
Vba(V)

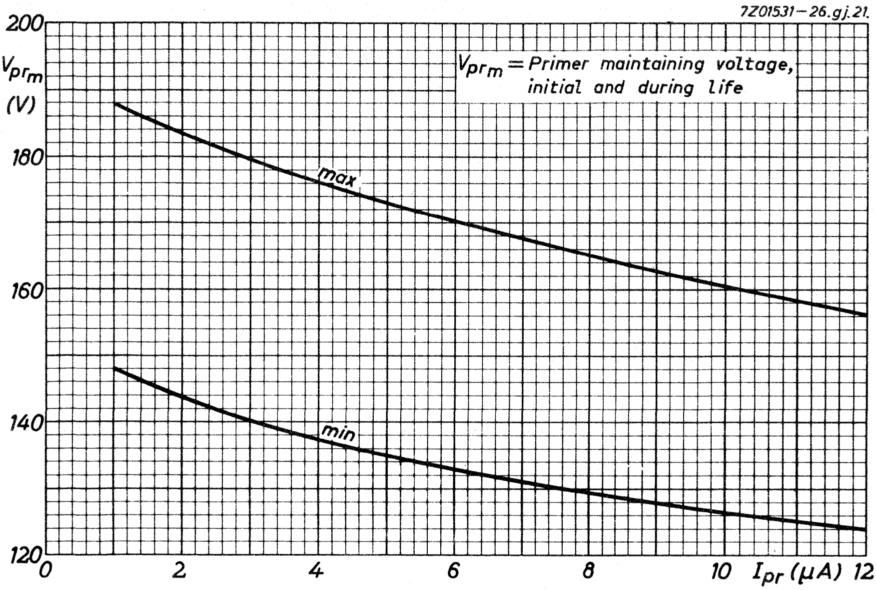

Oscillations in the order of 10 V peak to peak may occur depending on the peak current and circuit conditions. When drawing this curve these oscillations have not been taken into account.
V_m (V)
180
160
140
120
100
max
min
1
2
5
10
20
50
100
200
I_k, I_{kp} (mA)
1000
7Z02875-26.gj.21

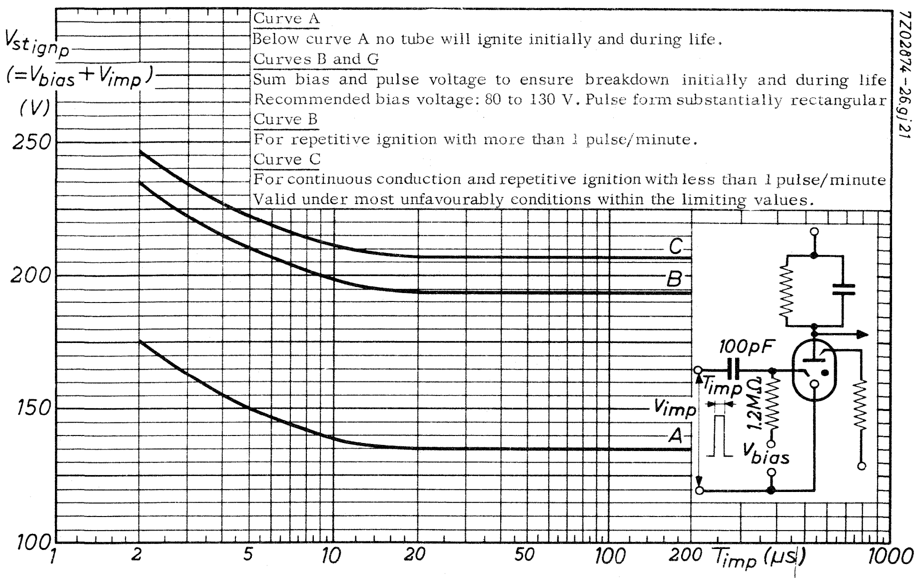
7Z02877-26.gj21

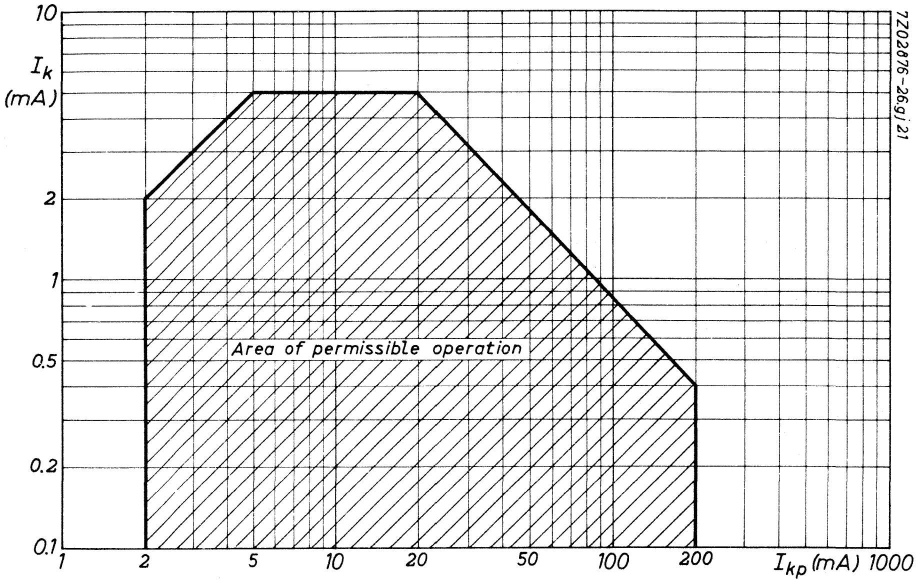




To determine the starter current in a particular application (sign and magnitude) a load line for Rst can be drawn on the Ist/vst curve. See example for Rst = 1 MΩ and a starter supply voltage of −100 V.


7Z01531–26.gj.21.
V_{prm} = Primer maintaining voltage, initial and during life
V_{prm} (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.
$V_{st\,ign_p}$
(= 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

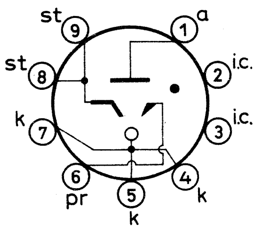
Gas-filled cold cathode trigger tube with electrical priming, and stable ignition characteristics, designed to be ignited only with positive voltages on the anode and starter intended for voltage control, sensitive relay applications, timers.

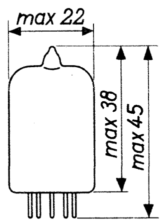
QUICK REFERENCE DATA			
Anode supply voltage	V_{ba}	240	V
Anode maintaining voltage	V_m	105	V
Max. average cathode current	I_k	40	mA
Starter to cathode ignition voltage	$V_{st\ ign}$	132	V
Starter transfer requirements			
capacitance	C_{st}	500	pF
current	I_{st}	45	μA

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Base: Noval





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.

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.

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)			2	ms
(see curve) (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 7	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.

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

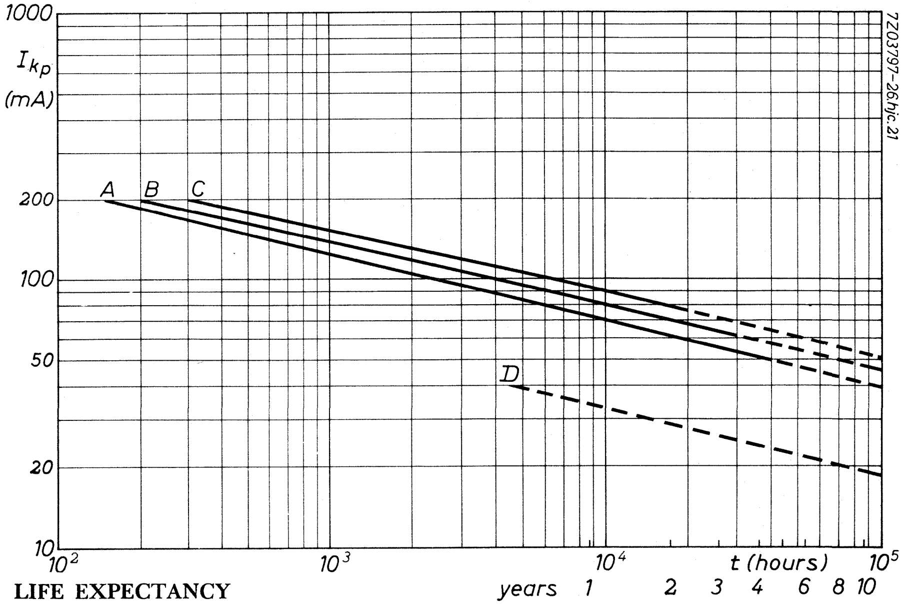
LIMITING VALUES (Absolute max. rating system)

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.

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 8 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.



LIFE EXPECTANCY

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

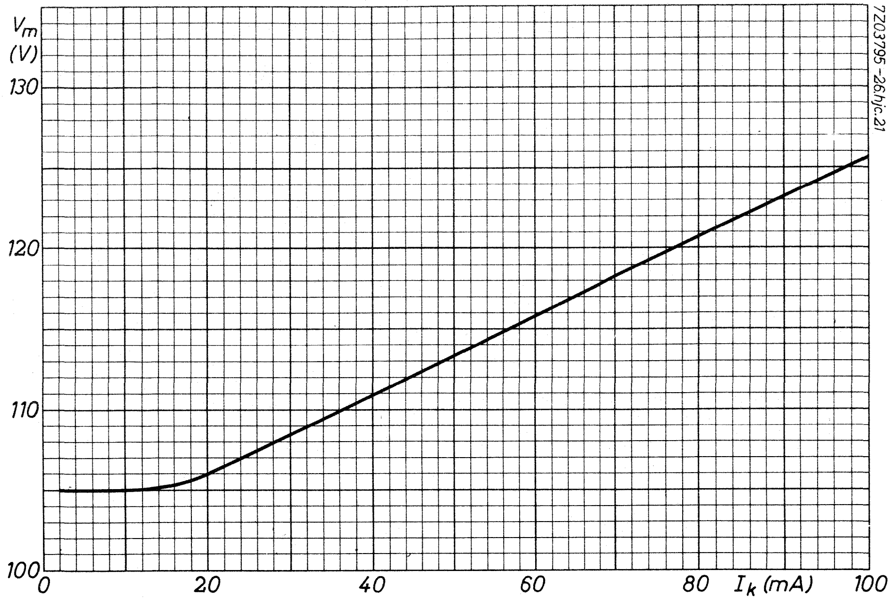
During periods of non-operation at room temperature the characteristics of the tube remain substantially constant. The total life expectancy in any given application is the sum of the non-operating periods and the operating life obtained from the curve.

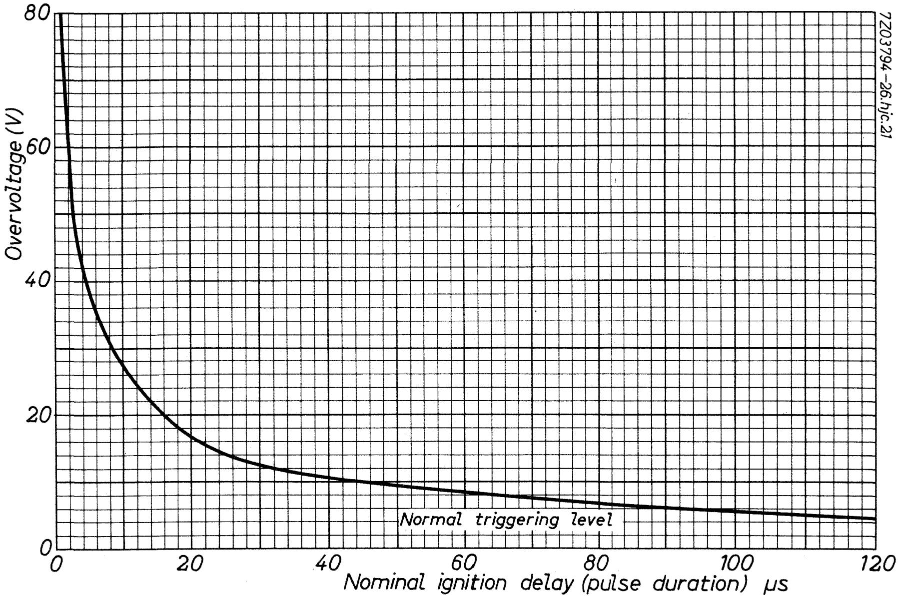
For a given value of cathode current, it is estimated that 80% of all tubes will remain within the end points concerned for longer than the time shown.

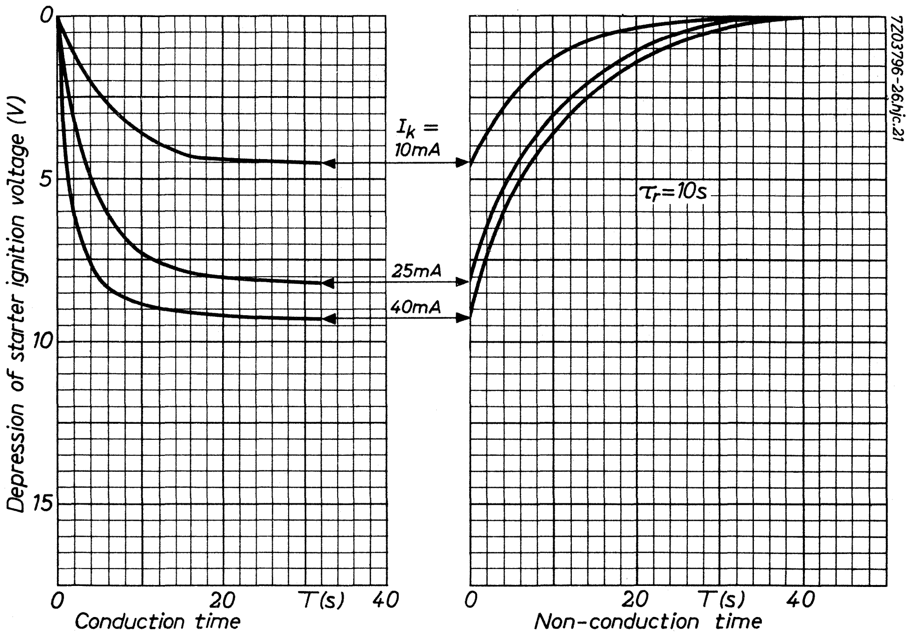
The time during which the starter ignition voltage will remain within $\pm 2\%$ of its original value, when the tube is operating continuously at room temperature from a half-wave rectified supply, is dependent on the peak cathode current passed. Curve A shows the relationship between the peak current 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.


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

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

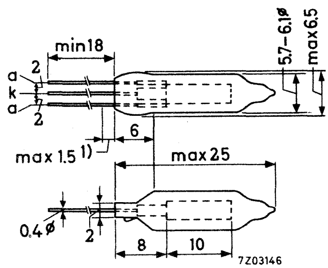
OPERATING PRINCIPLE

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.

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

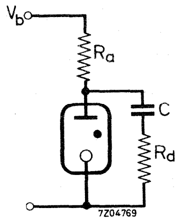
Conduction

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

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.

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.

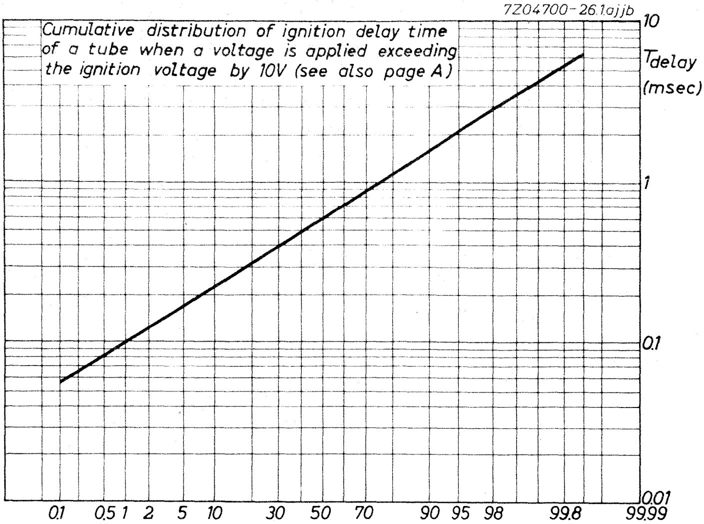
Shock resistance 500 g

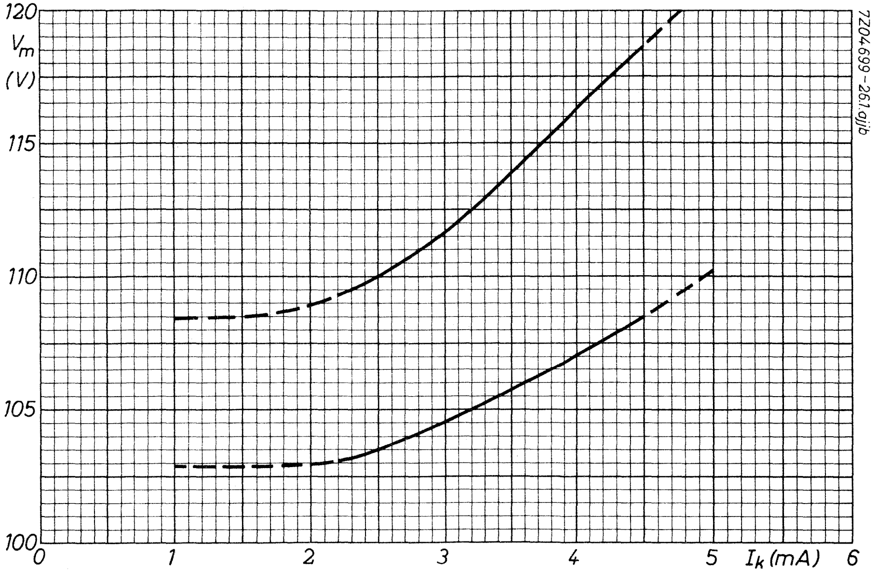
Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30° in each of 4 positions of the tube.

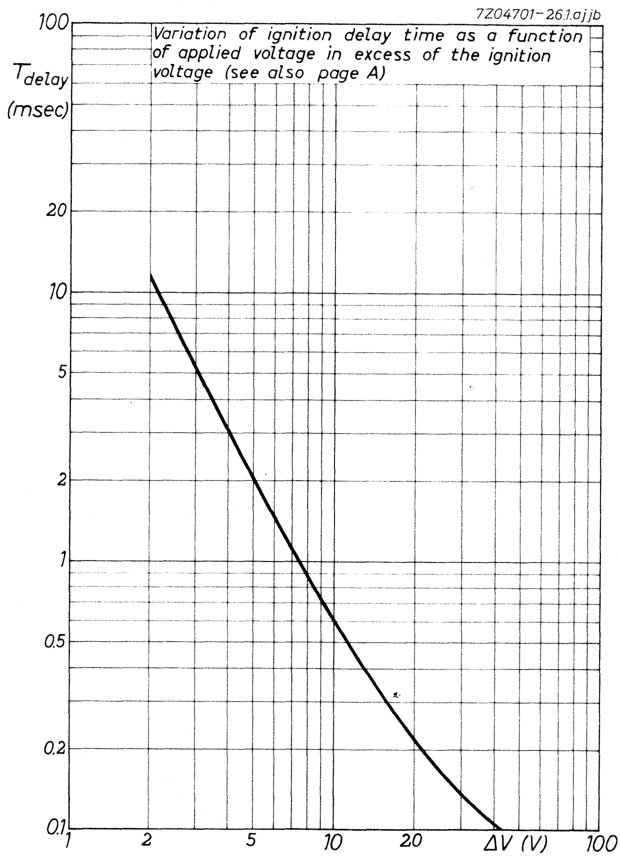
Vibration resistance 2.5 $g_{(peak)}$

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.


7Z04700-26.1ajjb
Cumulative distribution of ignition delay time of a tube when a voltage is applied exceeding the ignition voltage by 10V (see also page A)
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


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


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)
T_{delay} (msec)
100
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

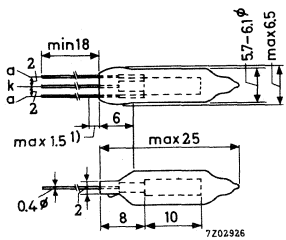
Indicator in low voltage transistor circuits. The diode can be used in combination with CdS photoconductive cells and it can be controlled by voltage signals down to 3 V.

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

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 15000 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.

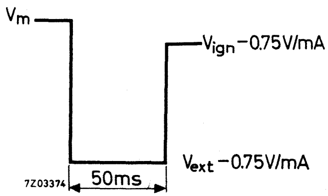
CHARACTERISTICS (continued)

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.

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	°C
		=	max.	70 °C + 10	°C/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.

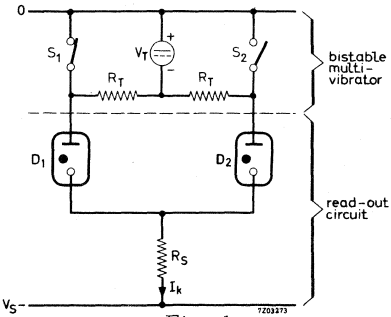


Fig. 1

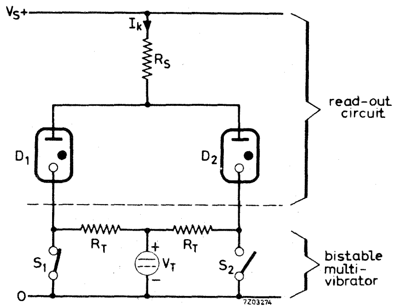


Fig. 2

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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).

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 $I_k > \frac{10 - V_T}{R_T + 2.5} \quad \frac{(V)}{(k\Omega)}$ 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 $I_k < \frac{V_T - 2.5}{5} \quad \frac{(V)}{(k\Omega)}$ 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 $I_k < \frac{V_T + 2}{5} \quad \frac{(V)}{(k\Omega)}$ 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.

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.

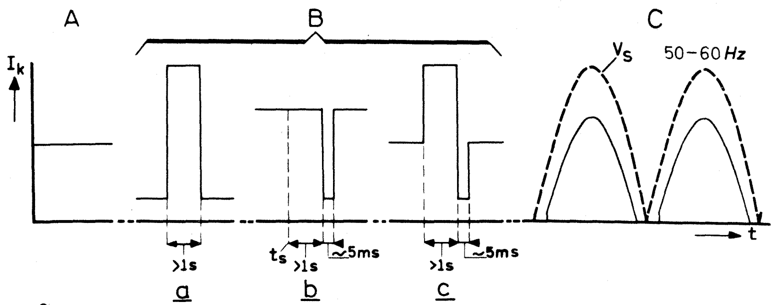


Fig. 3

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).

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 8, 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])

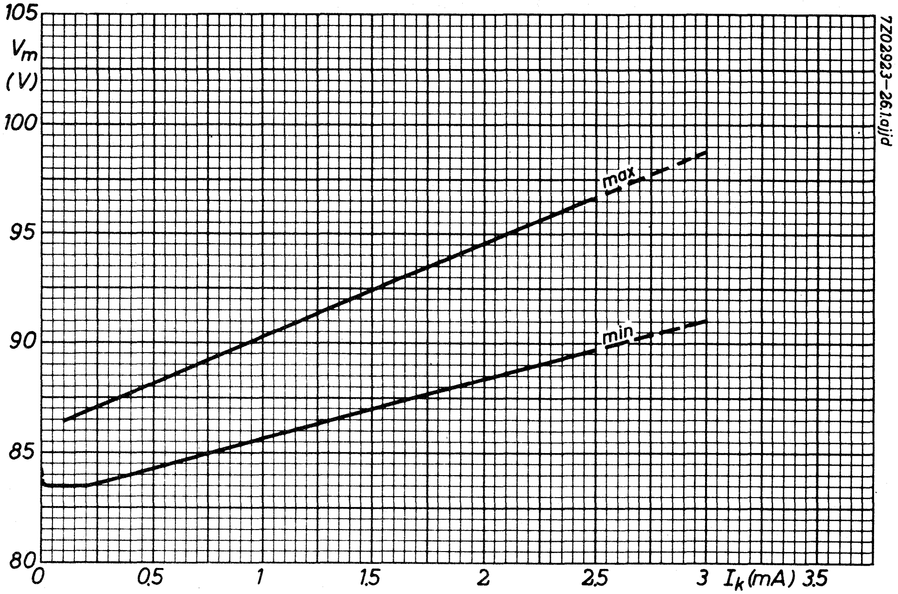
$$\frac{V_{S\,min} - V_{ign\,max}}{R_{S\,max}} = I_{kI} \qquad (1)$$

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

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

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.

[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).


105
V_m
(V)
100
95
90
85
80
max
min
0
0.5
1
1.5
2
2.5
3
I_k (mA)
3.5
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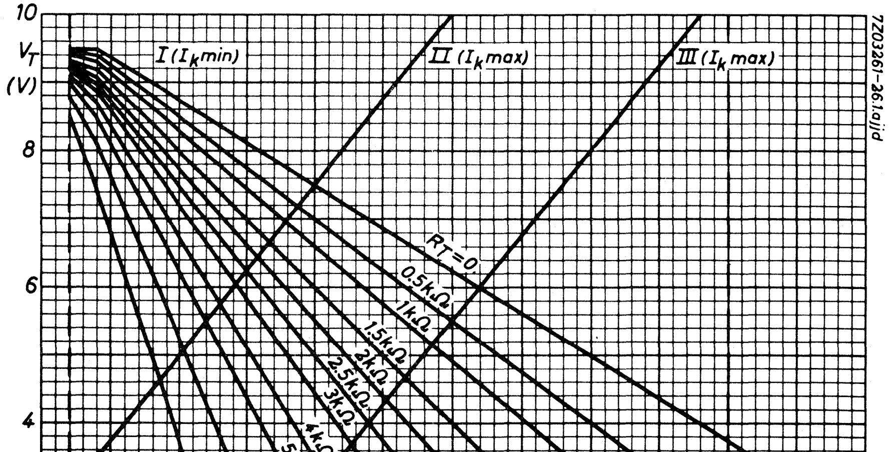

10
V_T
(V)
8
6
4
2
I (I_k min)
II (I_k max)
III (I_k max)
R_T=0
0.5kΩ
1kΩ
1.5kΩ
2kΩ
2.5kΩ
3kΩ
4kΩ
5kΩ
7kΩ
10kΩ
0
0.5
1
1.5
2
2.5
I_k (mA)
3
7Z03261-26.1.aj/d

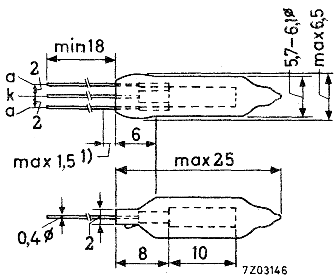
SWITCHING AND LIGHT DIODE

Long-life cold-cathode neon-filled subminiature switching and light diode with a large and stable difference between ignition and maintaining voltage intended for touch control applications e.g. in variable capacitance diode controlled radio or television tuners. The tube is shock and vibration resistant.

QUICK REFERENCE DATA			
Ignition voltage	V_{ign}	172	V
Maintaining voltage	V_m	107	V
Cathode current	I_k	3	mA

DIMENSIONS AND CONNECTIONS

Dimensions in mm



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 using 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 closer than 1,5 mm to the seals.

1) This part of the leads is not tinned.

CHARACTERISTICS AND OPERATING CONDITIONS

Valid over life and full temperature range unless otherwise stated.
The electrical characteristics are independent of ambient illumination.

Non conduction

Anode voltage below which ignition will not occur	$V_{ign_{min.}}$		161	V
Insulation resistance	r_{ins}	>	300	MΩ

Ignition

Anode voltage to ensure ignition	$V_{ign_{max.}}$		183	V
Ignition delay at V_{ign} + 10 V	T_{delay}	<	50	ms
at V_{ign} + 20 V	T_{delay}	<	20	ms
Typical max. individual variation of ignition voltage during life, within the V_{ign} limits given above	ΔV_{ign}	<	5	V

Conduction

Cathode current, average during any conduction period	I_k	>	2, 2	mA
average (T_{av} = max. 1 s)	I_k	<	4, 5	mA
Maintaining voltage at I_k = 3 mA	V_m	≥	103	V
		≤	111	V
Typical max. individual variation of maintaining voltage during life, within the V_m limits given above	ΔV_m	<	+2	V
			−4	V

Extinction

Extinction voltage	V_{ext}	>	100	V

LIMITING VALUES (Absolute max. rating system)

Cathode current, average for continuous conduction	I_k	min.	2,2	mA
average (T_{av} = max. 1 s)	I_k	max.	4,5	mA
Anode voltage, negative peak	$-V_{a_p}$	max.	200	V
Bulb temperature	t_{bulb}	min.	−55	^{o}C
		max.	+70	^{o}C

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 NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 30^{o} 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.

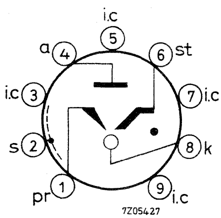
TRIGGER TUBE

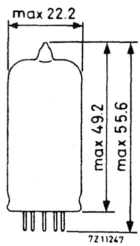
Gas filled cold cathode trigger tube with molybdenum cathode and electrical priming. The tube has been designed to be ignited with positive voltages on starter and anode only and can be fed from a.c. or d.c. anode voltages.

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		$V_{st\text{-}ign}$	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.

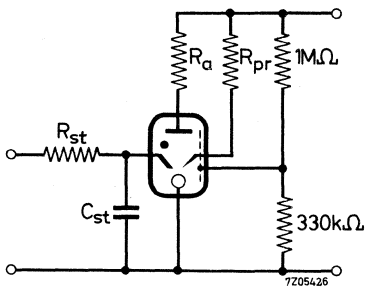
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

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



CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

(continued)

D.C. OPERATION

Anode voltage	V_a	min. 250 max. 350	V V
Starter ignition voltage	$V_{st\text{-}ign}$	min. 120 max. 140	V 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 max. 115	V 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 V_s	min. 45 max. 75	V_{RMS} V_{RMS}
Temperature	t_{bulb} t_{bulb}	min. -55 max. +70	^{o}C $^{o}C + 2\ ^{o}C/mA$

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.

TRIGGER TUBE

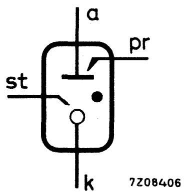
Ruggedized cold cathode trigger tube with pure molybdenum electrodes and very high light output for use in e.g., shift registers for running-text displays and in touch contact circuits.

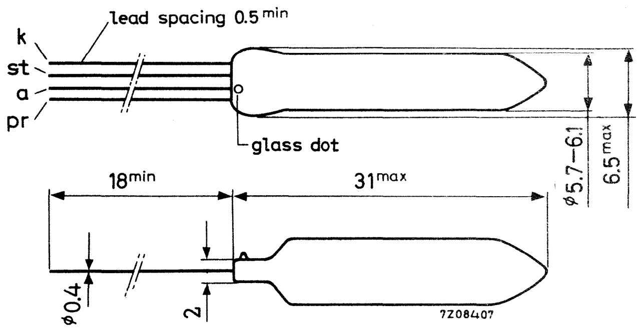
QUICK REFERENCE DATA				
Anode supply voltage	V_{ba}		300	V
Anode maintaining voltage	V_{ma}		133	V
Cathode current	I_k		2	mA
Starter to cathode voltage to ensure ignition	$V_{st_{ign}}$	min.	200	V
Light output	approx.		0.3	lm

DIMENSIONS AND CONNECTIONS

Dimensions in mm

Glass dot indicates anode lead





1. Soldered connections to the leads must be at least 5 mm from the glass and any bending of the leads must be done at least 1.5 mm from the glass.
2. During soldering 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 not less than 5 mm from the glass at a solder temperature of 240 °C during maximum 10 s.
4. The primer and starter circuit resistors and capacitors should be mounted close to the tube.
5. The tube should not be mounted close to conductors or components which give rise to strong electrical fields.

CHARACTERISTICS AND OPERATING CONDITIONS

Valid over life and full temperature range unless otherwise stated.
At the presence of a priming discharge the tube characteristics are independent of ambient light.

PRIMING CONDITIONS

Anode to primer supply voltage	$V_{ba\text{-}pr}$	> 265	V
Typical max. ignition delay (at an ambient light of min. 25 lx)		0.3	s
Anode to primer maintaining voltage at 20 μA	$V_{ma\text{-}pr}$	132	V
Primer current	I_{pr}	7.5 to 30	μA

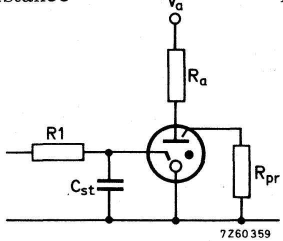
STAND-BY (main gap non-conducting)

Anode to cathode voltage,			
positive	V_a	< 350	V
negative	$-V_a$	< 100	V
Anode to starter voltage,			
positive	$V_{a\text{-}st}$	< 350	V
negative	$-V_{a\text{-}st}$	< 100	V
Starter to cathode voltage to ensure non-ignition,			
positive	V_{st}	< 160	V
negative	$-V_{st}$	< 100	V
Primer current	I_{pr}	< 30	μA

IGNITION REQUIREMENTS

a. D.C. triggering

Anode to cathode voltage	V_a	> 265	V
Starter to cathode voltage to ensure ignition	$V_{st_{ign}}$	> 200	V
Starter to cathode capacitor to ensure transfer	C_{st}	> 1.5	nF
Starter circuit charging resistance	R_1	> 0.5	MΩ



D.C. triggering

b. Bias + pulse triggering

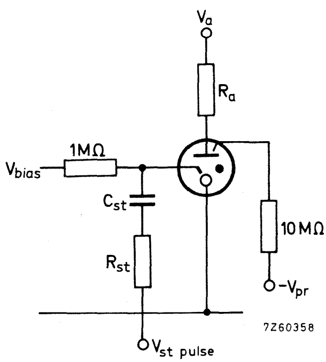
Anode to cathode voltage	V_a	> 265	> 220	V
Starter coupling capacitor	C_{st}	> 1	> 1	nF
Starter to cathode voltage	V_{st}	> 200	> 220	V
Starter series resistance				
at C_{st} = 1 nF	R_{st}	< 3.3		kΩ
at C_{st} = 1.5 nF	R_{st}	< 10		kΩ
Pulse duration	T_p	> 40		μs

MAIN GAP CONDUCTING

Anode maintaining voltage	V_{ma}	see page 4	
Cathode current range	I_k	1 to 3	mA

EXTINCTION REQUIREMENTS

Anode to cathode voltage at I_a = 3 mA	V_a	see page 7
Anode to starter coltage at I_a = 3 mA	V_{a-st}	see page 7



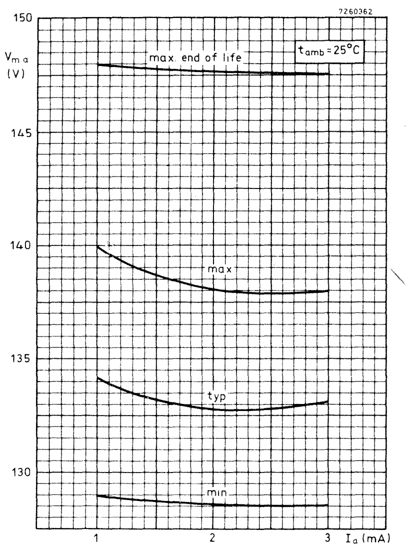
Bias + pulse triggering

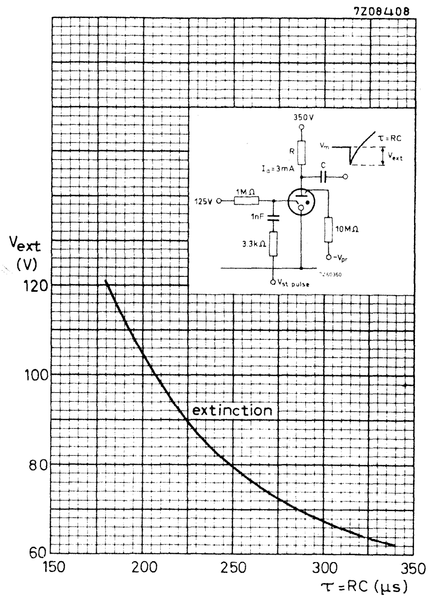
1) To avoid spurious ignition the rate of rise of applied anode voltage shall have a minimum time constant as given on page 7.

LIMITING VALUES (Absolute max. rating system)

Anode to cathode voltage, negative	$-V_a$	max.	100 V
Starter to cathode voltage, negative	$-V_{st}$	max.	100 V
Cathode current			
average during any conduction period	I_k	min.	1 mA
average (T_{av} = max. 20 ms)	I_k	max.	3 mA
peak	I_{kp}	max.	10 mA
Envelope temperature	t_{bulb}	max.	70 ^oC
	t_{bulb}	min.	−55 ^oC
Altitude	h	max.	20 km

WAVELENGTH OF RADIATED LIGHT 580 to 700 nm





Thyratrons

GENERAL OPERATIONAL RECOMMENDATIONS
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 $90^{\circ} \pm 30^{\circ}$ between V_a and V_f is recommended.

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 $-55\ ^{o}C$ and maxima $+75\ ^{o}C$.

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 $^{\circ}C$ 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.

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.

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.

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}).

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.

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

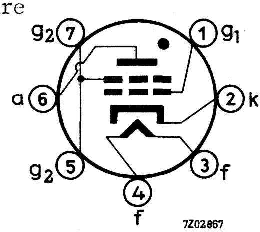
Grid No.1 to all other elements	C_{g_1}	=	2.4	pF
Anode to all other elements	C_a	=	1.6	pF
Anode to grid No.1	C_{ag_1}	=	26	mpF

MECHANICAL DATA

Dimensions in mm

Base: 7 pin miniature

Net weight: 10 g



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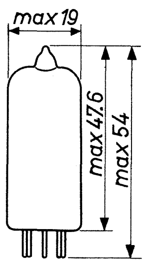

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Mounting position: any

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

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°.

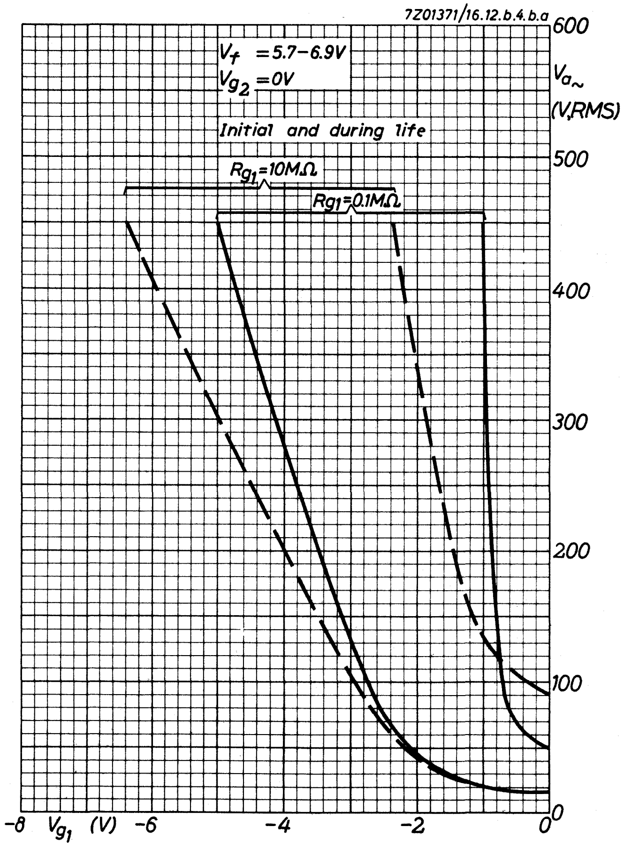
LIMITING VALUES for relay- and grid controlled service
(Absolute max. rating system)

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.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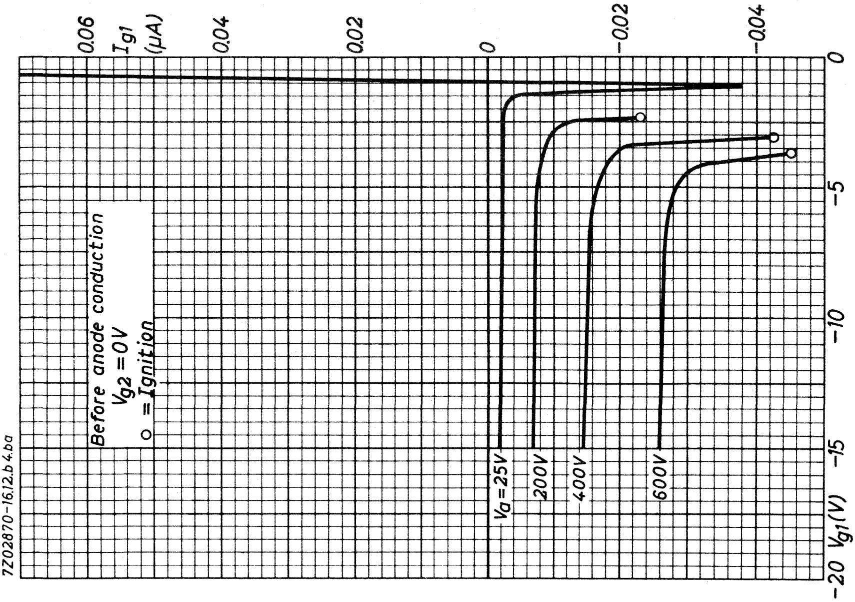
V_f = 5.7–6.9V
V_{g_2} = 0V
Initial and during life
R_{g1}=10MΩ
R_{g1}=0.1MΩ
600
$V_{a\sim}$
(V,RMS)
500
400
300
200
100
0
−8
V_{g_1} (V)
−6
−4
−2
0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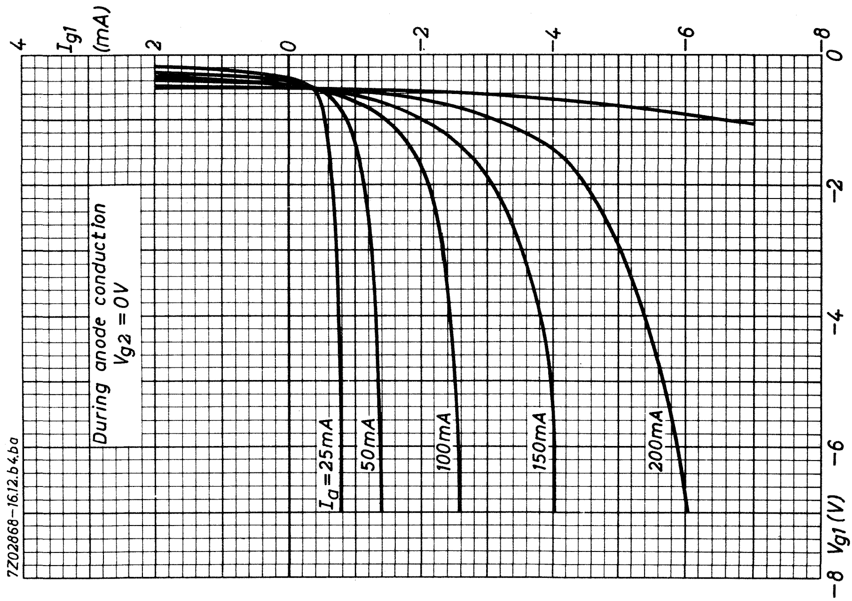
Before anode conduction
$V_{g2} = 0V$
○ = Ignition
I_{g1} (µA)
0.06
0.04
0.02
0
-0.02
-0.04
0
-5
-10
-15
-20
V_{g1} (V)
$V_a = 25V$
200V
400V
600V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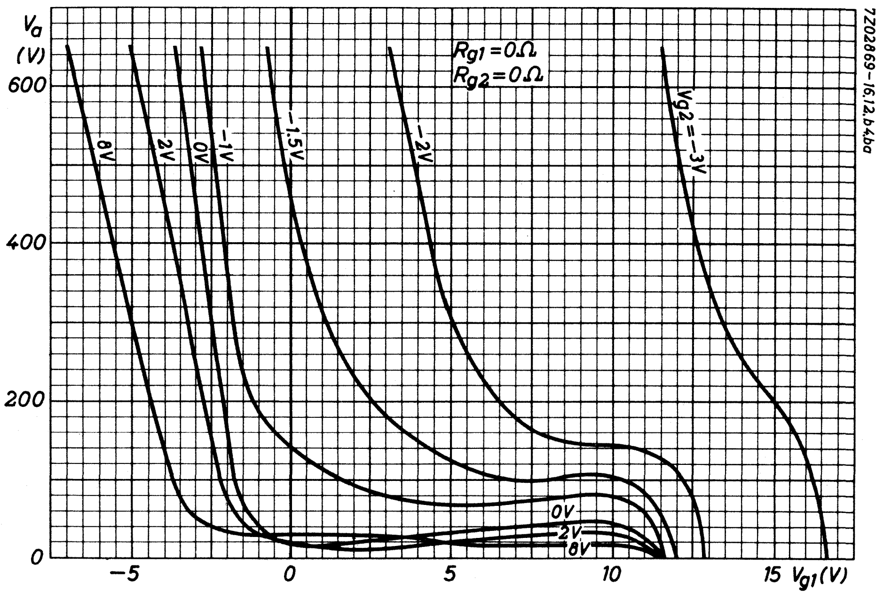
During anode conduction
$V_{g2} = 0V$
I_{g1} (mA)
4
2
0
-2
-4
-6
-8
0
-2
-4
-6
-8
V_{g1} (V)
$I_a = 25mA$
50mA
100mA
150mA
200mA



V_a (V)
600
400
200
0
−5
0
5
10
15 V_{g1}(V)
R_{g1} = 0Ω
R_{g2} = 0Ω
8V
2V
0V
−1V
−1.5V
−2V
V_{g2} = −3V
0V
2V
8V
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TRIODE THYRATRONS

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

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

HEATING: direct

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

CAPACITANCE

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

TYPICAL CHARACTERISTICS

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

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.

MECHANICAL DATA

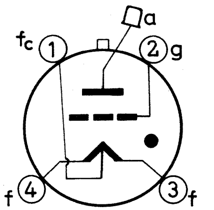
Dimensions in mm

Base : Medium 4p with bayonet

Socket : 2422 511 90003

Cap : 40619

Net weight: 90 g



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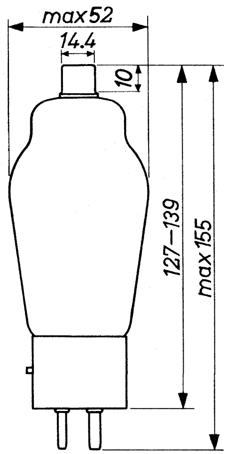


Mounting position: Vertical with base down

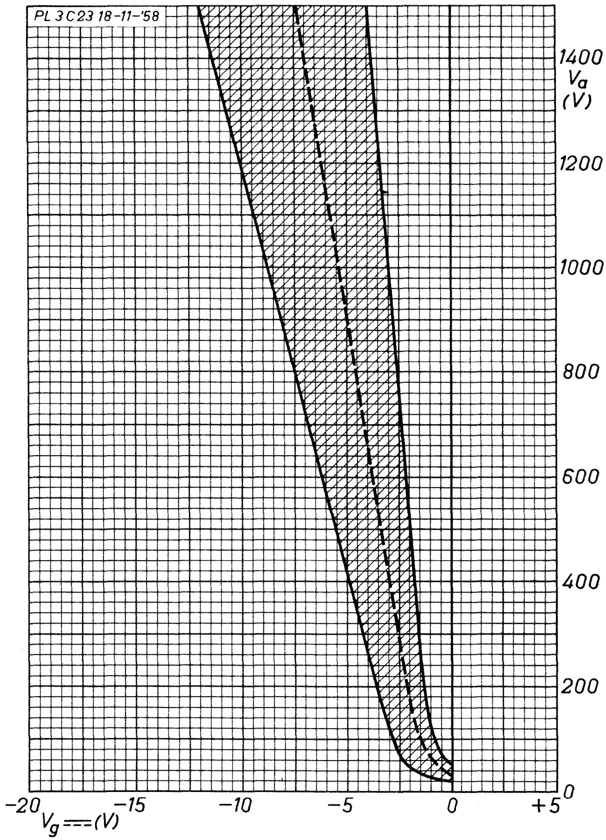
LIMITING VALUES (Absolute limits)

Peak forward anode voltage	V_{ap}	=	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	s)
Peak grid current	I_{gp}	=	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	s)
Peak cathode current	I_{kp}	=	max. 6.4	A
Surge cathode current	I_{surge}	=	max. 120	A
(Duration	T	=	max. 0.1	s)
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


PL 3C23 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.

