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Document in this file	Mullard technical handbook - Book 2 - Part 3 Gasfilled tubes - December 1969
Display devices in this document	Z504S, Z505S, Z520M, ZM1000, ZM1000R, ZM1001, ZM1001R, ZM1020, ZM1021, ZM1023, ZM1040, ZM1041, ZM1042, ZM1080, ZM1081, ZM1082, ZM1083, ZM1162, ZM1170, ZM1172, ZM1174, ZM1175, ZM1176, ZM1177, ZM1230, ZM1232

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Mullard

Technical handbook

BOOK

2

Valves and Tubes

Part 3

Gasfilled tubes

December 1969

GASFILLED TUBES

CONTENTS

Book 2 comprises the following parts—

Part 1 Receiving valves, television picture tubes.

Part 2 Electron-optical devices, radiation detectors.

Part 3 Gasfilled tubes.

Part 4 Transmitting and industrial heating valves.

Part 5 Microwave tubes and components.

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BOOK 2 (Part 3)

VALVES AND TUBES

Gasfilled tubes

Issued by

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These symbols are based on British Standard Specification No. 1409 : 1950, "Letter Symbols for Electronic Valves".

1. SYMBOLS FOR ELECTRODES

Anode	a	Fluorescent Screen or Target	t
Cathode	k	External Metallisation	M
Grid	g	Internal Metallisation	m
Heater	h	Deflector Electrodes	x or y
Filament	f	Internal Shield	s
Beam Plates	bp	Resonator	Res

NOTE 1. In valves having more than one grid, the grids are distinguished by numbers—g_1, g_2, etc., g_1 being the grid nearest the cathode.

NOTE 2. In multiple valves, electrodes of the different sections may be distinguished by adding one of the following letters:

Diode	d	Hexode	h
Triode	t	Heptode	h
Tetrode	q	Octode	h
Pentode	p	Rectifier	r

Thus, the grid of the triode section of a triode-hexode is denoted by g_t.

NOTE 3. Two or more similar electrodes which cannot be distinguished by any of the above means may be denoted by adding one or more primes to indicate to which electrode system the electrode forms a part.

Thus, the anode of the first diode in a double diode valve is denoted a′.

2. SYMBOLS FOR ELECTRIC MAGNITUDES

Voltages		Current	
Direct Voltage	V	Direct Current	I
Alternating Voltage (r.m.s.)	$V_{r.m.s.}$	Alternating Current (r.m.s.)	$I_{r.m.s.}$
Alternating Voltage (mean)	V_{av}	Alternating Current (mean)	I_{av}
Alternating Voltage (peak)	v_{pk}	Alternating Current (peak)	i_{pk}
Peak Inverse Voltage	P.I.V.	No Signal Current	I_o

Miscellaneous			
Frequency	f	Anode Efficiency	η
Amplification Factor	μ	Sensitivity	S
Mutual Conductance	g_m	Brightness	B
Conversion Conductance	g_c	Temperature	T
Distortion	D	Time	t

LIST OF SYMBOLS

	Inside Valve	Outside Valve
Resistance	r	R
Reactance	x	X
Impedance	z	Z
Admittance	y	Y
Mutual Inductance	m	M
Capacitance	c	C
Capacitance at Working Temperature	c_w	
Power	p	P

3. AUXILIARY SYMBOLS

Battery or other source of supply	b
Inverse (Voltage or Current)	inv
Ignition (Voltage)	ign
Extinction (Voltage)	ext
No Signal	o
Input	in
Output	out
Total	tot
Centre Tap	ct

4. COMPLEX SYMBOLS

Symbols in Sections 1 and 3 above may be used as subscripts to symbols in Section 2, to denote such magnitudes as Anode Current, Grid Volts, etc., e.g.:—

Anode Voltage	V_a
Control-Grid Voltage	V_{g1}
Anode Supply Voltage	$V_{a(b)}$
Filament Voltage	V_f
Heater Voltage	V_h
Anode Dissipation	p_a
Output Power	P_{out}
Drive Power	P_{drive}
Anode Current (D.C.)	I_a
Anode Current (A.C. r.m.s.)	$I_{a(r.m.s.)}$
No Signal Anode Current	$I_{a(o)}$
Control-Grid Current	I_{g1}
Total Distortion	D_{tot}
3rd Harmonic Distortion	D_3
Equivalent Noise Resistance	R_{eq}
Limiting Resistor	R_{lim}
Cathode Bias Resistor	R_k

	Internal	External
Anode Resistance	r_a	R_a
Insulation Resistance (heater to cathode)	r_{h-k}	
Resistance between Control-Grid and Cathode	r_{g1-k}	R_{g1-k}
Capacitance (cold)—		
Anode to all other electrodes		c_{a-all}
Anode to control-grid		c_{a-g1}
Control-grid to cathode at working temperature		$c_{g1-k(w)}$
Control-grid to all other electrodes except anode (Input Capacitance)		c_{in}
Anode to all other electrodes except control-grid (Output Capacitance)		c_{out}
Inner Amplification Factor		μ_{g1-g2}

Construction

The Mullard 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 divided 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 475V, (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

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

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.

DECADE SELECTOR AND COUNTING TUBE

Z504S

QUICK REFERENCE DATA

Short construction, bi-directional cold cathode, 10 output selector tube with neon type glow.

Maximum counting speed	5.0	kc/s
Supply voltage	475	V
Output		
voltage	35	V
current	340	μA
Indication	Self indicating	

No individual adjustment is necessary to align the bulb with the escutcheon.

This data should be read in conjunction with OPERATING NOTES - STEPPING TUBES which precede this section of the handbook.

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN (at an ambient temperature between 10° and 50°C unless otherwise stated.)

The values given state the range over which the tube will operate both initially and during life. No allowance has been made for supply voltage and component variations.

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

IGNITION REQUIREMENTS

Anode supply voltage range $V_{a(b)}$	375 to 1000	V
Minimum time constant of rise of anode supply voltage (see note 1)		
$V_{a(b)}$ <550V	1.0	ms
$V_{a(b)}$ ≥550V	6.0	ms

DISCHARGE AT REST ON A MAIN CATHODE

Maintaining voltage of anode to main cathode (see curve on page C1) (I_a = 340μA, V_{GDB} = +25 to +50V)

Typical maximum	205	V
Typical minimum	185	V
Main cathode current		
maximum (except during reset)	525	μA
minimum	250	μA
recommended	340	μA
Positive guide supply voltage V_{GDB}		
maximum	60	V
minimum	25	V
Maximum resistance between guides and guide supply	220	kΩ
Main cathode potential (except during reset)		
Non-conducting cathode		
maximum negative voltage	14	V
Conducting cathode		
maximum positive voltage (see note 2)	V_{GDB} minus 10	V
maximum negative voltage	0	V

STEPPING REQUIREMENTS

This section should be considered in conjunction with the figures given on pages D7 and D8.

Minimum discharge dwell time		
Main cathode	75	μs
guide A cathode	60	μs
guide B cathode	60	μs
Maximum interval between trailing edge of guide A pulse and leading edge of guide B pulse (double rectangular pulse drive)	3.0	μs

Negative guide voltage to step the discharge from a main cathode to an adjacent guide cathode.

maximum	140 minus V_{GDB}	V
minimum	45	V

Voltage difference required between a guide cathode and the adjacent guide cathode in order to step the discharge.

maximum	140	V
minimum (see note 3)	45	V

Positive guide supply voltage to step the discharge from a guide cathode to the next cathode.

maximum	50	V
minimum	25	V

Main cathode potential

Non-conducting cathodes		
maximum negative voltage	14	V
Conducting cathode		
maximum positive voltage (see note 2)	V_{GDB} minus 10	V
maximum negative voltage	0	V

RESETTING REQUIREMENTS

	Reset to Cathodes (7, 8, 9, 0, 1, 2, 3)	Reset to Cathodes (4, 5, 6)	
Maximum permitted negative main cathode voltage	240	140	V
Minimum negative main cathode voltage			
pulse duration >1.0ms	120	120 (see note 4)	V
pulse duration ≥200μs	130	-	V
Minimum pulse duration h	200	-	μs
Maximum reset cathode current (see note 5)	800	650	μA

LIFE AND RELIABILITY

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

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_0) 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.
Temperature	20 ± 5°C	

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

ABSOLUTE MAXIMUM RATINGS

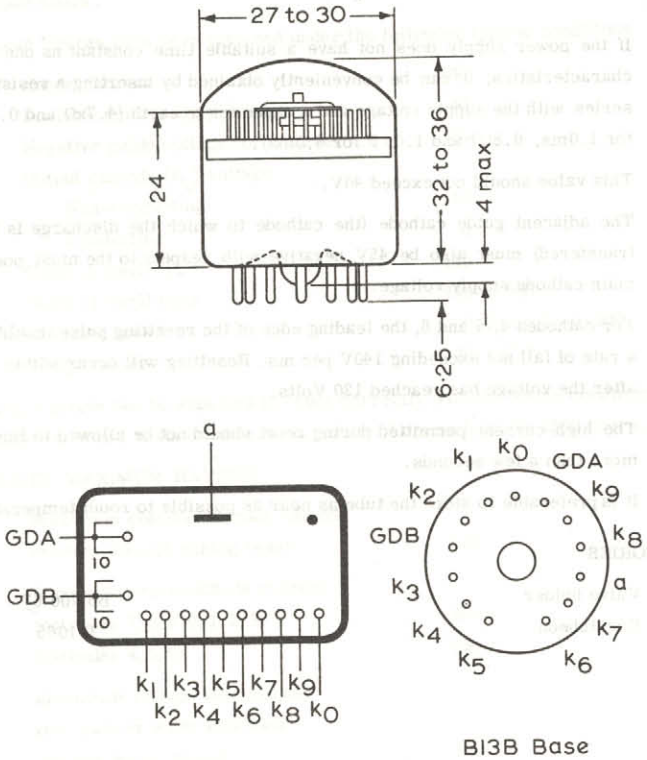
Maximum continuous main cathode current (except during reset)	525	μA
Maximum reset cathode current		
(cathodes 7, 8, 9, 0, 1, 2, 3)	800	μA
(cathodes 4, 5, 6)	650	μA
Maximum voltage between any two main or guide cathodes (except during reset)	140	V
Maximum positive guide supply voltage	60	V
Maximum ambient temperature for operation and standby (see note 6)	50	°C