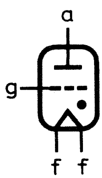
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	400	V
peak inverse	V_{ainvp}	max.	400	V
Anode current, average (T_{av} max. 10 s)	I_a	max.	100	mA
peak	I_{ap}	max.	4	A

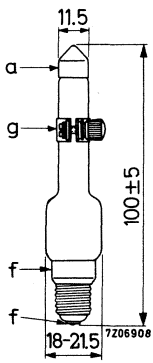
HEATING: direct

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

TYPICAL CHARACTERISTICS

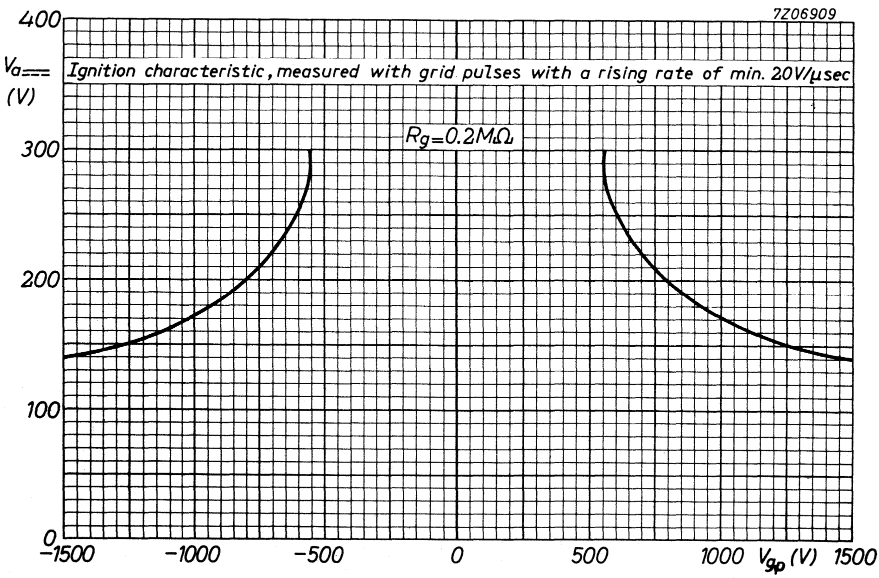
Arc voltage at I_a 0.1 A to 0.4 A	V_{arc}	20 to 35 V

LIMITING VALUES (Absolute max. rating system)

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

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.



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 furnaces, incandescent lamps and discharge lamps; for resistance welding up to 27 kVA.

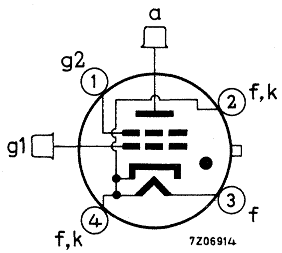
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	2500	V
peak inverse	V_{inv_p}	max.	2500	V
Anode current, average (T_{av} = max. 15 s)	I_a	max.	6.4	A
peak ($f \geq 25$ Hz)	I_{ap}	max.	40	A

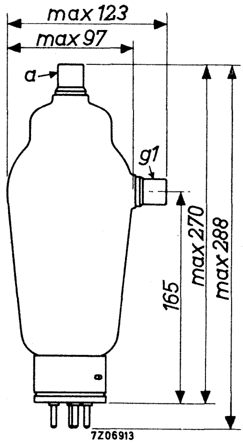
HEATING: indirect

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

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

Intermittent service

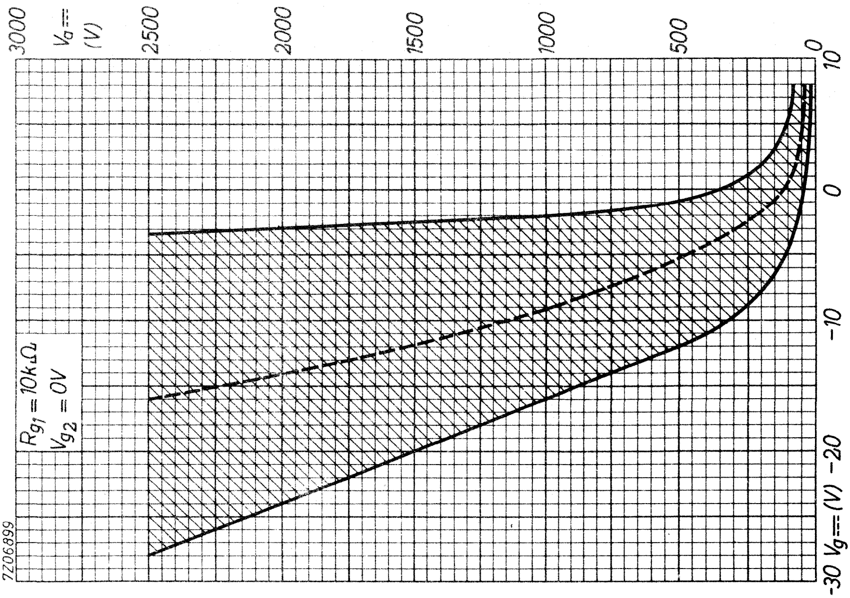
LIMITING VALUES (Absolute max. rating system)

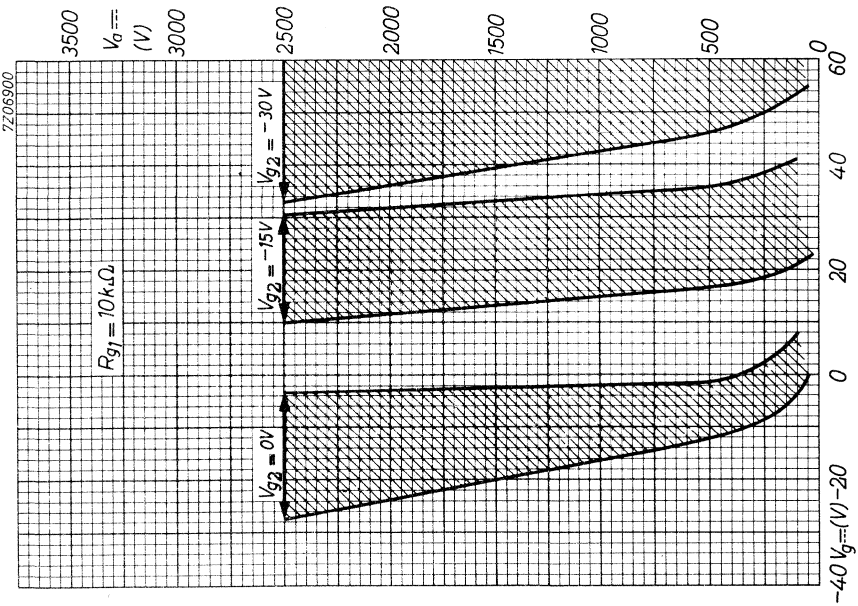
Anode voltage, peak forward	V_{ap}	max.	750	V
peak inverse	V_{invp}	max.	750	V
Grid No. 2 voltage	$-V_{g_2}$	max.	500	V
tube conducting	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage	$-V_{g_1}$	max.	1000	V
tube conducting	$-V_{g_1}$	max.	10	V
Anode current, peak ($f < 25$ Hz)	I_{ap}	max.	5.0	A
($f \geq 25$ Hz)	I_{ap}	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_{g2p}	max.	2.0	A
average (T_{av} = max. 5 s)	I_{g_2}	max.	0.5	A
Grid No. 1 current, peak	I_{g1p}	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

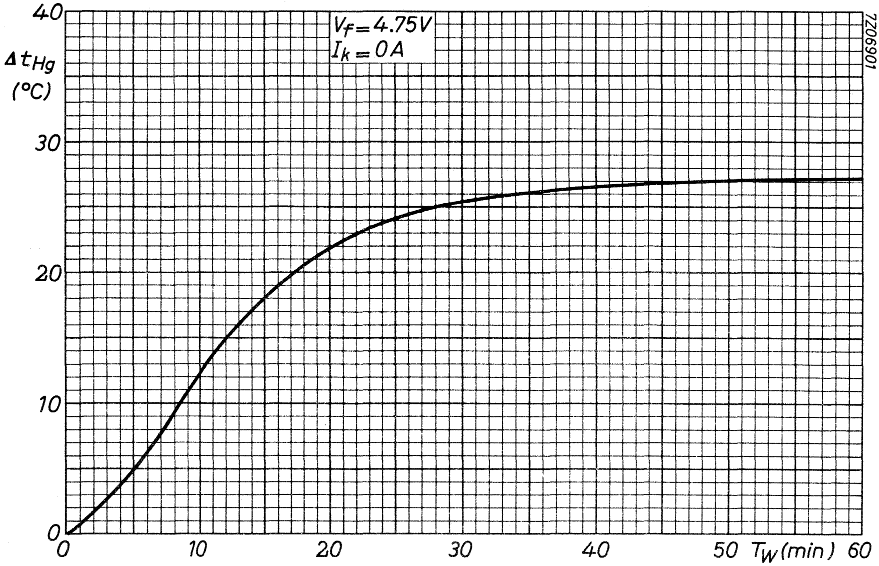
Continuous service

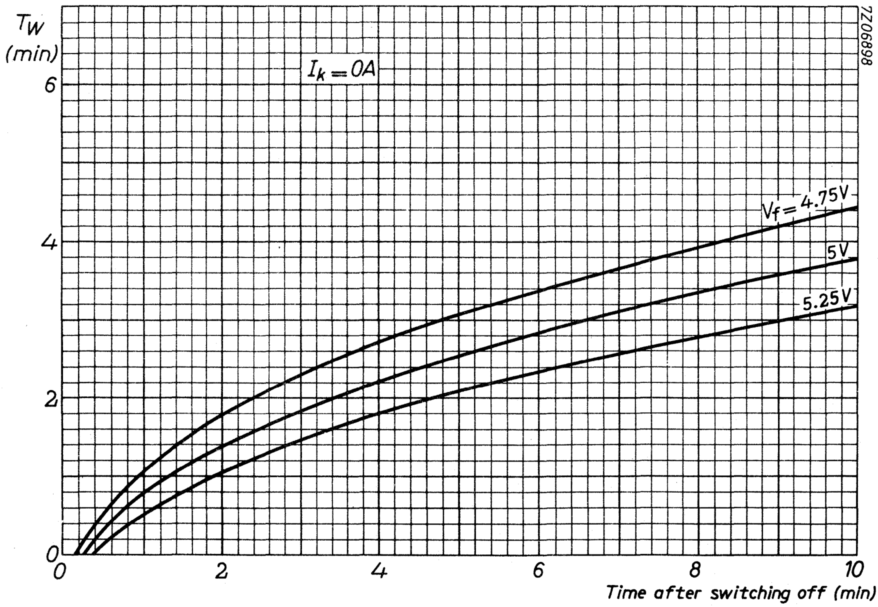
LIMITING VALUES (Absolute max. rating system)

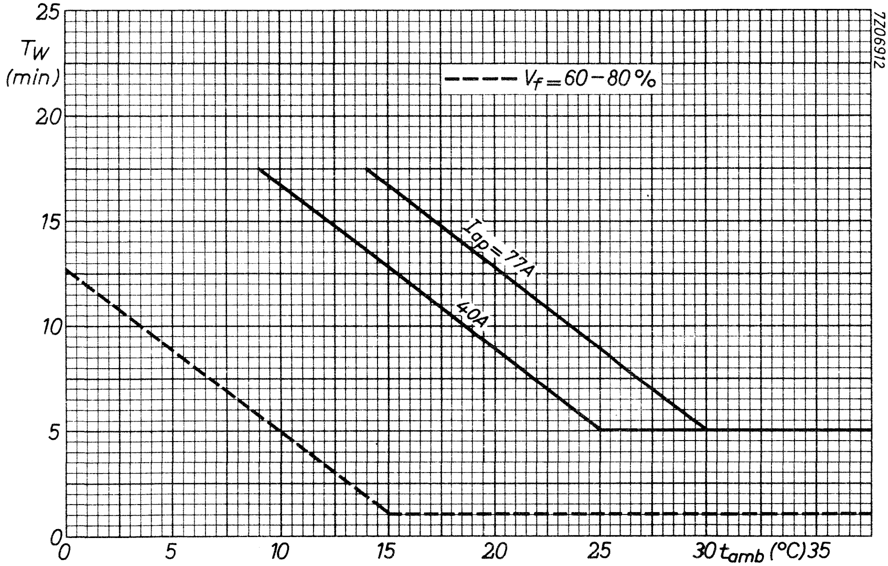
Anode voltage, peak forward	V_{a_p}	max.	2500	V
peak inverse	V_{inv_p}	max.	2500	V
Grid No. 2 voltage	$-V_{g_2}$	max.	500	V
tube conducting	$-V_{g_2}$	max.	10	V
Grid No. 1 voltage	$-V_{g_1}$	max.	1000	V
tube conducting	$-V_{g_1}$	max.	10	V
Anode current, peak ($f < 25$ Hz)	I_{a_p}	max.	12.8	A
($f \geq 25$ 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	^{o}C
recommended value	t_{Hg}		60	^{o}C


7206899
$R_{g1} = 10\,k\Omega$
$V_{g2} = 0\,V$
V_a (V)
3000
2500
2000
1500
1000
500
0
10
0
−10
−20
−30 V_g (V)


7206900
$R_{g1} = 10\,k\Omega$
$V_{g2} = -30\,V$
$V_{g2} = -15\,V$
$V_{g2} = 0\,V$
V_a (V)
3500
3000
2500
2000
1500
1000
500
0
60
40
20
0
−20
−40 V_g (V)


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


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


7Z06912
T_W (min)
25
20
15
10
5
0
$V_f = 60-80\%$
$I_{ap} = 77A$
40A
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.

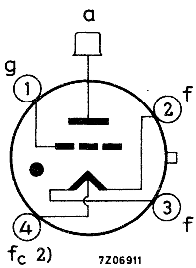
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	2000	V
peak inverse	V_{invp}	max.	2000	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	6.4	A
peak	I_{kp}	max.	80	A

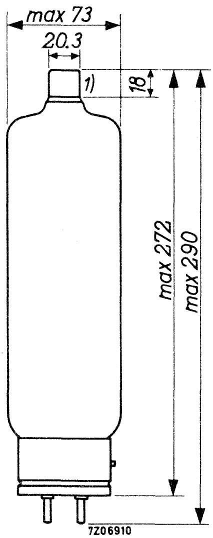
HEATING: direct

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.

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_{a_p}	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	^{o}C
Ambient temperature	t_{amb}	min.	-40	^{o}C
		max.	+50	^{o}C
Anode fuse		max.	20	A
recommended value			15	A

THYRATRON

Mercury-vapour triode thyratron intended for use in motor control equipment and resistance welding equipment.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	1500	V
peak inverse	V_{invp}	max.	2500	V
Cathode current, average (T_{av} = max. 10 s)	I_k	max.	10	A
peak	I_{kp}	max.	100	A

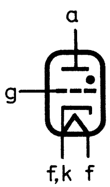
HEATING: indirect

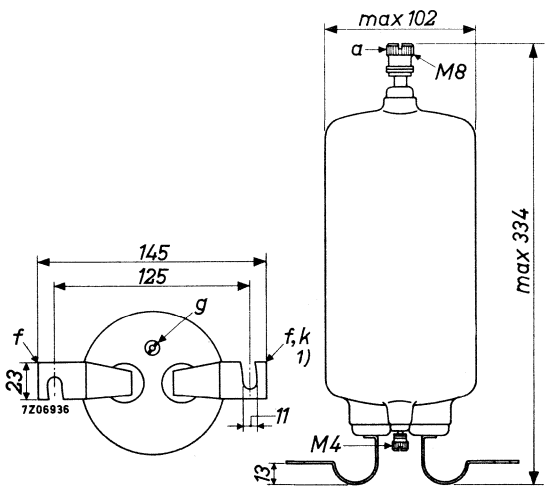
Heater voltage	V_f		5.0	V
Heater current	I_f		11	A
	I_f	max.	13	A
Waiting time (See also page 4)	T_w	min.	10	min

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.

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_{a_p}	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

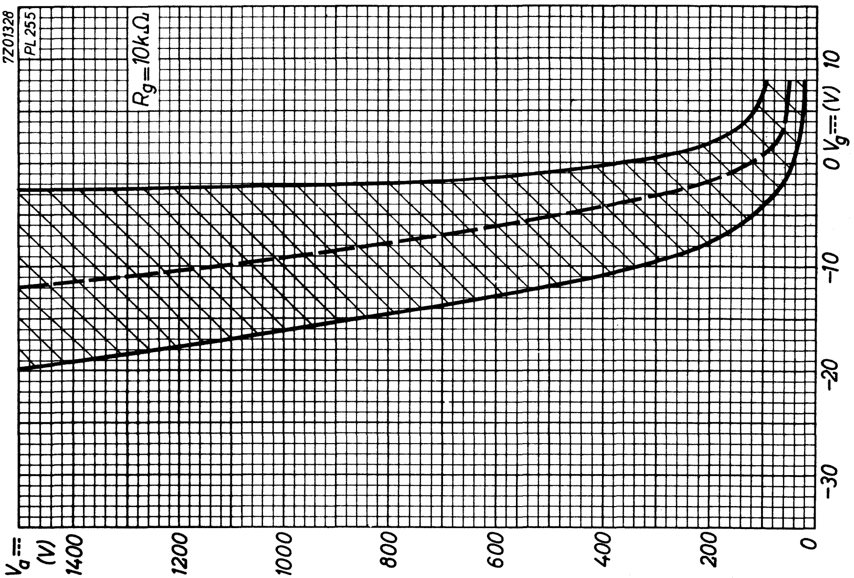
[1]) Overload during max. 5 s in each 5 minutes operation period.
[2]) Max. 1 cycle.

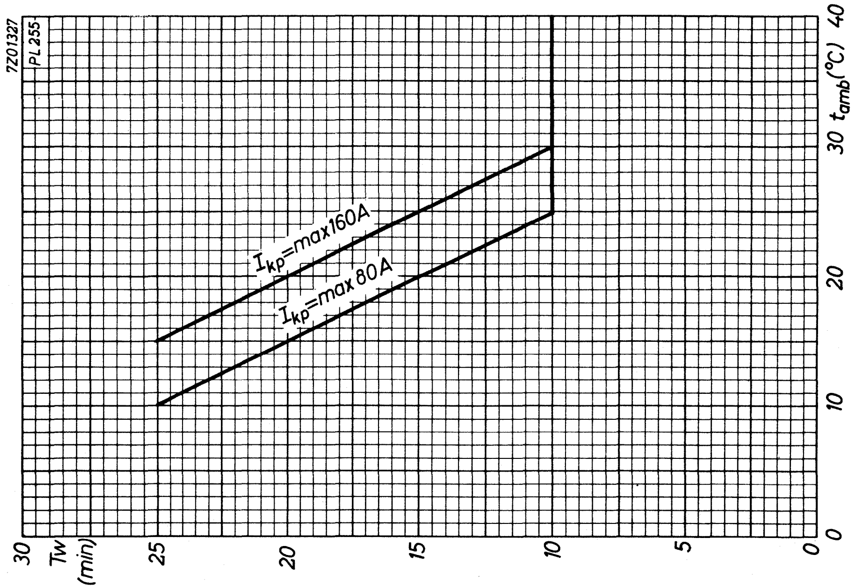
A.C. control and welding control

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


7Z01328
PL 255
Rg=10kΩ
Vg (V)
10
0
−10
−20
−30
Va (V)
1400
1200
1000
800
600
400
200
0


7Z01327
PL 255
Ikp=max160A
Ikp=max 80A
tamb(°C)
40
30
20
10
0
Tw (min)
30
25
20
15
10
5
0

THYRATRON

Mercury-vapour triode thyratron intended for use in motor control equipment, relay service and other industrial applications.

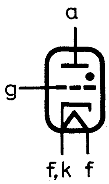
QUICK REFERENCE DATA				
Continuous service				
Anode voltage, peak forward	V_{ap}	max.	2000	V
peak inverse	V_{invp}	max.	2500	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	60	A
peak	I_{kp}	max.	200	A

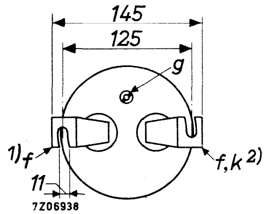
HEATING: indirect

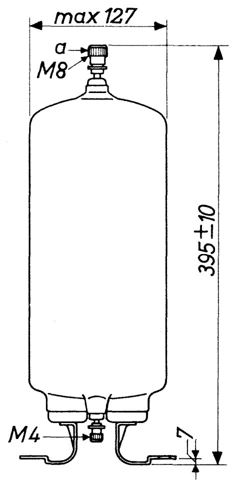
Heater voltage	V_f		5	V
Heater current	I_f		19	A
	I_f	max.	21	A
Waiting time (See also page 6)	T_w	min.	10	min

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

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.

Continuous service (continued)

LIMITING VALUES (Absolute max. rating system)

Anode fuse		max.			80		A
recommended value					60		A
Cathode current, peak	I_{kp}	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])	^{o}C
		min.	35	35	40	[2])	^{o}C
recommended value	t_{Hg}		60	60	60		^{o}C

A.C. control and welding control

Two tubes in inverse parallel

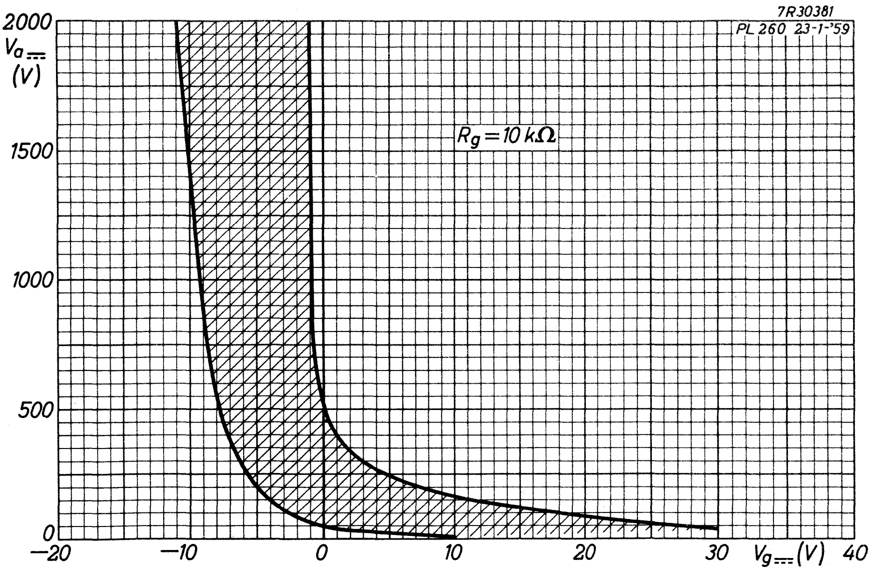
LIMITING VALUES (Absolute max. rating system)

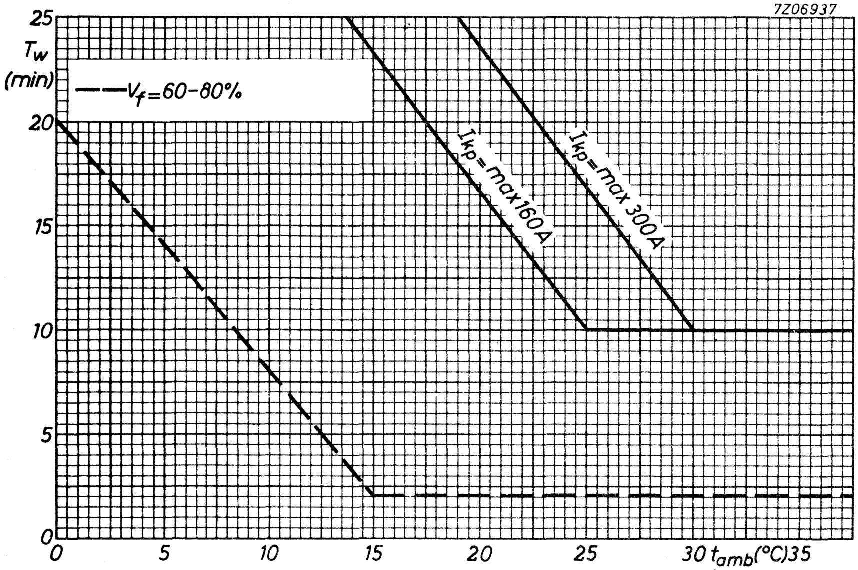
Frequency	f	max.			150	Hz
Anode voltage, peak forward	V_{ap}	max.			750	V
peak inverse	V_{inv_p}	max.			750	V
Grid voltage, before conduction	$-V_g$	max.			300	V
during conduction	$-V_g$	max.			10	V
Surge current, (T = max. 0.1 s)	I_{surge}	max.			2500	A
Grid current (V_a pos.)	I_g	max.			0.25	A [1])
Grid resistor	R_g	max.			20	kΩ
recommended value	R_g				10	kΩ
Mercury temperature	t_{Hg}	max.			80	^{o}C
		min.			40	^{o}C
recommended value	t_{Hg}				60	^{o}C
Duty factor	δ		0.1	0.5	1	
Cathode current, peak	I_{kp}	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

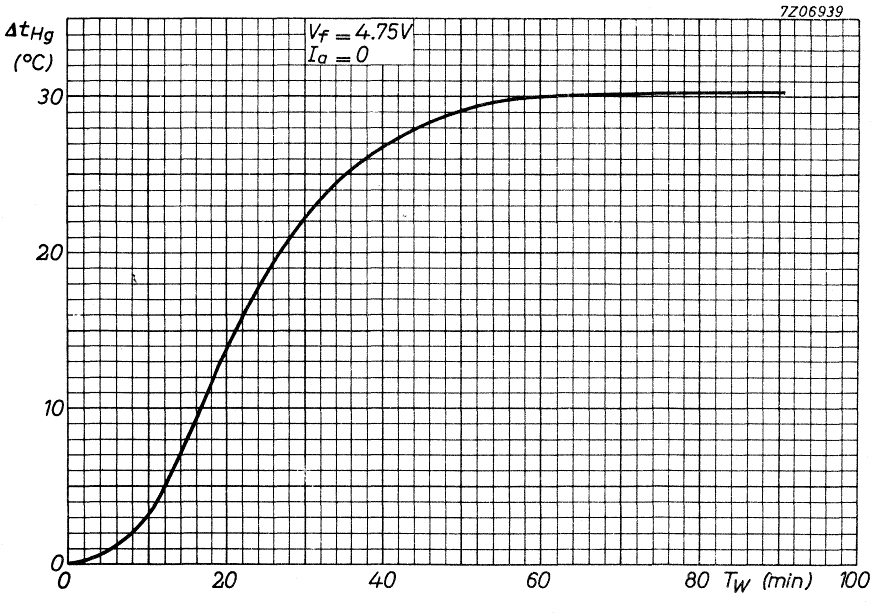
[1]) See page 4.

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.


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
25
T_w
(min)
V_f=60-80%
20
15
10
5
0
0
5
10
15
20
25
30 t_{amb}(°C)35
I_{kp}=max160A
I_{kp}=max 300A


7Z06939
Δt_{Hg}
(°C)
V_f = 4.75V
I_a = 0
30
20
10
0
0
20
40
60
80 T_W (min)
100

THYRATRON

Xenon-filled tetrode intended for use in electronic timers, in grid-controlled rectifiers with variable or constant output voltage.

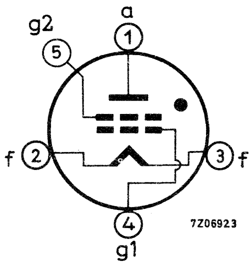
QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{ap}	max.	650	V
peak inverse	V_{invp}	max.	650	V
Anode current, average (T_{av} = max. 5 s)	I_a	max.	0.5	A
peak (f ≥ 25 Hz)	I_{ap}	max.	2	A

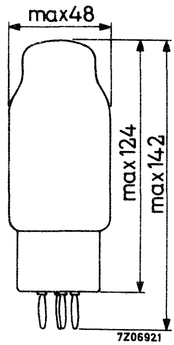
HEATING: direct

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	2422 512 02001
Net weight	75 g	

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	^{o}C
		min.	−75	^{o}C

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

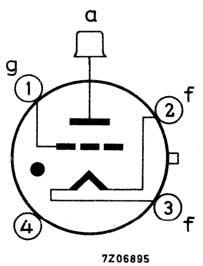
HEATING: direct

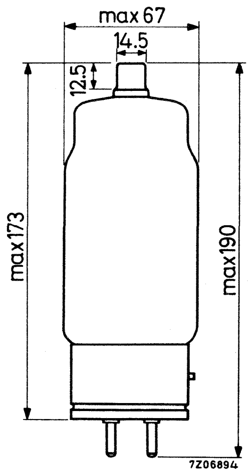
Filament voltage	V_f	2.5	V ± 5%
Filament current	I_f	12	A
Waiting time	T_w	min. 60	s

MECHANICAL DATA

Dimensions in mm

Base: Super Jumbo with bayonet





Mounting position: Arbitrary between horizontal and vertical with base down

Accessories

Socket	2422 511 01001
Cap connector	40619
Net weight	300 g

CAPACITANCES

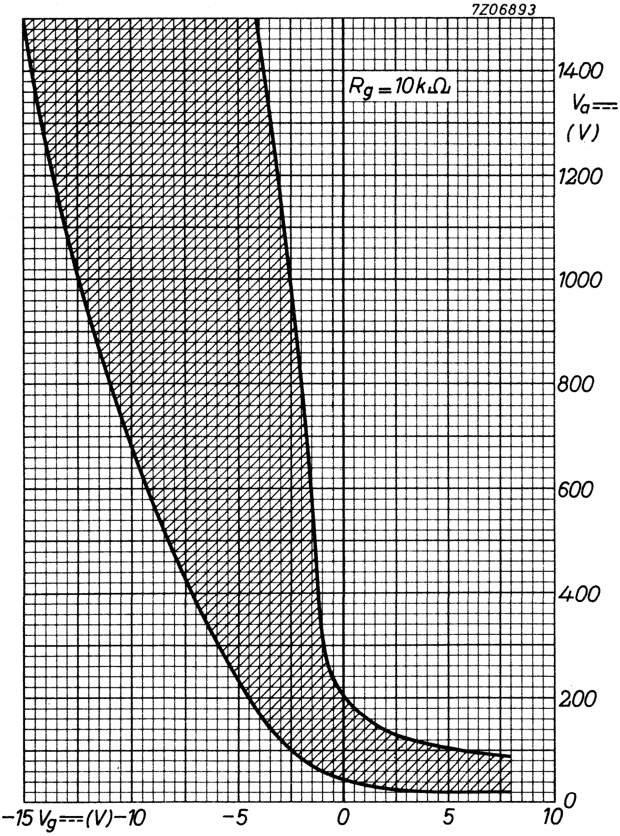
Anode to grid	C_{ag}	0.8	pF
Grid to filament	C_{gf}	45	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	12	V
Ionization time	T_{ion}	10	μs
Recovery time (Deionization time), (V_g = −250 V)	T_{dion}	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_{kp}	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


7Z06893
Rg = 10 kΩ
1400
Va ---
(V)
1200
1000
800
600
400
200
0
−15 Vg --- (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_{invp}	max.	1500	V
Cathode current, average (T_{av} = max. 15 s)	I_k	max.	6.4	A
peak	I_{kp}	max.	80	A

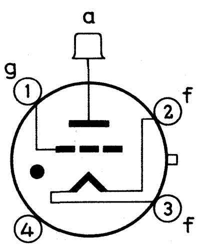
HEATING: direct

Filament voltage	V_f		2.5	V ± 5%
Filament current	I_f		21	A
Waiting time	T_w	min.	60	s

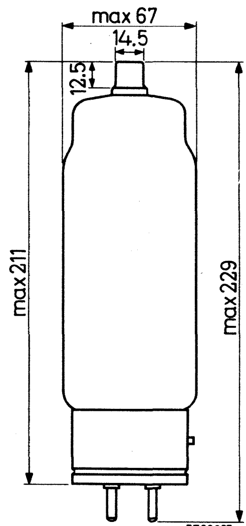
MECHANICAL DATA

Dimensions in mm

Base: Super Jumbo with bayonet



7Z06895



7Z06897

Mounting position: Arbitrary between horizontal and vertical with base down

Accessories

Socket	2422 511 01001
Cap connector	40619

MECHANICAL DATA (continued)

Net weight 340 g

CAPACITANCES

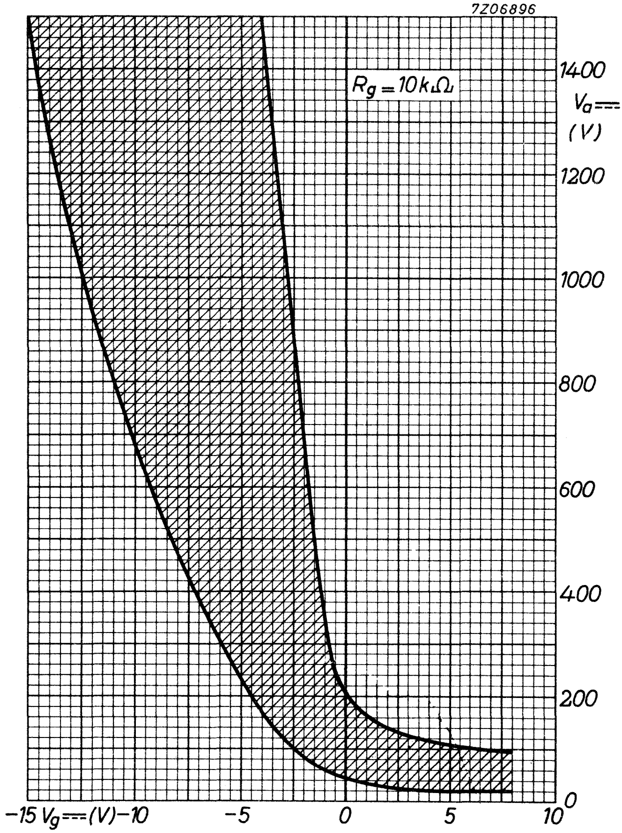
Anode to grid	C_{ag}	0.8	pF
Grid to filament	C_{gf}	45	pF

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.	100	kΩ
		min.	0.5	kΩ
recommended value	R_g		10	kΩ
Ambient temperature	t_{amb}	max.	+70	°C
		min.	−55	°C


7Z06896
$R_g = 10\,k\Omega$
1400
1200
1000
800
600
400
200
0
V_a === (V)
−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_{a_p}	max.	2500	V
	peak inverse	$V_{a\,inv_p}$	max.	5000	V
Anode current,	peak	I_{a_p}	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])

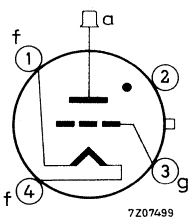
MECHANICAL DATA Dimensions in mm

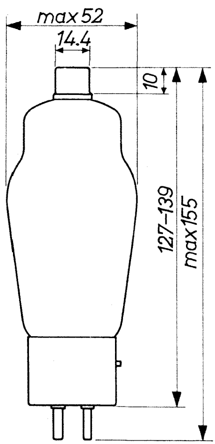
Base: Medium 4 p with bayonet

Socket: 2422 511 90003

Net weight: 100 g

Mounting position: vertical, base down





[1]) See curve page 4.

CAPACITANCES

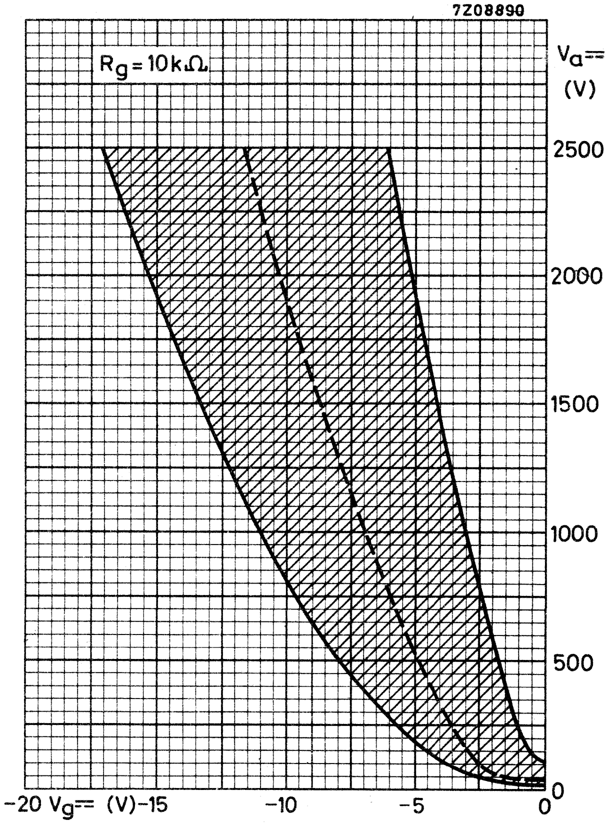
Anode to grid	C_{ag}		3.3	pF
Grid to filament	C_{gf}		5.0	pF

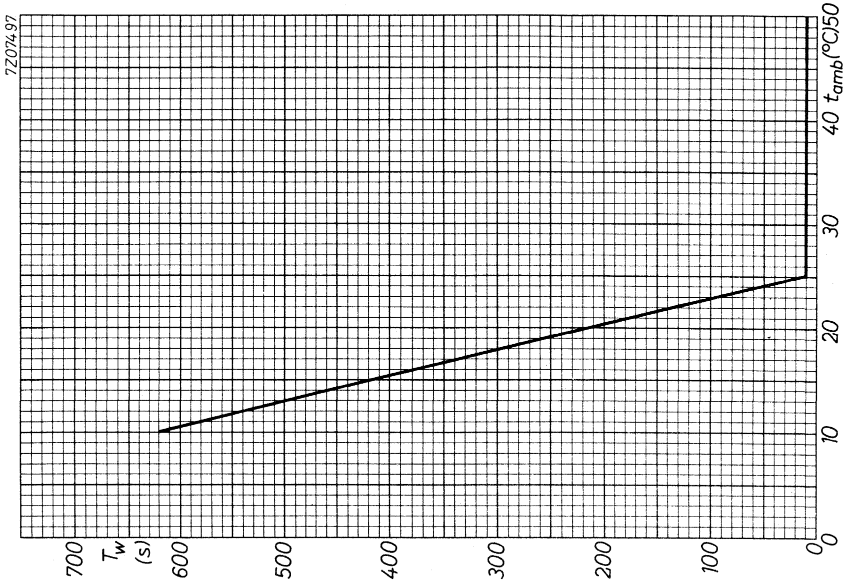
TYPICAL CHARACTERISTICS

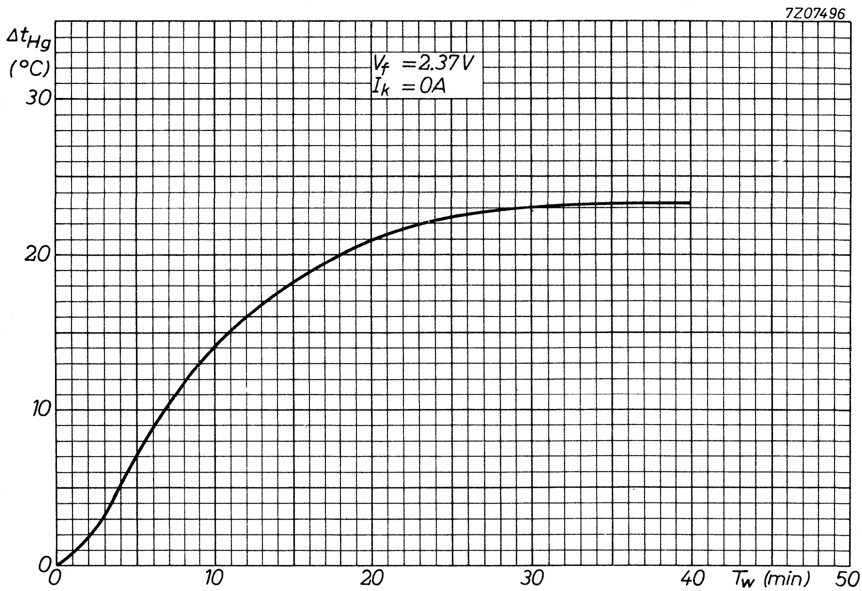
Arc voltage	V_{arc}		12	V
Ionization time	T_{ion}		10	μs
Deionization time	T_{dion}		1000	μs
Frequency	f	max.	150	Hz

LIMITING VALUES (Absolute max. rating system)

Anode voltage, forward peak	V_{a_p}	max.	2500	V
inverse peak	$V_{a\,inv_p}$	max.	5000	V
Grid voltage	$-V_g$	max.	500	V
tube conductive	$-V_g$	max.	10	V
Anode current, peak (f < 25 Hz)	I_{a_p}	max.	1	A
(f ≥ 25 Hz)	I_{a_p}	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	°C
recommended value	t_{Hg}		50	°C
Surge current (T = max. 0.1 s)	I_{surge}	max.	40	A


7Z08890
$R_g = 10 k\Omega$
V_a== (V)
2500
2000
1500
1000
500
0
-20 V_g== (V) -15
-10
-5
0


7Z07497
t_{amb} (°C)
50
40
30
20
10
0
0
100
200
300
400
500
600
700
T_w (s)


7Z07496
Δt_{Hg} (°C)
30
20
10
0
V_f = 2.37 V
I_k = 0 A
0
10
20
30
40
T_w (min)
50

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]

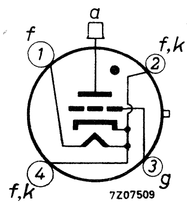
MECHANICAL DATA Dimensions in mm

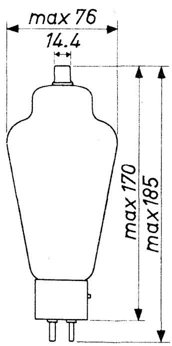
Base : Medium 4 p with bayonet

Socket : 2422 511 90003

Net weight: 125 g

Mounting position: Vertical, base down





[1]) See curve page 3.

CAPACITANCES

Anode to grid	C_{ag}		3.6	pF
Grid to cathode	C_{gk}		7.8	pF

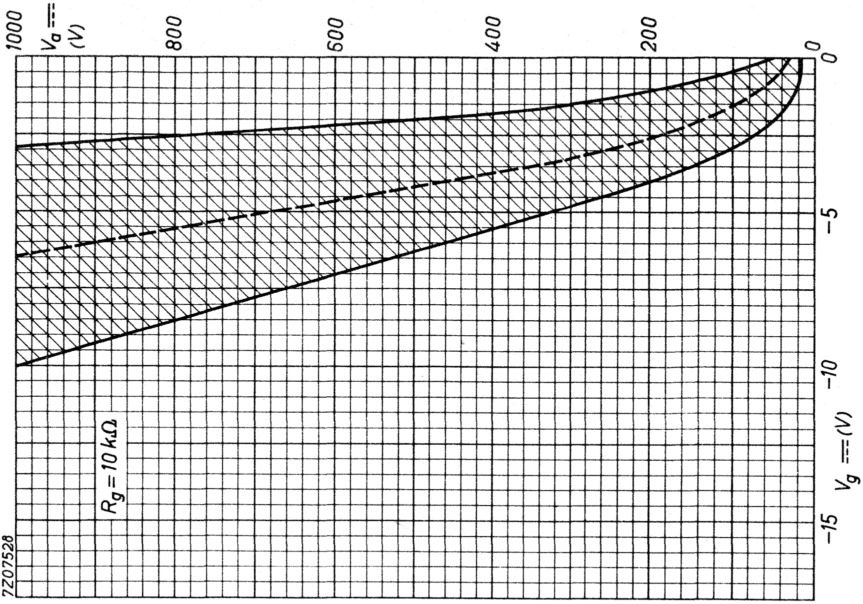
TYPICAL CHARACTERISTICS

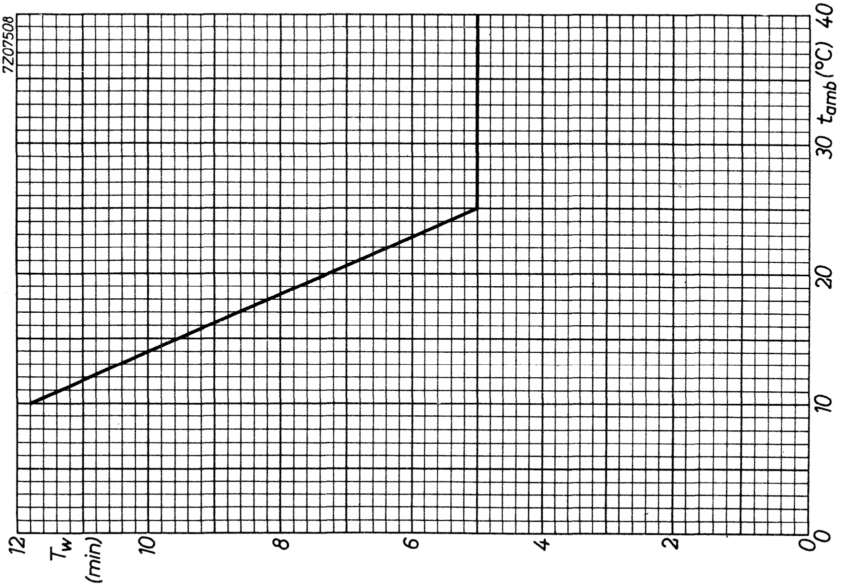
Arc voltage	V_{arc}		12	V
Ionisation time	T_{ion}		10	μs
Deionisation time	T_{dion}		1000	μs
Frequency	f	max.	150	Hz

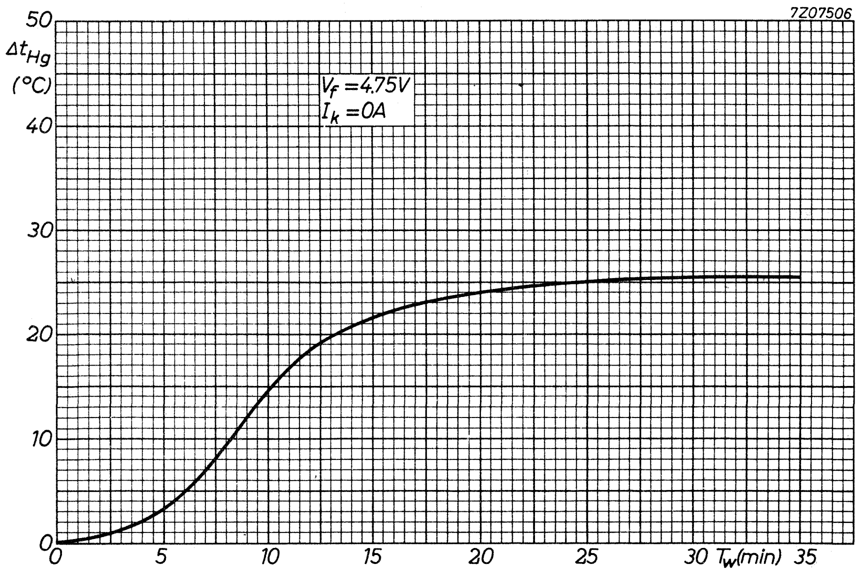
LIMITING VALUES (Absolute max. rating system)

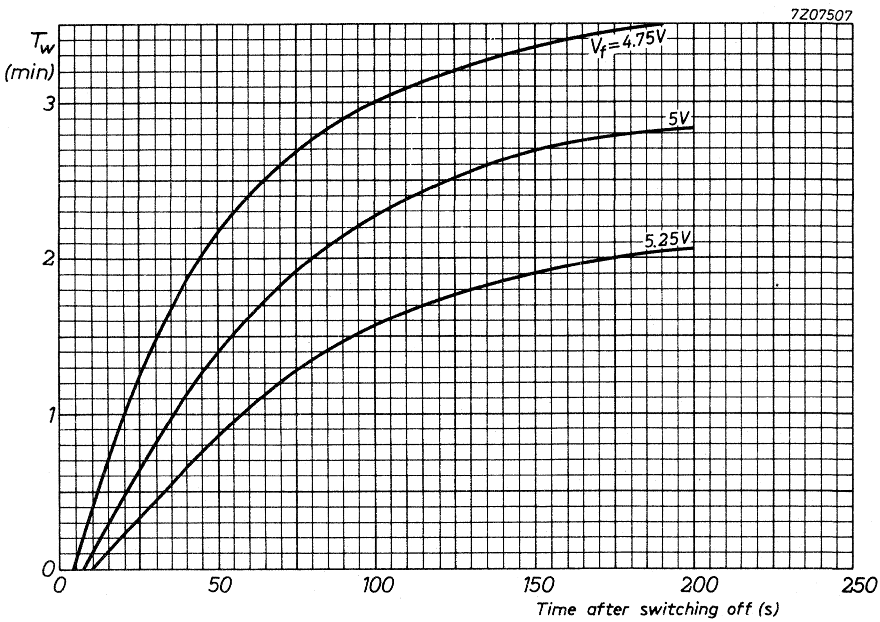
Anode voltage, forward peak	V_{ap}	max.	1000	V
inverse peak	$V_{a\,inv\,p}$	max.	1000	V
Grid voltage,	$-V_g$	max.	500	V
tube conductive	$-V_g$	max.	10	V
Cathode current, peak ($f < 25$ Hz)	I_{kp}	max.	5	A
($f \geq 25$ Hz)	I_{kp}	max.	15	A
		max.	40	A [1]
average (T_{av} = max. 15 s)	I_k	max.	2.5	A
		max.	1	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.