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 (4.7kΩ and 0.25μF for 1.0ms, 6.8kΩ and 1.0μF for 6.0ms).
2. This value should not exceed 40V.
3. The adjacent guide cathode (the cathode to which the discharge is being transfered) must also be 45V 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 140V per ms. Resetting will occur within 1ms 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.

ACCESSORIES

Valve holder	B8 700 67
Escutcheon	101065

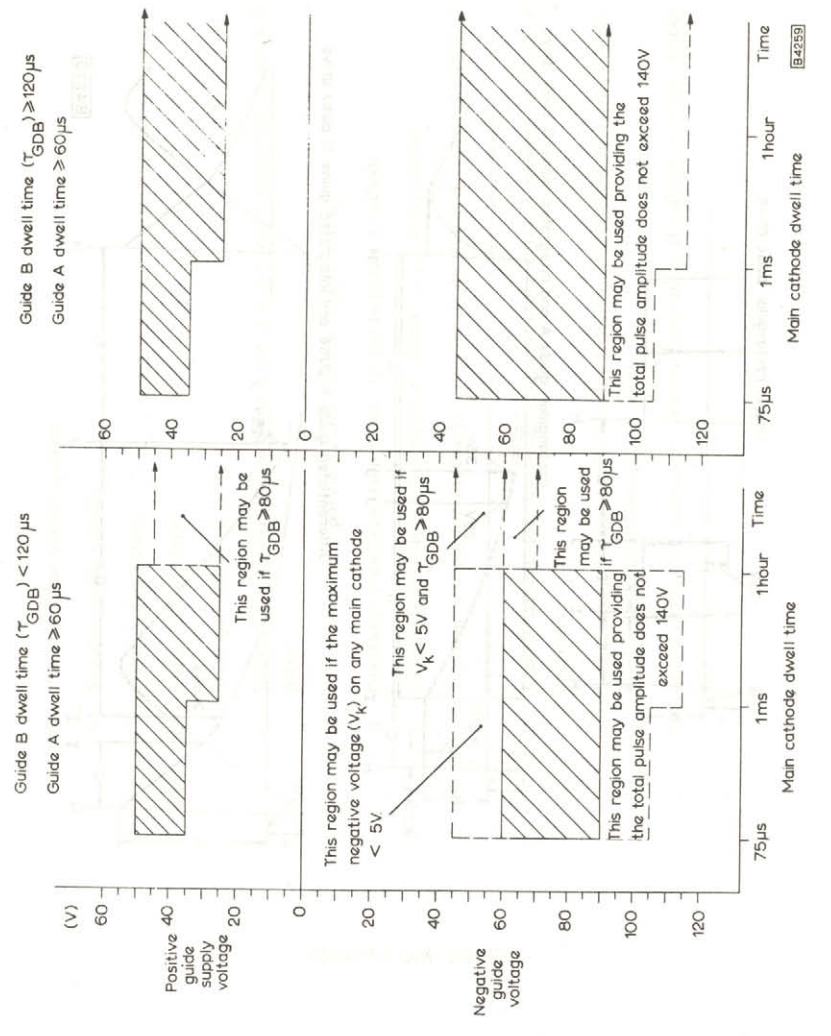


B13B Base

All dimensions in mm

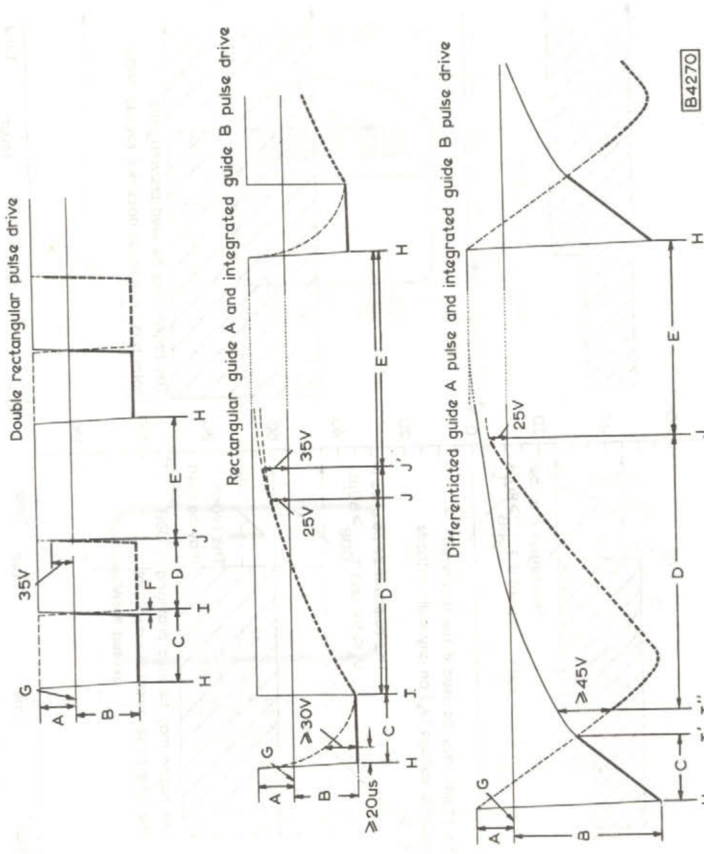
k_0 is aligned with pin 7 to within ± 3°

9129



GUIDE OPERATING VOLTAGES

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



GUIDE WAVEFORMS

A Positive guide supply voltage

B Negative guide voltage

C Guide A dwell time

D Guide B dwell time

E Main cathode dwell time

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