1000
V_a ⎓
(V)
800
600
400
200
0
0
−5
−10
−15
V_g ⎓ (V)
$R_g = 10\ k\Omega$
7Z07528


7Z07508
12
T_w
(min)
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

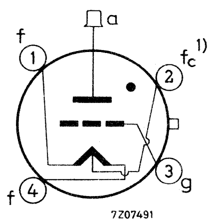
Base: Medium 4 p with bayonet

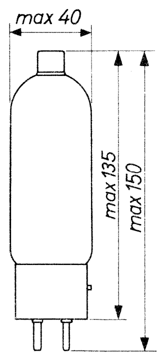
Socket: 2422 511 90003

Cap connector: 40619

Net weight: 95 g

Mounting position: any





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_{ap}	max.	900	V
inverse peak	$V_{a\,invp}$	max.	1250	V
Grid voltage	$-V_g$	max.	300	V
tube conductive	$-V_g$	max.	10	V
Cathode current, peak	I_{kp}	max.	30	A
average (T_{av} = max. 5 s)	I_k	max.	2.5	A
Grid current, peak	I_{gp}	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	°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).

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.	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

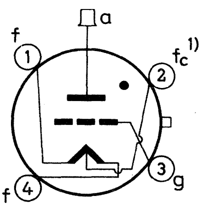
Base: Medium 4 p with bayonet

Socket: 2422 511 90003

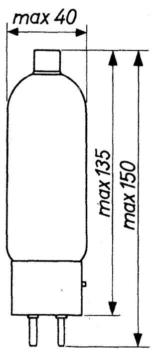
Cap connector: 40619

Net weight: 95 g

Mounting position: any



7Z07491



1) Load return

CAPACITANCES

Anode to grid	C_{ag}	3	pF
Grid to filament	C_{gf}	14	pF

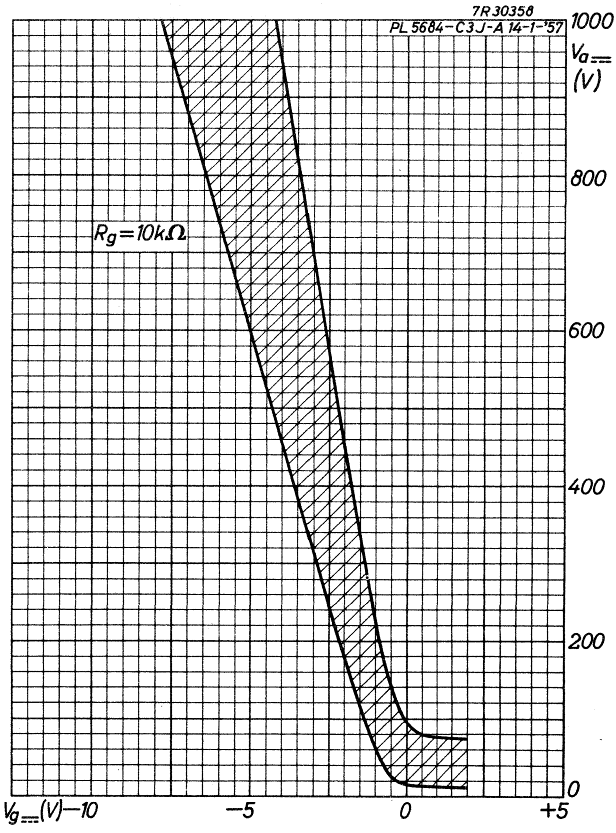
TYPICAL CHARACTERISTICS

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).


7R 30358
PL 5684-C3J-A 14-1-'57
1000
V_{a} (V)
800
600
400
200
0
$R_g = 10k\Omega$
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

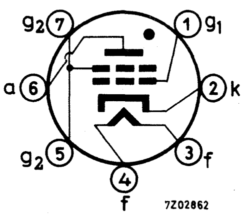
Grid No.1 to all	C_{g_1}	=	2.4	pF
Anode to all	C_a	=	1.6	pF
Anode to grid No.1	C_{ag_1}	=	26	mpF

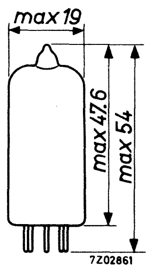
MECHANICAL DATA

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.

TYPICAL CHARACTERISTICS

Ionization time at $V_{a=}$ = 100 V, grid No.1 overvoltage = 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°.

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

Anode voltage,					
forward peak	V_{ap}	=	max.	650	V
inverse peak	$V_{a\,invp}$	=	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	^{o}C
Bulb temperature	t_{bulb}	=	max.	150	^{o}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.

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	^oC
Bulb temperature	t_{bulb}	=	max.	150	^oC

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.

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

SHOCK AND VIBRATION RESISTANCE

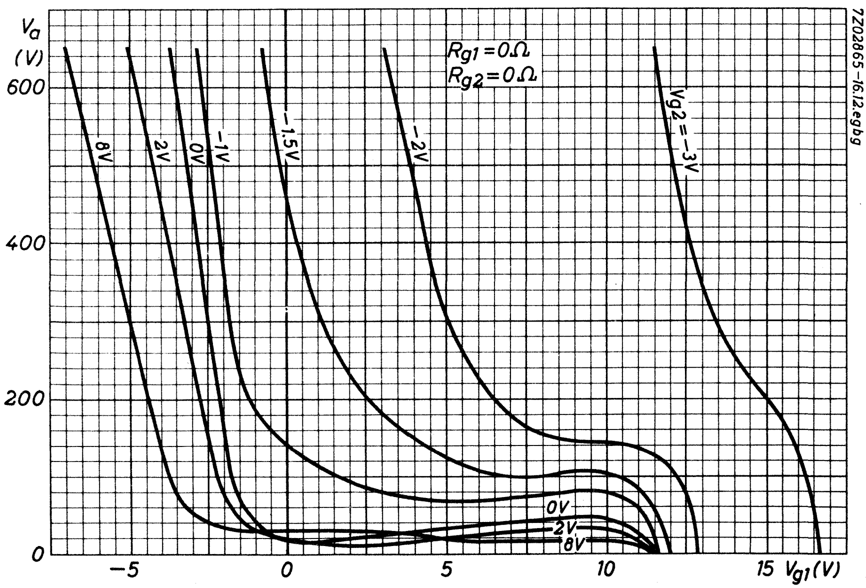
These conditions are used solely to assess the mechanical quality of the tube. The tube should not be continuously operated under these conditions.

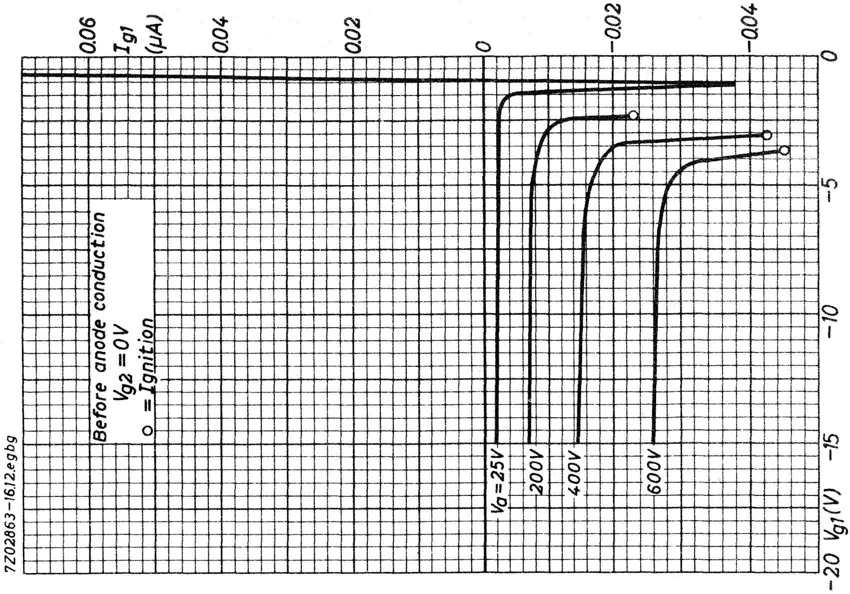
Shock resistance: 750 g

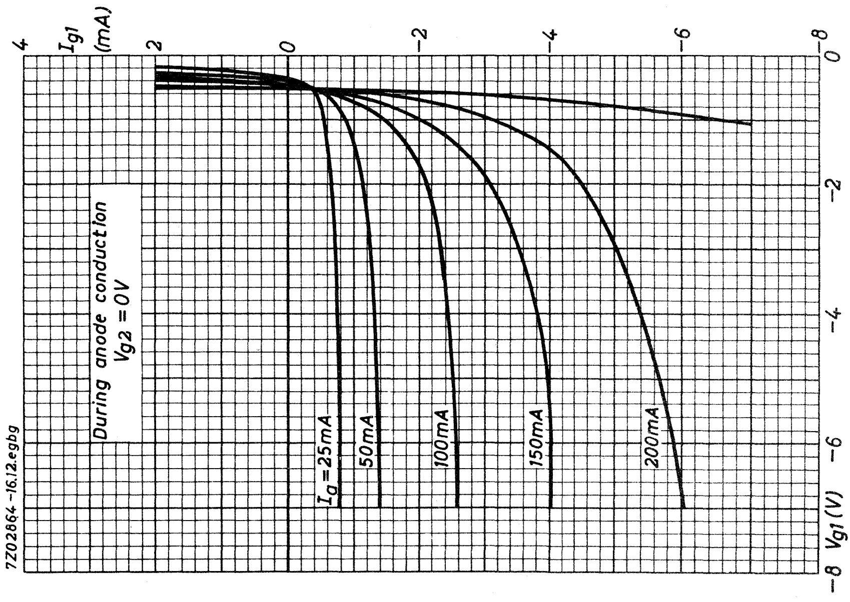
Forces as applied by the NRL impact machine for electronic devices caused by 5 blows of the hammer lifted over an angle of 48° in each of 4 different positions of the tube.

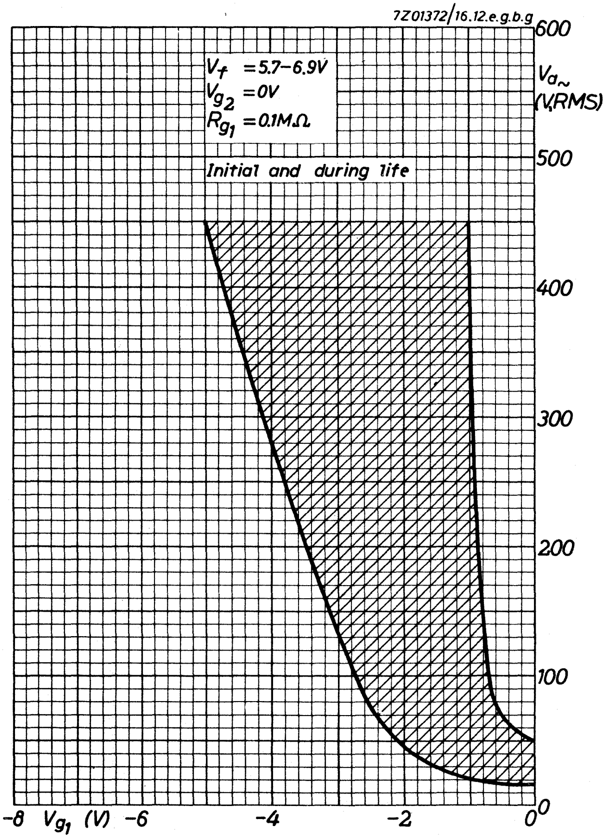
Vibration resistance: 2.5 g

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




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
Vg1 (V)
0
-5
-10
-15
-20


7Z02864-16.12.egbg
During anode conduction
Vg2 = 0V
Ig1 (mA)
4
2
0
-2
-4
-6
-8
Ia=25mA
50mA
100mA
150mA
200mA
Vg1 (V)
0
-2
-4
-6
-8


7Z01372/16.12.e.g.b.g
V_f = 5.7–6.9V
V_{g_2} = 0V
R_{g_1} = 0.1MΩ
Initial and during life
$V_{a\sim}$ (V,RMS)
600
500
400
300
200
100
0
-8
V_{g_1} (V)
-6
-4
-2
0

THYRATRON

Thyratron, inert gas filled tetrode, with negative control characteristic.

QUICK REFERENCE DATA				
Anode voltage, peak forward	V_{a_p}	max.	650	V
Cathode current, peak	I_{k_p}	max.	2	A
average	I_k	max.	300	mA

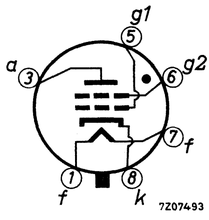
HEATING: direct

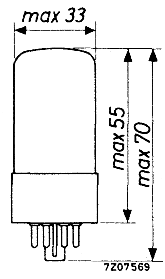
Heater voltage	V_f	6.3	V
Heater current	I_f	950	mA
Waiting time	T_w	min. 15	s

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, $R_{g_1} = 0\ \Omega$)	V_a/V_{g_1}	275	-
Ratio V_a/V_{g_2}, at striking point ($V_{g_1} = 0$ V, $R_{g_2} = 0\ \Omega$)	V_a/V_{g_2}	370	-

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.

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%.

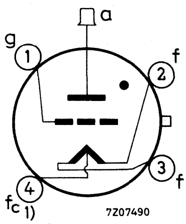
MECHANICAL DATA Dimensions in mm

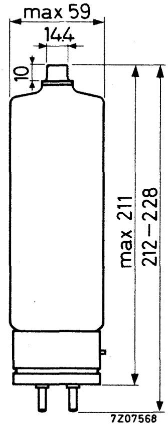
Base : Super jumbo with bayonet

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.

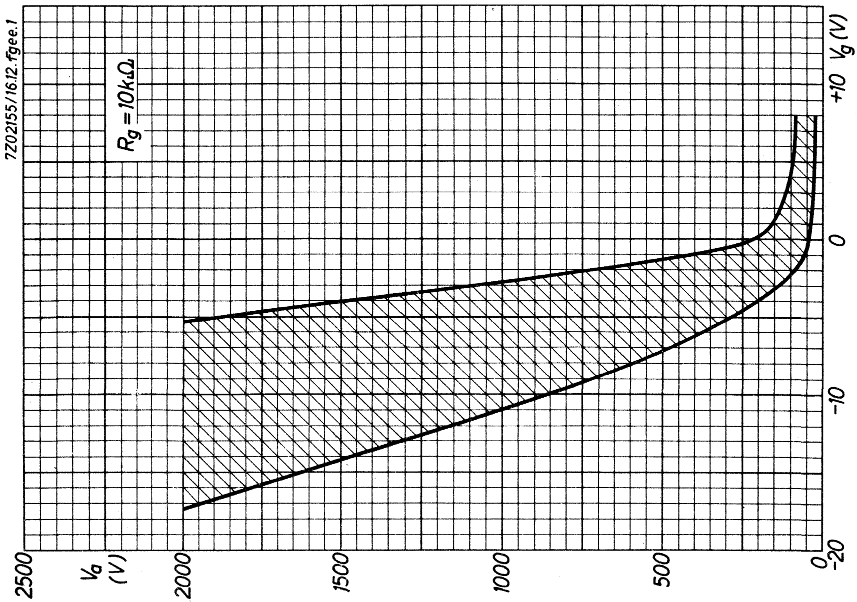
LIMITING VALUES (Absolute limits)

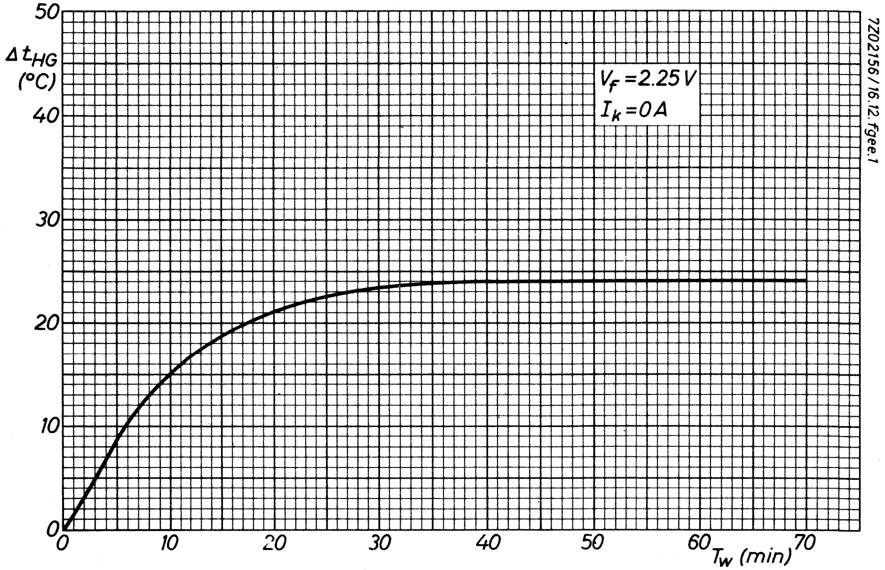
Anode voltage, peak forward	V_{a_p}	max. 2000	V
peak inverse	$V_{a\,inv\,p}$	max. 2000	V
Grid voltage,	$-V_g$	max. 300	V
tube conductive	$-V_g$	max. 10	V
Grid current	I_g	max. 0.25	A
Grid circuit resistance	R_g	max. 0.03	MΩ [1]
Cathode current, peak	I_{k_p}	max. 40	A
average (T_{av} = max. 15 s)	I_k	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.


7Z02155/16.12.fgee.1
$R_g = 10k\Omega$
+10 V_g (V)
0
−10
−20
2500
V_a (V)
2000
1500
1000
500
0


7Z02156/16.12.fgee.1
$V_f = 2.25\,V$
$I_k = 0\,A$
Δt_{HG} (°C)
50
40
30
20
10
0
0
10
20
30
40
50
60
70
T_w (min)

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]

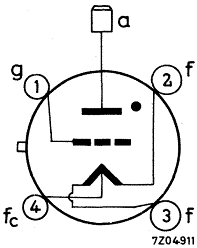
CAPACITANCES

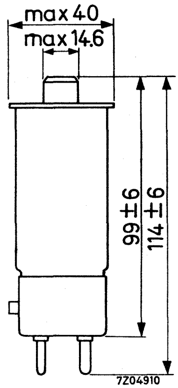
Anode to grid	C_{ag}	0.35	pF
Grid to cathode	C_{gf}	10	pF

[1]) Recommended value 60 s.

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	2422 511 04001
Top cap connector	type 40619

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc}	approx.	10	V
Commutation factor			10	VA/μs^2
Ignition delay time	T_{delay}	See page 5		
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

LIMITING VALUES (Absolute maximum rating system)

Anode voltage, forward and inverse peak				
$I_k < 1.6$ A, $I_{kp} < 20$ 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 6)				
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

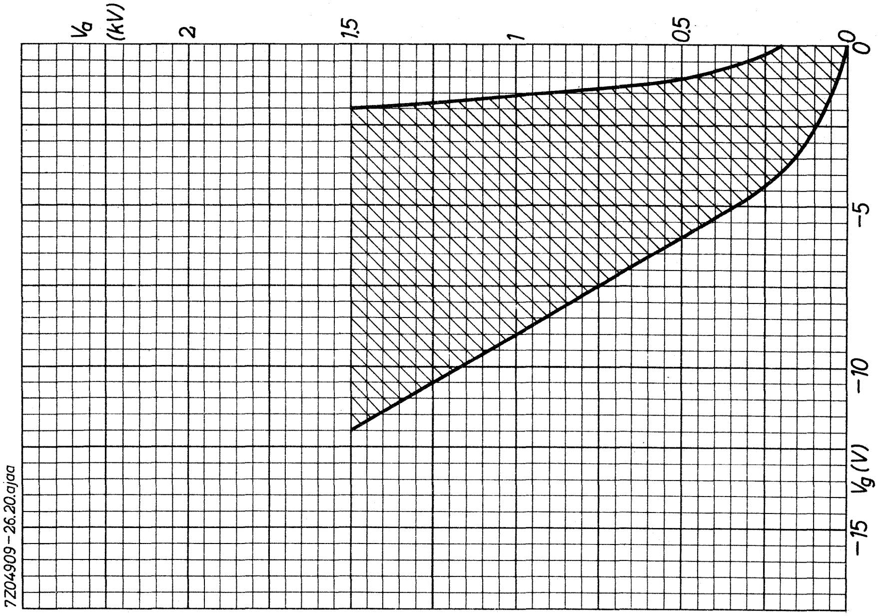
CIRCUIT DESIGN VALUES

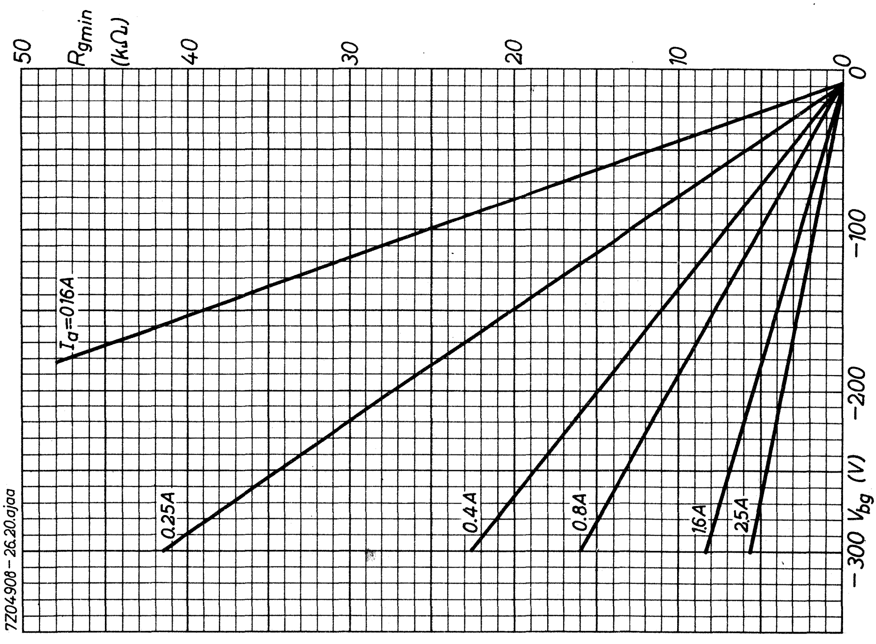
Grid circuit resistance	R_g	max.	100	kΩ
	R_g	see page 4 lower figure		

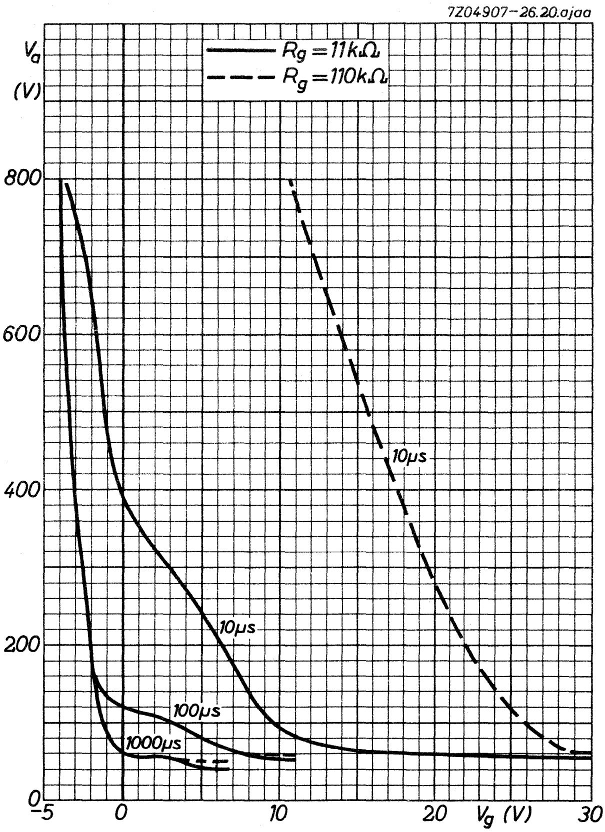
1) For operation with peak currents in excess of 20 A and a mean current of less than 0.5 A, such as occurs under ignitron firing service, a nominal heater voltage of 2.75 V may be used. Under these conditions a maximum peak anode voltage of 1.5 kV is permissible.

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.

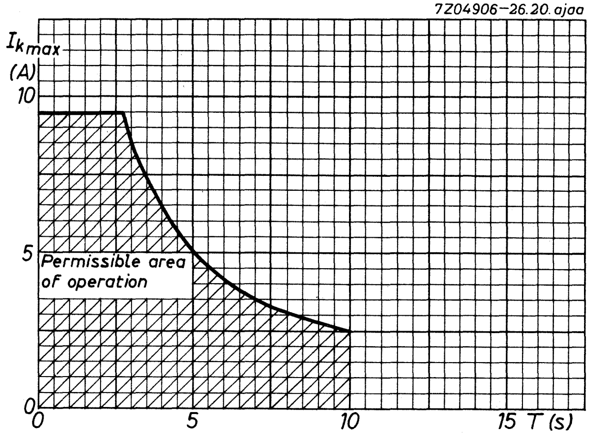
3) The anode structure must be left free to ensure cooling by free convection.

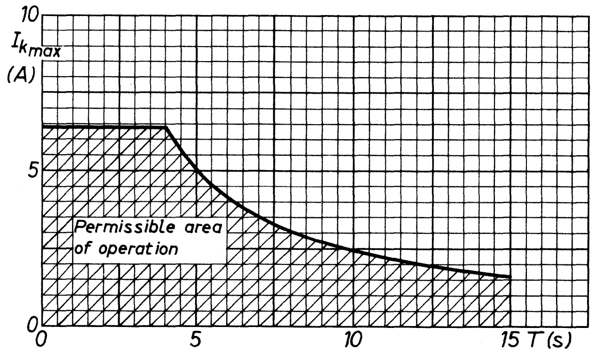

Va
(kV)
2
1.5
1
0.5
0
0
−5
−10
−15
Vg (V)
7Z04909−26.20.ajaa


50
Rgmin
(kΩ)
40
30
20
10
0
0
−100
−200
−300 Vbg (V)
Ia=016A
0.25A
0.4A
0.8A
1.6A
2.5A
7Z04908−26.20.ajaa



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.

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_{ap}	500	V
Cathode current, peak	I_{kp}	100	mA
average	I_k	22	mA

HEATING

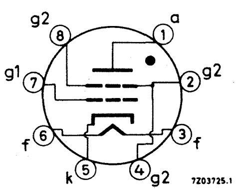
Indirect by A.C. or D.C.

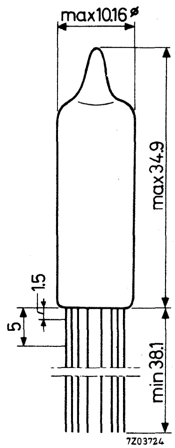
Heater voltage	V_f	6.3	V $\pm$ 10 %
Heater current	I_f	150	mA
Waiting time	T_w	10	s

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





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

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.

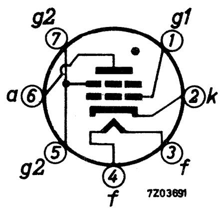
Heater voltage	V_f	6.3	V
Heater current	I_f	150	mA
Waiting time	T_w	10	s

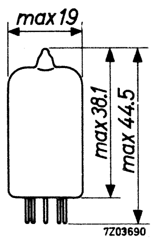
CAPACITANCES

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

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

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.

Industrial rectifying tubes

GENERAL OPERATIONAL RECOMMENDATIONS
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 $90^{\circ} \pm 30^{\circ}$ 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 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 $-55\ ^{\circ}C$ and maximum $+75\ ^{\circ}C$.

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.

For tubes filled with a mixture of mercury-vapour and inert gas the minimum value of ambient temperature is 0 °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.

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.

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.

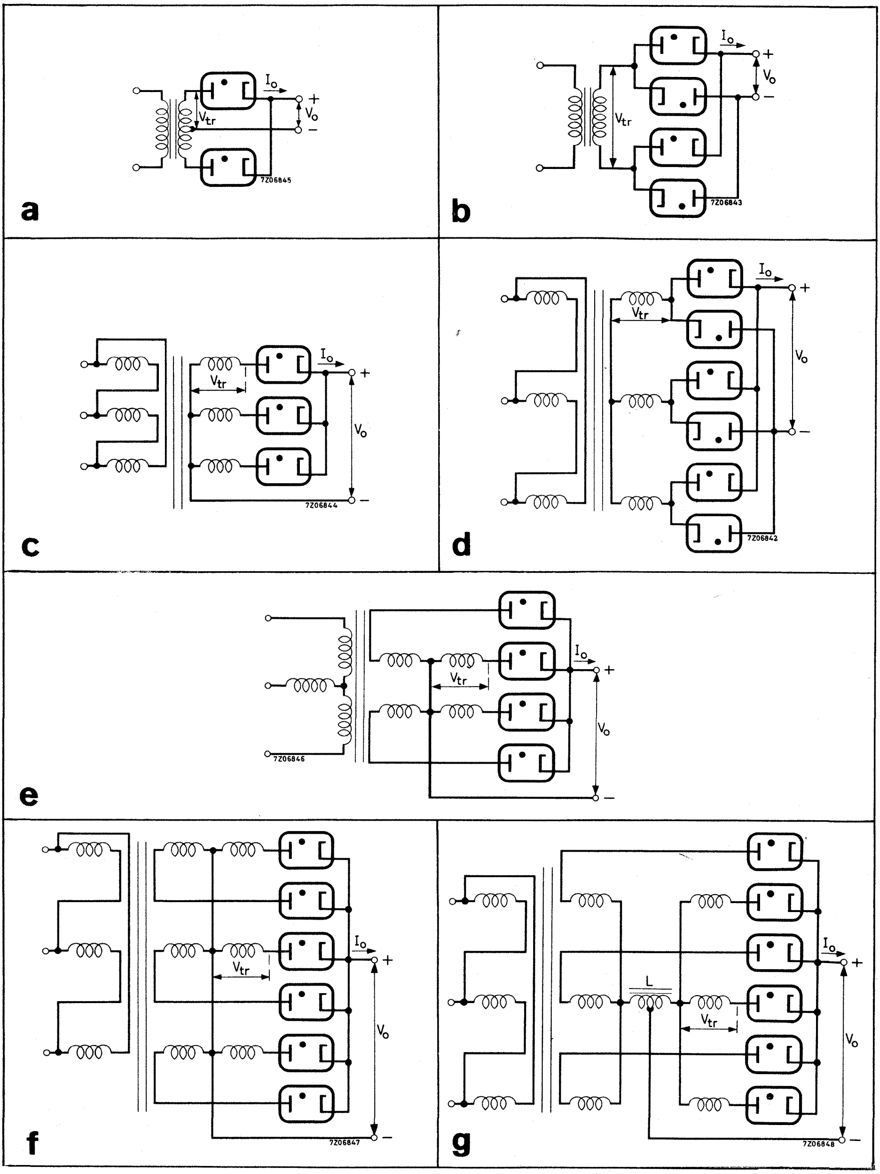
To ensure good voltage regulation on fluctuating loads the inductance value of the chocke should be large enough to give uninterrupted current at minimum load.

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.

RECTIFYING TUBE CIRCUITS



RATING SYSTEM

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

Absolute maximum rating system

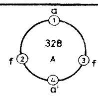
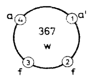
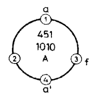
Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

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.

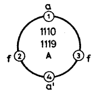
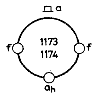
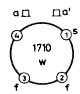
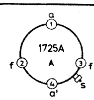
The equipment manufacturer should design so that, initially and throughout life, no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment,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

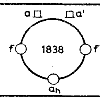
INDUSTRIAL RECTIFYING TUBES

Type	V_f(V) I_f(A)	Typical characteristics	Limiting values		Base
328 (M) Double anode rectifier	1, 9 3, 0	V_{arc} = 7 V V_{ign} = 16 V	V_{ainvp} = 90 V I_a = 0, 65 A I_{ap} = 4, 0 A	R_t = min 3 Ω t_{amb} −55 °C +75 °C	
354 (O) Single anode rectifier	1, 9 5, 5	V_{arc} = 8 V V_{ign} = 16 V	V_{ainvp} = 400 V I_a = 0, 25 A I_{ap} = 1, 25 A	R_t = min 50 Ω t_{amb} −55 °C +75 °C	Edison
367 (M) Double anode rectifier	1, 9 8, 0	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 140 V I_a = 3 A I_{ap} = 18 A	R_t = min 1 Ω t_{amb} −55 °C +75 °C	
451 (O) Double anode rectifier	1, 9 2, 8	V_{arc} = 7 V V_{ign} = 11 V	V_{ainvp} = 50 V I_a = 0, 65 A I_{ap} = 4, 0 A	R_t = min 3 Ω t_{Hg} = 30-75 °C	
1010 (O) Double anode rectifier	1, 9 3, 5	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 185 V I_a = 0, 65 A I_{ap} = 4, 0 A	R_t = min 10 Ω t_{amb} −55 °C +75 °C	
1037 (O) Double anode rectifier	1, 9 11	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 185 V I_a = 3, 0 A I_{ap} = 18 A	R_t = min 1,75 Ω t_{Hg} = 30-80 °C	Goliath
1039 (O) Double anode rectifier	1, 9 20	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 185 V I_a = 7, 5 A I_{ap} = 45 A	R_t = min 0,75 Ω t_{Hg} = 30-80 °C	Goliath
1049 (O) Double anode rectifier	1, 9 28, 5	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 185 V I_a = 12, 5 A I_{ap} = 75 A	R_t = min 0, 3 Ω t_{Hg} = 30-80 °C	Straps
1054 (O) Double anode rectifier	1, 9 68	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 150 V I_a = 20 A I_{ap} = 120 A	R_t = min 0,18 Ω t_{Hg} = 30-80 °C	Straps
1069K (O) Double anode rectifier	3, 25 70	V_{arc} = 10 V V_{ign} = 16 V	V_{ainvp} = 170 V I_a = 30 A I_{ap} = 200 A	R_t = min 0,12 Ω t_{Hg} = 30-75 °C	Straps

M = Maintenance type
O = Obsolescent type

Type	V_f(V) I_f(A)	Typical characteristics	Limiting values		Base
1110 (O) Double anode rectifier	1,9 3,5	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 185 V I_a = 0,85 A I_{ap} = 5,0 A	R_t = min 4 Ω t_{amb} −55 °C +75 °C	
1119 (O) Double anode rectifier	1,9 5,8	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 140 V I_a = 1,5 A I_{ap} = 9,0 A	R_t = min 1,8 Ω t_{amb} −55 °C +75 °C	
1138 (O) Single anode rectifier	2,5 27	V_{arc} = 10 V V_{ign} = 16 V	V_{ainvp} = 275 V I_a = 15 A I_{ap} = 85 A	R_t = min 0,3 Ω t_{Hg} = 30-80 °C	Goliath
1163 (M) Single anode rectifier	2,25 17	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 375 V I_a = 6 A I_{ap} = 36 A	R_t = min 0,5 Ω t_{amb} −55 °C +75 °C	Goliath
1164 (M) Single anode rectifier	2,5 25	V_{arc} = 9 V V_{ign} = 16 V	V_{ainvp} = 225 V I_a = 15 A I_{ap} = 90 A	R_t = min 0,3 Ω t_{amb} −55 °C +75 °C	Goliath
1173 (M) Single anode rectifier	1,9 13	V_{arc} = 12 V V_{ign} = 22 V	V_{ainvp} = 850 V I_a = 4 A I_{ap} = 20 A	R_t = min 0,75 Ω t_{Hg} = 30-75 °C	
1174 (M) Single anode rectifier	1,9 12	V_{arc} = 12 V V_{ign} = 22 V	V_{ainvp} = 850 V I_a = 6 A I_{ap} = 30 A	R_t = min 0,5 Ω t_{Hg} = 30-75 °C	
1176 (O) Single anode rectifier	1,9 28	V_{arc} = 12 V V_{ign} = 22 V	V_{ainvp} = 850 V I_a = 15 A I_{ap} = 75 A	R_t = min 0,2 Ω t_{Hg} = 30-75 °C	Straps
1177 (O) Single anode rectifier	1,9 60	V_{arc} = 12 V V_{ign} = 28 V	V_{ainvp} = 850 V Ia = 25 A I_{ap} = 135 A	R_t = min 0,1 Ω t_{Hg} = 30-75 °C	Straps
1710 (M) Double anode rectifier	1,9 8,0	V_{arc} = 10 V V_{ign} = 22 V	V_{ainvp} = 470 V I_a = 1,5 A I_{ap} = 9,0 A	R_t = min 2,5 Ω t_{Hg} = 30-80 °C	
1725A (M) Double anode rectifier	1,9 3,5	V_{arc} = 10 V V_{ign} = 22 V	V_{ainvp} = 470 V I_a = 0,65 A I_{ap} = 4,0 A	R_t = min 5 Ω t_{amb} −55 °C +75 °C	
1738 (M) Double anode rectifier	1,9 18	V_{arc} = 9 V V_{ign} = 20 V	V_{ainvp} = 300 V I_a = 7,5 A I_{ap} = 45 A	R_t = min 0,2 Ω t_{Hg} = 30-80 °C	Goliath

M = Maintenance type
O = Obsolescent type

Type	V_f(V) I_f(A)	Typical characteristics	Limiting values		Base
1749A (M) Double anode rectifier	1,9 25	V_{arc} = 10 V V_{ign} = 22 V	V_{ainvp} = 300 V I_a = 12,5 A I_{ap} = 75 A	R_t = min 0,1 Ω t_{Hg} = 30 - 80 °C	Straps
1788 (M) Double anode rectifier	1,9 11	V_{arc} = 9 V V_{ign} = 22 V	V_{ainvp} = 300 V I_a = 5 A I_{ap} = 30 A	R_t = min 0,3 Ω t_{Hg} = 30 - 80 °C	Goliath
1838 (M) Double anode rectifier	1,9 21,5	V_{arc} = 10 V V_{ign} = 22 V	V_{ainvp} = 360 V I_a = 7,5 A I_{ap} = 45 A	R_t = min 0,25 Ω t_{Hg} = 30 - 80 °C	
1849 (M) Double anode rectifier	1,9 29	V_{arc} = 10 V V_{ign} = 22 V	V_{ainvp} = 360 V I_a = 12,5 A I_{ap} = 75 A	R_t = min 0,2 Ω t_{Hg} = 30 - 80 °C	Straps
1859 (M) Double anode rectifier	1,9 60	V_{arc} = 12 V V_{ign} = 28 V	V_{ainvp} = 360 V I_a = 25 A I_{ap} = 150 A	R_t = min 0,1 Ω t_{Hg} = 30 - 80 °C	Straps

M = Maintenance type
O = Obsolescent type

Ignitrons

RECOMMENDED TYPES FOR NEW EQUIPMENT

Ignitrons

ZX1051
ZX1052
ZX1053
ZX1061
ZX1062

ZX1063
ZX1081
ZX1082

GENERAL OPERATIONAL RECOMMENDATIONS
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 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.

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 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.

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.

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 is the total permissible power 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. values 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.

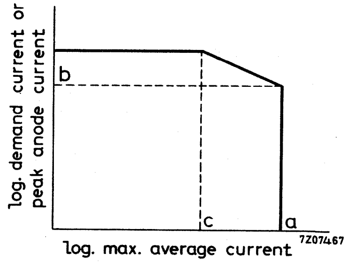
The longest time over which the max. average current may be calculated is the max. averaging time.

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.



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.

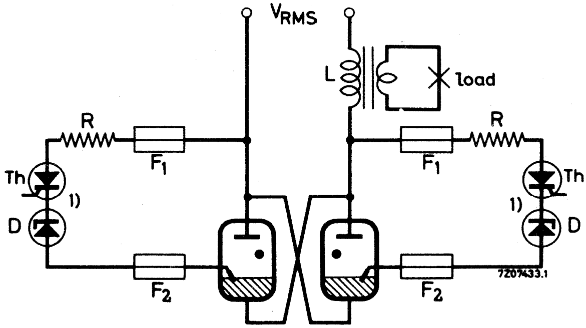


Fig.1

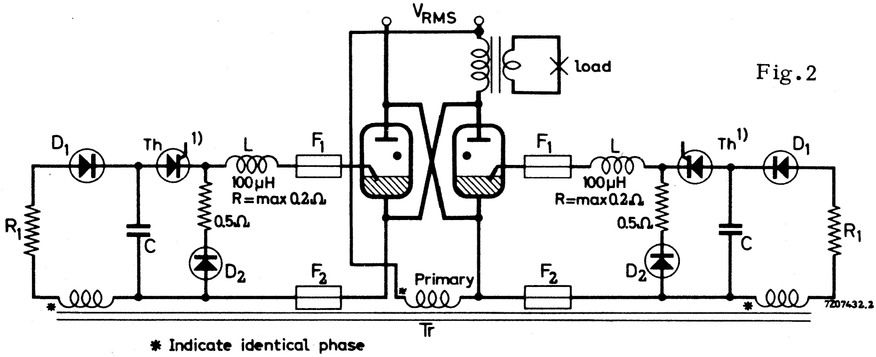


Fig.2

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.

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.

RATING SYSTEM

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

IGNITRONS

PL5551A	Replaced by ZX1051
PL5552A	Replaced by ZX1052
PL5553B	Replaced by ZX1053

IGNITRON

D-size ignitron intended for use in rectifier circuits and in single-phase and three-phase welding control and similar A.C. control applications.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel)		2400	kVA
Maximum average current		207	A
Ignitor voltage	max.	200	V
Ignitor current	max.	15	A

MECHANICAL DATA

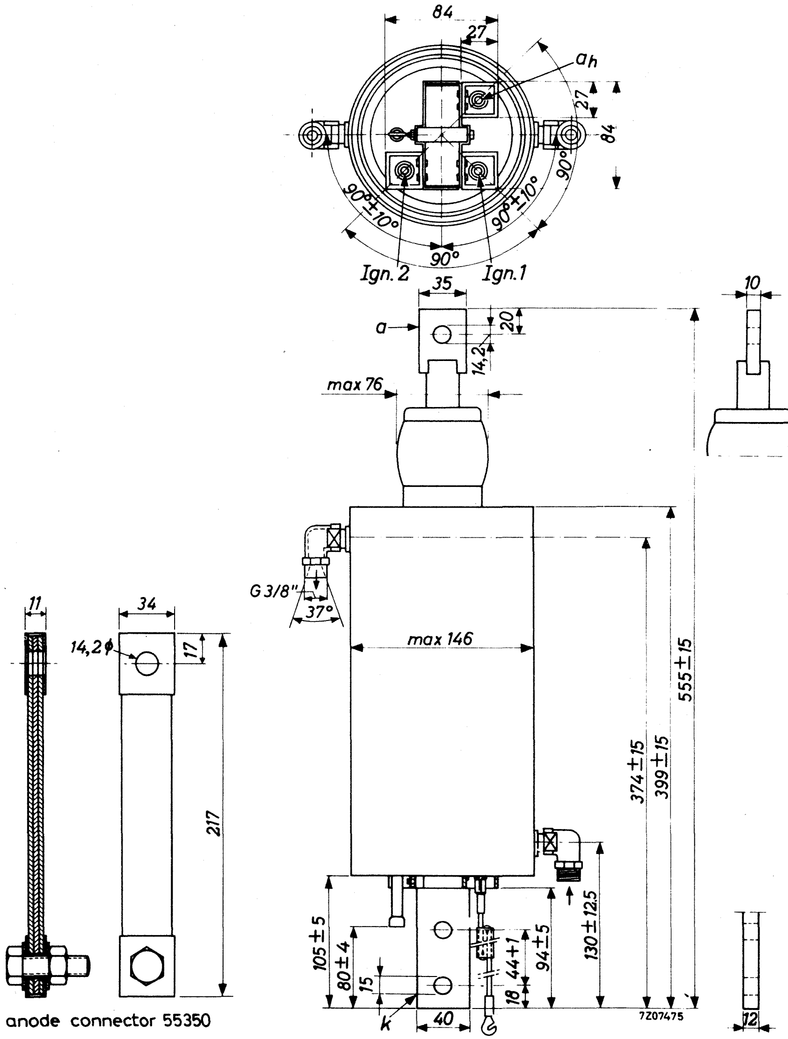
Dimensions and connections	see page 2	
Net weight	9.6	kg
Shipping weight	12.6	kg

ACCESSORIES

Ignitor cable		type 55351
Auxiliary anode cable		type 55351
Anode cable		type 55350
Water hose connections:	hose nipple	type TE1051c
	coupling nut	type TE1051b

DIMENSIONS AND CONNECTIONS

Dimensions in mm



TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 9 l/min)	p_i	max.	0.2	kg/cm^2
Temperature rise at max. average current (q = 9 l/min)	t_o-t_i		5.5	°C

LIMITING VALUES

Required water flow, at max. average current	q	min.	9	l/min
at no load	q	min.	3	l/min
Inlet temperature, for substantially constant load [1]	t_i	min.	6	°C [2]
for widely fluctuating load [1]	t_i	min.	20	°C

[1] When a number of tubes is cooled in series, t_i min. refers to the coldest tube.

[2] Recommended value min. 10 °C

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 wether phase control is used or not. The load must be limited so that at zero phase delay no overload will result.

Rectifier service and three-phase frequency changer

Mains frequency range		f		25	to	60	Hz
Max. anode voltage,	forward peak	V_{ap}	max.	900		2100	V
	reverse peak	V_{invp}	max.	900		2100	V
Max. anode current,	peak	I_{ap}	max.	1800		1200	A
	, average	I_{av}	max.	200		150	A
	, average [1] [3]	I_{av}	max.	300		225	A
	, average [2] [3]	I_{av}	max.	400		300	A
Max. surge current,	T_{max} = 0.15 s	I_{surge}	max.	12000		9000	A

Single phase A.C. control two tubes in inverse parallel connection

Mains frequency range		f		25	to	60	Hz
Max. mains voltage		V	max.	2400		2400	V_{RMS}
Max. demand power		P	max.	2400		1105	kVA
Max. average current,	T_{av} max. 1.66 s	I_{av}	max.	135		207	A
Max. surge current,	T_{max} = 0.15 s	I_{surge}	max.	6000		6000	A

LIMITING VALUES for auxiliary anode

Max. anode voltage,	forward peak	V_a	max.	160	V
	inverse peak	V_{invp}	max.	25	V [4]
	inverse peak	V_{invp}	max.	160	V [5]
Max. anode current,	peak	I_{ahp}	max.	20	A
	average, T_{av} = max. 10 s	I_{ah}	max.	5	A

1) Two-hours overload; T_{av} = max. 2 min; repeated not more than once every 24 h.
2) One minute overload; T_{av} = max. 1 min; repeated not more than once every 2 h.
3) Overload based on the thermal characteristics of the ignitron. During the intervals between the specified overloads, the rated continuous load may not be exceeded. The two specified periods with overload may not overlap.
4) Main anode conducting
5) Main anode not conducting

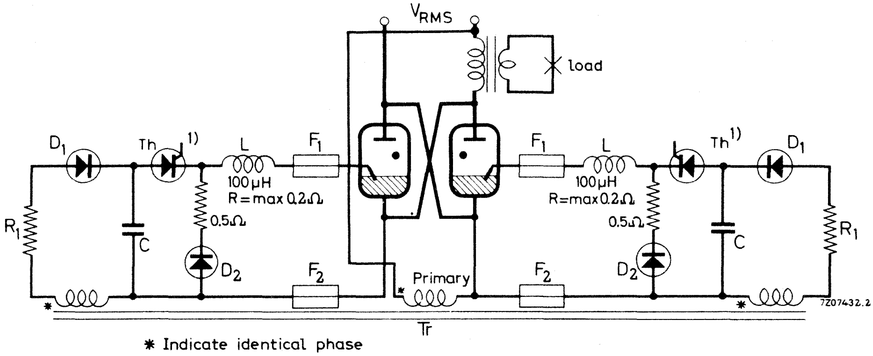
IGNITOR CHARACTERISTICS AND CIRCUIT REQUIREMENTS

LIMITING VALUES (Absolute max. rating system)

Ignitor voltage,	forward peak	V_{igp}	max.	V_{ap}	
	inverse peak (including any transients)	$-V_{igp}$	max.	5	V
Ignitor current,	forward peak	I_{igp}	max.	100	A
	forward RMS	I_{igRMS}	max.	15	A
	forward average (T_{av} = max. 10 s)	I_{ig}	max.	2	A

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

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		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

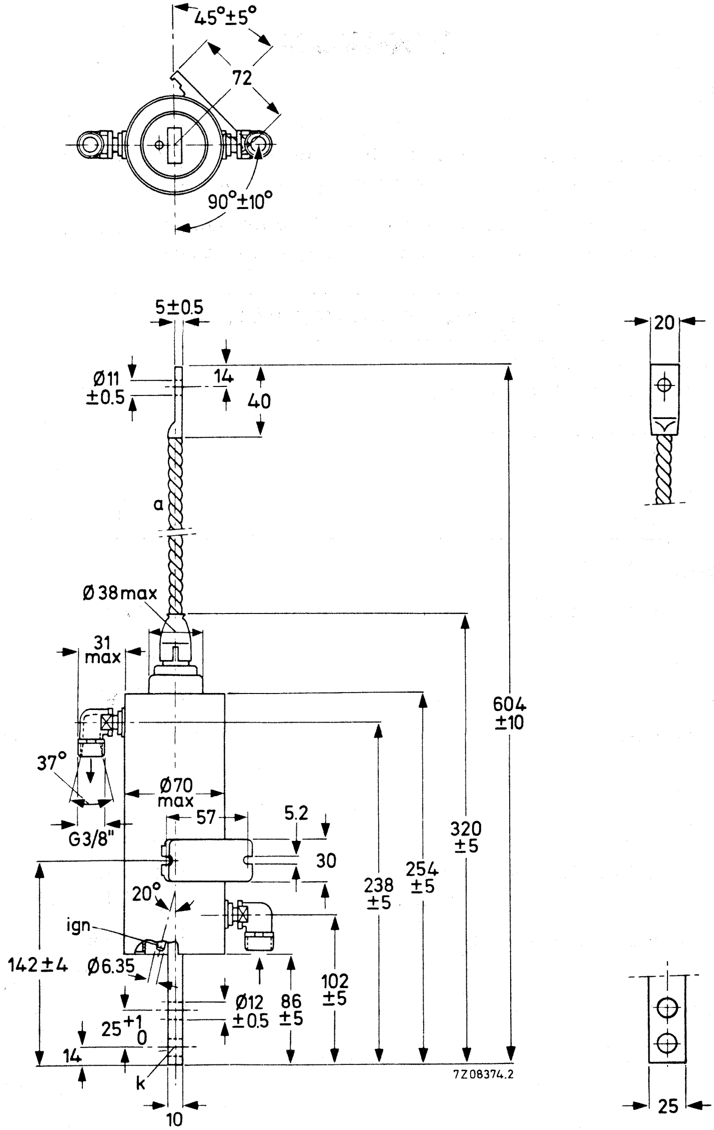
Dimensions and connections	see page 2
Net weight	1420 g
Shipping weight	2040 g
Mounting position	vertical, anode connection up

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm



TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 2 l/min)	p_i	max.	0.08	kg/cm^2
Temperature rise at max. average current (q = 2 l/min)	$t_o - t_i$	max.	6	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 9)	q	min.	2	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 continuous water flow at max. average current	q	min.	2	l/min
Inlet temperature 1)	t_i	min.	10	^oC
		max.	35	^oC
Temperature of thermostat mount 2)	t_m	max.	45	^oC

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 ^oC

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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.