G Potential of most positive main cathode supply voltage

H Discharge transfers from main cathode to guide A cathode

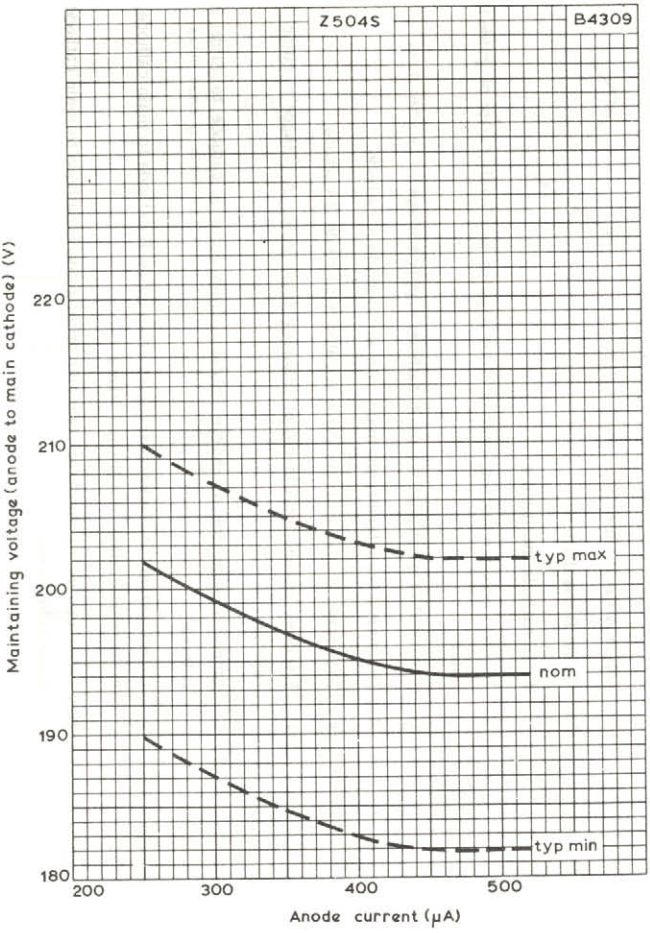
I Discharge transfers from guide A cathode to guide B cathode

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

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

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

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



ANODE TO MAIN CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST ANODE CURRENT

APPLICATION DATA

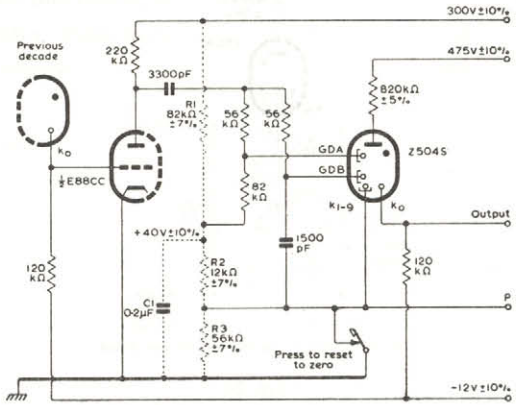
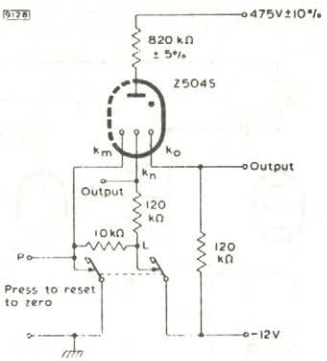


Fig. 1

Coupling stage suitable for use with Z504S

The potential divider R1, R2, R3 and C1 is used to define the positive guide bias and the reset voltages. The potential divider may be used as a common supply for up to five further coupling stages.