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 10, 11 and 12.

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220[1]	250	380	500	600	V
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
Duty factor	δ	2.8	2.8	4.2	5.6	6.7	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	400	400	320	280	260	A
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
Duty factor	δ	15.6	15.6	23.5	31.1	37.7	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	320	320	260	220	200	A
Max. surge current RMS (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.

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 current	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.

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_{ig}		150	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	T_{ig}	max.	50	μs [1])

Ignition circuit requirements

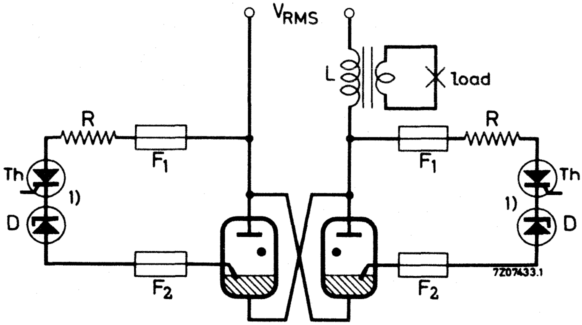
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dT	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

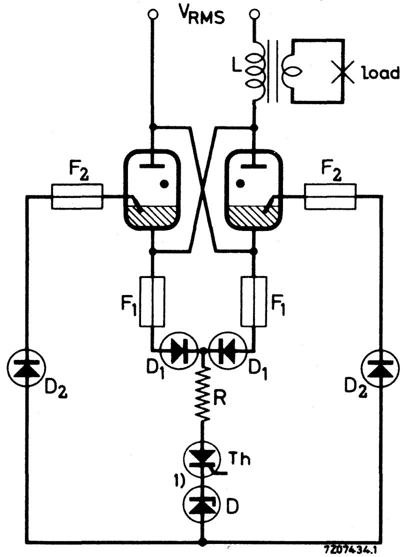
IGNITOR CHARACTERISTICS AND IGNITRON CIRCUIT REQUIREMENTS

(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

D = zener voltage ≥ 18 V

---

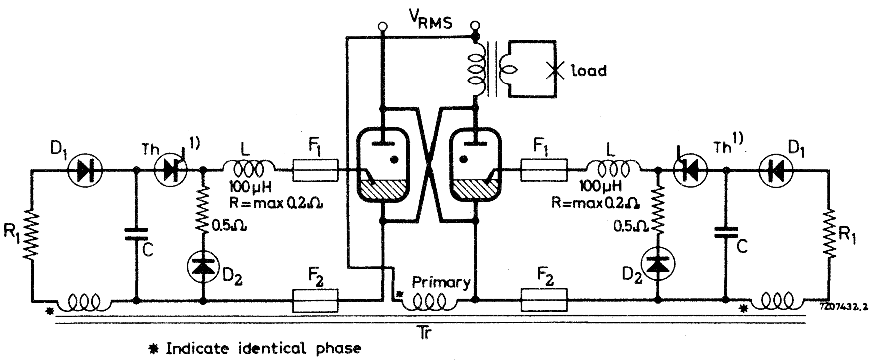
1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(continued)

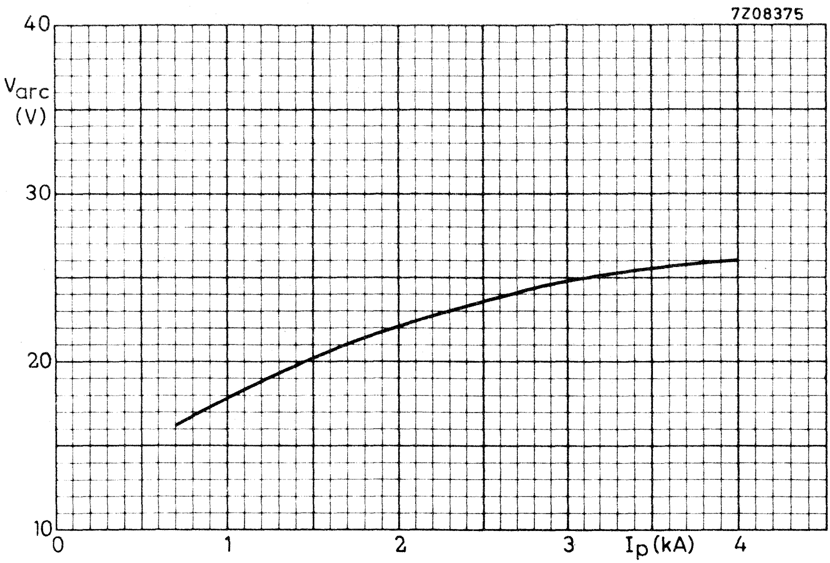
B. Separate excitation

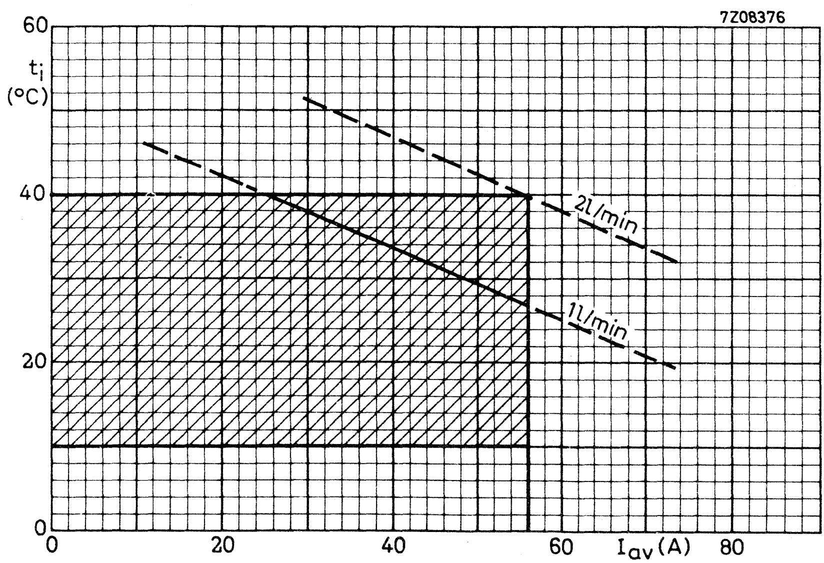
Recommended circuit for separate excitation



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.



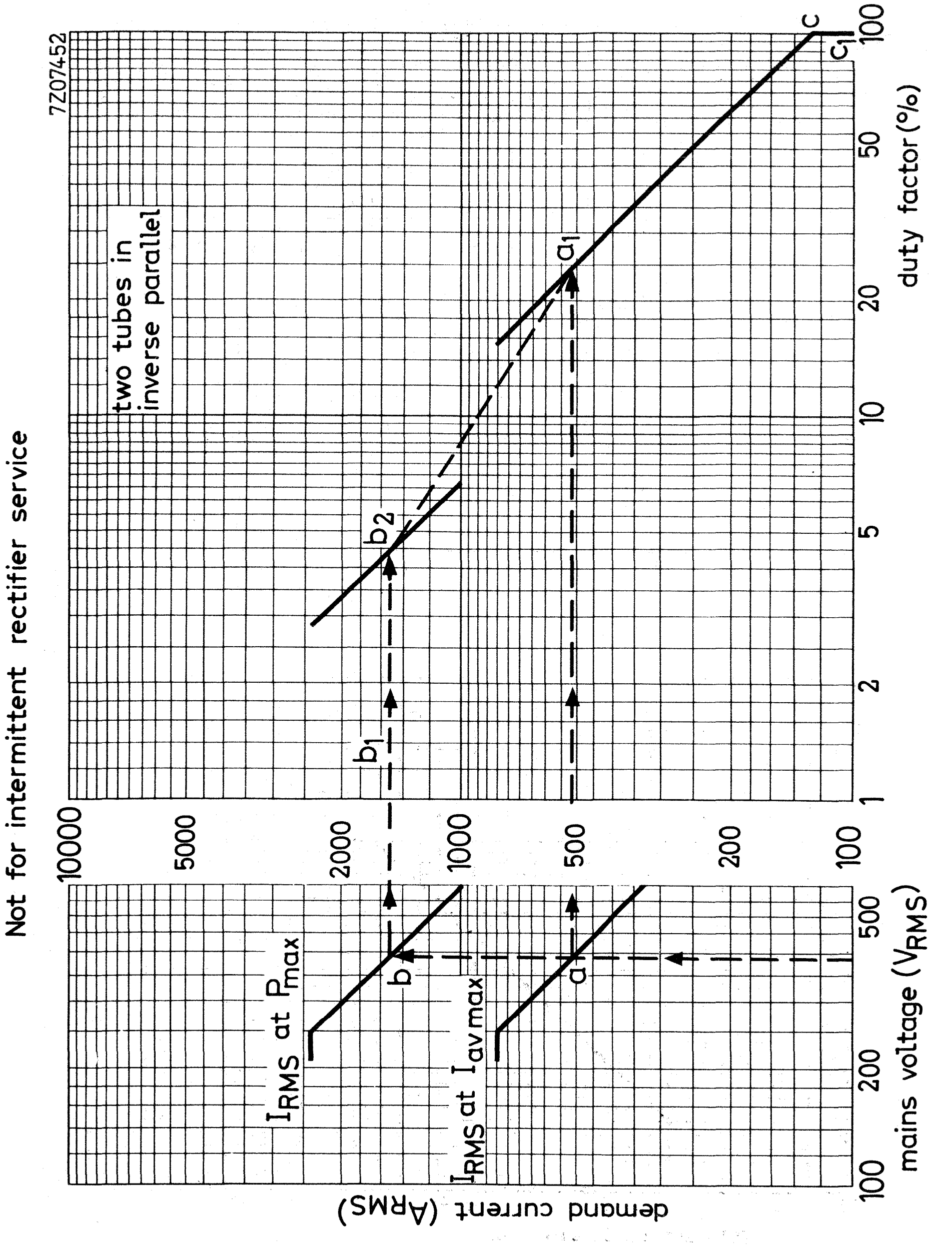


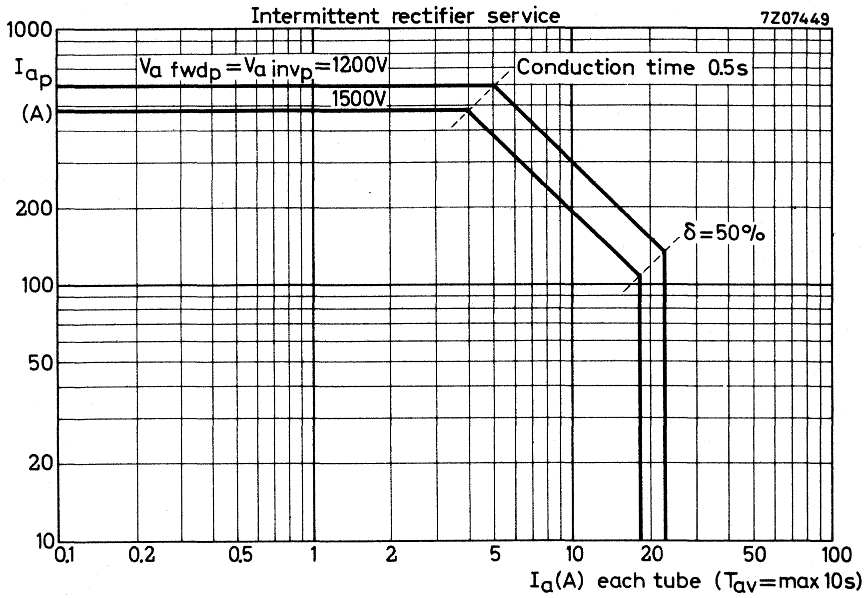
Minimum required continuous waterflow (two tubes cooled in series)

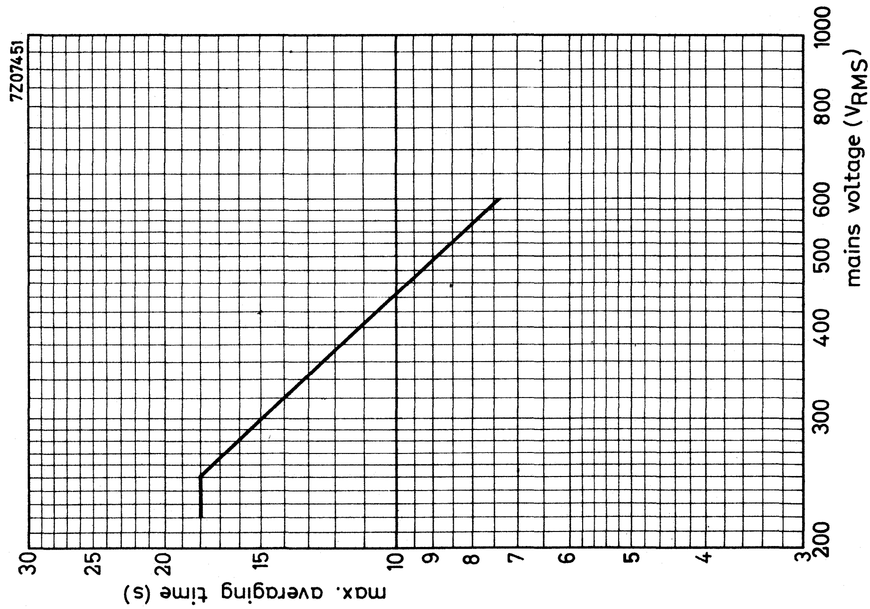
Graph to determine demand current versus duty factor as a function of the mains voltage (page 11)

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.


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
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 (%)


Intermittent rectifier service
7Z07449
1000
I_{ap}
(A)
200
100
50
20
10
0.1
0.2
0.5
1
2
5
10
20
50
100
V_a fwd$_p$ = V_a inv$_p$ = 1200V
1500V
Conduction time 0.5s
δ = 50%
I_a(A) each tube (T_{av} = max 10s)


7Z07451
mains voltage (V_{RMS})
200
300
400
500
600
800
1000
max. averaging time (s)
30
25
20
15
10
9
8
7
6
5
4
3

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		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

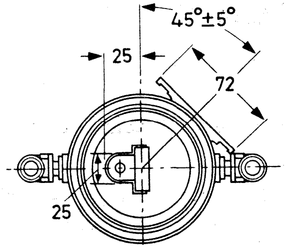
Dimensions and connections	see page 2
Net weight	2820 g
Shipping weight	4080 g
Mounting position	vertical, anode connection up

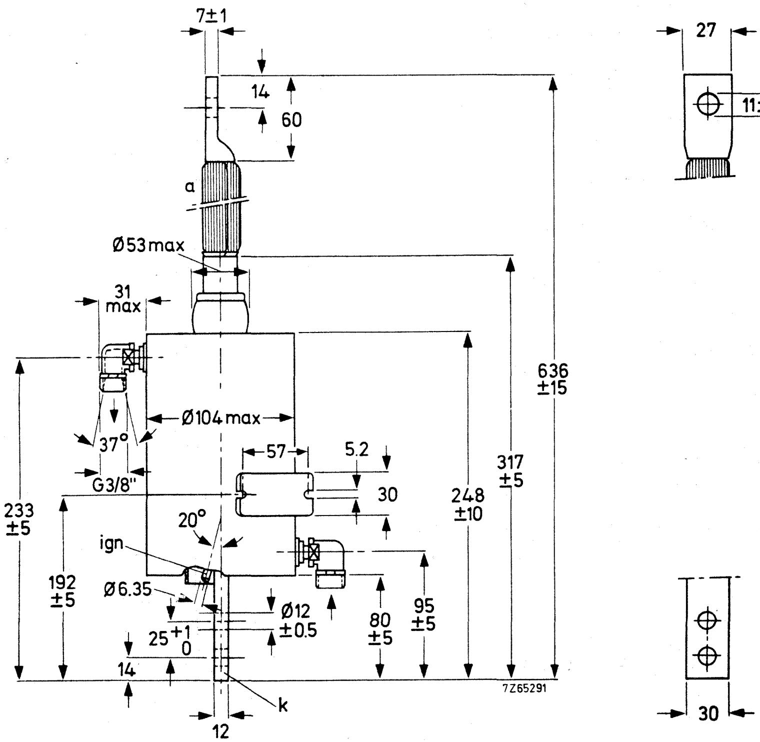
Accessories

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm





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 10)	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.

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 8, 9, and 11

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220[1]	250	380	500	600	V
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
Duty factor	δ	3.5	3.5	5.3	7.0	8.4	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	900	900	720	630	580	A
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
Duty factor	δ	19.4	19.4	29.5	39.0	47.0	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	140	140	140	140	140	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	700	700	570	500	450	A
Max. surge current RMS (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.

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_{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_{ig}		150	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	T_{ig}	max.	50	µs [1]

Ignition circuit requirements

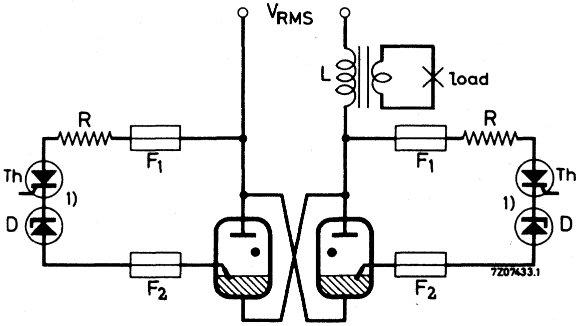
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dT	min.	0.1	A/µs

[1] Ignition time is taken from the instant that the stated voltage and current are reached.

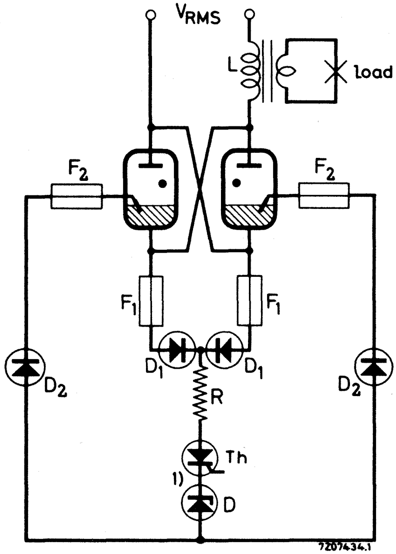
IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(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

D = zener voltage $\geq$ 18 V

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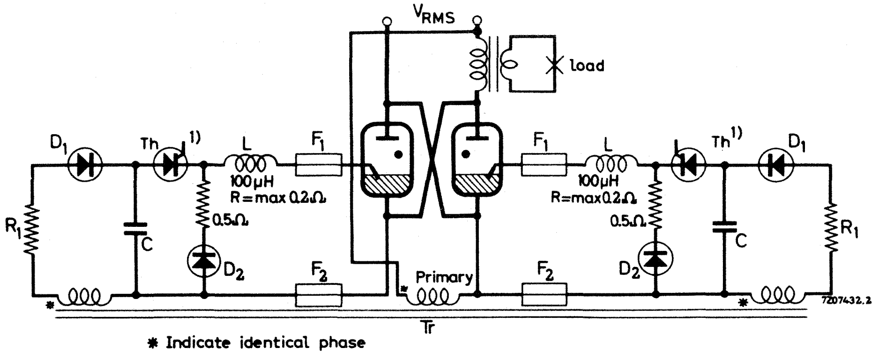
1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(continued)

B. Separate excitation

Recommended circuit for separate excitation



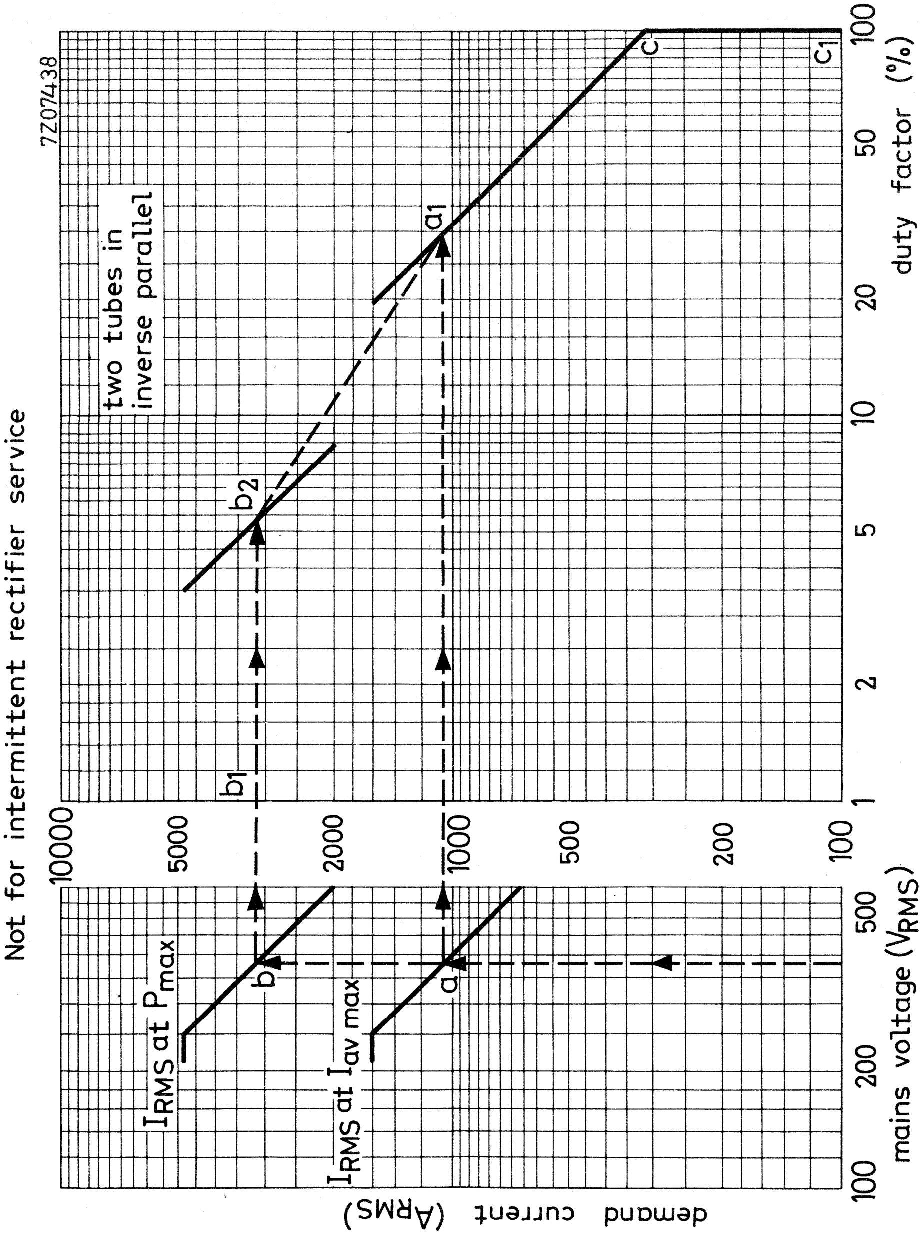
Capacitor value	C	2	8	µF
Capacitor voltage	V_c	650	400	V ±10%
Peak value of closed circuit current		80 to 100		A

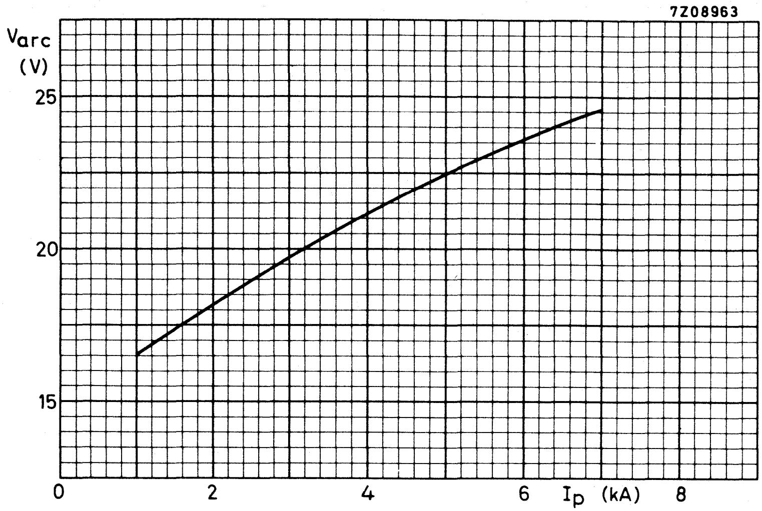
1) The thyristor may be substituted by a thyratron.

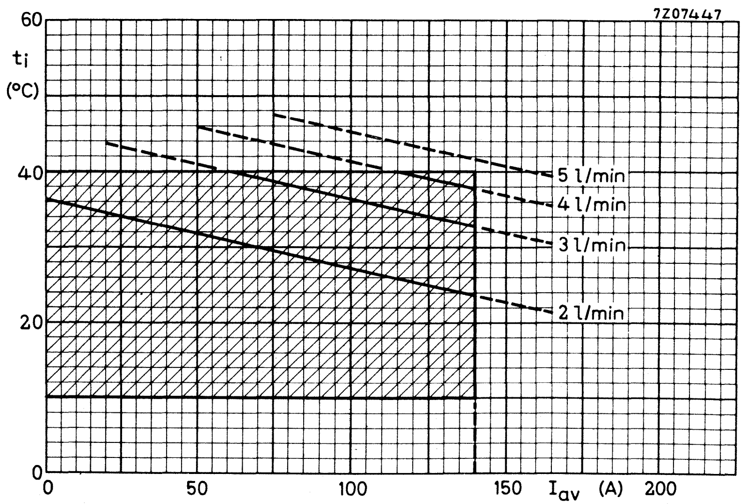
Graph to determine demand current versus duty factor as a function of the mains voltage (page 9)

Construction:

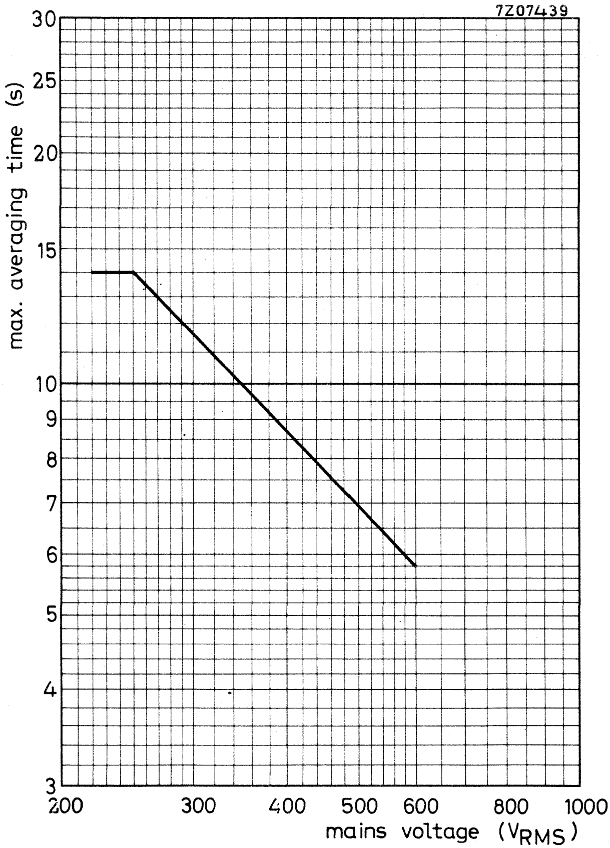
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.


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
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





Minimum required continuous waterflow (two tubes cooled in series)


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 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)		2400	kVA
Maximum average current		355	A
Ignitor voltage		180	V
Ignitor current	max.	12	A

MECHANICAL DATA

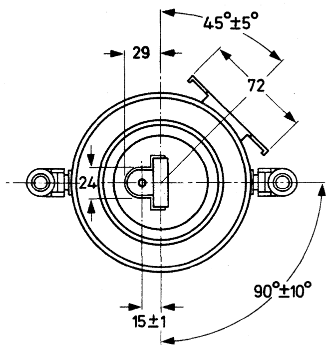
Dimensions and connections	see page 2
Net weight	8.7 kg
Shipping weight	11 kg
Mounting position	vertical, anode connection up

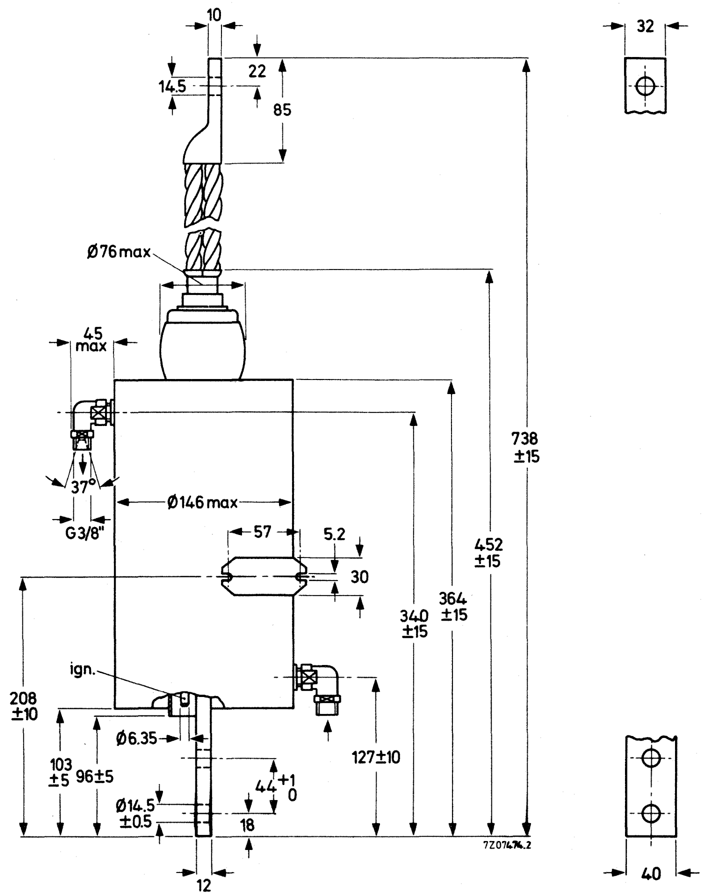
Accessories

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm





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	°C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (see also page 9)	q	min.	9	l/min.
Inlet temperature [1]	t_i	min.	10	°C
		max.	40	°C
Temperature of thermostat mount [2]	t_m	max.	50	°C

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	°C
		max.	35	°C
Temperature of thermostat mount [2]	t_m	max.	45	°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.

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 10, 11 and 12

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220[1]	250	380	500	600	V
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
Duty factor	δ	4.4	4.4	6.8	8.8	10.6	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	25	25	25	25	25	c/T_{av} max
Integrated RMS load current	$I_{F\ RMS}$	2000	2000	1640	1420	1300	A
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
Duty factor	δ	24.6	24.6	37.5	49.3	60.0	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	140	140	140	140	140	c/T_{av}max
Integrated RMS load current	$I_{F\ RMS}$	1600	1600	1300	1130	1020	A
Max. surge current RMS (T_{max} = 0.15 s)	I_{surge}	27	27	17.8	13.5	11.2	kA

[1]) For mains voltages below 250V(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.

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_{ap} 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_{ap}	1140	840	672	A
Averaging time	T_{av} max	6.25	6.25	6.25	s
Ratio I_a/I_{ap} (T_{av} = max. 0.5 s)	I_a/I_{ap} max	1/6	1/6	1/6	
Ratio I_{surge}/I_{ap} (T_{max} = 0.15 s)	I_{surge}/I_{ap} 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

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS
(continued)

A. Anode excitation

Ignitor characteristics

Firing voltage	V_{ig}	180	V
Firing current	I_{ig}	6 to 8	A
		max. 12	A
Ignition time at the above voltage or current	T_{ig}	max. 100	μs [1]

Ignition circuit requirements

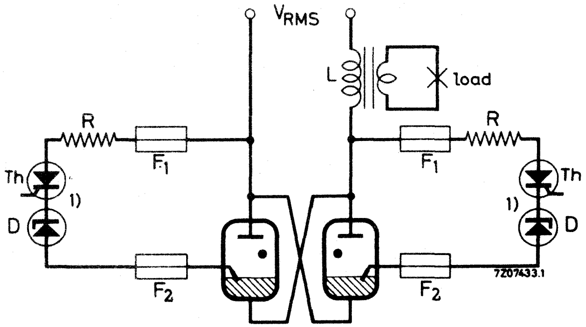
Peak voltage required to fire	V_p	min. 200	V
Peak current required for anode take over	I_p	15 to 30	A [2]
Rate of rise of ignitor current	di/dT	min. 0.1	A/μs

[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.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

Recommended circuits for anode excitation



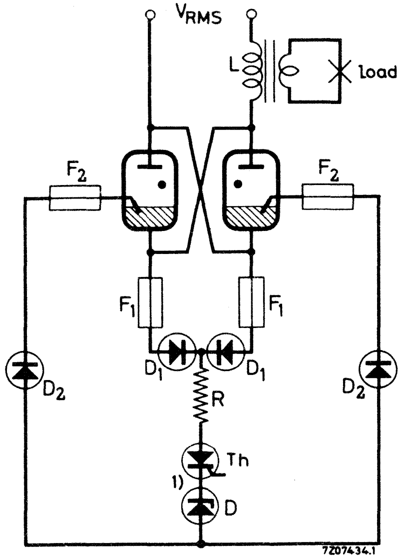
Anode excitation with individual thyristors

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

D = zener voltage ≥ 18 V



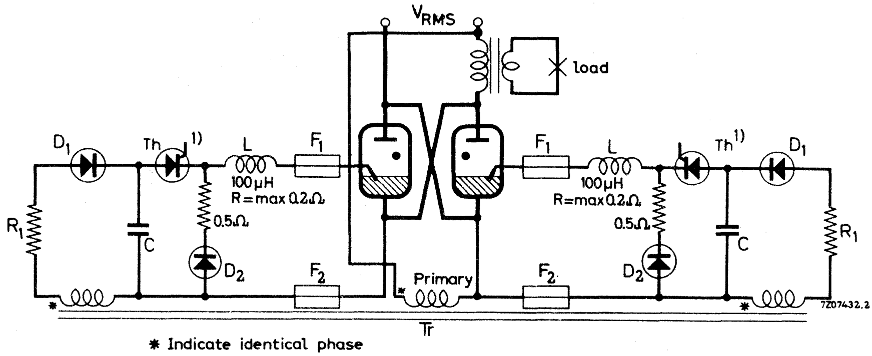
Anode excitation with common thyristor

1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

B. Separate excitation

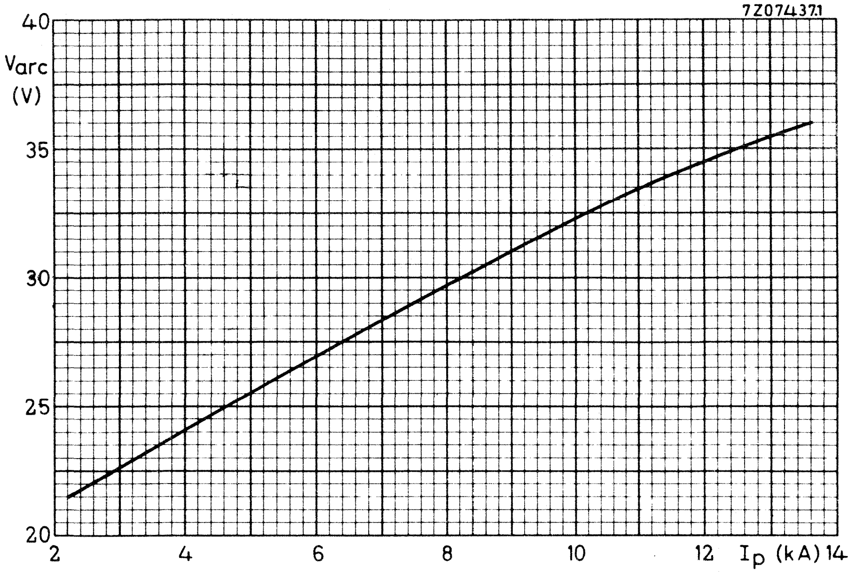
Recommended circuit for separate excitation

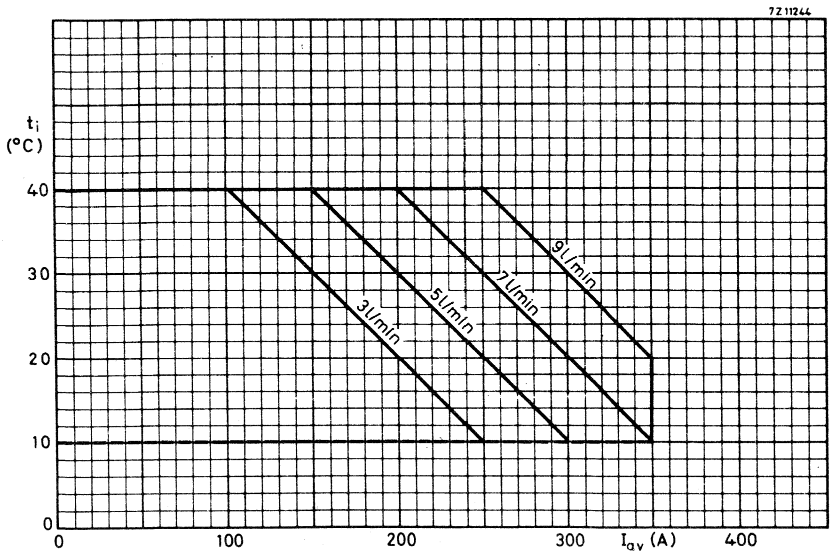


✱ Indicate identical phase

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.



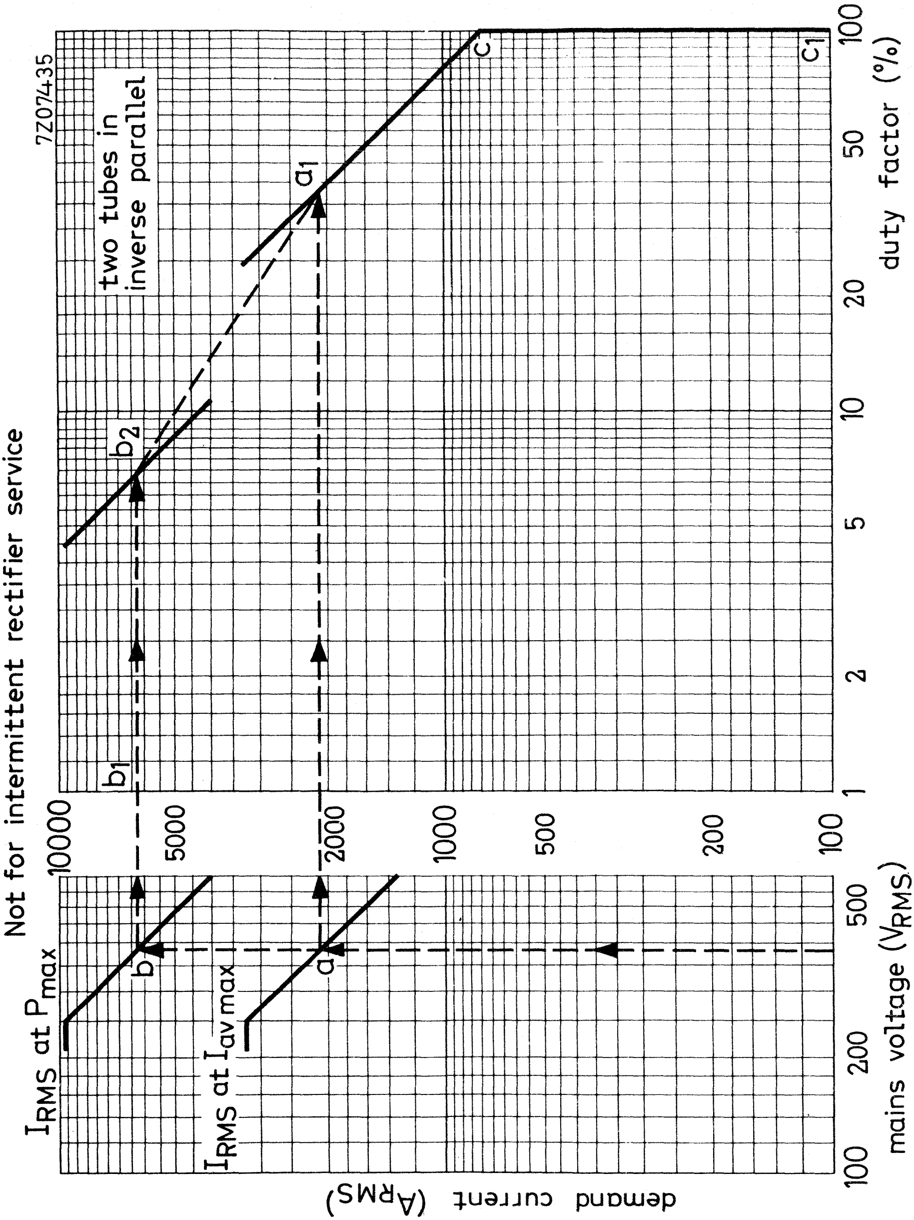


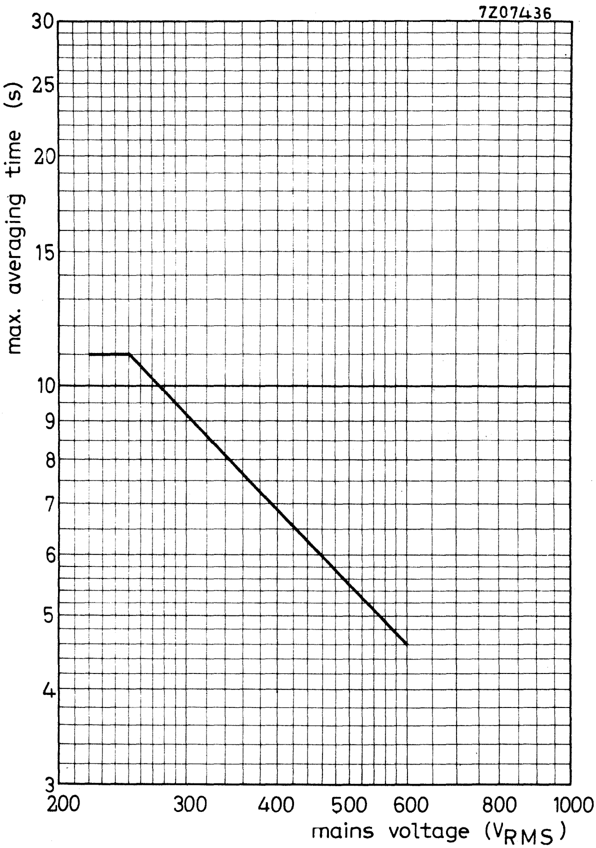
Minimum required continuous waterflow (two tubes cooled in series)

Graph to determine demand current versus duty factor as a function of the mains voltage (page 11)

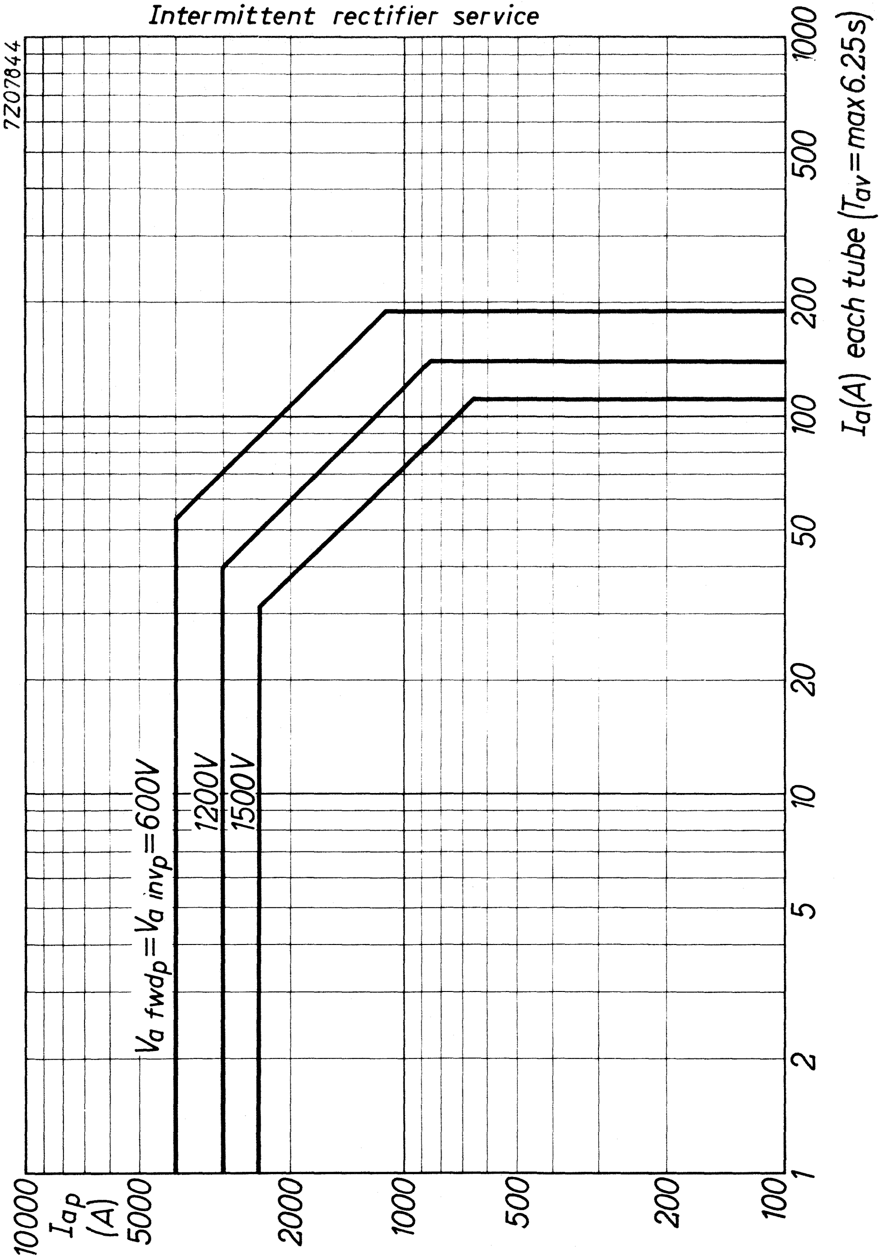
Construction:

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.


Not for intermittent rectifier service
two tubes in inverse parallel
7Z07435
I_RMS at P_max
I_RMS at I_av max
demand current (A_RMS)
mains voltage (V_RMS)
duty factor (%)
10000
5000
2000
1000
500
200
100
100
200
500
1
2
5
10
20
50
100
a
b
a1
b1
b2
c
c1


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 (V_{RMS})

Intermittent rectifier service



IGNITRON

Uprated A 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 and quick change water connections.

QUICK REFERENCE DATA			
Maximum demand power (two tubes in inverse parallel) at 600 V_{RMS}		1200	kVA
Maximum average current		35	A
Ignitor voltage		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

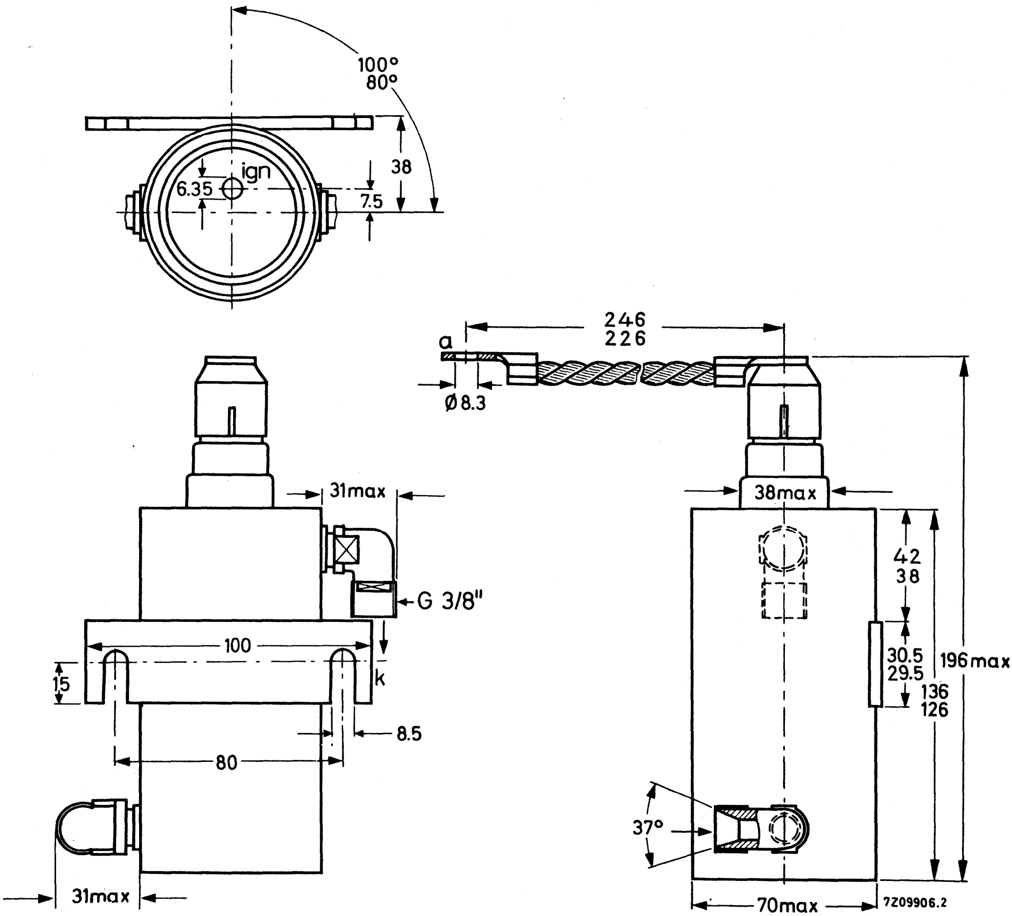
Dimensions and connections	see page 2
Net weight	1250 g
Shipping weight:	1800 g
Mounting position	vertical anode connection up

Accessories

Ignitor cable		type 55351
Water hose connections:	hose nipple	type TE1051c
	coupling nut	type TE1051b

DIMENSIONS AND CONNECTIONS

Dimensions in mm



OBSOLESCENT TYPE

TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 2 l/min)	p_i	max. 0.1	kg/cm^2
Temperature rise at max. average current (q = 2 l/min)	$t_o - t_i$	max. 5	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 8)	q	min. 2	l/min
Inlet temperature 1)	t_i	min. 10	^oC
		max. 40	^oC

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	^oC

ELECTRICAL DATA (see page 4)

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.

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.

Single phase A.C. control, two tubes in inverse parallel connection

Table I. See also pages 9, 10 and 11

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220[1])	250	380	500	600	V
Max. averaging time	$T_{av\ max}$	18	18	11.8	9.4	8	s
A. Max. demand power							
Max. demand power	P_{max}	550	630	850	1050	1200	kVA
Corresponding max. average current	I_{av}	21	21	21	21	21	A
Demand current	I_{RMS}	2500	2500	2250	2100	2000	A
Duty factor	δ	1.9	1.9	2.1	2.2	2.3	%
Number of cycles within T_{av} max. [2])	n (50 Hz)	16	16	12	10	9	c/$T_{av\,max}$
Integrated RMS load current	$I_{F\ RMS}$	345	345	325	310	300	A
B. Max. average current							
Max. average current	I_{AVmax}	33	33	33	33	33	A
Corresponding max. demand power	P	180	210	280	350	400	kVA
Demand current	I_{RMS}	850	850	750	700	660	A
Duty factor	δ	8.7	8.7	9.9	10.6	11.2	%
Number of cycles within T_{av} max. [2])	n (50 Hz)	78	78	58	50	45	c/$T_{av\,max}$
Integrated RMS load current	$I_{F\ RMS}$	250	250	235	230	220	A
Max. surge current (T_{max} = 0.15 s)	RMS I_{surge}	7000	7000	6300	5900	5600	A

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.

---

[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.

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_{ig}		150	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	I_{ig}	max.	50	μs [1]

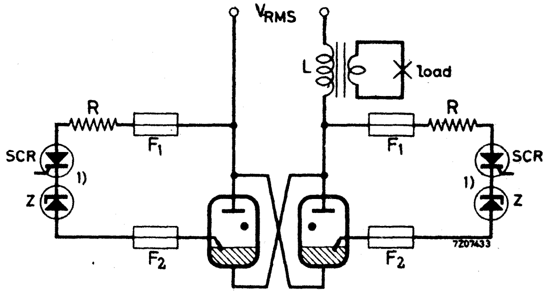
Ignition circuit requirements

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

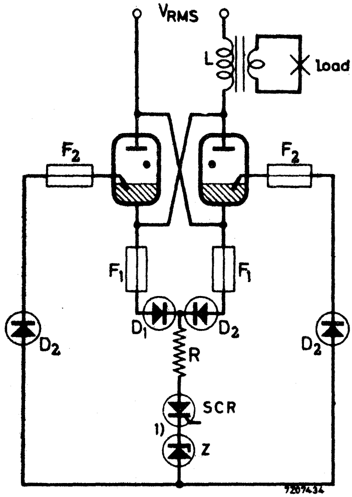
[1] Ignition time is taken from the instant that the stated voltage and current are reached.

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

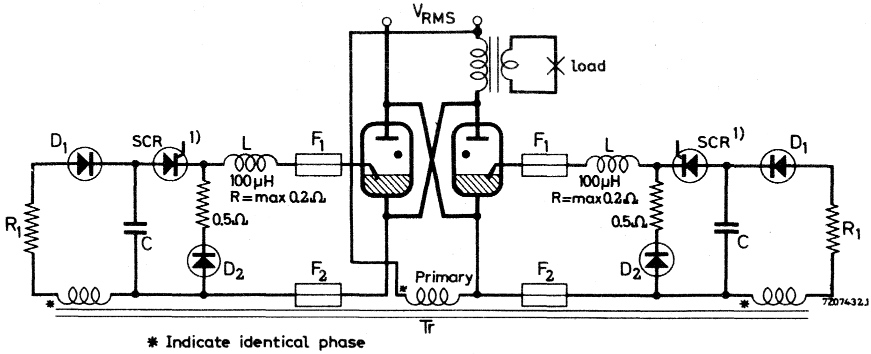
Z = zener voltage ≥ 18 V

1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS (continued)

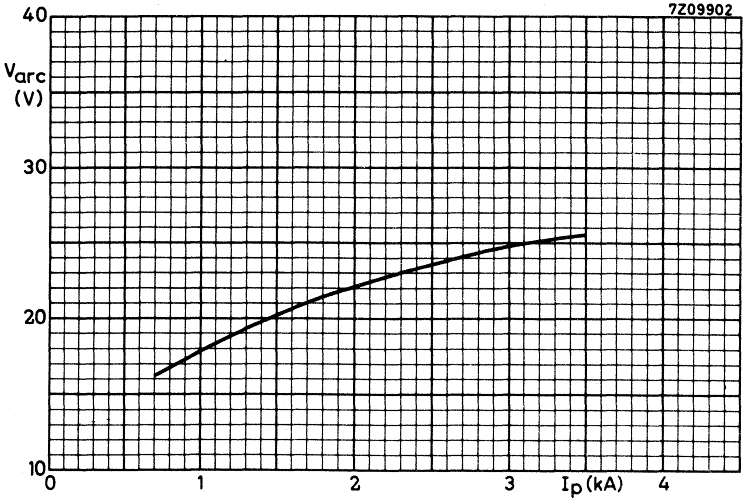
B. Separate excitation

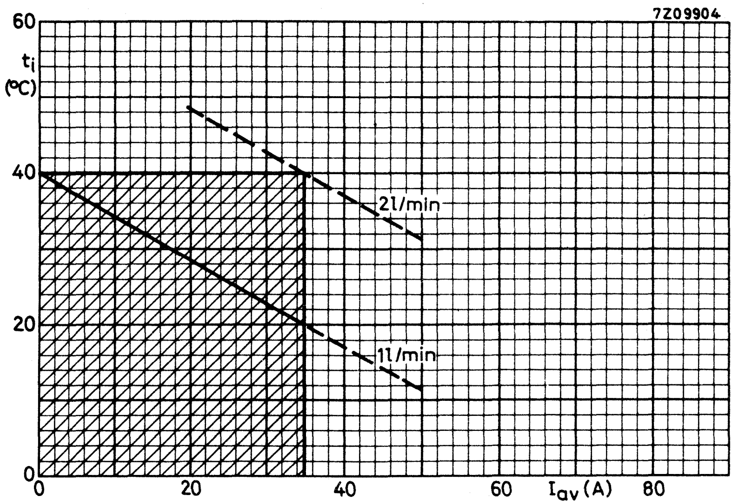
Recommended circuit for separate excitation



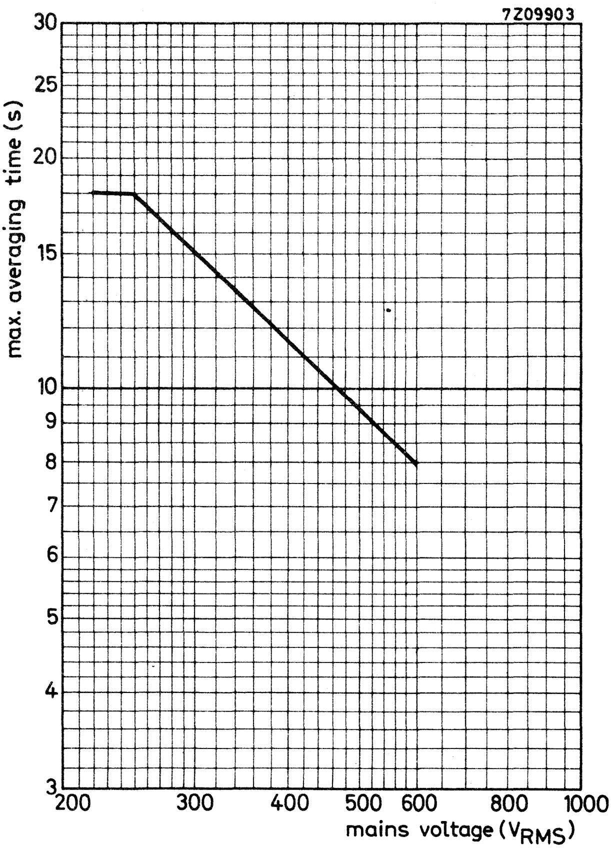
Capacitor value	C	2	8	μF
Capacitor voltage	V_c	650	400	V $\pm$10%
Peak value of closed circuit current		80 to 100		A

1) The thyristor may be substituted by a thyratron.





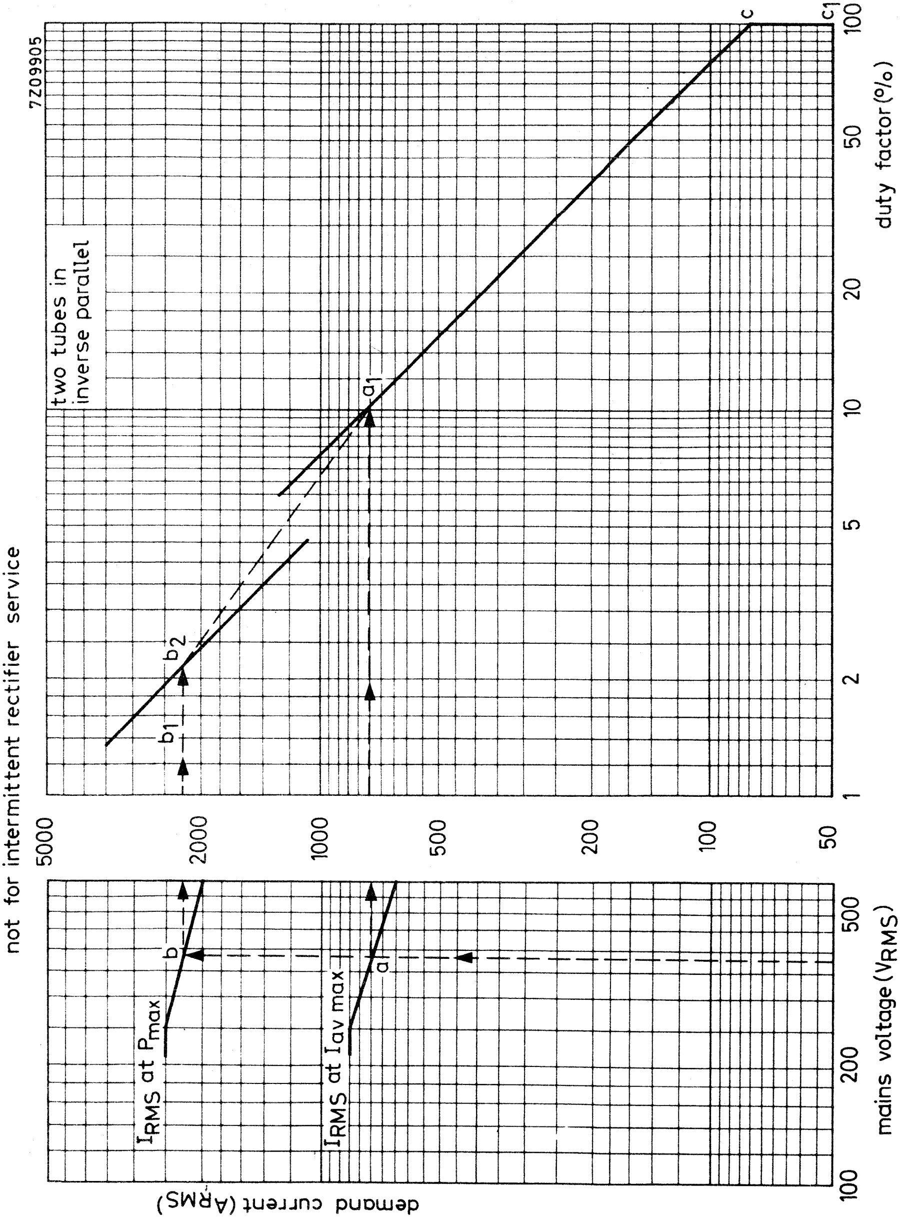
Minimum required continuous waterflow (two tubes cooled in series)


7Z09903
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})

Grap to determine demand current versus duty factor as a function of the mains voltage (page 11)

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.



7Z09905
not for intermittent rectifier service
two tubes in inverse parallel
duty factor (%)
1
2
5
10
20
50
100
a1
b1
b2
c
c1
5000
2000
1000
500
200
100
50
demand current (A_RMS)
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
b
mains voltage (V_{RMS})
100
200
500

IGNITRON

Uprated 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) at 600 V_{RMS}		1200	kVA
Maximum average current		70	A
Ignitor voltage		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

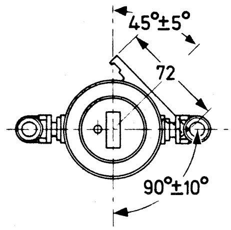
Dimensions and connections	see page 2
Net weight	1660 g
Shipping weight	2280 g
Mounting position	vertical, anode connection up

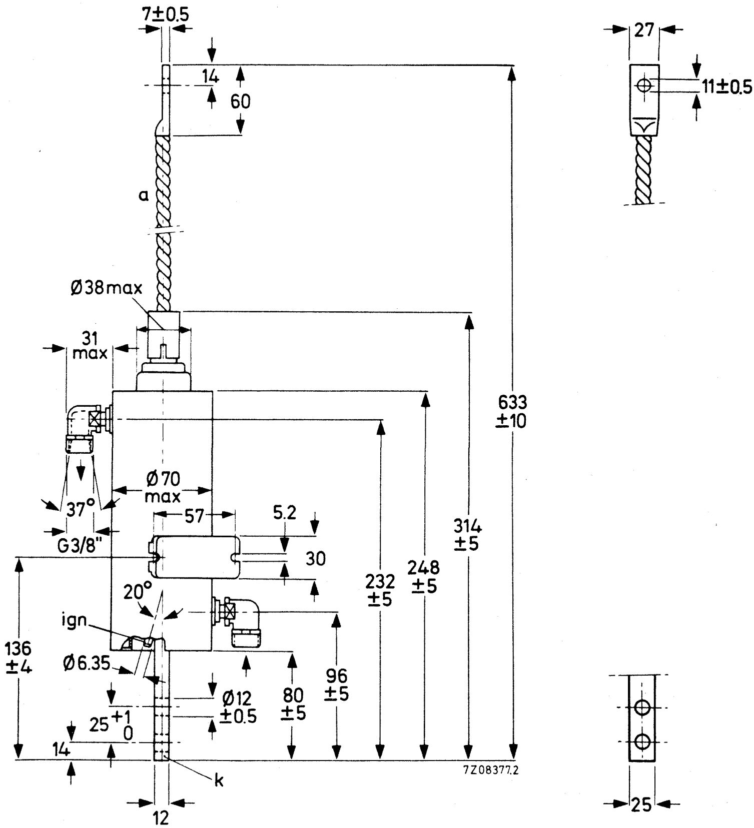
Accessories

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm





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.	5.5	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 9)	q	min.	3	l/min
Inlet temperature	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 continuous water flow at max. average current	q	min.	4	l/min
Inlet temperature [1]	t_i	min.	10	^oC
		max.	35	^oC
Temperature of thermostat mount [2]	t_m	max.	45	^oC

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	^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 at the last but one tube.

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 10 and 11

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220[1]	250	380	500	600	V
Max. averaging time	$T_{av\ max}$	24	24	15.8	12	10	s
A. Max. demand power							
Max. demand power	P_{max}	550	630	850	1050	1200	kVA
Corresponding max. average current	I_{av}	38	38	38	38	38	A
Demand current	I_{RMS}	2500	2500	2250	2100	2000	A
Duty factor	δ	3.3	3.3	3.8	4.0	4.2	%
Number of cycles within $T_{av\ max}$ [2]	n (50 Hz)	40	40	30	24	21	c/$T_{av\ max}$
Integrated RMS load current	$I_{F\ RMS}$	460	460	440	420	410	A
B. Max. average current							
Max. average current	I_{AVmax}	70	70	70	70	70	A
Corresponding max. demand power	P	180	210	280	350	400	kVA
Demand current	I_{RMS}	850	850	750	700	660	A
Duty factor	δ	18.3	18.3	20.8	22.2	23.5	%
Number of cycles within $T_{av\ max}$. [2]	n (50 Hz)	220	220	164	134	118	c/$T_{av\ max}$
Integrated RMS load current	$I_{F\ RMS}$	360	360	340	330	320	A
Max. surge current RMS (T_{max} = 0.15 s)	I_{surge}	7000	7000	6300	5900	5600	A

[1]) For mains voltages below 250V(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.

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	1500	1200	A
Corresponding average current	I_{av}	20	16	A
B. Max. average current				
Anode current, average	I_{av} max	70	56	A
Corresponding peak	I_{a_p}	420	336	A
Averaging time	T_{av} max	6.25	6.25	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_{a_p} (T_{max} = 0.15 s)	I_{surge}/I_{a_p} 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.

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_{ig}		150	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	T_{ig}	max.	50	μs [1]

Ignition circuit requirements

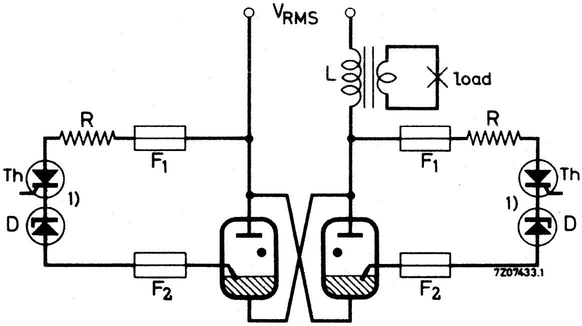
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dT	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

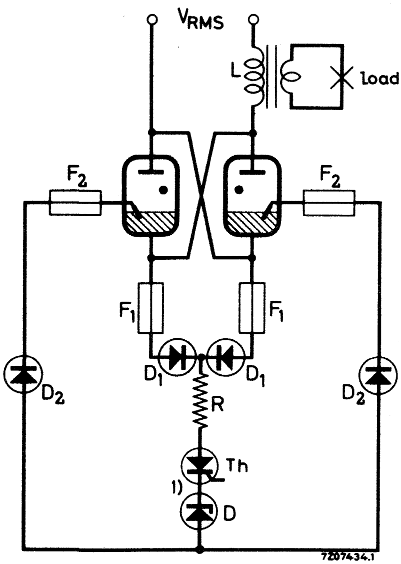
IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(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				
D	=	zener voltage ≥ 18 V				

Anode excitation with common thyristor

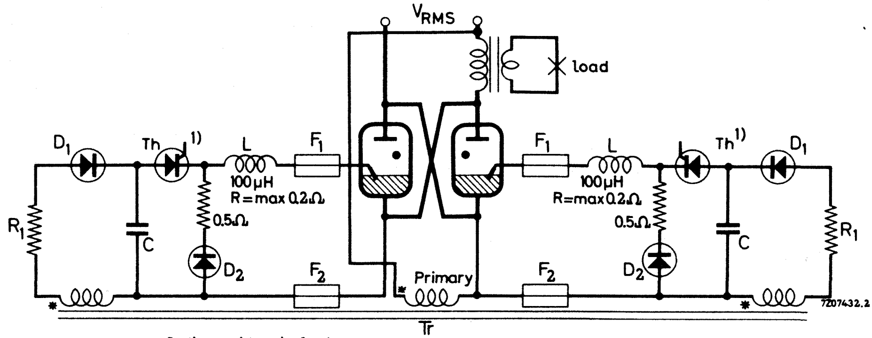
1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(continued)

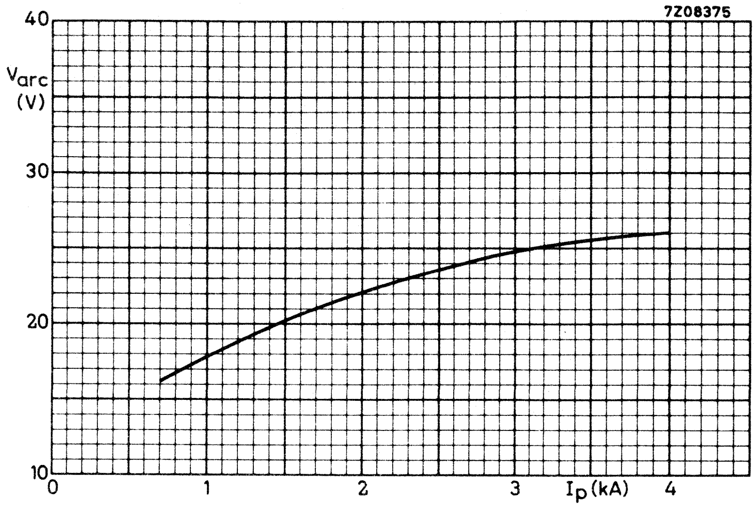
B. Separate excitation

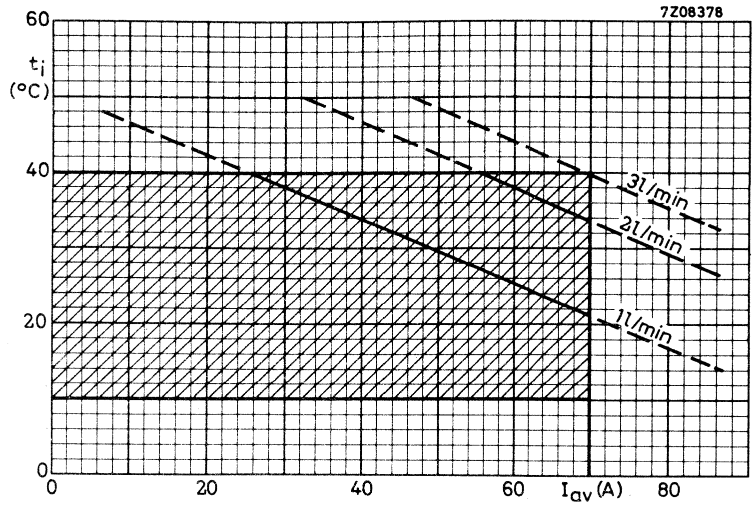
Recommended circuit for separate excitation



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.



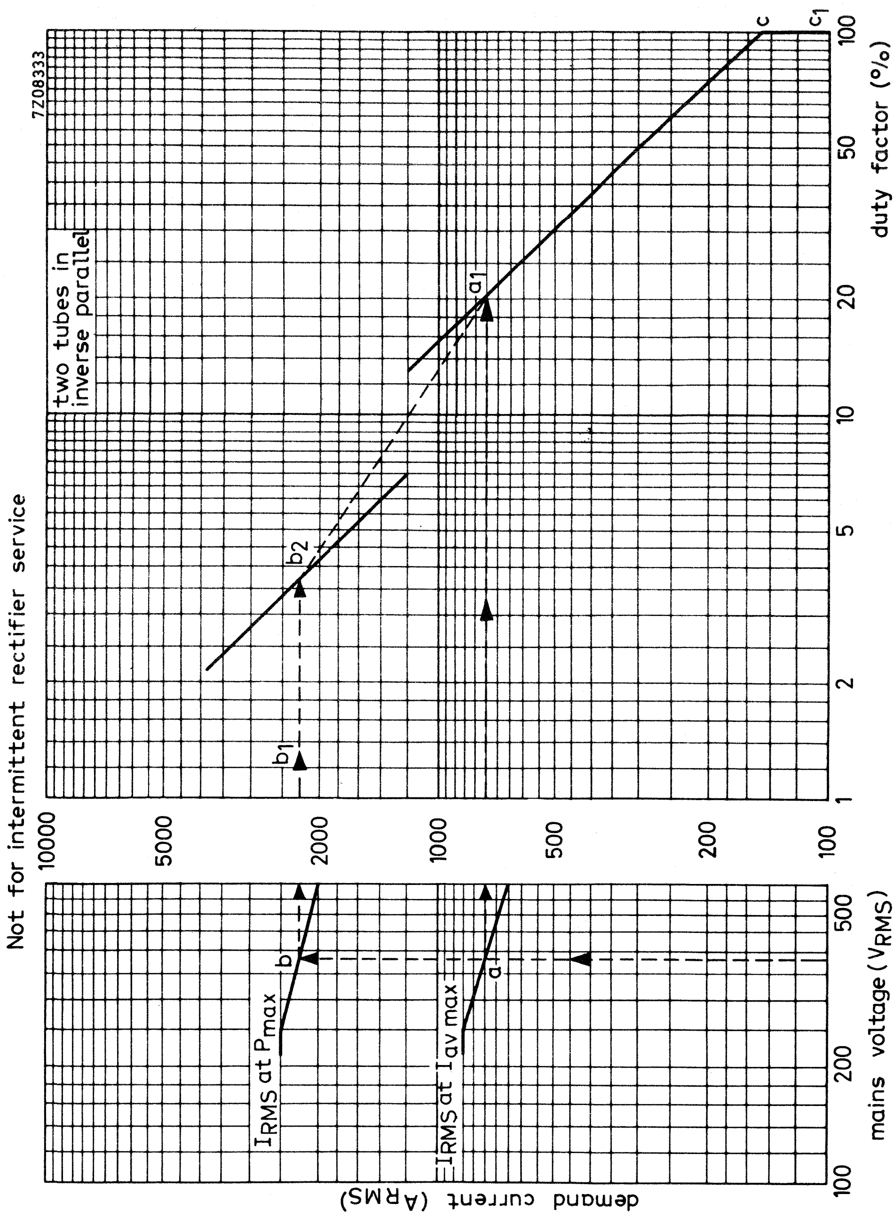


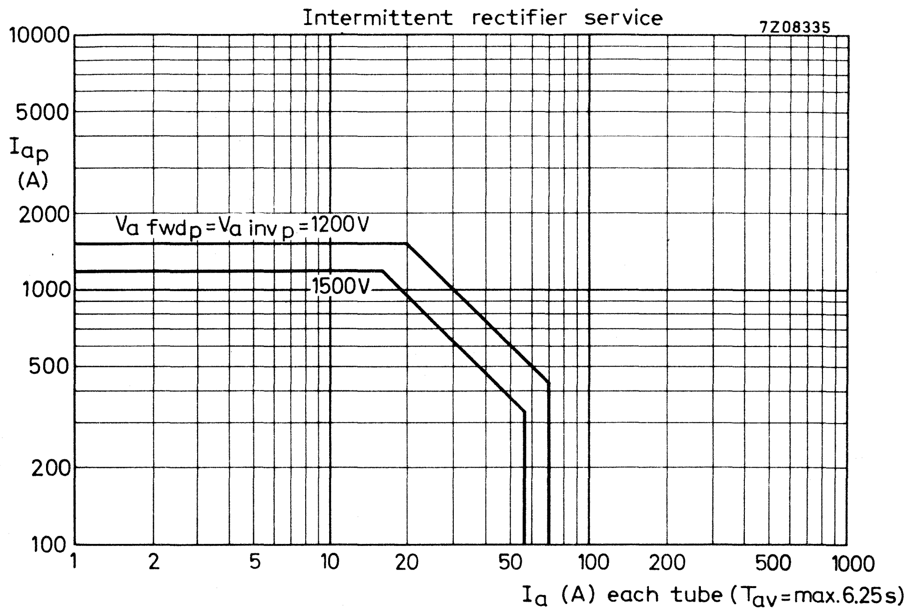
Minimum required continuous waterflow (two tubes cooled in series)

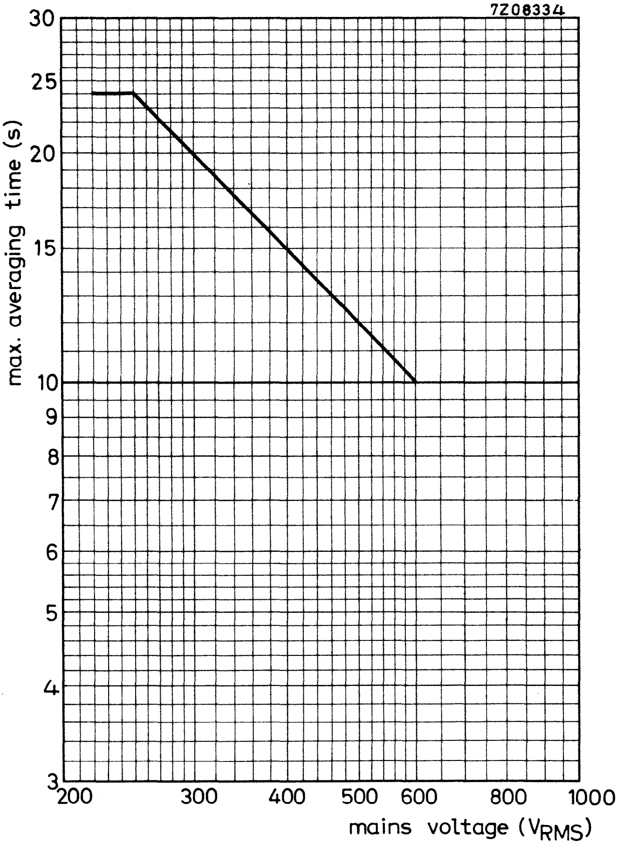
Graph to determine demand current versus duty factor as a function of the mains voltage (page 11)

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.


Not for intermittent rectifier service
7Z08333
two tubes in inverse parallel
demand current (A_{RMS})
10000
5000
2000
1000
500
200
100
duty factor (%)
1
2
5
10
20
50
100
mains voltage (V_{RMS})
100
200
500
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
7Z08335
10000
5000
2000
1000
500
200
100
I_{ap} (A)
$V_{a\,fwd\,p} = V_{a\,inv\,p} = 1200\,V$
1500V
1
2
5
10
20
50
100
200
500
1000
I_a (A) each tube (T_{av} = max. 6.25 s)


7Z08334
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		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

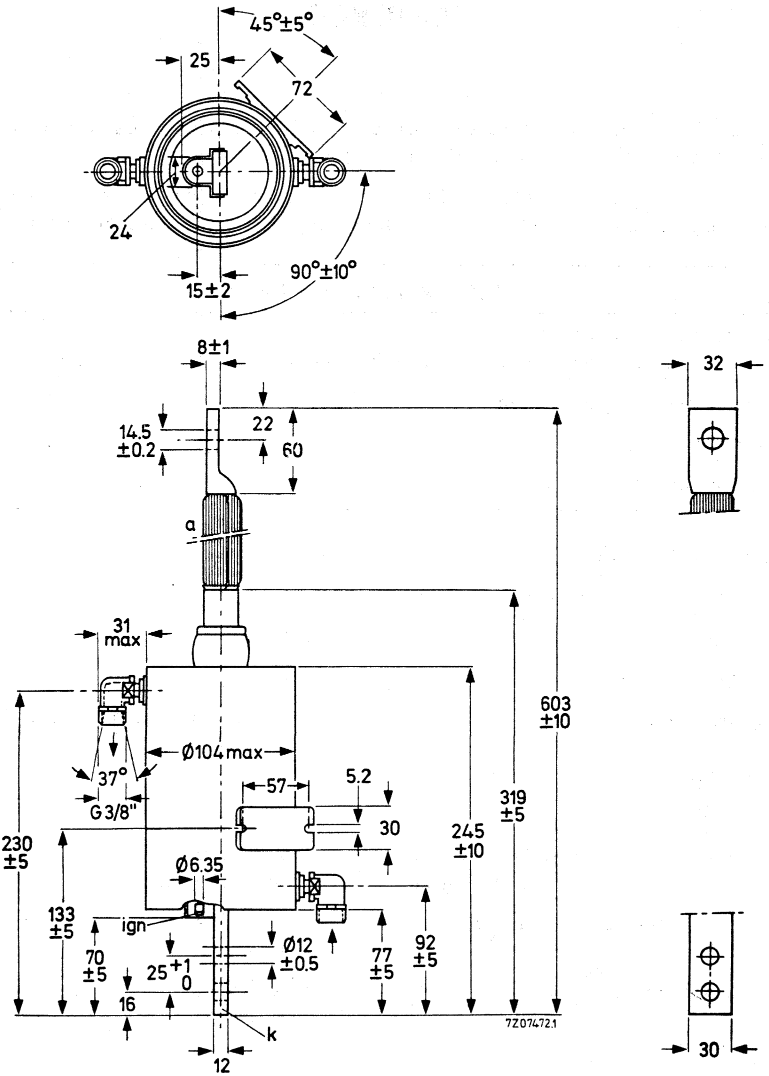
Dimensions and connections	see page 2
Net weight	2900 g
Shipping weight	4160 g
Mounting position	vertical, anode connection up

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

→ DIMENSIONS AND CONNECTIONS

Dimensions in mm



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	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 10)	q	min. 6	l/min
Inlet temperature [1]	t_i	min. 10	^oC
		max. 40	^oC
Temperature of thermostat mount [2]	t_m	max. 50	^oC

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	^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.

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 8, 9 and 11.

Mains frequency range		25 to 60					Hz
Mains voltage	V_{RMS}	220[1]	250	380	500	600	V
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
Duty factor	δ	4.9	4.9	5.6	6.1	6.4	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	51	51	38	32	27	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	1100	1100	1030	990	970	A
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
Duty factor	δ	24.2	24.2	27.2	30.0	31.4	%
Number of cycles within T_{av} max. [2]	n (50 Hz)	254	254	190	157	136	c/T_{av} max
Integrated RMS load current	$I_{F\,RMS}$	810	810	760	730	710	A
Max. surge current RMS (T_{max} = 0.15 s)	I_{surge}	14.0	14.0	12.2	11.2	10.6	kA

1) For mains voltages below 250V(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.

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_{ig}		150	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	T_{ig}	max.	50	μs [1]

Ignition circuit requirements

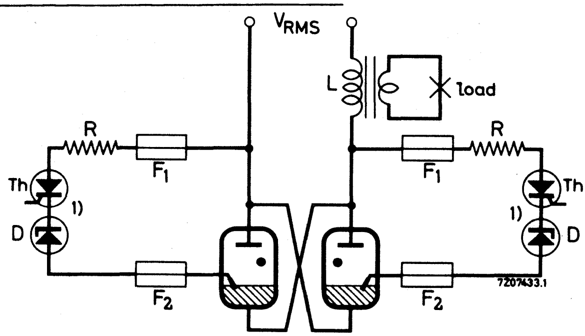
Peak voltage required to fire	V_p	min.	200	V
Peak current required to fire	I_p	min.	12	A
Rate of rise of ignitor current	di/dT	min.	0.1	A/μs

[1]) Ignition time is taken from the instant that the stated voltage and current are reached.

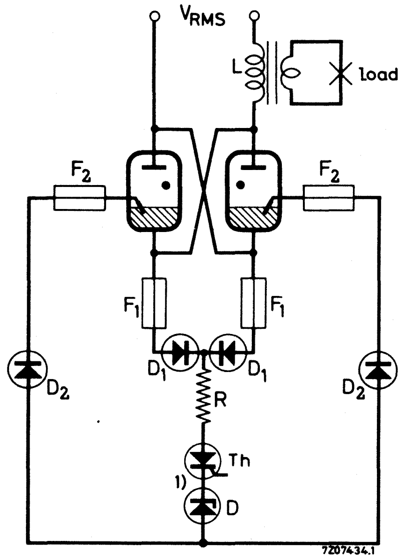
IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

(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

D = zener voltage ≥ 18 V

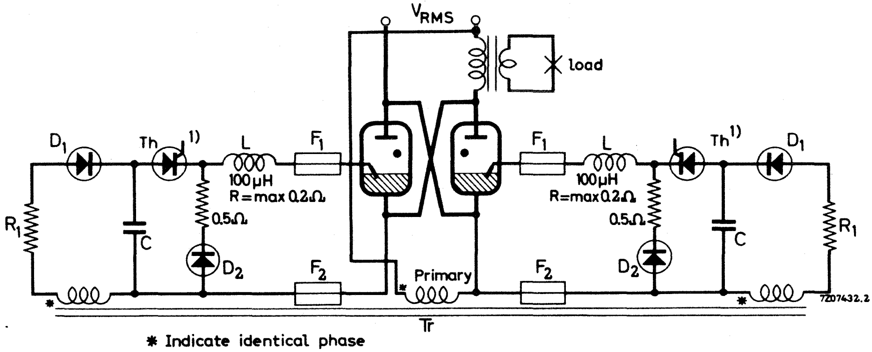
---

1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS (continued)

B. Separate excitation

Recommended circuit for separate excitation



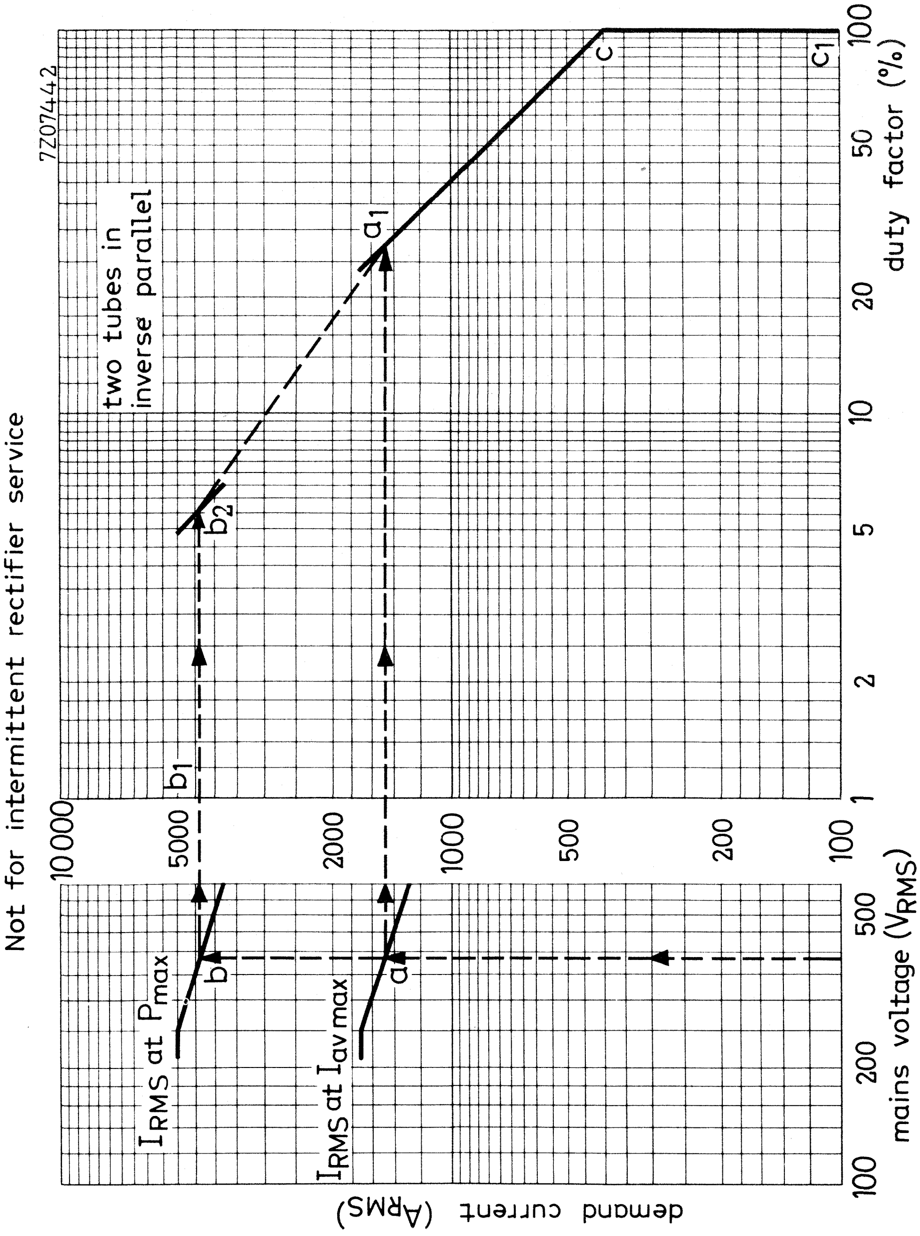
Capacitor value	C	2	8	μF
Capacitor voltage	V_c	650	400	V ±10%
Peak value of closed circuit current		80 to 100		A

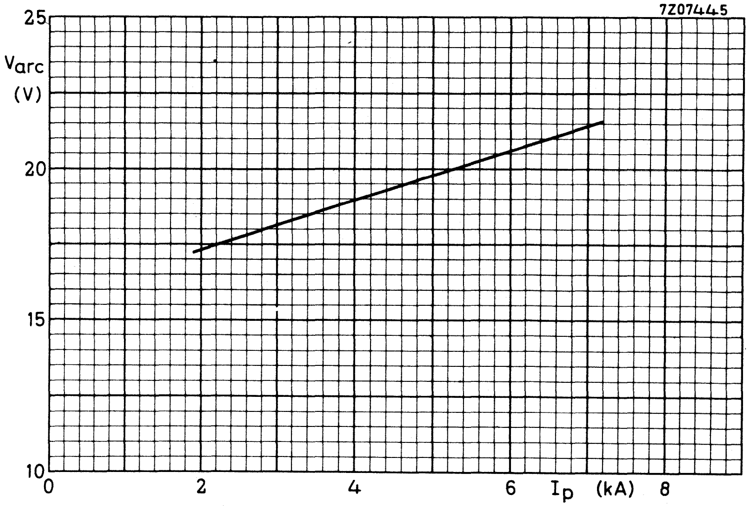
[1]) The thyristor may be substituted by a thyratron.

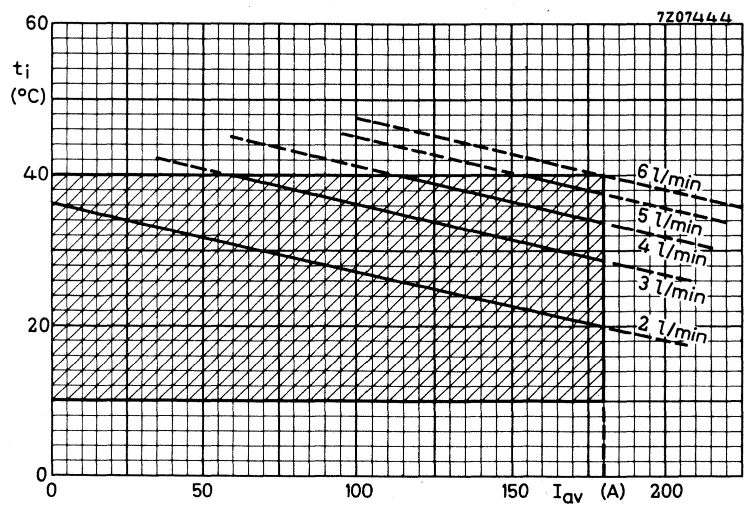
Graph to determine demand current versus duty factor as a function of the mains voltage (page 9)

Construction:

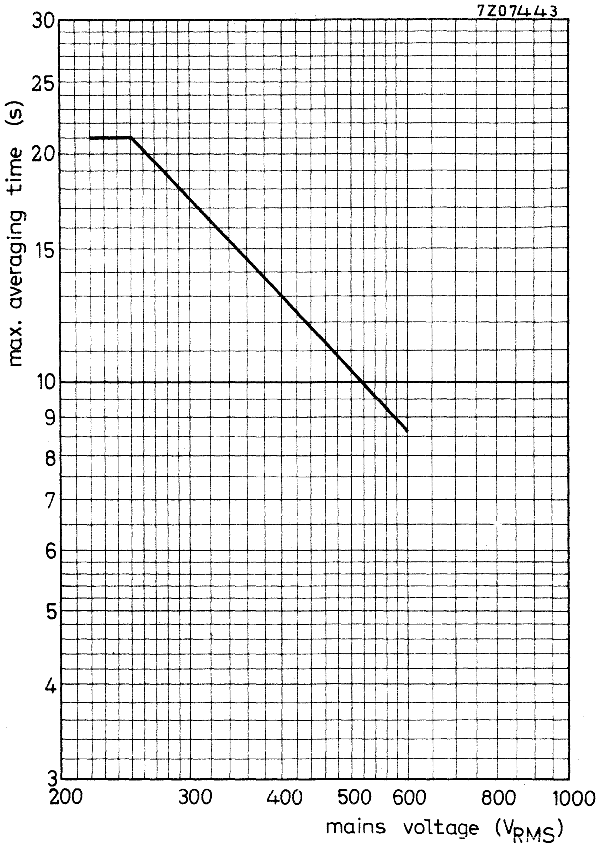
1. Determine cross points in the left hand graph for the chosen mains voltage (points a and b).
2. Draw horizontal lines from the points a and b to determine cross points a_1 and b_2 in the right hand graph.
3. The boundary of the operating area for the pertaining mains voltage is thus determined by straight line interconnections of b_1, b_2, a_1, c, c_1.