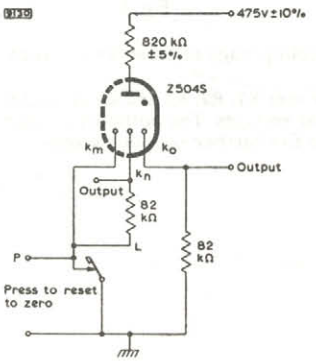
Two circuits illustrating alternative methods of connecting the main cathodes of Z504S are shown in figure 2.



All components ±10% unless otherwise stated

Fig. 2a

This circuit gives an output of 35V from k_o and outputs of 35V from each of the cathodes in group k_n.



All components ±10% unless otherwise stated

Fig. 2b

This circuit gives an output of 23V from k_o and outputs of 23V from each of the cathodes in group k_n. This circuit cannot be directly coupled to the coupling stage in figure 1.

In the two circuits in figure 2, k_m refers to the main cathodes from which no output is required, whilst k_n refers to the main cathodes, excepting k_o from which an output pulse is required. Each cathode in the k_n group must be connected to point L via a separate resistor.

DECADE SELECTOR AND COUNTING TUBE

Z505S

QUICK REFERENCE DATA

Short construction, bi-directional, cold cathode, 10 output selector tube with glow indication.

Maximum counting speed	50	kHz
Supply voltage	500	V
Output		
voltage	24	V
current	800	μA
Indication	Self indicating	

No individual adjustment is necessary to align the bulb with the escutcheon.

This data should be read in conjunction with OPERATING NOTES - STEPPING TUBES

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN (at an ambient temperature between 10°C and 50°C unless otherwise stated).

The values given state the range over which the tube will operate both initially and during life. No allowance has been made for supply voltage and component variations.

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

IGNITION REQUIREMENTS

Anode supply voltage range $V_{a(b)}$	400 to 1000	V
Minimum time constant of rise of anode supply voltage (see note 1)	2.0	ms

DISCHARGE AT REST ON A MAIN CATHODE

Maintaining voltage of anode to main cathode

($I_a = 800\mu A$, $V_{GD(b)} = 55V$)

Typical maximum	275	V
Typical minimum	240	V
Main cathode current		
Maximum (except during reset)	1000	μA
Minimum	600	μA
Recommended	800	μA
Positive guide supply voltage $V_{GD(b)}$		
Maximum	65	V
Minimum	40	V
Maximum resistance between guides and guide supply	22	kΩ

Main cathode potential (except during reset)

Non-conducting cathode		
Maximum negative voltage	14	V
Conducting cathode		
Maximum positive voltage (see note 2)	28	V
Maximum negative voltage	0	V

STEPPING REQUIREMENTS

This section should be considered in conjunction with the figures given on pages D6 and D7.

Minimum discharge dwell time		
Main cathode	8.0	μs
Guide A cathode	6.0	μs
Guide B cathode	6.0	μs
Maximum interval between trailing edge of guide A pulse and leading edge of guide B pulse (double rectangular pulse drive)	0.3	μs

Negative guide voltage to step the discharge from a main cathode to an adjacent guide cathode.

Maximum	80	V
Minimum	30	V

Voltage difference required between a guide cathode and the adjacent guide cathode in order to step the discharge.

Maximum	140	V
Minimum (see note 3)	30	V

Positive guide supply voltage to step the discharge from a guide cathode to the next main cathode.

Maximum	65	V
Minimum	40	V

Main cathode potential

Non-conducting cathodes

Maximum negative voltage	14	V

Conducting cathode

Maximum positive voltage (see note 2)	28	V
Maximum negative voltage	0	V

RESETTING REQUIREMENTS (see note 4)

Maximum permitted negative main cathode voltage	140	V
Minimum negative main cathode voltage (see note 5)	100	V

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	800	μA
Positive guide supply voltage	60	V
Negative guide voltage for transfer	50	V
Output cathode (K_o) voltage		
Non-conducting	5.0	V
Conducting	-5.0	V
Guide A dwell time	6.0	μs
Guide B dwell time	6.0	μs
Main cathode dwell time	8.0	μs
Temperature	20 ± 5	°C

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Maximum continuous main cathode current (except during reset)	1000	μA
Maximum voltage between any two main or guide cathodes (except during reset)	140	V
Maximum positive guide supply voltage	65	V
Maximum negative reset voltage	140	V
Maximum ambient temperature for operation and standby (see note 6)	50	°C