Not for intermittent rectifier service
two tubes in inverse parallel
7Z07442
duty factor (%)
mains voltage (V_{RMS})
demand current (A_{RMS})
I_{RMS} at P_{max}
I_{RMS} at $I_{av\,max}$
a
a1
b
b1
b2
c
c1
10 000
5000
2000
1000
500
200
100
1
2
5
10
20
50
100
100
200
500





Minimum required continuous waterflow (two tubes cooled in series)


7Z07443
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

D 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)		3225	kVA
Maximum average current		400	A
Ignitor voltage		180	V
Ignitor current	max.	12	A

MECHANICAL DATA

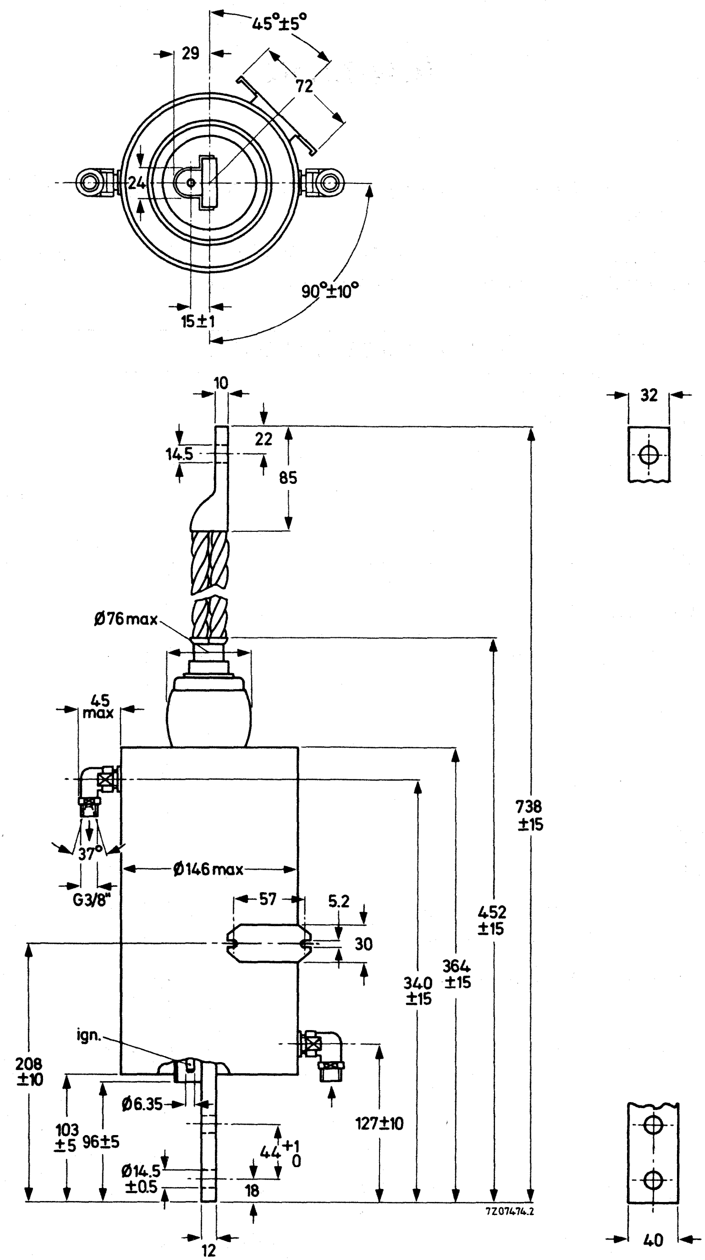
Dimensions and connections	see page 2
Net weight	8.5 kg
Shipping weight	10.8 kg
Mounting position	vertical, anode connection up

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm



TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 10 l/min)	p_i	max.	0.35	kg/cm^2
Temperature rise at max. average current (q = 10 l/min)	t_o-t_i		9	^{o}C

LIMITING VALUES

A.C. control service

Required water flow at max. average current (See also page 8)	q	min.	10	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

[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.

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 1. See also pages 10, 11 and 12.

Mains frequency range	f	25 to 60					Hz
Mains voltage	V_{RMS}	220 [1]	250	380	500	600	V
Max. averaging time	$T_{av}max$	12.5	12.5	8.4	6.4	5.3	s
A. Max. demand power							
Max. demand power	P_{max}	2200	2500	2750	3000	3225	kVA
Corresponding average current	I_{av}	210	210	210	210	210	A
Demand current	I_{RMS}	10000	10000	7250	6000	5380	A
Duty factor	δ	4.7	4.7	6.5	7.8	8.7	%
Number of cycles within $T_{av}max.$ [2]	n (50 Hz)	29	29	27	25	23	c/$T_{av}max.$
Integrated RMS load current	$I_{F\,RMS}$	2160	2160	1850	1670	1580	A
B. Max. average current							
Max. average current	$I_{av}max$	400	400	400	400	400	A
Corresponding demand power	P	735	835	915	1000	1075	kVA
Demand current	I_{RMS}	3335	3335	2415	2000	1795	A
Duty factor	δ	26.6	26.6	36.8	44.4	49.5	%
Number of cycles within $T_{av}max$ [2]	n (50 Hz)	166	166	155	142	132	c/$T_{av}max.$
Integrated RMS load current	$I_{F\,RMS}$	1720	1720	1465	1330	1260	A
Max. surge current $T_{max.}$ = 0.15 s	RMS I_{surge}	28	28	21	17	15	kA

[1]) For mains voltage below 250V(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.

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_{ig}		180	V
Firing current	I_{ig}		6 to 8	A
		max.	12	A
Ignition time at the above voltage or current	T_{ig}	max.	50	µs [1]

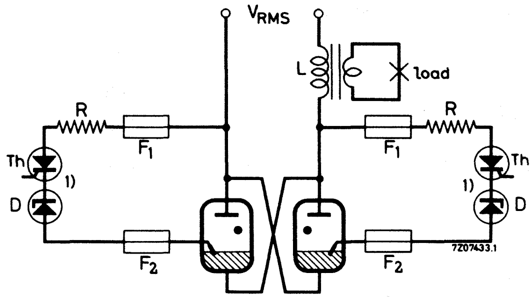
Ignition circuit requirements

Peak voltage required to fire	V_p	min.	200	V
Peak current required for anode take over	I_p		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.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

Recommended circuits for anode excitation



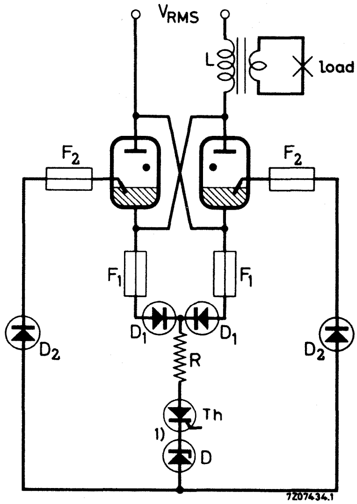
Anode excitation with individual thyristors

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

D = zener voltage $\geq$ 18 V



Anode excitation with common thyristor

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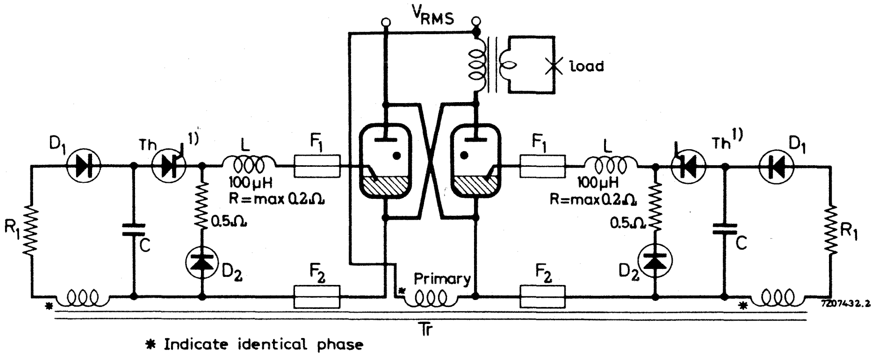
1) The thyristor-zener diode combination may be substituted by a thyratron.

IGNITOR CHARACTERISTICS AND IGNITION CIRCUIT REQUIREMENTS

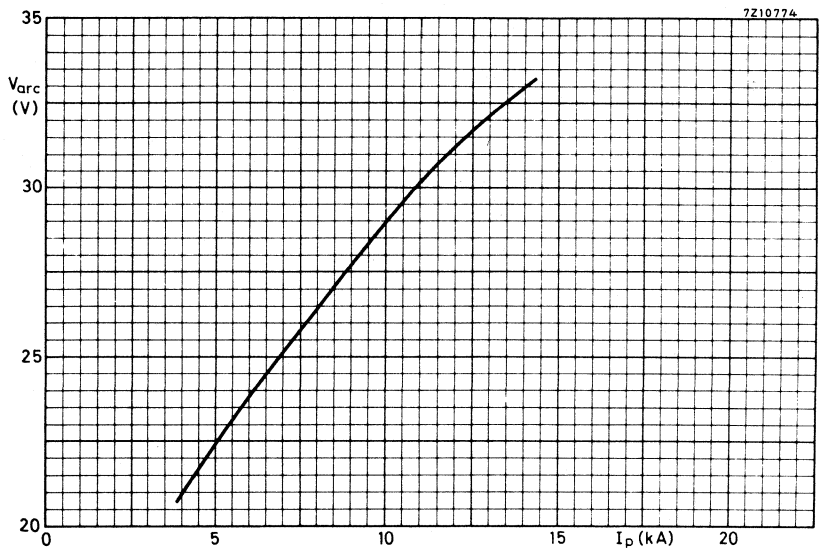
B. Separate excitation

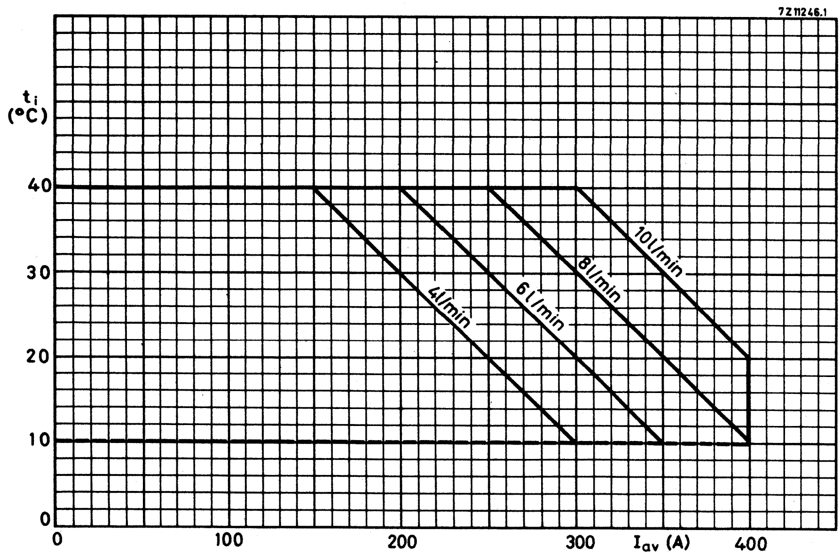
Recommended circuit for separate excitation



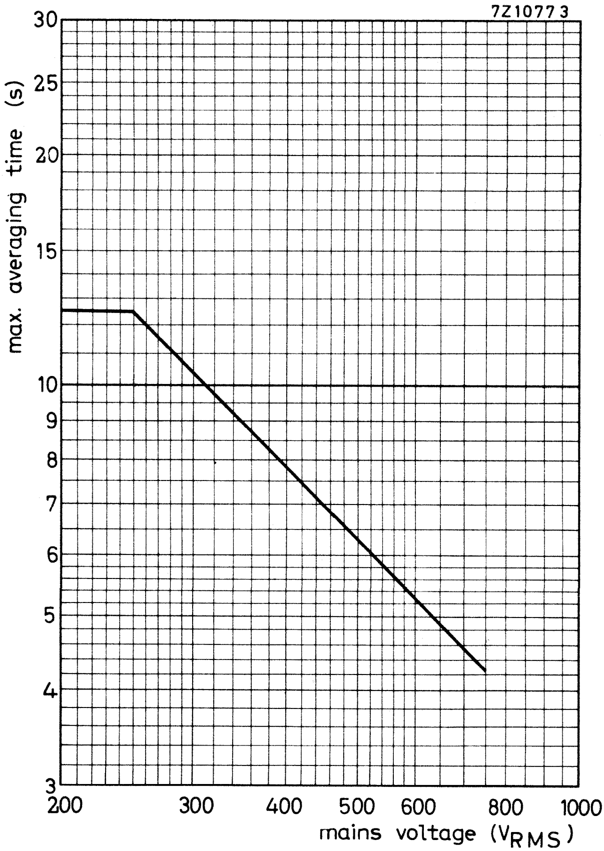
Capacitor value	2	μF
Capacitor voltage	650	V ± 10%
Peak value of closed circuit current	80 to 100	A

1) The thyristor may be substituted by a thyratron.





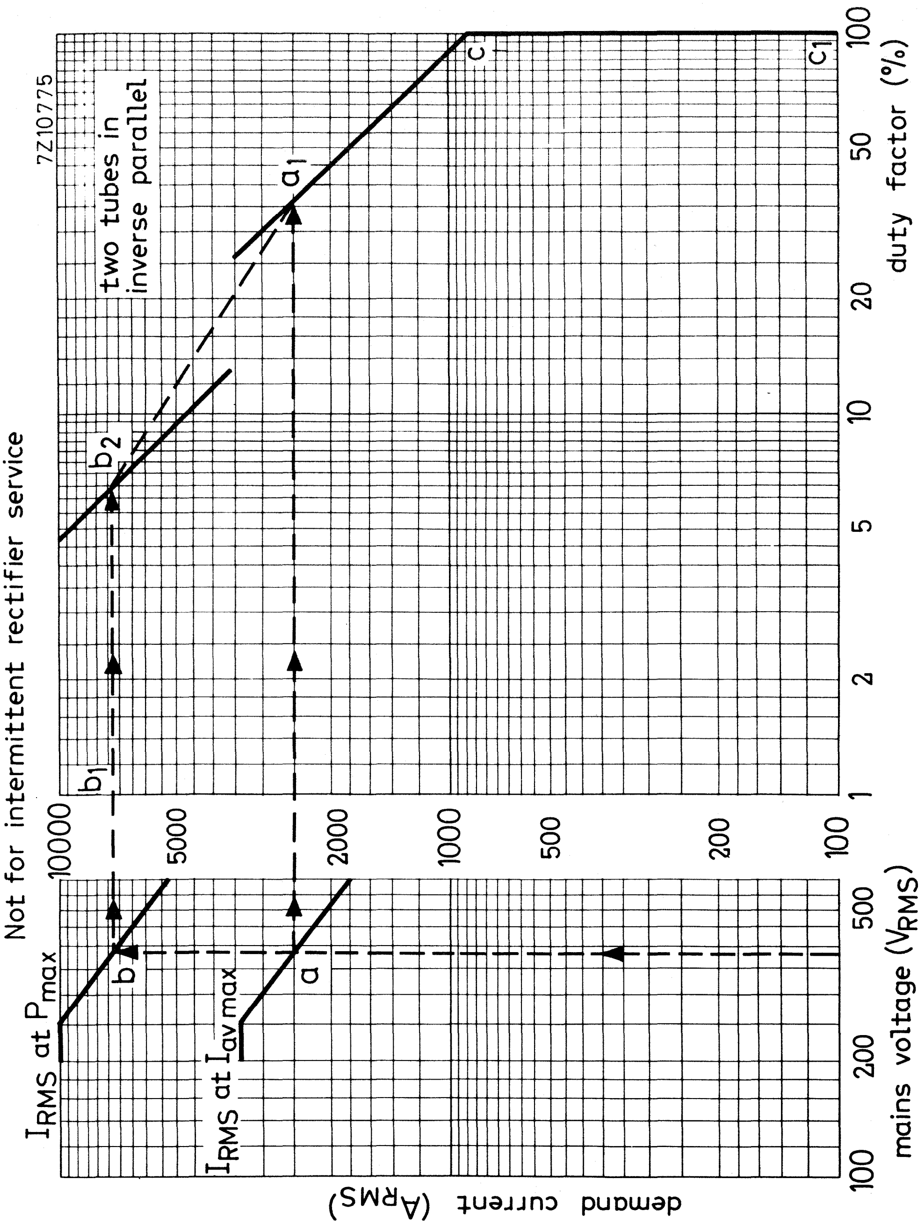
Minimum required continuous waterflow (two tubes cooled in series)


7Z10773
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})

Graph to determine demand current versus duty factor as a function of the mains voltage (page 11)

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.


Not for intermittent rectifier service
two tubes in inverse parallel
7Z10775
I_RMS at P_max
I_RMS at I_av max
a
a1
b
b1
b2
c
c1
duty factor (%)
1
2
5
10
20
50
100
mains voltage (V_RMS)
100
200
500
demand current (A_RMS)
100
200
500
1000
2000
5000
10000

IGNITRON

B-size ignitron in coaxial construction 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		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

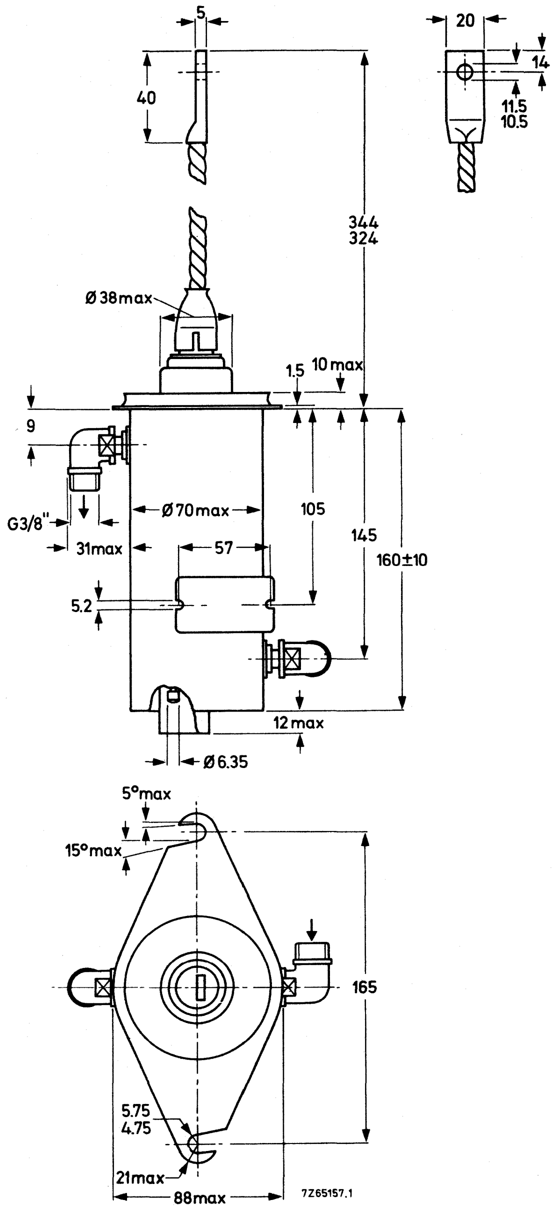
Dimensions and connections	see page 2
Net weight	1.4 kg
Shipping weight	2.1 kg
Mounting position	vertical, anode connection up

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm



TEMPERATURE LIMITS AND COOLING

TYPICAL CHARACTERISTICS

Pressure drop of cooling water (q = 2 l/min)	p_i	max.	0.08	kg/cm^2
Temperature rise at max. average current (q = 2 l/min)	$t_o - t_i$	max.	6	°C

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 9)	q	min.	2	l/min
Inlet temperature 1)	t_i	min.	10	°C
		max.	40	°C
Temperature of thermostat mount 2)	t_m	max.	50	°C

Intermittent rectifier service or three-phase welding service

Required continuous water flow at max. average current	q	min.	2	l/min
Inlet temperature 1)	t_i	min.	10	°C
		max.	35	°C
Temperature of thermostat mount 2)	t_m	max.	45	°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.

ELECTRICAL DATA

For electrical data please refer to type ZX1051

IGNITRON

C-size ignitron in coaxial construction 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		150	V
Ignitor current	max.	12	A

MECHANICAL DATA

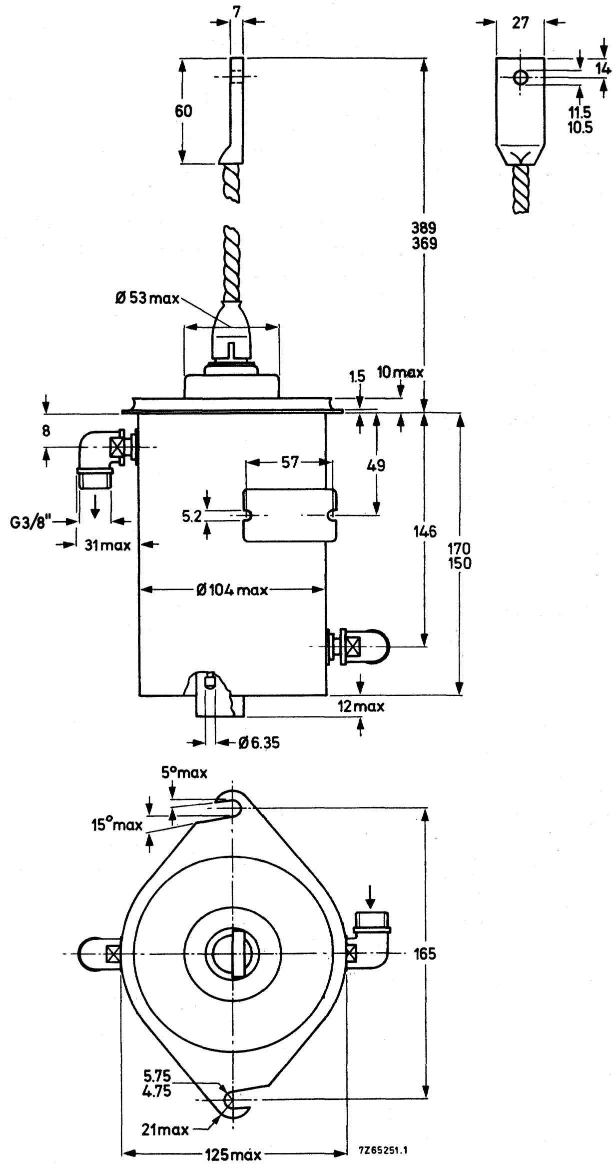
Dimensions and connections	see page 2
Net weight	2.4 kg
Shipping weight	3.7 kg
Mounting position	vertical, anode connection up

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

DIMENSIONS AND CONNECTIONS

Dimensions in mm



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	^oC

LIMITING VALUES (Absolute max. rating system)

A.C. control service

Required water flow at max. average current (See also page 10)	q	min	5	l/min
Inlet temperature[1])	t_i	min. max.	10 40	^oC ^oC
Temperature of thermostat mount[2])	t_m	max.	50	^oC

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	^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.

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.

For electrical data please refer to type ZX1052

High-voltage rectifying tubes

HIGH-VOLTAGE RECTIFYING TUBES

LIST OF SYMBOLS

Remarks

a. In the case of indirectly heated tubes the voltages on the various electrodes are with respect to the cathode, in the case of a.c. fed, directly heated tubes with respect to the electrical centre of the filament, unless otherwise stated.
b. The symbols for voltages and currents quoted below represent the average values of the concerning voltages and currents, unless otherwise stated.
c. The positive electrical current is directed opposite to the direction of the electron current

Anode	a
Capacitance between anode and grid (the other elements being earthed)	C_{ag}
Capacitance between grid and all other elements except anode	C_g
Frequency	f
Filament or heater	f
Grid	g
Anode current	I_a
Filament or heater current	I_f
Grid current	I_g
D.C. output current of a rectifying tube	I_o
Peak value of a current	I_p
Fault current	I_{surge}
Cathode	k
Resistance in grid lead	R_g
Ambient temperature	t_{amb}
Averaging time	T_{av}
Deionisation time	T_{dion}
Temperature of condensed mercury	t_{Hg}
Ionisation time	T_{ion}

Waiting time (= time which has to pass between switching on of the filament or heater voltage and switching on of the other voltages)	T_w
Anode voltage	V_a
Arc voltage	V_{arc}
Heater voltage	V_f
Grid voltage	V_g
Inverse voltage	V_{inv}
D.C. voltage supplied by a rectifying tube	V_o
Secondary transformer voltage	V_{tr}
Output power	W_o

GENERAL OPERATIONAL RECOMMENDATIONS
HIGH-VOLTAGE RECTIFYING TUBES

The following instructions apply in general to all types of high-voltage rectifying tubes. If there are additional instructions for any type of tube it will be indicated on the technical data sheets of the concerning type.

MOUNTING

The mercury-vapour filled types must be mounted vertically with the base or filament strips at the lower end. The mounting position of the gas-filled types is in general arbitrary.

The tubes must be mounted so that air can circulate freely around them. Therefore the clearance between the tubes and other components of the circuit and between the tubes and the cabinet walls should be at least half the maximum bulb diameter. The minimum clearance between tubes should be 3/4 the maximum bulb diameter.

It should be realised that a minimum clearance is also required for reasons of high voltage insulation.

When a tube is operating and the cooling is only obtained by natural convection the temperature distribution along the bulb will be such that the lowest temperature occurs at the bottom. This distribution is of special importance in the case of mercury-vapour filled types in order to condense the mercury-vapour in the lower part of the tube. Where additional cooling is necessary this cooling should not disturb this normal temperature distribution along the bulb.

Generally if shock or vibration exceeds 0.5 g a shock absorbing device should be used.

The electrode connections, except those of the tube socket, 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 should be sufficient to avoid overheating by the current. However, to maintain the normal temperature distribution along the bulb the conductors should not conduct too much heat away from the tube. (It should be noted that in rectifier circuits the r.m.s. value of the anode current may reach 2.5 times the average value.)

FILAMENT SUPPLY

In order to obtain the maximum life of a directly heated cathode, a filament transformer with centre-tap and a phase shift of $90^{o} \pm 30^{o}$ between V_a and V_f is recommended. Series connection of filaments is not allowable.

The filament voltage at nominal mains voltage must be measured at the terminals of the tube. Permanent deviations up to 2.5% from the published value can be accepted. It is therefore recommended that the filament transformer be equipped with suitable tappings. Temporary variations should not exceed 5%.

However to ensure maximum life it is important to keep the filament voltage as near as possible to the nominal value.

In calculating the rating of the filament transformer a spread in the filament current of $\pm$10% form tube to tube should be taken into account, whilst for directly heated tubes the d.c. current flowing through the heater winding should also be considered. It is recommended to furnish the filament transformer with several taps on the primary especially in case of h.t.-insulated high magnetic leakage transformers.

TEMPERATURE

1. Tubes filled with mercury vapour

In the technical data of these tube types temperature limits for the condensed mercury are given. During operation the condensed mercury should only be visible in the neighbourhood of the socket or the lowest part of the bulb. Care should be taken to ensure that the condensed mercury temperature during operation is between the published temperature limits. Too low a temperature gives low gas pressure which results in a low current carrying capability, high arc drop and consequently shortening of life. Too high a temperature gives high gas pressure which results in a reduction of the permissible peak inverse and forward voltage.

Accurate values of the condensed mercury temperature can be measured by means of a thermocouple placed against the envelope, but good technique and instruments are necessary for this measurement. In general temperature values of sufficient accuracy can be obtained by using a normal mercury thermometer the mercury vessel of which is wrapped in staniol strips and that can be fixed against the bulb by means of a cotton thread.

The temperature measurements should be made at the coldest part of the bulb where the mercury vapour condenses which in general will be just above the base or the lower connections.

In addition to the temperature limits for the condensed mercury sometimes limits for the ambient temperature are given. For each type there is a specific difference between ambient and condensed mercury temperature. High ambient temperature can make it desirable to decrease this difference, which can be obtained by directing a low velocity air flow of ambient temperature or less to the glass just above the base.

The condensed mercury temperature is decisive in all cases.

The ambient temperature can be measured by a thermometer which has been screened against direct heat radiation. The measurement should be carried out at a distance of max. once and min. half the tube diameter from the tube at the same height as the condensed mercury or just above the base.

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 maximum $+75$ °C.

SWITCHING ON

If switching on of the rectifier takes place twice a day or less the allowable peak anode current when switching on may amount up to twice the maximum published value for I_{a_p}.

1. Tubes filled with mercury vapour.

It is necessary to allow time for the cathode to reach its operating temperature before drawing anode current. Therefore the minimum cathode heating time is given in the published data sheets of each type. After the cathode heating time the high voltage may be switched on provided the temperature of the condensed mercury is not too low and all the condensed mercury is confined to the lower part of the bulb.

Sometimes a heat conserving hood is prescribed for the tube. The purpose of this hood is to avoid condensation of the mercury vapour on the electrodes and upper part of the bulb whilst the tube is cooling.

Switching on (not after transport) may be done at a condensed mercury temperature which lies 5 to 10 °C below the published minimum temperature (minimum waiting time required). However, it is good practice to switch on after the temperature has reached its minimum published value (recommended waiting time).

The waiting times, the minimum required and the recommended one can be read from the curve representing the condensed mercury temperature rise as a function of time with only the filament voltage applied to the tube.

Switching on after transport or after a considerable interruption of operation should be done according to the instructions on the published data sheets.

In order to avoid long preheating times it is recommended to leave the filament supply on during standby periods (e.g. overnight) at 60 to 80% of the nominal value.

Standby position for mercury vapour filled tubes.

In order to have a spare tube always ready for immediate operation it is recommended to have a spare position where a tube stands with continuously a filament voltage of 60-80% of the nominal voltage applied.

When for a certain type a heat conserving hood is prescribed this hood should be fitted on the tube.

2. Tubes with inert gas-filling

It is necessary to allow the cathode to reach operating temperature before drawing anode current. The relevant minimum cathode heating time is given in the technical data sheets of each type. After warming up the anode voltage may be applied provided that the ambient temperature is not below the minimum published value.

No other delays apart from the cathode heating delay are required.

LIMITING VALUES

The limiting values should be used in accordance with the "Absolute maximum rating system" as defined by 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, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking 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 components 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.

For some ratings of 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. During normal operation or frequent switching the peak current should not 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.

The I_{surge} is the maximum fault current which should ever be allowed to pass through the tube. (See section "Short circuit protection".)

DESIGN VALUES

1. V_{arc}

The value published for V_{arc} applies to average operating conditions.

2. Frequency

Unless otherwise stated the maximum frequency at which the tubes may run under full load is 150 Hz. Under special conditions (derating of voltage and current) higher frequencies may be used; details should be obtained from the manufacturer.

TYPICAL OPERATING CONDITIONS

Sometimes 2 columns of operating conditions are given viz. one giving theoretical values based on the absolute maxima and one giving more practical values in which mains fluctuations of max. 10% and a voltage drop in tube, transformer, filter etc. of max. 8% are incorporated.

SHORT CIRCUIT PROTECTION

In order to prevent the tube from being damaged by passing too high a fault current a value for the maximum permissible 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 during switching-on or during operation.

A simple method to limit the surge current to the maximum rating is to put a series resistance in the anode circuit which in most cases will also be necessary because the relation between the ohmic and the inductive resistance of the short circuit path should be at least 0.3.

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. Of course r.f. should be prevented from reaching the rectifier by r.f. chokes and condensers.

In circuits with gas filled tubes oscillation in the transformer windings can occur especially in grid controlled circuits. These oscillations should be reduced by suitable circuits as excessive peak inverse voltages may occur, causing arc back. The use of two parallel RC circuits is advisable.

An air choke in the order of 100 μH should be connected in series with and close to the anode connection. This choke can advantageously be wound from resistance wire in order to help short circuit protection.

SMOOTHING CIRCUITS

In order to limit the peak anode current in a rectifying tube it is necessary to use a choke-input filter.

If switching on of the rectifier takes place twice a day or less the allowable peak anode current when switching on may reach a value of twice the published max. value for I_{ap}.

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. Damping of this choke will be necessary.

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 MERCURY-VAPOUR OF GAS-FILLED TUBES

As individual gas or mercury-vapour filled tubes may have slightly different characteristics two or more tubes must not be connected directly in parallel.

Parallel operation is permissible when series resistances are used and the peak voltage drop over this series resistance is at least the ignition voltage. Coupling transformers in the anode leads of parallel connected tubes can serve the same purpose.

GRID CONTROLLED RECTIFIERS

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 less negative than -10 volts during this phase. This precaution will prevent an increase in electrode emission due to excessive electrode dissipation, sputtering of electrode material, changes in the control characteristics caused by shift in contact potential and, in the case of inert gas-filled tubes, a rapid gas clean-up. 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 grid 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 fixed negative grid bias and narrow positive firing pulses.

However, for bridge circuits the minimum width of these pulses should be sufficiently large to secure safe "take-over" of the discharge.

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

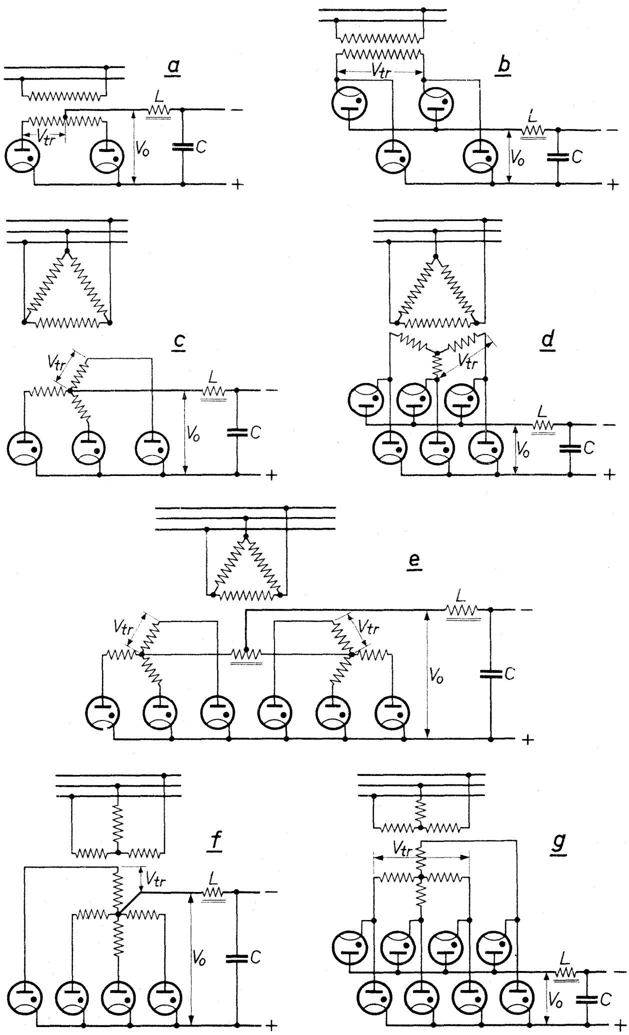
To keep the instant of ignition as constant as possible a large value of excitation voltage is recommended.

The use of a negative grid bias (50 to 120 volts) and a sharp positive grid pulse is recommended. The magnitude of the grid pulse should be 100 to 200 volts with a grid series resistor of 10 kΩ and a maximum impedance of the peaking transformer of 10 kΩ. If a sinusoidal grid voltage is used r.m.s. values of 50 to 120 volts in combination with a negative grid bias of 50 to 120 volts are recommended.

BRIDGE CIRCUITS (diagrams b, d and g)

For output voltages of more than 6 kV bridge circuits are recommended because of the lower peak inverse anode voltage and the larger range of applicable ambient temperatures.

The current angle of the grid should be for 2 phase bridge circuits > 90°, for 3 phase > 60°, and for 4 phase > 45°.



GRID-CONTROLLED HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA				
Peak inverse voltage	$V_{a\ inv_p}$	max.	13	kV
Peak forward voltage	V_{a_p}	max.	13	kV
Output current	I_o	max.	1	A
Peak anode current	I_{a_p}	max.	4	A
Negative grid voltage	$-V_g$	max.	300	V
Peak grid current	I_{g_p}	max.	50	mA

For electrical data please refer to type DCG6/6000

MECHANICAL DATA (Dimensions in mm)

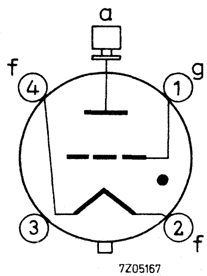
Base : Jumbo 4 p. with bayonet

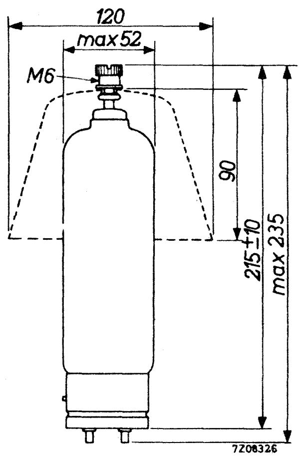
Socket : 2422 511 02001

Anode cap : 40616

This cap must always be mounted on the tube, thus also during preheating

Net weight: 240 g





Mounting position: vertical with base down

HIGH-VOLTAGE
MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA					
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	3000	V
Output current	I_o	=	max.	250	mA
Peak anode current	I_{a_p}	=	max.	1250	mA

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=	4	V
Filament current	I_f	=	2.5	A

In order to ameliorate the life of the tube a preheating time of the filament of at least 15 sec. is recommended

Phase shift of $90^o \pm 30^o$ between V_a and V_f and use of a centre-tapped filament transformer are recommended

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 250 mA)	=	12	V

LIMITING VALUES (Absolute limits)

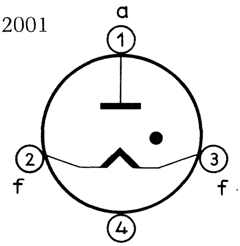
Frequency	f	=	max.	500	Hz
Peak inverse voltage up to 150 Hz	$V_{a\,inv_p}$	=	max.	3000	V
Peak inverse voltage up to 500 Hz	$V_{a\,inv_p}$	=	max.	2550	V
Output current	I_o	=	max.	250	mA
Peak anode current	I_{a_p}	=	max.	1250	mA
Ambient temperature	t_{amb}	=		10 to 40	^oC

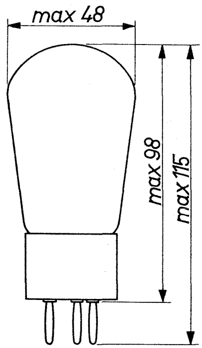
MECHANICAL DATA Dimensions in mm

Base : A

Socket : 2422 512 02001

Net weight : 45 g





Mounting position : vertical with base down

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected

Peak inverse voltage $V_{a\,inv_p}$ = 3 kV				
Circuit [1]	Transformer voltage V_{tr} (V_{RMS})	Output voltage V_o (V)	Output current I_o (A)	Power output W_o (kW)
a	1060	950	0.5	0.48
b	2120	1910	0.5	0.95
c	1220	1430	0.75	1.07
d	2120	2870	0.75	2.15
e	1060	1240	1.5	1.86
f	1060	1350	1.0	1.35
g	2120	2700	1.0	2.70

[1]) For circuits see page 8 in front of this section.

HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA								
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	10	kV	max.	2	kV
Output current	I_o	=	max.	0.25	A	max.	0.5	A
Peak anode current	I_{ap}	=	max.	1	A	max.	2	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=		2.5	V
Filament current	I_f	=		4.8	A
Cathode heating time	T_w	=	min.	30	s

Phase shift of $90^{\circ} \pm 30^{\circ}$ between V_a and V_f and use of a centre-tapped filament transformer is recommended

After transport and after a long interruption of service a waiting time of at least 30 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed

TYPICAL CHARACTERISTICS

Arc voltage V_{arc} (I_a = 0.25 A) = 12 V

LIMITING VALUES (Absolute limits)

Output current	I_o	=	max.	0.25	A	max.	0.5	A
Peak anode current	I_{ap}	=	max.	1	A	max.	2	A
Peak inverse voltage	$V_{a\,invp}$	=	max.	10	kV	max.	2	kV
(Frequency	f	=	max.	150	Hz	max.	150	Hz)
Condensed mercury temperature [1])	t_{Hg}	=		25 to 60	$^{\circ}$C		25 to 70	$^{\circ}$C
Ambient temperature [2])	t_{amb}	=		15 to 40	$^{\circ}$C		15 to 50	$^{\circ}$C

[1]) If the equipment is started not more than twice daily it is permitted to apply the high tension at a condensed mercury temperature of 20 $^{\circ}$C

[2]) With convection cooling only

MECHANICAL DATA

Dimensions in mm

Mounting position: vertical with base down

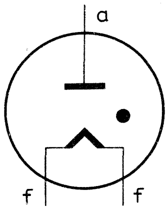
DCG4/1000 ED

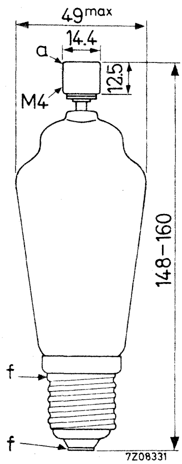
Base : Edison

Socket : E3 000 22

Anode connector : 40619

Net weight : 65 g





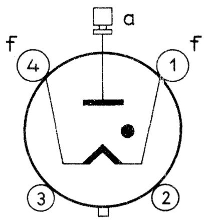
DCG4/1000 G = 866A

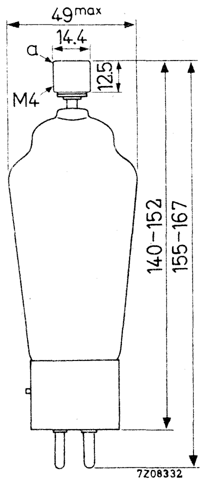
Base : Medium 4p with bayonet

Socket : 2422 511 04001

Anode connector : 40619

Net weight : 80 g





[1]) At voltages above 2 kV the socket must be insulated from the chassis.

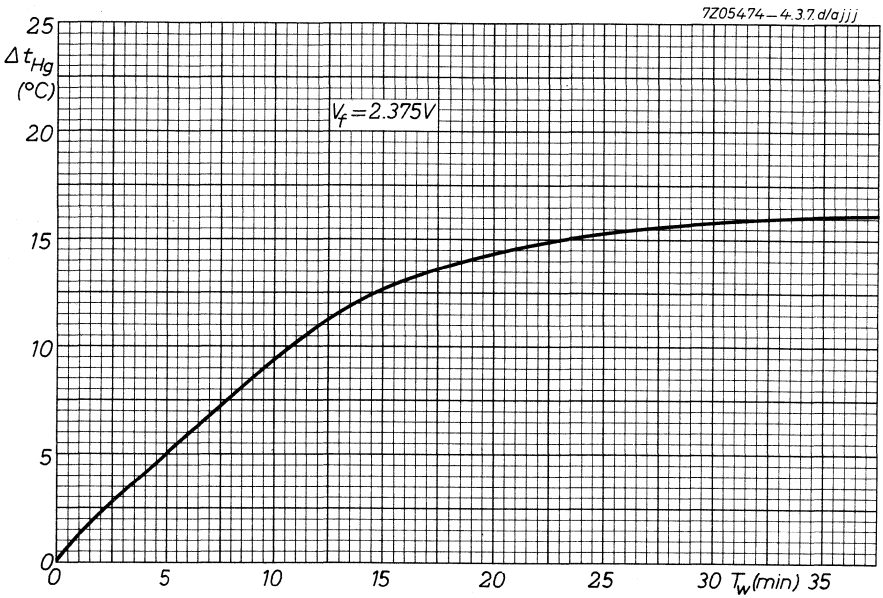
OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected

Peak inverse voltage $V_{a\,invp}$ = 10 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (W)
a	3.5	3.2	0.5	1590
b	7.1	6.4	0.5	3180
c	4.1	4.8	0.75	3600
d	7.1	9.6	0.75	7200
e	3.5	4.1	1.5	6200
f	3.5	4.5	1	4500
g	7.1	9.0	1	9000

Peak inverse voltage $V_{a\,invp}$ = 2 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (W)
a	0.71	0.63	1	630
b	1.41	1.27	1	1270
c	0.82	0.96	1.5	1430
d	1.41	1.91	1.5	2870
e	0.71	0.83	3	2480
f	0.71	0.90	2	1800
g	1.41	1.80	2	3600

[1]) For circuits see page 8 in front of this section.


7Z05474-4.3.7.d/ajjj
25
Δ t_{Hg}
(°C)
20
15
10
5
0
V_f = 2.375V
0
5
10
15
20
25
30 T_w(min) 35

HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA					
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	13	kV
Output current	I_o	=	max.	1.25	A
Peak anode current	I_{a_p}	=	max.	5	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=		4	V
Filament current	I_f	=		7	A
Cathode heating time	T_w	=	min.	30	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and/or use of a centre-tapped filament transformer are recommended.

After transport and after a long interruption of service a waiting time of at least 30 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed.

TYPICAL CHARACTERISTICS

Arc voltage V_{arc} (I_a = 1.25 A) = 12 V

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\,inv_p}$	=	max.	13	kV	max.	10	kV
(Frequency	f	=	max.	150	Hz	max.	150	Hz)
Output current	I_o	=	max.	1.25	A	max.	1.25	A
(Averaging time	T_{av}	=	max.	10	s	max.	10	s)
Peak anode current	I_{a_p}	=	max.	5	A	max.	5	A
Surge current	I_{surge}	=	max.	40	A	max.	40	A
(Duration	T	=	max.	0.1	s	max.	0.1	s)
Condensed mercury temperature [1]	t_{Hg}	=		25 to 55	^oC		25 to 60	^oC
Ambient temperature [2]	t_{amb}	=		10 to 35	^oC		10 to 40	^oC

[1][2] See page 2

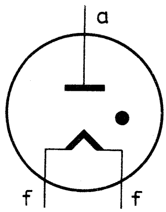
MECHANICAL DATA (Dimensions in mm)

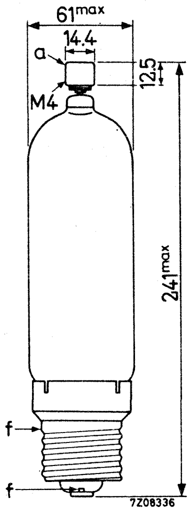
Base : Goliath

Socket : 65909BG/01

Anode connector : 40619

Net weight : 200 g





Mounting position: vertical with base down

OPERATING CONDITIONS

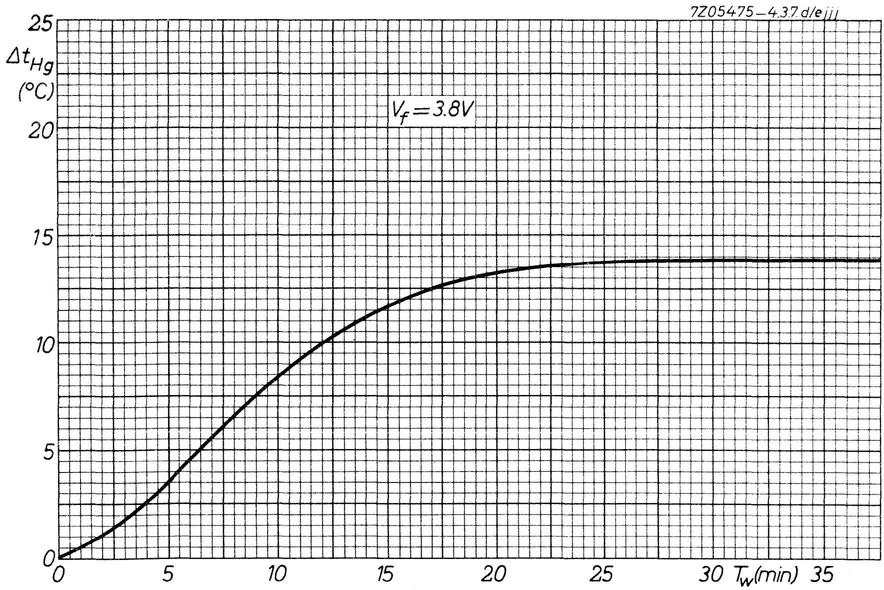
Transformer regulation and voltage drops in the tubes are neglected.

Peak inverse voltage $V_{a\,inv_p}$ = 13 kV				
Circuit 3)	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	4.6	4.1	2.5	10.3
b	9.2	8.3	2.5	20.7
c	5.3	6.2	3.75	23.3
d	9.2	12.4	3.75	46.6
e	4.6	5.4	7.5	40.4
f	4.6	5.8	5.0	29
g	9.2	11.6	5.0	58

1) If the equipment is started not more than twice daily it is permitted to apply the high tension at a condensed mercury temperature of 20 °C.

2) With natural cooling.

3) For circuit see page 8 in front of this section.


7Z05475-4.3.7.d/ejjj
25
Δt_{Hg}
(°C)
20
15
10
5
0
$V_f = 3.8V$
0
5
10
15
20
25
30
T_w(min)
35

HIGH-VOLTAGE
MERCURY-VAPOUR RECTIFYING TUBE

DCG5/5000GB	replaced by type ZY1000
DCG5/5000GS	replaced by type ZY1001
DCG5/5000EG	replaced by type ZY1002

HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA								
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	15	kV	max.	2.5	kV
Output current	I_o	=	max.	3	A	max.	5	A
Peak anode current	I_{ap}	=	max.	12	A	max.	20	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=		5	V
Filament current	I_f	=		11.5	A
Cathode heating time	T_w	=	min.	60	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and use of a centre-tapped filament transformer is recommended.

After transport and after a long interruption of service a waiting time of at least 30 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed.

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 3 A) =	12	V
Equilibrium condensed mercury temperature rise over ambient temperature	no load	19	^oC
	full load	21	^oC

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\,inv_p}$	=	max.	15	kV	max.	2.5	kV
(Frequency	f	=	max.	150	Hz	max.	150	Hz)
Output current	I_o	=	max.	3	A	max.	5	A
(Averaging time	T_{av}	=	max.	10	s	max.	10	s)
Peak anode current	I_{ap}	=	max.	12	A	max.	20	A
Surge current	I_{surge}	=	max.	120	A	max.	200	A
(Duration	T	=	max.	0.1	s	max.	0.1	s)

LIMITING VALUES (Absolute limits) (continued)

Peak inverse voltage	$V_{a\,inv_p}$		15	10	2.5	kV
Condensed mercury temperature	t_{Hg}	1)	25–55	25–60	25–75	°C
Ambient temperature	t_{amb}	2)	15–35	15–40	15–55	°C

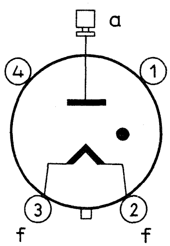
MECHANICAL DATA (Dimensions in mm)

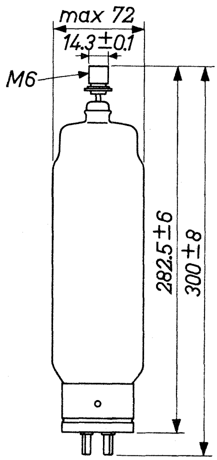
Base : Super Jumbo with bayonet

Anode connector : 40619

Socket : 2422 511 01001

Net weight : 450 g





Mounting position : vertical with base down

1) If the equipment is started not more than twice daily, it is permitted to apply high tension at a condensed mercury temperature of 20 °C

2) With natural cooling

MAXIMUM OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected.