NOTES

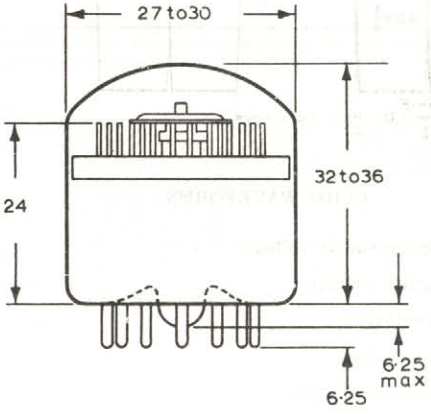
1. If the power supply does not have a suitable time constant as one of its characteristics, it can be conveniently obtained by inserting a resistor in series with the supply voltage and a capacitor to earth (4.7kΩ and 0.5μF for 2.0ms).
2. The maximum voltage difference between any two main cathodes except during reset must not exceed 28 volts.
3. The adjacent guide cathode (the cathode to which the discharge is being transferred) must also be 30 volts 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 for more than a few seconds.
5. If the cathode current falls below 700μA and the positive guide supply voltage applied to the tube approaches the minimum value of 40 volts, the negative voltage required for resetting may rise to 110 volts.
6. It is preferable to store the tube as near as possible to room temperature.

ACCESSORIES

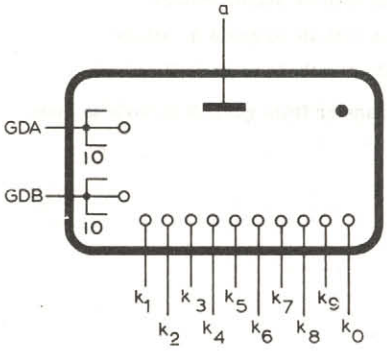
Valve holder	B8 700 67
Escutcheon	101065

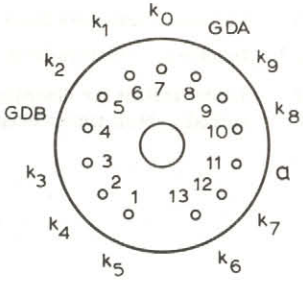
DECADE SELECTOR AND COUNTING TUBE

Z505S



The tubulation does not project beyond the pins



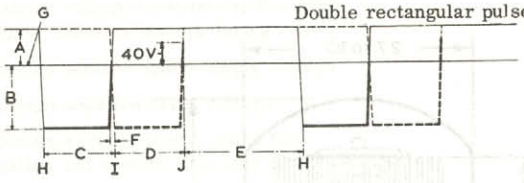


B13B Base

All dimensions in mm

k_0 is aligned with pin 7 to within ±3°

B6707



GUIDE WAVEFORMS

A Positive guide supply voltage

B Negative guide voltage

C Guide A dwell time

D Guide B dwell time

E Main cathode dwell time

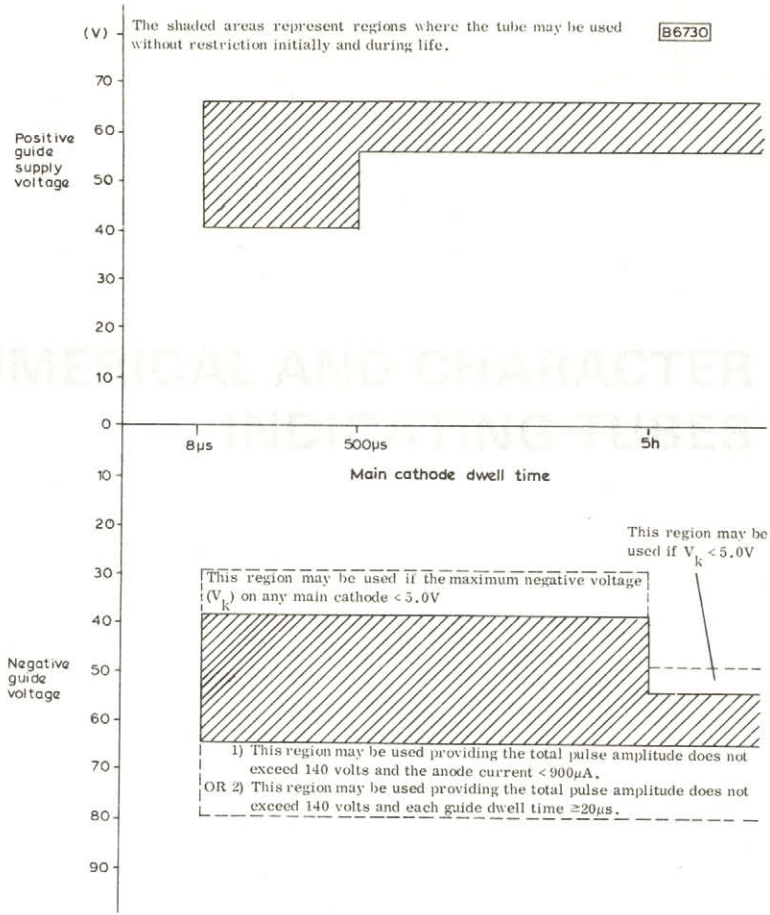
F Interval between trailing edge of guide A pulse and leading edge of guide B pulse

G Potential of most positive main cathode supply voltage

H Discharge transfers from main cathode to guide A cathode

I Discharge transfers from guide A cathode to guide B cathode

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



GUIDE OPERATING VOLTAGES

NUMERICAL INDICATOR TUBES

ZM1000 ZM1000R

QUICK REFERENCE DATA

Cold cathode, neon filled, side viewing indicator tubes with long life expectancy. The ZM1000R is coated with a red filter to improve the contrast of display. These tubes incorporate a decimal point and are fitted with a pin base to suit the standard grid (2.54mm). A primer allows ionisation without delay in strobe type or blanking applications.

Numeral height	14	mm
Minimum distance between mounting centres	19	mm
Numerals	1 2 3 4 5 6 7 8 9 0	
Decimal point	to the left of the numerals	
Cathode current, average	2.5	mA
maximum peak	12	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND OPERATING CONDITIONS (Measured at 0 to 70°C)

Minimum anode-to-cathode voltage necessary for ignition	170	V
Anode-to-cathode maintaining voltage		See page 3
Anode-to-cathode voltage below which all tubes will extinguish	118	V
Cathode current (with or without decimal point $V_{kk} > V_{kk}$ min., I_{kk} +ve see page 4)		
Minimum (see note 1)	1.5	mA
Maximum	4.5	mA
Cathode selecting voltage		See page 4
Cathode resistor, decimal point (see note 2)	100 ± 10%	kΩ
Primer resistor	10 ± 10%	MΩ

D.C. OPERATION

See pages 3, 4, 5 and 6

PULSE OPERATION

Minimum pulse duration	100	μs

Peak currents up to 12mA can be allowed provided the average current value does not exceed 2.5mA. To avoid excessive glow on "off" cathodes, the cathode selecting voltage should exceed 65V.

LIFE EXPECTANCY at anode current of 2.5mA (see note 3)

Sequentially changing the display from one numeral to another, every 1000 hours or less	100 000	h

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Minimum anode-to-cathode voltage necessary for ignition	170	V
Cathode current		
Maximum average (averaged over any 20ms)	4.5	mA
Maximum peak	12	mA
Minimum average (averaged over any conduction period)	1.5	mA
Cathode selecting voltage		See page 4
Bulb temperature		
Maximum	+70	^{o}C
Minimum (see note 3)	-50	^{o}C

MOUNTING POSITION

Any

OPERATING NOTES

1. The minimum average current (averaged over any conduction period) of 1.5mA is necessary to ensure complete cathode coverage initially and throughout life.

2. Lower values of this resistor are permitted. The anode current should be increased due to the increase of decimal point current resulting from the decrease of this resistor.

3. For bulb temperatures below $10^{o}C$ the life expectancy of the tube is substantially reduced and the characteristics are changed (see page 3). For equipment to be used over a wide temperature range, "constant current operation" (high supply voltage with a high anode series resistor) is recommended.

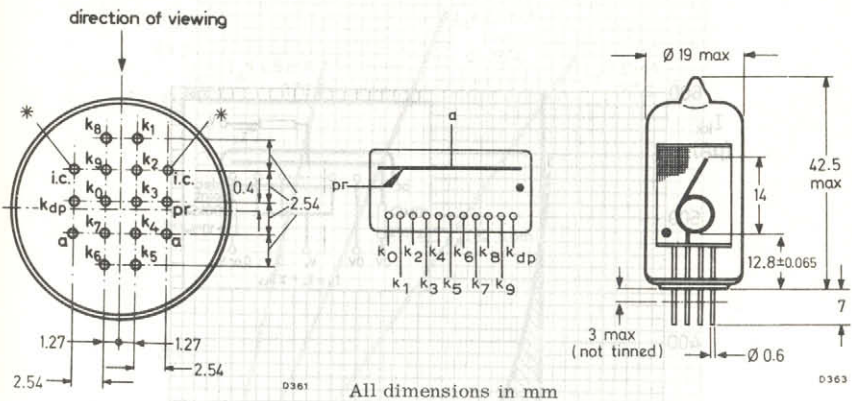
4. The pins are tinned and may be dip-soldered to a minimum of 5mm from the seals at a solder temperature of $240^{o}C$ for a maximum of 10 seconds.