Peak inverse voltage $V_{a\,inv_p}$ = 15 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	5.3	4.8	6	28.8
b	10.6	9.6	6	57.6
c	6.1	7.2	9	64.8
d	10.6	14.4	9	130
e	5.3	6.2	18	112
f	5.3	6.7	12	80.4
g	10.6	13.5	12	162

Peak inverse voltage $V_{a\,inv_p}$ = 2.5 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	0.88	0.79	10	7.9
b	1.76	1.58	10	15.8
c	1.02	1.19	15	17.9
d	1.76	2.38	15	35.8
e	0.88	1.03	30	30.9
f	0.88	1.13	20	22.6
g	1.76	2.26	20	45.2

[1] For circuits see page 8 in front of this section.

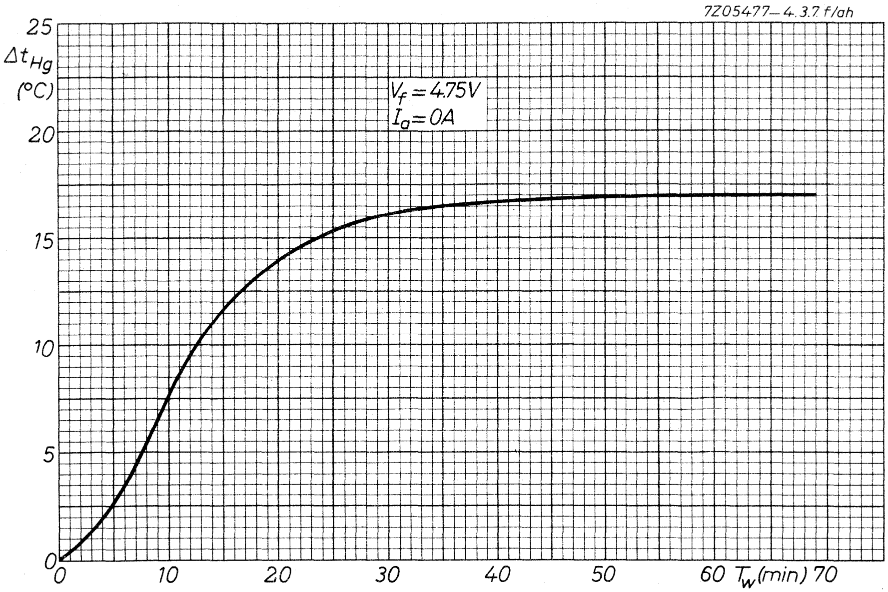
TYPICAL OPERATING CHARACTERISTICS

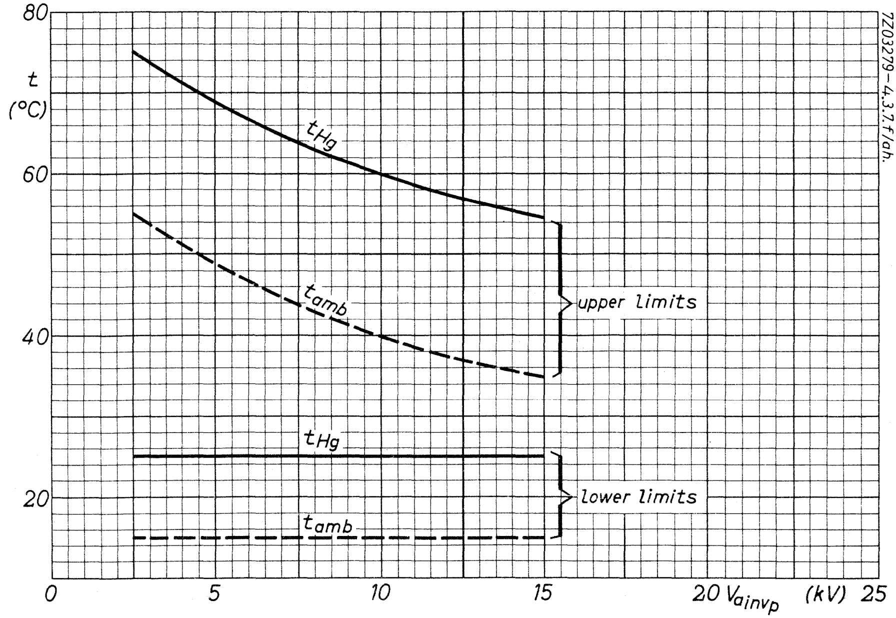
Peak inverse voltage $V_{a\,inv_p}$ = max. 15 kV [2]				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output [3] voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	4.8	4.0	6	24
b	9.6	8.0	6	48
c	5.55	6.0	9	54
d	9.6	12.0	9	108
e	4.8	5.15	18	93
f	4.8	5.6	12	67
g	9.6	11.2	12	134

[1]) For circuits see page 8 in front of this section

[2]) This value corresponds to a nominal peak inverse anode voltage of 13.6 kV, allowing a mains voltage fluctuation of ± 10 %

[3]) Tube voltage drop and losses in transformer, filter, etc., amounting to 8% of the output voltage across the load, have already been deducted


7Z05477—4.3.7 f/ah
25
Δt_{Hg}
(°C)
20
15
10
5
0
$V_f = 4.75V$
$I_a = 0A$
0
10
20
30
40
50
60
T_w(min)
70


7Z03279—4.3.7 f/ah.
80
t
(°C)
60
40
20
t_{Hg}
t_{amb}
upper limits
t_{Hg}
t_{amb}
lower limits
0
5
10
15
20
V_{ainvp}
(kV)
25

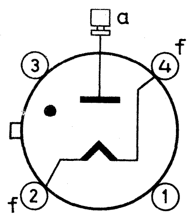
HIGH-VOLTAGE
MERCURY-VAPOUR RECTIFYING TUBE

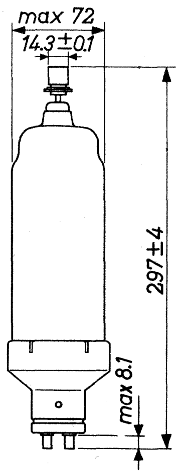
MECHANICAL DATA Dimensions in mm

Base : Jumbo 4p with bayonet

Socket : 2422 511 02001

Anode connector : 40619





For further data and curves of this type please refer to type DCG6/18

GRID-CONTROLLED HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA					
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	13	kV
Peak forward voltage	V_{a_p}	=	max.	13	kV
Output current	I_o	=	max.	1	A
Peak anode current	I_{a_p}	=	max.	4	A
Negative grid voltage	$-V_g$	=	max.	300	V
Peak grid current	I_{g_p}	=	max.	50	mA

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=		5	V
Filament current	I_f	=		6.5	A
Cathode heating time	T_w	=	min.	60	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and use of a centre-tapped filament transformer are recommended.

After transport and after a long interruption of service a waiting time of at least 60 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed.

CAPACITANCES

Anode to grid	C_{ag}	=	3	pF
Grid to cathode	C_g	=	8	pF

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 1 A)	=	12	V
Ionization time	T_{ion}	=	10	μs
Deionization time	T_{dion}	=	250	μs

LIMITING VALUES (Absolute limits)

When the anode voltage V_a is negative,
the grid voltage must never be positive

Peak inverse voltage	$V_{a\,inv_p}$	=	max.	13	kV
(Frequency	f	=	max.	150	Hz)
Peak anode voltage	V_{a_p}	=	max.	13	kV
Output current	I_o	=	max.	1	A
(Averaging time	T_{av}	=	max.	10	s)
Peak anode current	I_{a_p}	=	max.	4	A
Surge current	I_{surge}	=	max.	40	A
(Duration	T	=	max.	0.1	s)
Negative grid voltage [1]	$-V_g$	=	max.	300	V
Grid current	I_g	=	max.	10	mA
(Averaging time	T_{av}	=	max.	10	s)
Peak grid current	I_{g_p}	=	max.	50	mA
{ Peak inverse voltage	$V_{a\,inv_p}$	=		13	kV
{ Condensed mercury temperature [2]	t_{Hg}	=		25 to 55	°C
{ Ambient temperature [3]	t_{amb}	=		15 to 30	°C
{ Peak inverse voltage	$V_{a\,inv_p}$	=		10	kV
{ Condensed mercury temperature [2]	t_{Hg}	=		25 to 60	°C
{ Ambient temperature [3]	t_{amb}	=		15 to 35	°C

[1]) Before conduction

[2]) If the equipment is started not more than twice daily it is permitted to apply high tension at a condensed mercury temperature of 20°C

[3]) With natural cooling

7Z2 2460

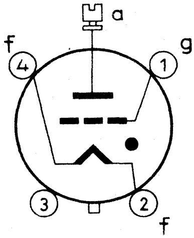
MECHANICAL DATA (Dimensions in mm)

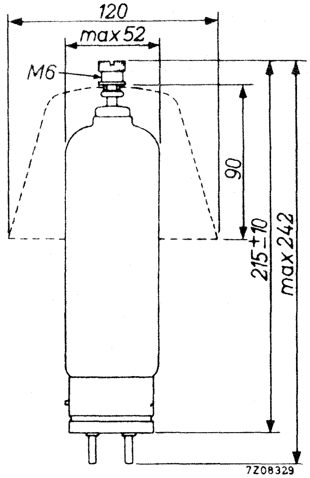
Base : Super jumbo with bayonet

Socket : 2422 511 01001

Anode cap : 40616 1)

Net weight : 240 g





Mounting position: vertical with base down

1) This cap must always be mounted on the tube, thus also during preheating

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected.

Grid voltage	V_g ($V_{a\ inv_p}$ = 13 kV) =	−100	V
Grid voltage	V_g ($V_{a\ inv_p}$ = 10 kV) =	−50	V
Grid current	I_g =	1	mA

Peak inverse voltage $V_{a\ inv_p}$ = 13 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	4.6	4.1	2	8.3
b	9.2	8.3	2	16.6
c	5.3	6.2	3	18.6
d	9.2	12.4	3	37.2
e	4.6	5.4	6	32.4
f	4.6	5.8	4	23.4
g	9.2	11.7	4	46.8

Peak inverse voltage $V_{a\ inv_p}$ = 10 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	3.5	3.2	2	6.4
b	7	6.4	2	12.8
c	4.1	4.8	3	14.4
d	7	9.6	3	28.8
e	3.5	4.1	6	24.8
f	3.5	4.5	4	18
g	7	9	4	36

[1]) For circuits see page 8 in front of this section

GRID-CONTROLLED HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA				
Peak inverse voltage	$V_{a\,inv_p}$	= max.	15	kV
Peak forward voltage	V_{a_p}	= max.	15	kV
Output current	I_o	= max.	10	A
Peak anode current	I_{a_p}	= max.	45	A
Peak grid voltage	V_{g_p}	= max.	600	V

CATHODE : oxide-coated

HEATING: indirect, cathode connected to heater

Heater voltage	V_f	=	5	V
Heater current	I_f	=	14	A
Cathode heating time	T_w	= min.	10	min.

After transport and after a long interruption of service a waiting time of at least 45 minutes between the switching on of the heater voltage and the switching on of the anode voltage should be observed. Moreover, 10 minutes after having switched on the heater voltage, preheating of the anode must be started by connecting the anode to a supply voltage V_b = max. 500 V via a resistor limiting the current I_o to 6 A.

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 15 A) =	12	V
Equilibrium condensed mercury temperature rise over ambient temperature	no load	27	^oC
	full load	30	^oC

LIMITING VALUES (Absolute limits)

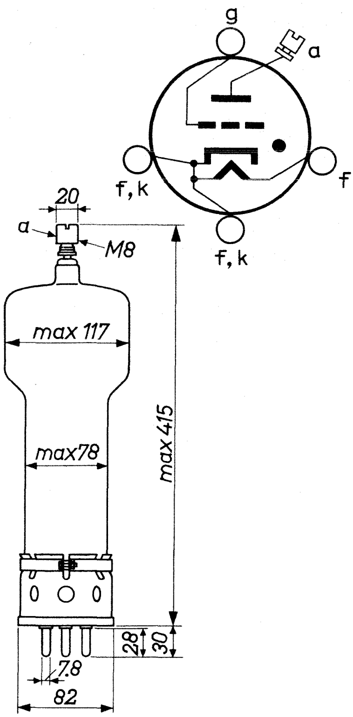
Peak inverse voltage	$V_{a\,inv_p}$	=	max.	15	kV
(Frequency	f	=	max.	150	Hz)
Peak anode voltage	V_{a_p}	=	max.	15	kV
Output current for continuous operation	I_o	=	max.	10	A
(Averaging time	T_{av}	=	max.	10	s)
Output current for intermittent operation	I_o	=	max.	15	A
(Averaging time	T_{av}	=	max.	10	s)
Peak anode current	I_{a_p}	=	max.	45	A
Surge current	I_{surge}	=	max.	600	A
(Duration	T	=	max.	0.1	s)
Peak grid voltage	V_{g_p}	=	max.	600	V
Grid resistor	R_g	=	max.	20	kΩ
Peak inverse voltage	$V_{a\,inv_p}$	=	15	10	kV
Condensed mercury temperature [1]	t_{Hg}	=	25 to 60	25 to 65	°C
Ambient temperature [2]	t_{amb}	=	10 to 30	10 to 35	°C

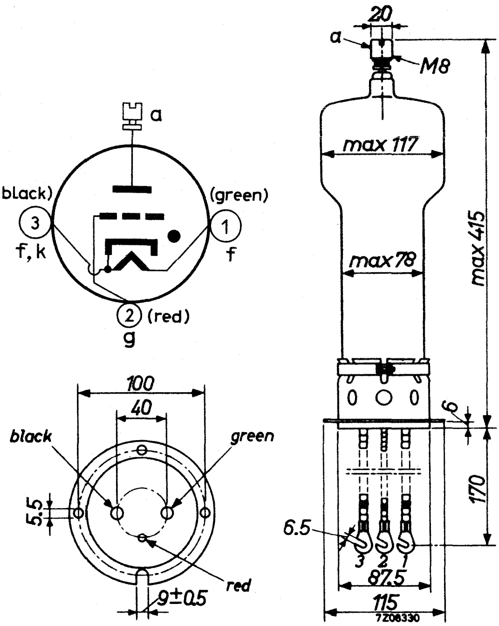
[1]) If the equipment is started not more than twice daily it is permitted to apply high tension at a condensed mercury temperature of 20 °C.

[2]) With natural cooling. The tube can be operated at higher ambient temperatures than the stated maxima, when the difference between the ambient and the condensed mercury temperature (30 °C with natural cooling) is reduced by an air flow directed at the bulb just above the base. A reduction to less than 10 °C can easily be obtained with a simple airjet.

MECHANICAL DATA

Dimensions in mm





DCG7/100

DCG7/100B

Socket : 40409

Anode connector : 40620

Mounting position: vertical with anode terminal up

Net weight: 1200 g

MAXIMUM OPERATING CONDITIONS

Peak inverse voltage $V_{a\,inv_p}$ = 15 kV 2)				
Circuit 1)	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	5.3	4.8	20	96
b	10.6	9.6	20	192
c	6.1	7.2	30	216
d	10.6	14.4	30	432
e	5.3	6.2	60	372
f	5.3	6.7	40	268
g	10.6	13.5	40	540

TYPICAL OPERATING CONDITIONS

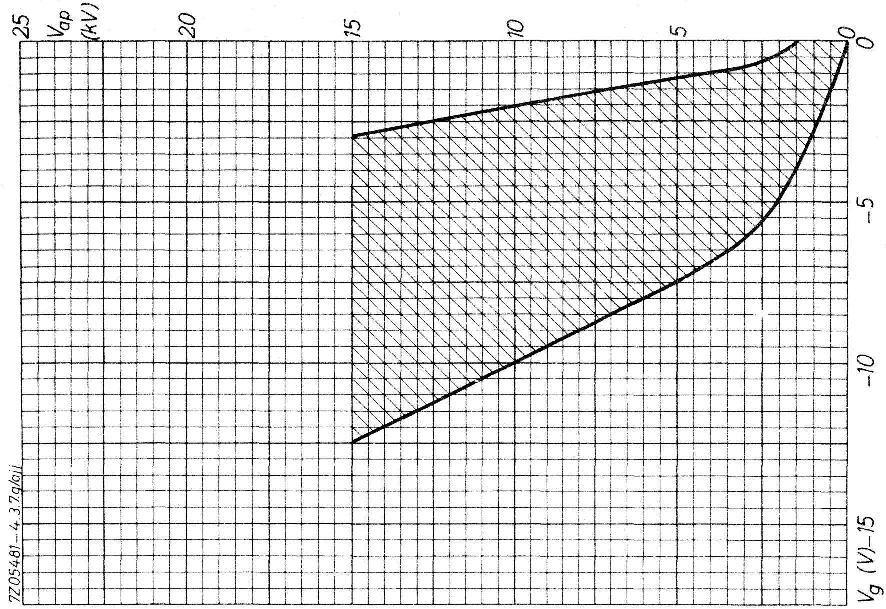
Peak inverse voltage $V_{a\,inv_p}$ = 15 kV 3)				
Circuit 1)	Transformer voltage V_{tr} (kV_{RMS})	Output 4) voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	4.8	4	20	80
b	9.6	8	20	160
c	5.55	6	30	180
d	9.6	12	30	360
e	4.8	5.15	60	309
f	4.8	5.6	40	224
g	9.6	11.2	40	448

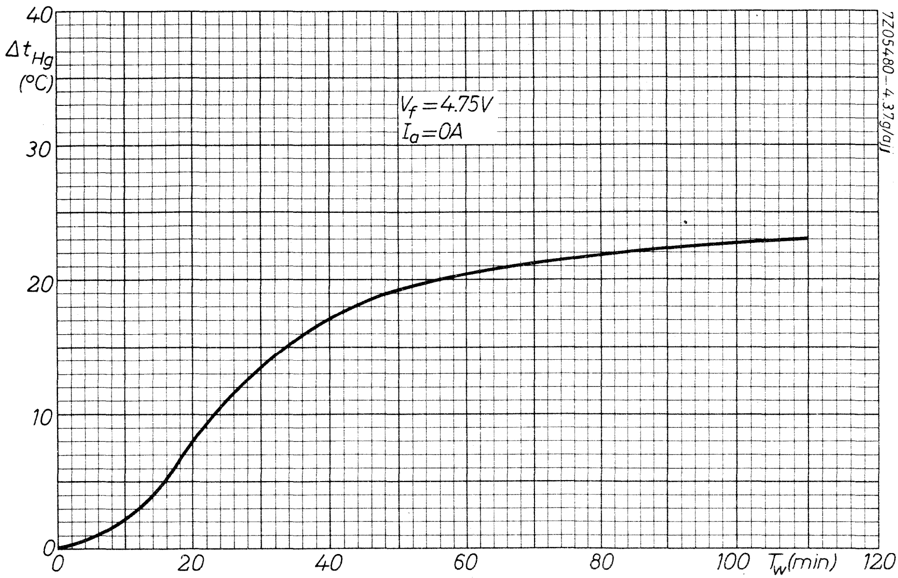
1) For circuits see page 8 in front of this section

2) Transformer regulation and voltage drops in the tubes are neglected

3) This value corresponds to a nominal peak inverse anode voltage of 13.6 kV, allowance being made for mains voltage fluctuations of ± 10 %

4) Tube voltage drop and losses in transformer, filter, etc., amounting to 8% of the output voltage across the load, have already been deducted


25
V_{ap} (kV)
20
15
10
5
0
0
−5
−10
V_g (V) −15
7Z05481−4.3.7.a/a/jj


40
Δt_{Hg} (°C)
30
20
10
0
$V_f = 4.75V$
$I_a = 0A$
0
20
40
60
80
100
T_w (min)
120
7Z05480−4.3.7.g/a/jj

HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA				
Peak inverse voltage	$V_{a\,inv_p}$	= max.	21	kV
Output current	I_o	= max.	2.5	A
Peak anode current	I_{a_p}	= max.	10	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f	=	5	V
Filament current	I_f	=	13.5	A
Cathode heating time	T_w	= min.	90	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and/or use of a centre-tapped filament transformer are recommended

After transport and after a long interruption of service a waiting time of at least 60 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\,inv_p}$	= max.	21	15	10	kV
(Frequency	f	= max.	150	150	150	Hz)
Output current	I_o	= max.	2.5	2.5	2.5	A
(Averaging time	T_{av}	= max.	30	30	30	s)
Peak anode current	I_{a_p}	= max.	10	10	10	A
Surge current	I_{surge}	= max.	100	100	100	A
(Duration	T	= max.	0.1	0.1	0.1	s)
Condensed mercury temperature [1]	t_{Hg}	=	25-45	25-50	25-60	^oC
Ambient temperature [2]	t_{amb}	=	15-30	15-35	15-45	^oC

[1]) If the equipment is started not more than twice daily it is permitted to apply high tension at a condensed mercury temperature of 20^oC.

[2]) With natural cooling

TYPICAL CHARACTERISTICS

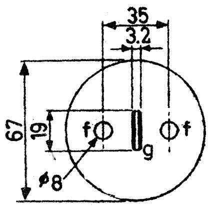
Deionization time	T_{dion}	<	500	μs
Ionization time	T_{ion}	<	10	μs
Arc voltage	V_{arc} (I_a = 2.5 A)	=	12	V

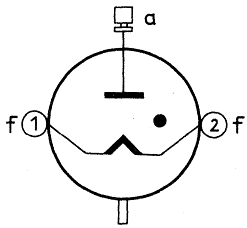
MECHANICAL DATA Dimensions in mm

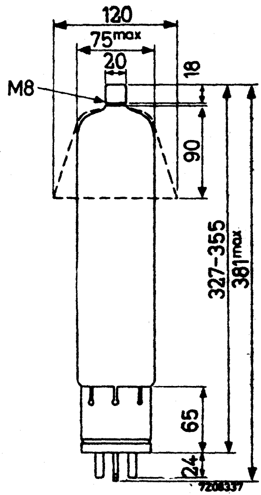
Anode connector : 40620

Anode cap : 40616

Net weight : 0.75 g







Mounting position: vertical with base down

The anode cap 40616 must always be mounted on the tube, thus also during pre-heating

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected

Peak inverse voltage $V_{a\ inv_p}$ = 21 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	7.4	6.7	5	33.5
b	14.8	13.4	5	67
c	8.6	10	7.5	75
d	14.8	20	7.5	150
e	7.4	8.7	15	130
f	7.4	9.5	10	95
g	14.8	19	10	190

[1]) For circuits see page 8 in front of this section

GRID-CONTROLLED HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBE

QUICK REFERENCE DATA				
Peak inverse voltage	$V_{a\,inv_p}$	max.	27	kV
Peak forward voltage	V_{a_p}	max.	27	kV
Output current	I_o	max.	2.5	A
Peak anode current	I_{a_p}	max.	10	A
Negative grid voltage	$-V_g$	max.	300	V
Peak grid current	I_{g_p}	max.	125	mA

HEATING: direct; filament oxide-coated

Filament voltage	V_f		5	V
Filament current	I_f		13.5	A
Cathode heating time	T_w	min.	90	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and use of a centre-tapped filament transformer are recommended

After transport and after a long interruption of service a waiting time of at least 60 minutes between the switching on of the filament voltage and the switching on of the anode voltage should be observed

CAPACITANCES

Anode to grid	C_{ag}	4	pF
Grid to cathode	C_g	13	pF

TYPICAL CHARACTERISTICS

Deionization time	T_{dion}	<	500	μs
Ionization time	T_{ion}	<	10	μs
Arc voltage	V_{arc} (I_a = 2.5 A)		12	V

LIMITING VALUES (Absolute limits)

When the anode voltage V_a is negative, the grid voltage must never be positive

Peak inverse voltage	$V_{a\,inv_p}$	max.	27	kV
(Frequency	f	max.	150	Hz)
Peak anode voltage	V_{a_p}	max.	27	kV
Output current	I_o	max.	2.5	A
(Averaging time	T_{av}	max.	30	s)
Peak anode current	I_{a_p}	max.	10	A
Surge current	I_{surge}	max.	100	A
(Duration	T	max.	0.1	s)
Negative grid voltage	$-V_g$	max.	300	V [1])
Grid current	I_g	max.	25	mA
(Averaging time	T_{av}	max.	30	s)
Peak grid current	I_{g_p}	max.	125	mA

$V_{a\,inv_p}$	27	21	15	13	10	kV
t_{Hg} [2])	30-40	30-45	25-50	25-55	25-60	^oC
t_{amb} [3])	20-25	20-30	15-35	15-40	15-45	^oC

[1]) Direct voltage; before conduction

[2]) If the equipment is started not more than twice daily it is permitted to apply high tension at a condensed mercury temperature which is 5 ^oC less than the values mentioned in the table

[3]) With natural cooling

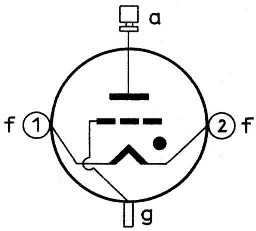
MECHANICAL DATA (Dimensions in mm)

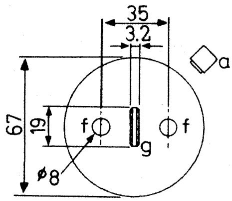
Anode connector: 40620

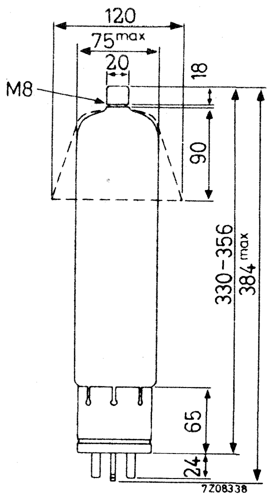
Anode cap : 40616

This cap must always be mounted on the tube, thus also during preheating

Net weight: 0.75 kg







Mounting position: vertical with base down

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected

Grid voltage	V_g ($V_{a\,inv_p}$ = 27 kV)	−100	V
Grid voltage	V_g ($V_{a\,inv_p}$ = 10 kV)	−50	V
Grid current	I_g	2	mA

Peak inverse voltage $V_{a\,inv_p}$ = 27 kV				
Circuit [1]	Transformer voltage	Output voltage	Output current	Power output
	V_{tr} (kV_{RMS})	V_o (kV)	I_o (A)	W_o (kW)
a	9.5	8.6	5	43
b	19.1	17.2	5	86
c	11	12.9	7.5	97
d	19.1	25.8	7.5	194
e	9.5	11.2	15	168
f	9.5	12.1	10	121
g	19.1	24.3	10	243

[1]) For circuits see page 8 in front of this section

HIGH-VOLTAGE XENON-FILLED RECTIFYING TUBE

QUICK REFERENCE DATA								
Peak inverse voltage	$V_{a\,inv_p}$	max.	10	kV	max.	5	kV
Output current	I_o	max.	0.25	A	max.	0.5	A
Peak anode current	I_{a_p}	max.	1	A	max.	2	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f		2.5	V
Filament current	I_f		5	A
Cathode heating time	T_w	min.	10	s

Phase shift of $90^o \pm 30^o$ between V_a and V_f and use of a centre-tapped filament transformer are recommended. In order to obtain a low ignition voltage the voltage on pin 4 should be positive with respect to pin 1 at the moment of ignition.

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 0.5 A)	12	V

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\,inv_p}$	max.	10	kV	max.	5	kV
(Frequency	f	max.	150	Hz	max.	500	Hz)
Output current	I_o	max.	0.25	A	max.	0.5	A
(Averaging time	T_{av}	max.	15	s	max.	15	s)
Peak anode current	I_{a_p}	max.	1	A	max.	2	A
Surge current	I_{surge}	max.	20	A	max.	20	A
(Duration	T	max.	0.1	s	max.	0.1	s)
Ambient temperature	t_{amb}		−55 to +75	^oC		−55 to +75	^oC

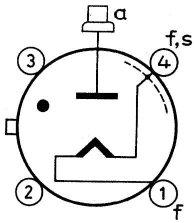
MECHANICAL DATA (Dimensions in mm)

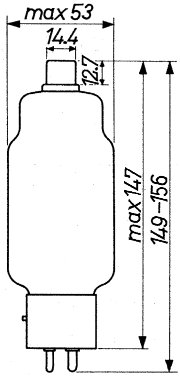
Base : medium 4p with bayonet

Socket : 2422 511 04001 [1])

Anode connector : 40619

Net weight : 100 g





Mounting position : arbitrary

[1]) At voltages above 2 kV the socket must be insulated from the chassis.

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected.

Peak inverse voltage $V_{a\,inv_p}$ = 10 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	3.5	3.2	0.5	1.6
b	7.1	6.4	0.5	3.2
c	4.1	4.8	0.75	3.6
d	7.1	9.6	0.75	7.2
e	3.5	4.1	1.5	6.2
f	3.5	4.5	1.0	4.5
g	7.1	9.0	1.0	9.0

Peak inverse voltage $V_{a\,inv_p}$ = 5 kV				
Circuit [1]	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	1.8	1.6	1.0	1.6
b	3.5	3.2	1.0	3.2
c	2.0	2.4	1.5	3.6
d	3.5	4.8	1.5	7.2
e	1.8	2.1	3.0	6.2
f	1.8	2.2	2.0	4.5
g	3.5	4.5	2.0	9.0

[1]) For circuits see page 8 in front of this section

HIGH-VOLTAGE
XENON-FILLED RECTIFYING TUBE

QUICK REFERENCE DATA				
Peak inverse voltage	$V_{a\,inv_p}$	max.	10	kV
Output current	I_o	max.	1.25	A
Peak anode current	I_{a_p}	max.	5	A

HEATING: direct; filament oxide-coated

Filament voltage	V_f		5	V
Filament current	I_f		7.1	A
Cathode heating time	T_w	min.	30	s

Phase shift of $90^\circ \pm 30^\circ$ between V_a and V_f and use of a centre-tapped filament transformer are recommended. In order to obtain a low ignition voltage the voltage on pin 4 should be positive with respect to pin 2 at the moment of ignition.

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_a = 1.25 A)	12	V

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\,inv_p}$	max.	10	kV
(Frequency	f	max.	150	Hz)
Output current	I_o	max.	1.25	A
(Averaging time	T_{av}	max.	15	s)
Peak anode current	I_{a_p}	max.	5	A
Surge current	I_{surge}	max.	50	A
(Duration	T	max.	0.1	s)
Ambient temperature	t_{amb}		−55 to +70	°C

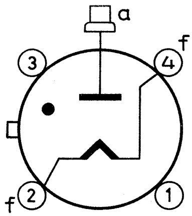
MECHANICAL DATA (Dimensions in mm)

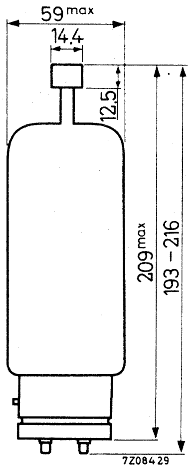
Base : Jumbo 4p

Socket : 2422 511 02001

Anode connector : 40619

Net weight : 190 g





Mounting position : arbitrary

OPERATING CONDITIONS

Transformer regulation and voltage drops in the tubes are neglected.

Peak inverse voltage $V_{a\,inv_p}$ = 10 kV				
Circuit [1])	Transformer voltage V_{tr} (kV_{RMS})	Output voltage V_o (kV)	Output current I_o (A)	Power output W_o (kW)
a	3.5	3.2	2.5	8
b	7.1	6.4	2.5	16
c	4.1	4.8	3.75	18
d	7.1	9.6	3.75	36
e	3.5	4.1	7.5	31
f	3.5	4.5	5.0	22.5
g	7.1	9.0	5.0	45

[1]) For circuits see page 8 in front of this section

GRID-CONTROLLED HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBES

QUICK REFERENCE DATA						
Peak inverse voltage	$V_{a\ inv_p}$	max.	21	15	2.5	kV
Peak forward voltage	V_{a_p}	max.	21	15	2.5	kV
Output current	I_o	max.	2.5	3	5	A
Peak anode current	I_{a_p}	max.	10	12	20	A

HEATING : direct; filament oxide coated

Filament voltage	V_f		5	V	[1]
Filament current	I_f		13	A	
Waiting time	T_w	min.	90	s	[2]

TYPICAL CHARACTERISTICS

Deionization time	T_{dion}	< 500	μs
Ionization time	T_{ion}	< 10	μs
Arc voltage	V_{arc} (I_o = 3 A)	12	V

LIMITING VALUES (Absolute limits)

Peak inverse voltage	$V_{a\ inv_p}$	max. 21	15	2.5	kV	[3]
Peak forward voltage	V_{a_p}	max. 21	15	2.5	kV	
Output current	I_o	max. 2.5	max. 3	max. 5	A	[4]
Peak anode current	I_{a_p}	max. 10	max. 12	max. 20	A	
Surge current	I_{surge}	max. 100	max. 120	max. 200	A	[5]
Negative grid voltage	$-V_g$	max. 300	max. 300	max. 300	V	[6]
Grid circuit resistance	R_g	min. 10 max. 100	min. 10 max. 100	min. 10 max. 100	kΩ kΩ	[7]

[1][2][3][4][5][6][7] See page 2

TEMPERATURE LIMITS (Absolute limits)

Peak inverse voltage	$V_{a\ inv_p}$	21	15	10	2.5	kV
Condensed mercury temperature	t_{Hg}	25-45	25-55	25-60	25-75	^{o}C [8]
Ambient temperature	t_{amb}	15-30	15-35	15-40	15-55	^{o}C [9]

---

1) Phase shift of $90^{o} \pm 30^{o}$ between V_a and V_f and/or use of a centre-tapped filament transformer are recommended.

2) For average conditions, i.e. temperature within limits and proper distribution of mercury (see page 5).
After transport and also after a long interruption of service a longer waiting time is required before anode voltage is applied to ensure proper distribution of the mercury. In general, a time of 60 minutes will be sufficient.

3) f max. 150 Hz

4) T_{av} max. 30 s

5) T max. 0.1 s

6) Direct voltage; before conduction

7) Recommended value 33 kΩ

8) If the equipment is started not more than twice daily it is permitted to apply high tension at a condensed mercury temperature of 20 °C.

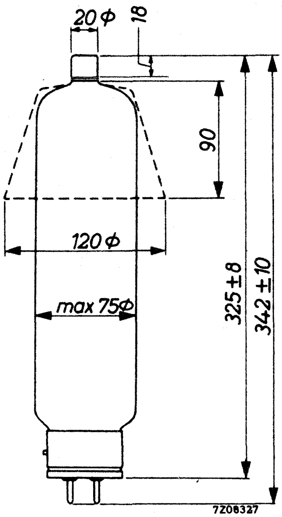
9) Approximate values with natural cooling.
The ambient temperature is defined as the temperature of the surrounding air and should be measured under the following conditions:
a. normal atmospheric pressure
b. the tube should be adjusted to the worst probable operating conditions
c. the temperature should be measured when thermal equilibrium has been reached
d. the distance of the thermometer from the envelope shall be 75 mm (measured in the 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.

MECHANICAL DATA

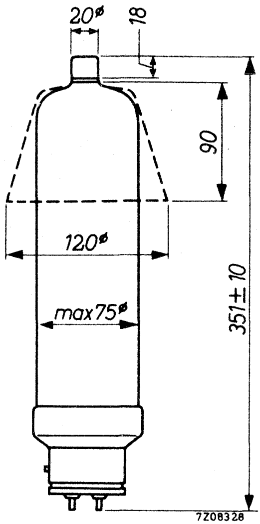
Dimensions in mm

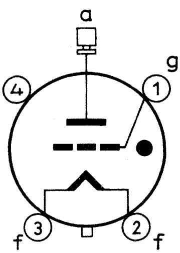
Net weight: 0.75 kg

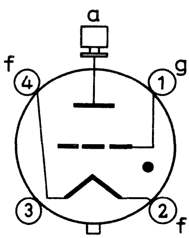
ZT 1000



ZT 1001







Base: Super Jumbo with bayonet

Socket : 2422 511 01001

Anode connector: 40620

Anode cap : 40616

Base: Jumbo 4p with bayonet

Socket : 2422 511 02001

Anode connector: 40620

Anode cap : 40616

Mounting position: vertical with base down

The anode cap 40616 is not delivered with the tube but must always be mounted on the tube, thus also during preheating.

OPERATING CONDITIONS

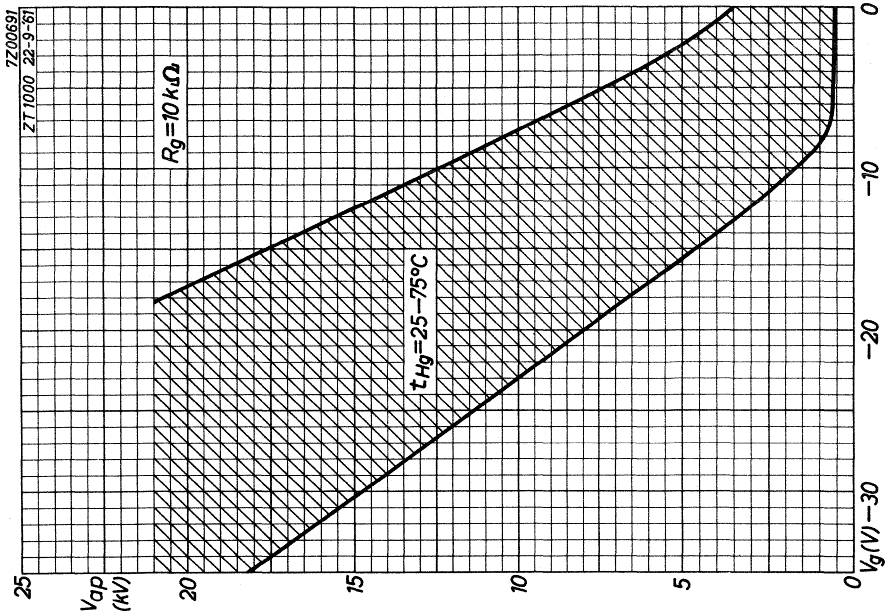
Transformer regulation and voltage drop in the tubes have been neglected

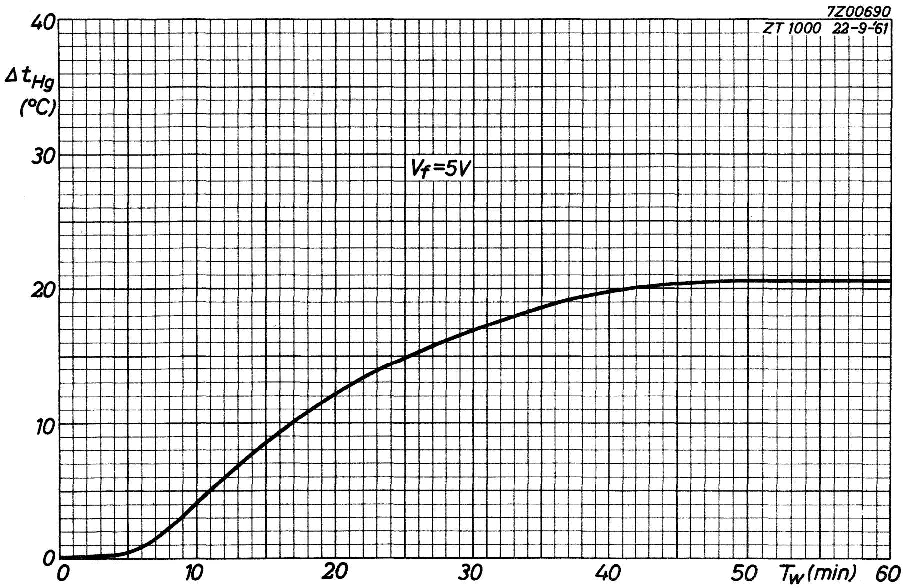
Grid voltage	V_g ($V_{a\ invp}$ = 21 kV)	-100	V
Grid voltage	V_g ($V_{a\ invp}$ = 10 kV)	-50	V
Grid current	I_g	2	mA

Peak anode inverse voltage $V_{a\ invp}$ = 21 kV				
Circuit [1]	Transformer voltage	Output voltage	Output current	Output power
	V_{tr} (kV_{RMS})	V_o (kV)	I_o (A)	W_o (kW)
a	7.4	6.7	5	33.5
b	14.8	13.4	5	67
c	8.5	10	7.5	75
d	14.8	20	7.5	150

Peak anode inverse voltage $V_{a\ invp}$ = 15 kV				
Circuit [1]	Transformer voltage	Output voltage	Output current	Output power
	V_{tr} (kV_{RMS})	V_o (kV)	I_o (A)	W_o (kW)
a	5.3	4.8	6	28.8
b	10.6	9.6	6	57.6
c	6.1	7.2	9	64.8
d	10.6	14.4	9	130

[1]) See page 8 in front of this section


7Z00691
ZT 1000 22-9-'61
R_g=10 kΩ
t_{Hg}=25−75°C
0
−10
−20
−30
V_g(V)
25
V_{ap} (kV)
20
15
10
5
0


7Z00690
ZT 1000 22-9-'61
40
Δt_{Hg} (°C)
30
20
10
0
V_f=5V
0
10
20
30
40
50
T_w(min)
60

HIGH-VOLTAGE MERCURY-VAPOUR RECTIFYING TUBES

QUICK REFERENCE DATA					
Peak inverse voltage	$V_{a\ inv_p}$	max.	13.5	7	kV
Output current	I_o	max.	1.5	1.75	A
Peak anode current	I_{a_p}	max.	6	7	A

HEATING: direct; filament oxide coated

Filament voltage	V_f		5	V
Filament current	I_f		7	A
Waiting time ($t_{Hg} > 25\ ^oC$)	T_w	min.	30	s

A phase shift of $90^o \pm 30^o$ between V_a and V_f and the use of a centre-tapped filament transformer are recommended.

When the condensed mercury temperature $t_{Hg} < 25\ ^oC$ the waiting time can be found with the aid of the curve on page A.

After transport or after long interruptions of operation the waiting time need not be prolonged.

TYPICAL CHARACTERISTICS

Arc voltage	V_{arc} (I_o = 1.5 A)	12	V

LIMITING VALUES (Absolute limits)

Mains frequency	f	up to 150	150	Hz
Peak inverse anode voltage	$V_{a\,inv_p}$	max. 13.5	7	kV
Output current	I_o	max. 1.5	1.75	A
(Averaging time	T_{av}	max. 10	10	s)
Peak anode current	I_{a_p}	max. 6	7	A
Peak surge current	$I_{surge\,p}$	max. 50	50	A
(Duration	T	max. 0.1	0.1	s)
Condensed mercury temperature	t_{Hg}	25 to 55	25 to 70	°C [1]
Ambient temperature	t_{amb}	10 to 30	10 to 45	°C [2]

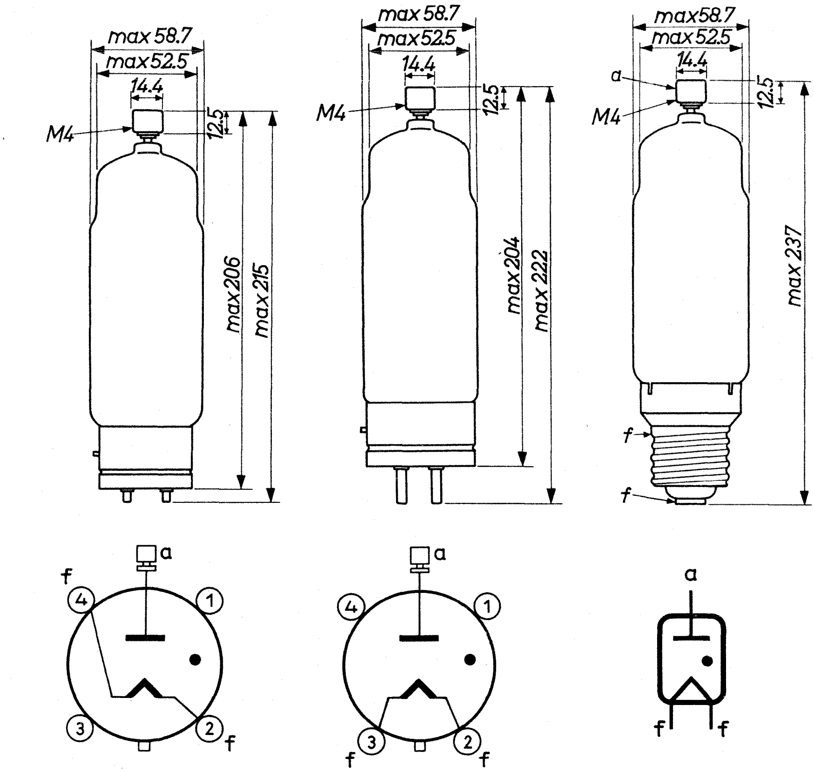
[1] If the equipment is started not more than twice daily, it is permitted to apply the high tension at a condensed mercury temperature of 20 °C.

[2] Approximate values with natural cooling. The tube may be operated at higher ambient temperatures than the stated maxima, provided the difference between ambient and condensed mercury temperature (approximately 25 °C with natural cooling) is reduced by an air flow directed to the bulb just above the base. A reduction of the difference to less than 10 °C can easily be obtained with a simple air jet. Maximum life and best performance will be obtained when the condensed mercury temperature is kept at approx. 35 °C.

MECHANICAL DATA Dimensions in mm

Net weight: 200 g

ZY1000 **ZY1001** **ZY1002**

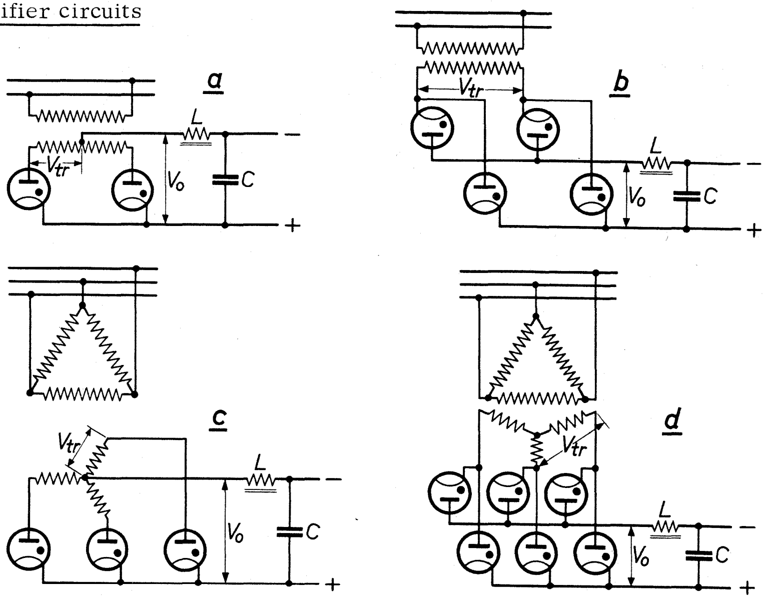


ZY1000	ZY1001	ZY1002
Base : Jumbo 4p with bayonet	Base : Super Jumbo with bayonet	Base : Goliath
Socket: 2422 511 02001	Socket: 2422 511 01001	Socket: 65909 BG/01
Anode connector: 40619	Anode connector: 40619	Anode connector: 40619

Mounting position: vertical with base down

OPERATING CONDITIONS

Rectifier circuits



Maximum operating conditions

Transformer losses and voltage drops in the tubes have been neglected.

Peak inverse voltage $V_{a\ inv_p}$ = 13.5 kV				
Circuit	Transformer voltage	Output voltage	Output current	Output power
	V_{tr} (kV, RMS)	V_o (kV)	I_o (A)	W_o (kW)
a	4.75	4.3	3.0	12.9
b	9.55	8.6	3.0	25.8
c	5.50	6.45	4.5	29
d	9.55	12.9	4.5	58

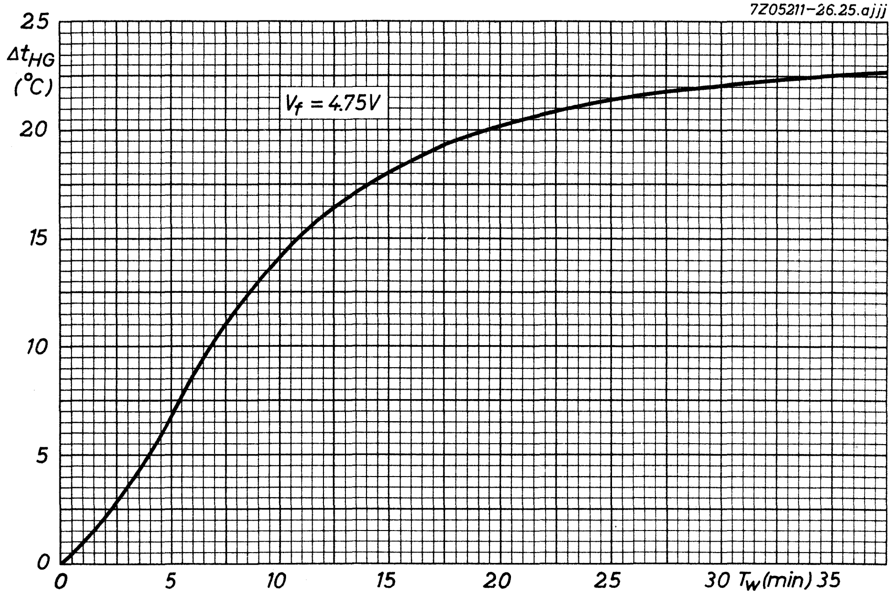
OPERATING CONDITIONS (continued)

Typical operating conditions

Peak inverse voltage $V_{a\,inv_p}$ = 12.3 kV (max. 13.5 kV [1])				
Circuit	Transformer voltage	Output voltage [2]	Output current	Output power
	V_{tr} (kV, RMS)	V_o (kV)	I_o (A)	W_o (kW)
a	4.35	3.6	3.0	10.8
b	8.7	7.2	3.0	21.6
c	5.0	5.4	4.5	24.3
d	8.7	10.8	4.5	48.6

[1]) Corresponding with mains voltage fluctuations of 10%

[2]) Tube voltage drops and losses in transformer, filter, etc., amounting to 8% of the voltage across the load, have already been deducted.


7Z05211-26.25.ajjj
25
Δt_{HG}
(°C)
20
15
10
5
0
$V_f = 4.75V$
0
5
10
15
20
25
30 T_W(min) 35

Miscellaneous

DRY REED SWITCH

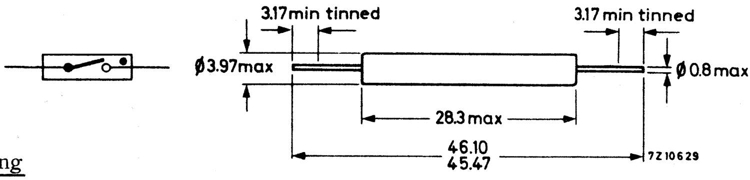
Miniature dry reed switch hermetically sealed in a gas-filled glass capsule. Single-pole, single-throw type, having normally open contacts, and containing two magnetically actuated reeds. The switch is of the double-ended type and may be actuated by means of either an electromagnet or a permanent magnet or combinations of both. The switch is intended for use in telephone equipment and other applications where exceptional reliability is required.

QUICK REFERENCE DATA	
Contact	S.P.S.T. normally open
Switched power	max. 5 W
Switched voltage	max. 65 V ←
Switched current	max. 100 mA
Failure rate	$< 5 \times 10^{-8}$

MECHANICAL DATA

Dimensions in mm

Contact material	gold
Contact arrangement	normally open
Terminal finish	tinned
Resonant frequency of single reed	approx. 1650 Hz
Net weigth	approx. 0.6 g
Mounting position	any



Mounting

The leads should not be bent nearer than 2 mm to the glass-to-metal seals.
Stress on the glass-to-metal seals should be avoided.
The robustness of terminations is tested according to IEC Publication 68-2-21. test Ua (load 2.75 kg), Ub (load 1 kg, 2 bends), and Uc. ←
Care must be taken to prevent stray magnetic fields from influencing the operating and measuring conditions.

Soldering

The switch may be soldered direct 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.

Dip-soldering is permitted to a minimum of 4 mm from the seals at a solder temperature of 240 °C during maximum 10 s.

Solderability

Solderability is tested according to IEC Publication 68-2-20, test T, solder globule method.

CHARACTERISTICS

Non-operative

Breakdown voltage		min.	1000	V
Insulation resistance, initial (V = 100 V)		min.	10^5	MΩ
Capacitance	without test coil		0.70	pF
	with earthed test coil		0.35	pF
Non-operative ampere turns		max.	30	A.T. [1]

Operative

Operating ampere turns	max.	58	A.T. [1]
Operating time, including bounce	av.	0.6	ms [1][2]
	max.	1.0	ms [1][2]
Switched current	max.	100	mA

Hold

Hold ampere turns	min.	27	A.T. [1]
Current through closed contacts	max.	1	A
Contact resistance, initial	min.	60	mΩ [1][3]
	max.	150	mΩ [1][3]

Release

Release ampere turns	max.	15	A.T. [1]
Release time	max.	50	μs [1][2]
Switched current	max.	100	mA
Switched power	max.	5	W

[1]) Measured in a standard coil of 5000 turns of 42 SWG single enamelled copper wire on a coil former of 25.4 mm winding length and a core diameter of 8.75 mm.

[2]) Measured with 80 A.T.

[3]) Measured with 40 A.T.

LIMITING VALUES (Absolute max. rating system)

See also "Life expectancy and reliability"

Switched power	max.	5	W
Switched voltage	max.	65	V
Switched current	max.	100	mA
surge (T = max. 100 ns)	max.	1.5	A
Temperature, operating	min.	−55	°C
	max.	+80	°C

LIFE EXPECTANCY AND RELIABILITY

End of life is assumed to be reached when:

a) the contact resistance exceeds 1 Ω for no load conditions or 2.5 Ω for loaded conditions

b) the release time exceeds 2.5 ms (latching or contact sticking)

No load conditions

Life expectancy min. 10^7 operations with a failure rate of less than 5.5×10^{-9} with 90% confidence level.

Loaded conditions

Life expectancy min. 5×10^6 operations with a failure rate of less than 10^{-8} with 90% confidence level.

If inductive loads are to be interrupted, contact protection is recommended (diode or RC network).

Reliability - testing conditions

Capacitive loading resulting in a peak current of 0.8 A $i_1/i_2 = 1.4$, T = 80 ns to 100 ns, see Fig. 1. Nominal switched voltage 50 V, nominal switched current 100 mA.

Under these conditions a life of more than 5×10^6 operations can be reached with a failure rate of less than 8.5×10^{-9}.

Remark

Higher loads may be switched if a reduced life expectancy and reliability are acceptable. The manufacturer should be consulted before doing so.

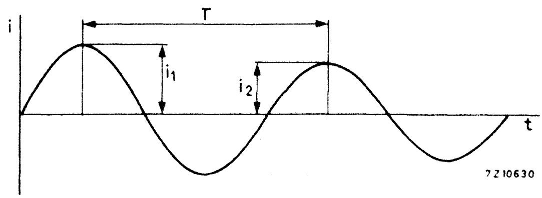


Fig. 1

SHOCK AND VIBRATION

Impact : Acceleration 50 g during 11 ms, due to a force perpendicular to the flat sides of the reeds.
Such an impact will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 A.T. coil to open.

Vibration: Frequency range 50 Hz to 1500 Hz, acceleration 20 g due to a force perpendicular to the flat side of the reed.
Such a vibration will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 A.T. coil to open.

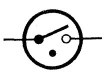
DRY REED SWITCH

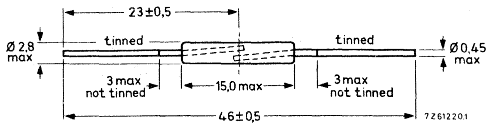
Micro dry reed switch hermetically sealed in a gas-filled glass capsule.
Single-pole, single-throw type, having normally open contacts, and containing two magnetically actuated reeds. The switch is of the double-ended type and may be actuated by means of either an electromagnet or a permanent magnet or combinations of both.
The switch is intended for use in push buttons or similar devices, in conjunction with semiconductor circuits.

QUICK REFERENCE DATA		
Contact	S.P.S.T. normally open	
Switched power	10	W
Switched voltage	100	V
Switched current	500	mA
Contact resistance (initial)	160	mΩ

MECHANICAL DATA Dimensions in mm

Contact arrangement	normally open
Terminal finish	tinned
Resonant frequency of single reed	approx. 2900 Hz
Net weight	approx. 0,16 g
Mounting position	any


7Z61219



7Z61220.1

Mechanical strength

The robustness of terminations is tested according to IEC Publication 68-2-21, test Ua (load 2 kg), Ub (load 1 kg, 2 bends), and Uc (3 x 360^{o}).

Mounting

The leads should not be bent nearer than 1 mm to the glass-to-metal seals.
Stress on the seals should be avoided.
Care must be taken to prevent stray magnetic fields from influencing the operating and measuring conditions.

Soldering

The switch may be soldered direct 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.

Dip-soldering is permitted to a minimum of 3 mm from the seals at a solder temperature of 240 °C during maximum 10 s.

Solderability

Solderability is tested according to IEC Publication 68-2-20, test T, solder globule method.

Weldability

The terminals are weldable.

CHARACTERISTICS

Non-operative					
Breakdown voltage	min.	400			V
Insulation resistance, initial	min.	10^3			MΩ
Capacitance, without test coil	max.	0,2			pF
		coil I	coil II	coil III	[1]
Non-operative ampere turns	max.	30	17	24	A.T.
Operative					
Operating ampere turns	max.	70	31	53	A.T.
Operating time, including bounce	typ.	0,5 [2]			ms
	max.	1,0 [2]			ms
Bounce time	typ.	0,4 [2]			ms
	max.	0,7 [2]			ms
Hold					
Hold ampere turns	min.	30	17	24	A.T.
Contact resistance, initial	typ.	160 [3]			mΩ
	max.	300 [3]			mΩ
Release					
Release ampere turns	max.	10	7	9	A.T.
Release time	max.	50 [2]			μs

[1]) Coil I : Standard coil
Coil II : Recommended coil — see page 4
Coil III : Miniature coil A according to MIL-S-55433A

[2]) Measured with 100 A.T.

[3]) Measured with 70 A.T., distance between measuring points: 41 mm.
Wire resistance typ. 2,5 mΩ/mm.

LIMITING VALUES (Absolute max. rating system)

Switched power	max.	10	W
Switched voltage	max.	100	V
Switched current	max.	500	mA
Current through closed contacts	max.	1	A
Temperature, storage and operating	max.	125	°C [1]
	min.	-55	°C

LIFE EXPECTANCY AND RELIABILITY

For life expectancy data end of life is defined as being reached when:
either a) the contact resistance once exceeds 1 Ω for no-load conditions or 10 Ω for loaded conditions, measured 5 ms after energizing the coil ;
or b) the release time once exceeds 5 ms (latching or contact sticking).

No-load conditions

Life expectancy min. 10^7 operations with a failure rate of less than 10^{-8} with a confidence level of 90 %.
After each operation a) and b) are tested.

Loaded conditions (Resistive load: 14 V, 2,4 mA)

Life expectancy min. 10^7 operations with a failure rate of less than 10^{-8} with a confidence level of 90 %.
After each operation points a) and b) are tested.

Note

Switching other loads involves different life expectancy and reliability. Consult us beforehand.

SHOCK AND VIBRATION

Impact: Acceleration 50 g during 11 ms, due to a force perpendicular to the flat sides of the reeds.
Such an impact will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 A.T. coil to open.

Vibration: Frequency range 50 Hz to 2500 Hz, acceleration 10 g due to a force perpendicular to the flat sides of the reeds.
Such a vibration will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 A.T. coil to open.

[1]) Excursions up to 150 °C may be permissible. Consult us.

COILS

Coil I: Standard coil

5000 turns of 42 SWG single enamelled copper wire on a coil former of 25,4 mm winding length and a core diameter of 8,75 mm.

Coil II, Recommended coil

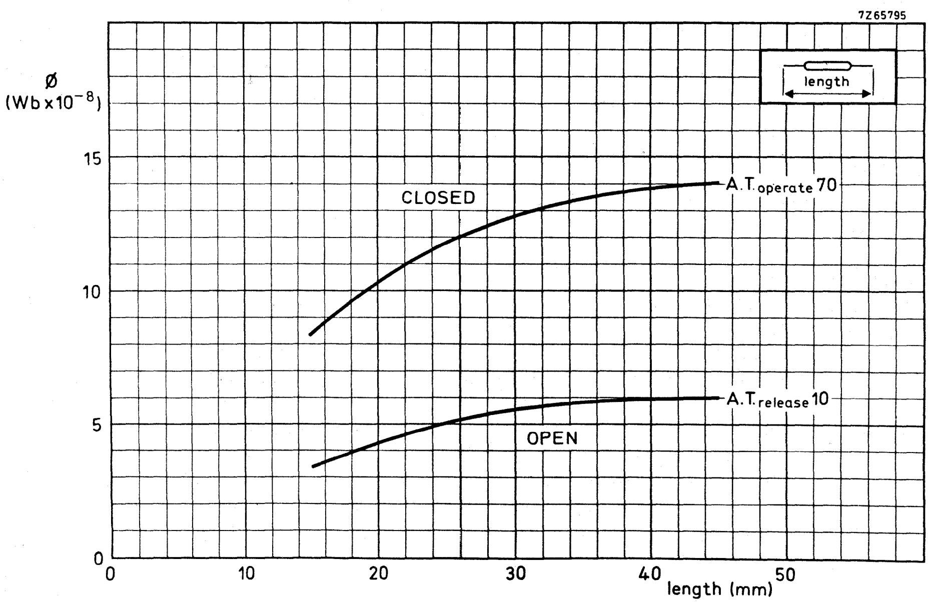
5000 turns of 46 SWG single enamelled copper wire on a coil former of 7,1 mm winding length, a core diameter of 3,7 mm and an outer diameter of 8,3 mm.

Coil III: Miniature coil A according to MIL-S-55433A

10 000 turns of 48 SWG single enamelled copper wire on a coil former of 19,05 mm winding length and a core diameter of 4,32 mm.

Permanent magnets

The graph shows the relationship between the flux to operate or to release the RI-20 and its total length.



$1\ Wb = 10^8\ Mx$

SURGE ARRESTORS

EXPLANATION OF PUBLISHED DATA

1. Starting voltage (Ignition voltage; V_{ign})

   The specified minimum and maximum starting voltage values indicate the voltage limits below which no ignition will take place and above which all tubes will ignite.

2. Extinguishing voltage (V_{ext})

   At voltages equal to or lower than the voltage specified, the discharge is extinguished.

3. Line voltage (V_{line})

   Surge arresters can be used for the protection of lines, the maximum operating voltage of which does not exceed the value specified. It is clear that surge arresters can also be used for the protection of lines and apparatus to which under normal conditions no voltage is applied.

4. Surge current (I_{surge})

   The values specified for the maximum temporary current and the appartaining period of time should be regarded as design values and are a measure for the ability to discharge large quantities of electrical energy during a brief period.

   Heavy discharges (within the time specified) resulting in currents that are about equal to the maximum surge current can be drawn off several times.

   Moderate discharges can take place many times before the surge arrester will fail. Failure will generally be due to too large deviations from the published starting and extinguishing voltages.

   If there is a great change of heavy continuous discharges, it is recommended to insert a series resistor, e.g. a voltage dependent resistor. In doing so the surge arrester will be protected against too large energies, whilst a voltage dependent resistor (exponent at least 4 to 5) will ensure extinguishing when discharge has taken place, also in the case of power lines.

5. Fuse in series

In the case of discharges of long duration e.g. as a result of direct contact between low and high-tension lines, care should be taken that the lines to be protected are disconnected, since otherwise damage will be caused to the surge arrester. A series-connected fuse may serve this purpose. The value published applies to a normal fuse type.

6. Capacitive discharge

Like the surge current value the value (expressed in watt seconds) given under this heading is a measure for the power of the surge arrester. For this value it also holds that energies equal to the value published can be drawn off a few times, and that energies that are several times smaller can be drawn off many times before the surge arrester will be unserviceable.

RARE GAS CARTRIDGES											
Type		4349	4369	4370	4371	4372	4378	4379	4383	4390	4397
Starting voltage	V	130-180	150-200	80-120	150-200	280-350	80-120	280-350	280-350	700-910	400-500
Min. extinguishing voltage	V	110	110	60	110	250	60	130	130	200	200
Surge current, max.	A	5	10	10	5	2.5	10	10	5	25	5
	sec	3	3	3	3	1	3	3	3	3	1
Fuse in series	max. A	6	10	10	6	6	10	10	6	25	6
Capacitive discharge	W_s	10	10	10	10	10	10	10	10	500	10
Max. line voltage	$V_=$	70	70	36	70	200	36	50	50	175	150
	$V_\sim$	75	75	50	75	180	50	180	180	300	230

CURRENT REGULATORS

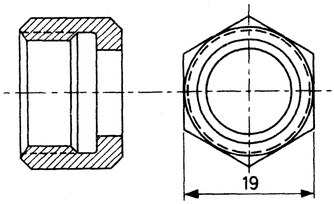
Type	I (A)	V (V)	Current tolerances from tube to tube			Max. dimensions in mm		
			V (V)	I_{min}	I_{max}	l	l' 1)	dia.
329	1.15	10-30	20	1.08 A	1.22 A	119	101	34
340	5.9	3-10	7	5.5 A	6.3 A	156	–	53
1904	0.1	30-80	60	96 mA	104 mA	100 2) 110 3)	– 92 3)	39
1905	1	2-6	4	960 mA	1.04 A	100	–	35
1908	0.8	5-15	5 7 15	740 mA 760 mA 770 mA	820 mA 860 mA 860 mA	107	89	35
1909	0.635	5-45	30	605 mA	665 mA	123	105	56
1910	1.4	5-15	5 8.5 15	1.3 A 1.35 A 1.35 A	– 1.5 A 1.5 A	110	92	35
1913	2	4-12	8	1.92 A	2.08 A	129	–	41
1918-01	0.1	4-10	7	97 mA	108 mA	67	–	21.5
1923	0.43	15-45	30	410 mA	450 mA	98	–	39
1927	0.18	40-120	80	172 mA	188 mA	138	120	40.5
1928	0.18	80-240	160	172 mA	188 mA	147	129	40.5
1941	0.3	80-200	140	289 mA	311 mA	162 4) 154 5)	144 4) –	53

1) Length without pins
2) Swan
3) 3-p
4) A
5) Edison

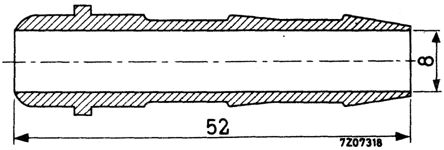
Associated accessories

COOLING WATER CONNECTION FOR IGNITRONS

TE 1051b Cap Nut (Thread 3/8" gas)



TE 1051c Connection for 9 mm Hose



Material: brass

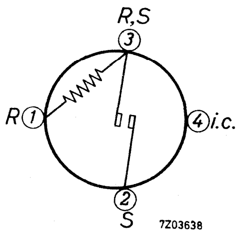
BIMETAL RELAY

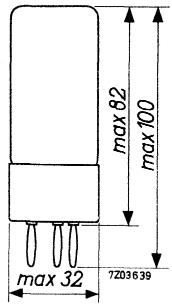
Bimetal relay

QUICK REFERENCE DATA			
Heater current	I_r	85 to 115	mA
Timing		150 to 30	s

DIMENSIONS AND CONNECTIONS Dimensions in mm

Base: A





HEATING

Heater current	I_r	85 to 115	mA
At $t_{amb} < 25\ ^oC$ the recommended min. value is 95 mA			
Resistance of the heating element R	R	370	Ω

OPERATING CHARACTERISTICS at $t_{amb} = 25\ ^oC$

Heater current	I_r	85	95	115	mA
Timing		max. 150	55 to 85	min.30	s

LIMITING VALUES (Absolute max. rating system)

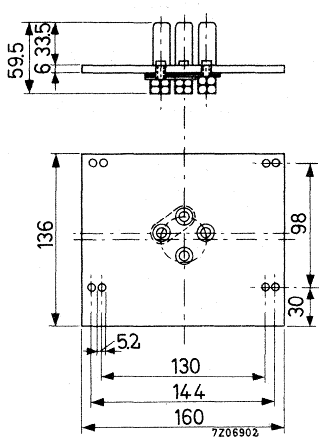
Heater current	I_r	max.	125	mA
Ambient temperature	t_{amb}	max.	+60	^oC
Current	t_{amb}	min.	−10	^oC

Mains voltage	Maximum current: When switching on	Maximum current: When switching off
220 V⎓	1.5 A	250 mA
220 V~	1.5 A	250 mA
380 V~	0.7 A	75 mA

ACCESSORIES

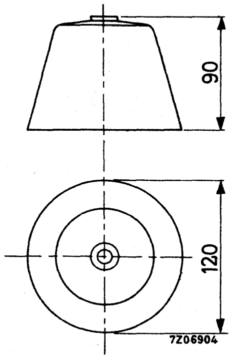
Socket type 40465

TUBE SOCKET



Material: Pertinax Insulating Material

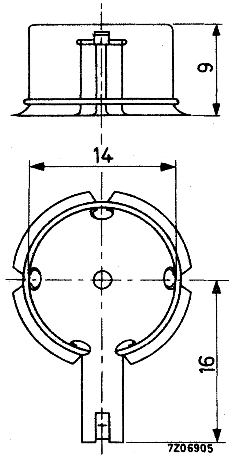
ANODE CAP



Material: Phenolic

TOP CAP CONNECTOR

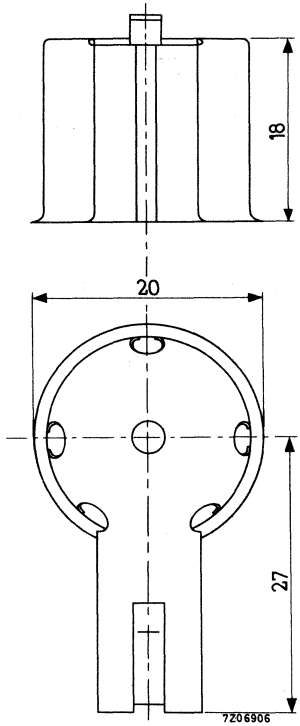
FOR TOP CAPS WITH 14.38 mm $\emptyset$ (IEC 67-III-1b, type 3).



Material: brass, nickel plated

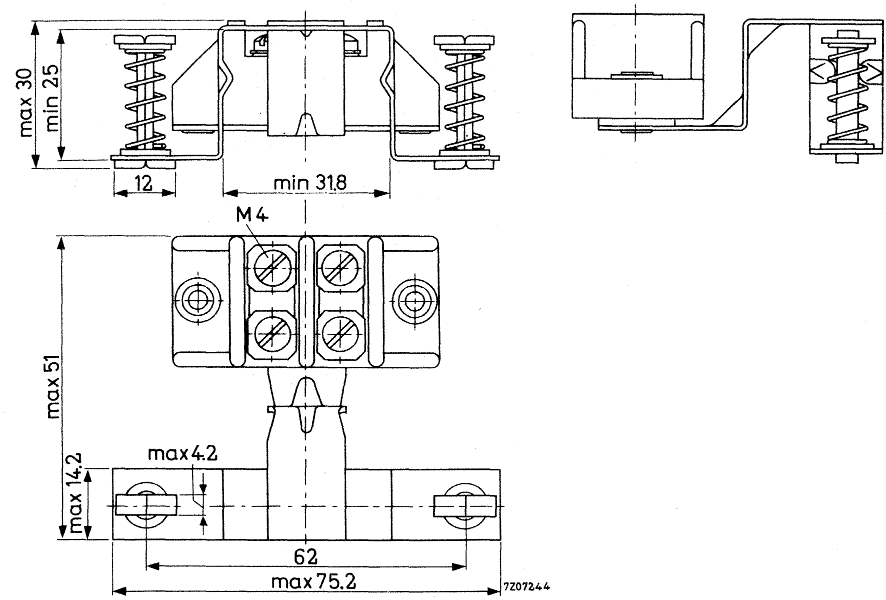
TOP CAP CONNECTOR

FOR TOP CAPS WITH 20.32 mm Ø (IEC 67-III-1b, type 4).

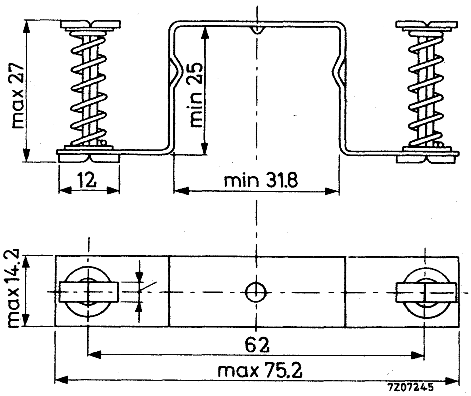


Material: brass, nickel plated

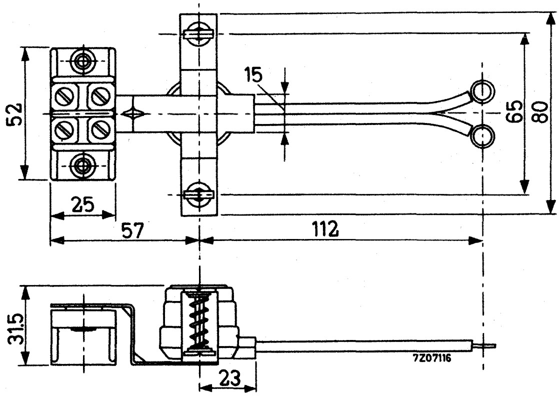
STRAP FOR THERMOSTAT



STRAP FOR THERMOSTAT



WATER SAVING THERMOSTAT



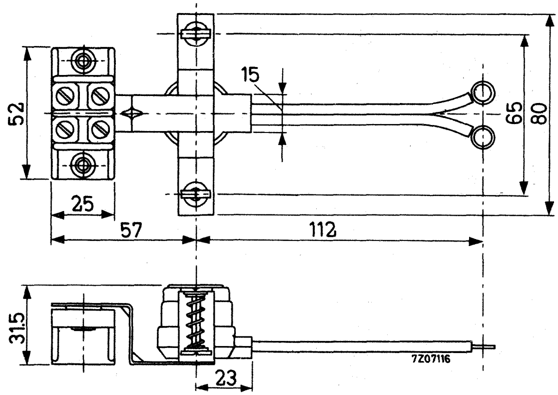
The thermostat has a normally open contact which closes at a typical plate temperature of 35 $\pm$3 ^{o}C and reopens at 30 $\pm$3 ^{o}C

Contact ratings

30	V_{dc}	10	A
125	V_{rms}	10	A
250	V_{rms}	8	A
600	V_{rms}	0.5	A

Max. voltage between ignitron and thermostat 600 V_{rms}

PROTECTING THERMOSTAT



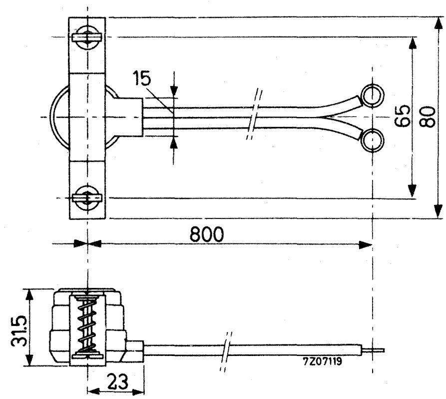
The thermostat has a normally closed contact which opens at a typical plate temperature of 52 ±3 °C and recloses at 41 ±3 °C

Contact ratings

30	V_{dc}	10	A
125	V_{rms}	10	A
250	V_{rms}	8	A
600	V_{rms}	0.5	A

Max. voltage between ignitron and thermostat 600 V_{rms}

WATER SAVING THERMOSTAT



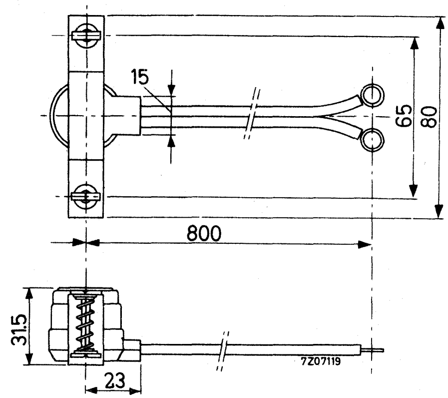
The thermostat has a normally open contact which closes at a typical plate temperature of 35 $\pm$ 3 ^{o}C and reopens at 30 $\pm$3 ^{o}C

Contact ratings

30	V_{dc}	10	A
125	V_{rms}	10	A
250	V_{rms}	8	A
600	V_{rms}	0.5	A

Max. voltage between ignitron and thermostat 600 V_{rms}

PROTECTING THERMOSTAT



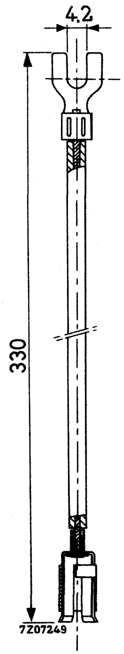
The thermostat has a normally closed contact which opens at a typical plate temperature of 52 ± 3 ^{o}C and recloses at 41 ± 3 ^{o}C

Contact ratings

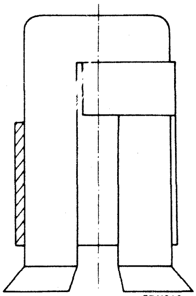
30	V_{dc}	10	A
125	V_{rms}	10	A
250	V_{rms}	8	A
600	V_{rms}	0.5	A

Max. voltage between ignitron and thermostat 600 V_{rms}

IGNITOR CABLE



IGNITOR CONNECTOR

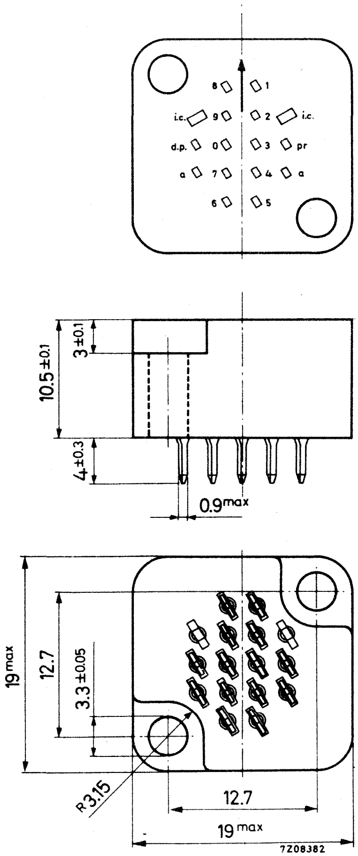


14 PIN TUBE SOCKET

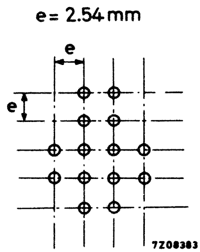
Socket for over chassis mounting and mounting on a printed wiring board with reference grid according to IEC publication 97.
The socket is compatible with 14 pin base (e.g. ZM1000).

MECHANICAL DATA

Dimensions in mm



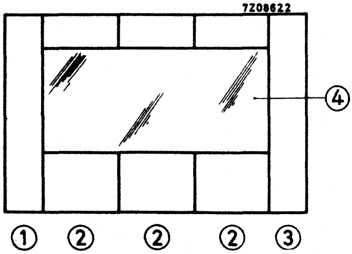
Hole pattern in printed wiring board
(for bottom view of socket)



Material: Phenolic
Contacts: Fork shaped, silver plated

SNAP-FIT INDICATOR-TUBE ASSEMBLY

A snap-fit indicator-tube assembly consists of a left-hand end piece ①, a number of snap-fit tube holders ②, as many as there are indicator tubes to be fitted side by side, a right-hand end piece ③, and a filter plate ④, which forms the front panel. The filter plate is preferably of the blue-light absorbing type made of, for instance, circular-polarized material.

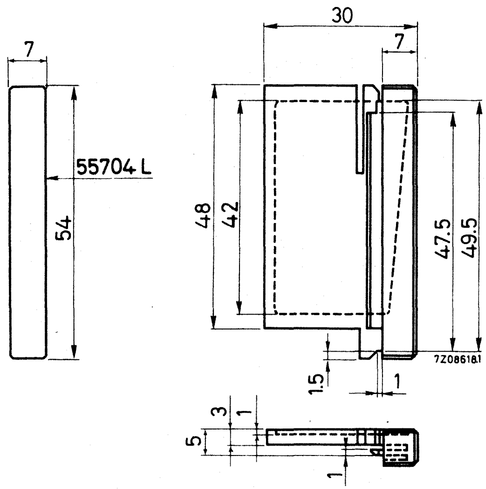


The various items can be fitted easily into a rectangular window cut in the frontplate of a piece of equipment; no tools are needed for mounting and this can take place from the front.
A snap-fit indicator-tube assembly can be used with front plates 1.6±0.2 mm thick.

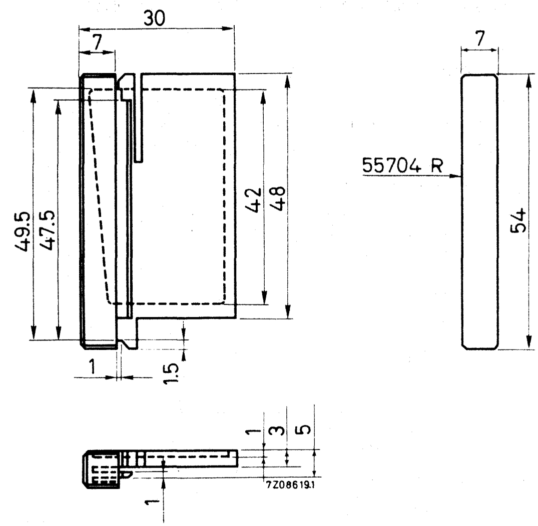
DIMENSIONS in mm

Material: gray plastic.

Left-hand end piece

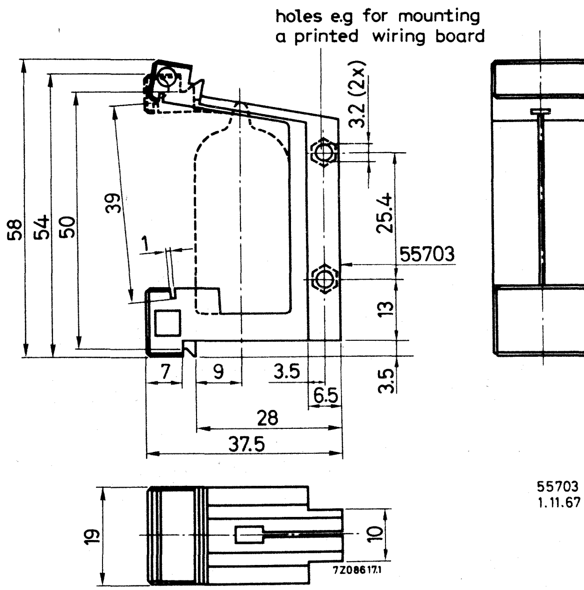


Right-hand end piece

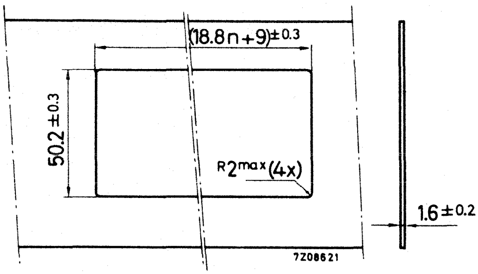


These two items are supplied together under type number 55704

Snap-fit tube holder Type number 55703



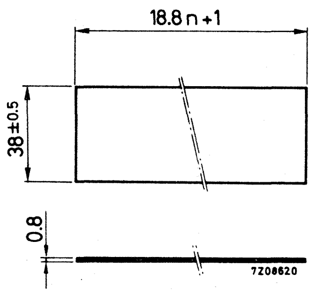
Window to be cut in the front plate



n = number of tube holders type 55703.

plate thickness 1.6 ± 0.2 mm

Filter plate (not included in the delivery)



n = number of tube holders 55703

MOUNTING INSTRUCTIONS

1. Slide one of the end pieces into position in the window cut in the front plate; Figs. 1a and 1b show this for the left-hand end piece.

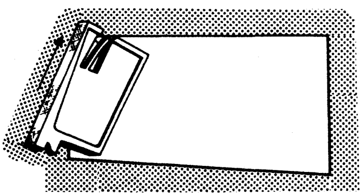


Fig.1a

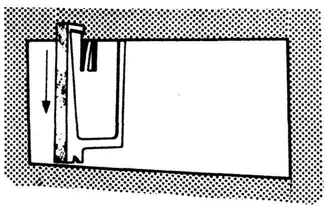


Fig.1b

2. Slide the snap-fit tube holders into position one by one, see Fig.2a and 2b.

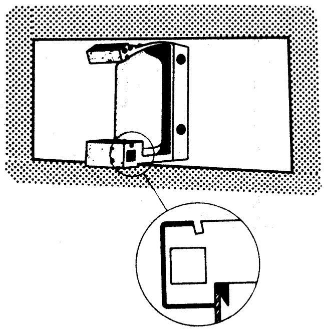


Fig.2a

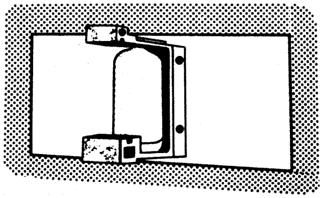


Fig.2b

3. After the last tube holder has been moved to its place, slide the filter plate into the grooves provided for the purpose, see Fig.3. Slide the other end piece into position in the manner explained for the first end piece.

Removal of the various items takes place in the reversed order.

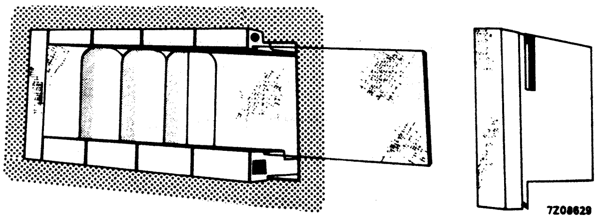
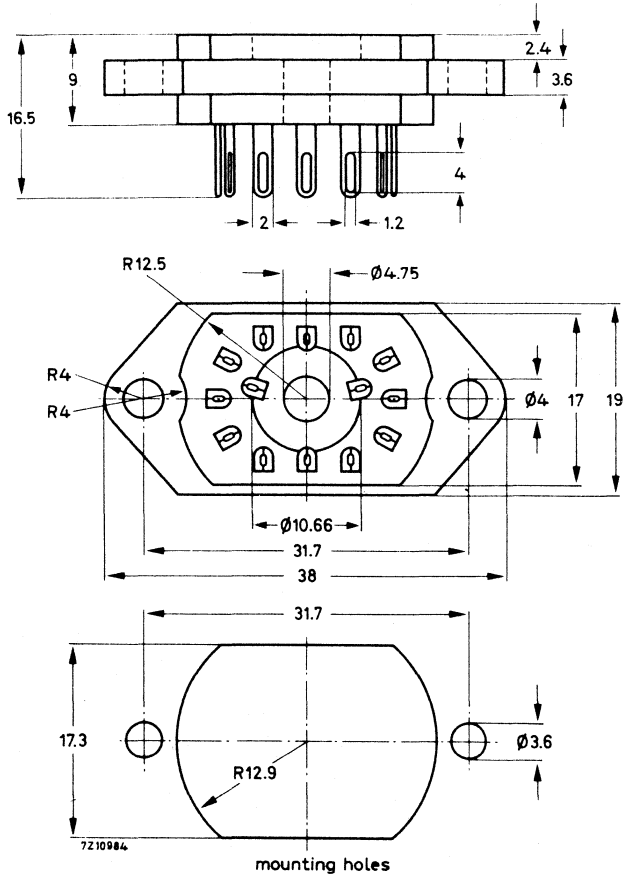


Fig.3

14–PIN TUBE SOCKET

14-pin socket, intended for use with close mounted rectangular envelope indicator tubes.

MECHANICAL DATA Dimensions in mm

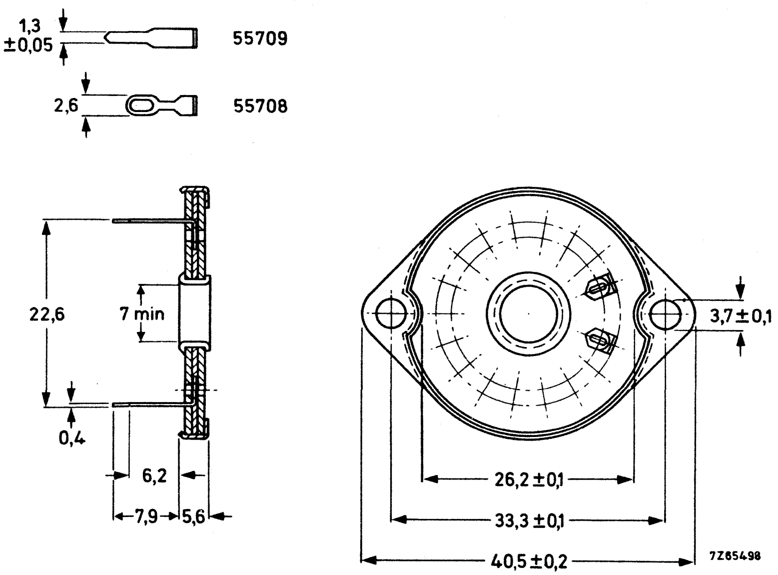


SOCKET FOR 17-PIN BASE

Socket (laminated) with scraping contacts, compatible with 17-pin base as used with "Pandicon"* tubes, e.g. ZM1200.

55708 For chassis mounting. Soldering tags with eyelets.
55709 For printed wiring. Soldering tags on circle.

The contacts are silver plated.



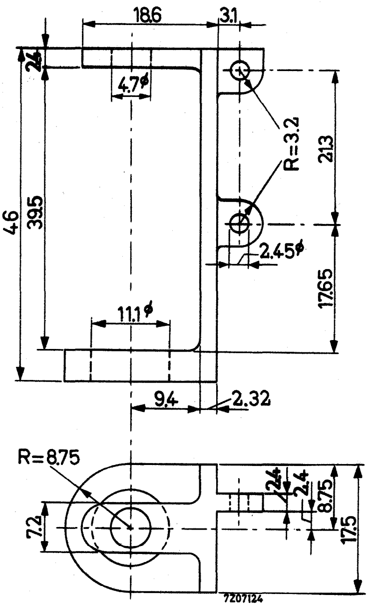
*Registered Trade Mark for multiple indicator tubes.

MOUNTING BRACKET FOR INDICATOR TUBES

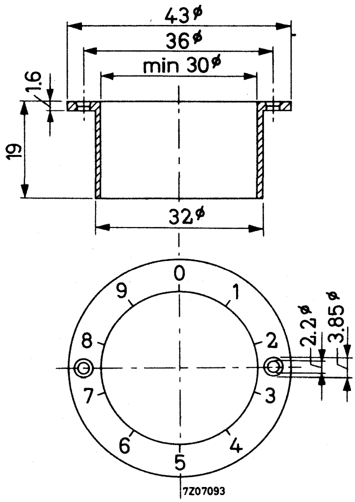
This bracket provides a simple means of mounting an indicator tube of dimensions similar to the ZM1080 series directly to the edge of a printed circuit board.

Dimensions in mm

Material : plastic



ESCUTCHEON



INDEX OF TYPENUMBERS

Type No.	Section	Type No.	Section	Type No.	Section
AGR9950	H.V.	PL5551A	Ign.	ZM1014	C.S.I.T.
DCG1/250	H.V.	PL5552A	ign.	ZM1020	C.S.I.T.
DCG4/1000	H.V.	PL5553B	Ign.	ZM1020/01	C.S.I.T.
DCG4/5000	H.V.	PL5555	Ign.	ZM1021	C.S.I.T.
DCG5/5000	H.V.	PL5557	Thyr.	ZM1022	C.S.I.T.
DCG6/18	H.V.	PL5559	Thyr.	ZM1022p	C.S.I.T.
DCG6/18GB	H.V.	PL5632/C3J	Thyr.	ZM1023	C.S.I.T.
DCG6/6000	H.V.	PL5684/C3JA	Thyr.	ZM1024	C.S.I.T.
DCG7/100	H.V.	PL5727	Thyr.	ZM1028	C.S.I.T.
DCG7/100B	H.V.	PL6574	Thyr.	ZM1030	C.S.I.T.
DCG9/20	H.V.	PL6755A	Thyr.	ZM1031/01	C.S.I.T.
DCG12/30	H.V.	TE1051b	Acc.	ZM1032	C.S.I.T.
DCX4/1000	H.V.	TE1051c	Acc.	ZM1033/01	C.S.I.T.
DCX4/5000	H.V.	Z70U	Tr.T.	ZM1040	C.S.I.T.
RI-12	Misc.	Z504S	C.S.I.T.	ZM1041	C.S.I.T.
RI-20	Misc.	Z505S	C.S.I.T.	ZM1042	C.S.I.T.
OA2	V.S.R.T.	Z803U	Tr.T.	ZM1042/01	C.S.I.T.
OA2WA	V.S.R.T.	ZA1002	Tr.T.	ZM1043	C.S.I.T.
OB2	V.S.R.T.	ZA1004	Tr.T.	ZM1043/01	C.S.I.T.
OB2WA	V.S.R.T.	ZA1006	Tr.T.	ZM1080	C.S.I.T.
PL2D21	Thyr.	ZC1040	Tr.T.	ZM1081	C.S.I.T.
PL3C23A	Thyr.	ZC1050	Tr.T.	ZM1082	C.S.I.T.
PL10	Thyr.	ZM1000	C.S.I.T.	ZM1083	C.S.I.T.
PL105	Thyr.	ZM1001	C.S.I.T.	ZM1162	C.S.I.T.
PL106	Thyr.	ZM1002	C.S.I.T.	ZM1174	C.S.I.T.
PL255	Thyr.	ZM1005	C.S.I.T.	ZM1175	C.S.I.T.
PL260	Thyr.	ZM1010	C.S.I.T.	ZM1176	C.S.I.T.
PL1607	Thyr.	ZM1011	C.S.I.T.	ZM1177	C.S.I.T.
PL5544	Thyr.	ZM1012	C.S.I.T.	ZM1200	C.S.I.T.
PL5545	Thyr.	ZM1013	C.S.I.T.	ZM1202	C.S.I.T.

Acc. = Accessories
C.S.I.T. = Counter-, selector and indicator tubes
H.V. = High-voltage rectifying tubes
Ign. = Ignitrons
I.R.T. = Industrial rectifying tubes
Misc. = Miscellaneous
Thyr. = Thyratrons
Tr.T. = Trigger tubes and switching diodes
V.S.R.T. = Voltage stabilizing and reference tubes

Type No.	Section	Type No.	Section	Type No.	Section
ZM1204	C.S.I.T.	1037	I.R.T.	5643	Thyr.
ZM1206	C.S.I.T.	1039	I.R.T.	5696	Thyr.
ZM1230	C.S.I.T.	1049	I.R.T.	40409	Acc.
ZM1232	C.S.I.T.	1054	I.R.T.	40616	Acc.
ZM1310	C.S.I.T.	1069K	I.R.T.	40619	Acc.
ZM1320	C.S.I.T.	1110	I.R.T.	40620	Acc.
ZM1325	C.S.I.T.	1119	I.R.T.	40713	Acc.
ZT1000	H.V.	1138	I.R.T.	40714	Acc.
ZT1001	H.V.	1163	I.R.T.	55305	Acc.
ZT1011	Thyr.	1164	I.R.T.	55306	Acc.
ZX1051	Ign	1173	I.R.T.	55317	Acc.
ZX1052	Ign.	1174	I.R.T.	55318	Acc.
ZX1053	Ign.	1176	I.R.T.	55351	Acc.
ZX1060	Ign.	1177	I.R.T.	55357	Acc.
ZX1061	Ign.	1710	I.R.T.	55702	Acc.
ZX1062	Ign.	1725A	I.R.T.	55703	Acc.
ZX1063	Ign.	1738	I.R.T.	55704	Acc.
ZX1081	Ign.	1749A	I.R.T.	55705	Acc.
ZX1082	Ign.	1788	I.R.T.	55708	Acc.
ZY1000	H.V.	1838	I.R.T.	55709	Acc.
ZY1001	H.V.	1849	I.R.T.	56022	Acc.
ZY1002	H.V.	1859	I.R.T.	56072	Acc.
ZZ1000	V.S.R.T.	1904	Misc.		
75C1	V.S.R.T.	1905	Misc.		
83A1	V.S.R.T.	1908	Misc.		
85A2	V.S.R.T.	1909	Misc.		
90C1	V.S.R.T.	1910	Misc.		
150B2	V.S.R.T.	1913	Misc.		
328	I.R.T.	1918-01	Misc.		
329	Misc.	1923	Misc.		
340	Misc.	1927	Misc.		
354	I.R.T.	1928	Misc.		
367	I.R.T	1941	Misc.		
451	I.R.T.	4152/02	Acc.		
1010	I.R.T.	4349 to 4397	Misc.		

Acc. = Accessories
C.S.I.T. = Counter-, selector and indicator tubes
H.V. = High-voltage rectifying tubes
Ign. = Ignitrons
I.R.T. = Industrial rectifying tubes
Misc. = Miscellaneous
Thyr. = Thyratrons
V.S.R.T. = Voltage stabilizing and reference tubes

Some devices are labelled

Maintenance type

Obsolescent type

or

Obsolete type

Maintenance type	-	Available for equipment maintenance No longer recommended for equipment production.
Obsolescent type	-	Available until present stocks are exhausted.
Obsolete type	-	No longer available.

Voltage stabilizing - and reference tubes

Counter-, selector - and indicator tubes

Trigger tubes and switching diodes

Thyratrons

Industrial rectifying tubes

Ignitrons

High - voltage rectifiying tubes

Miscellaneous

Associated accessories

Printed in the Netherlands 9399 241 22501