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

ACCESSORIES

Printed wiring mounting board (19 × 100mm) on which the tube can be mounted. Afterwards the combination can be mounted on a vertical printed wiring board carrying the drive circuit. Can also be used with the snap-fit tube holder 55703	55701
Tube socket (for 2.54mm grid). Phenolic. Tinned contacts	55702
Snap-fit tube holder	55703
Set of one left-hand and one right-hand end piece to complete the snap-fit indicator tube assembly	55704

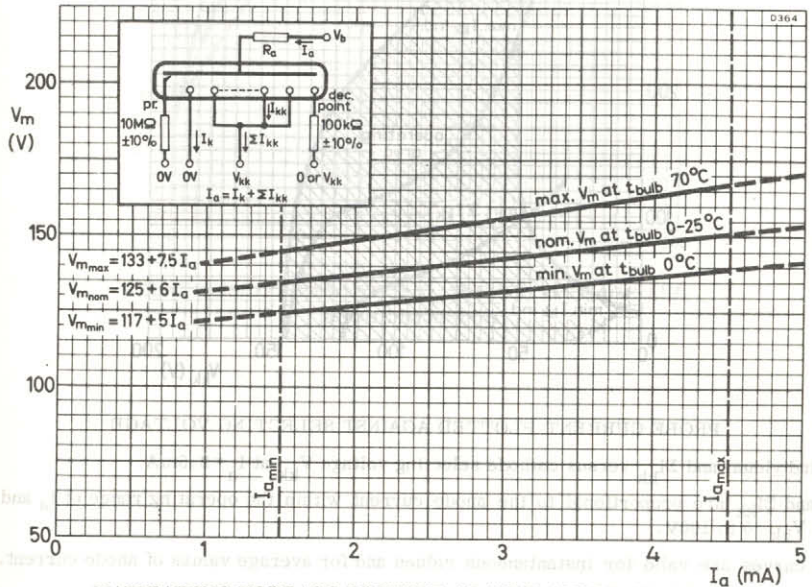
OUTLINE AND DIMENSIONS



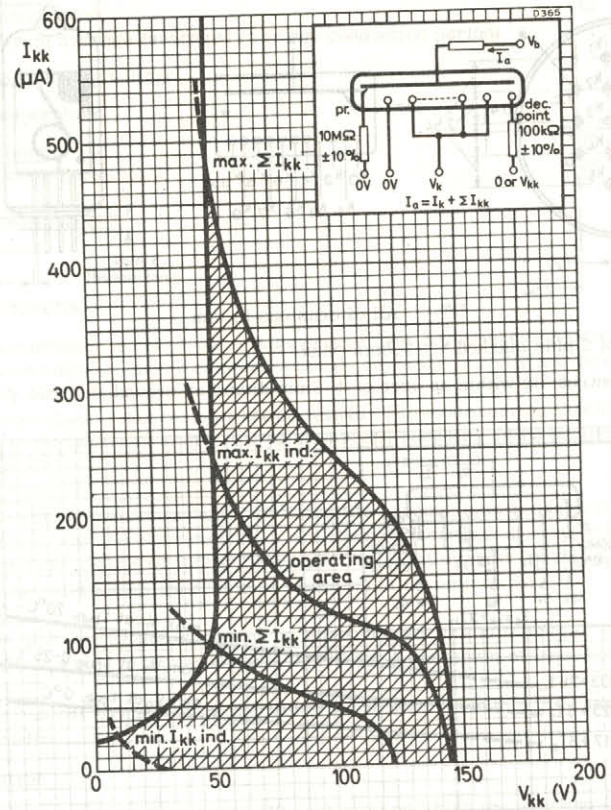
All dimensions in mm

*Length of 2 pins marked * = 2.8mm max.

All pin centres lie within an area of 0.3mm diameter around the true geometrical position.



MAINTAINING VOLTAGE PLOTTED AGAINST ANODE CURRENT



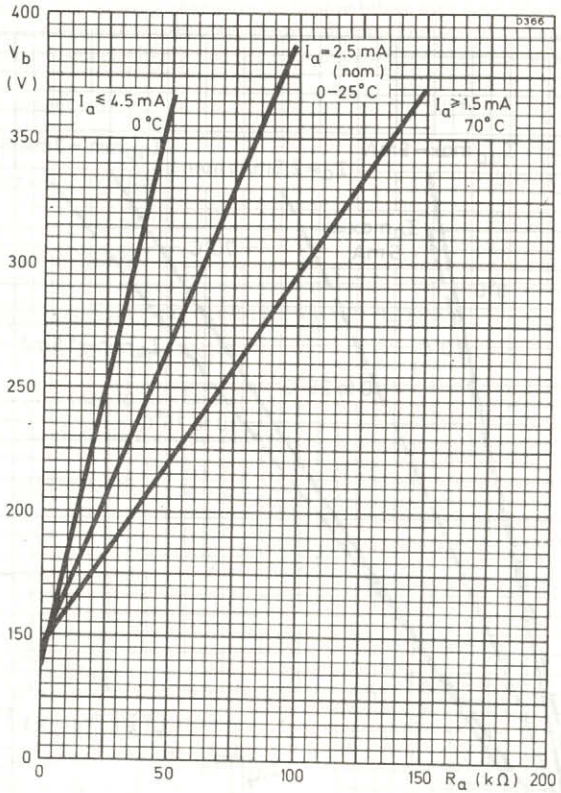
PROBE CURRENT PLOTTED AGAINST SELECTING VOLTAGE

I_{kk} individual and ΣI_{kk} versus cathode selecting voltage V_{kk} at I_a = 2.5mA.

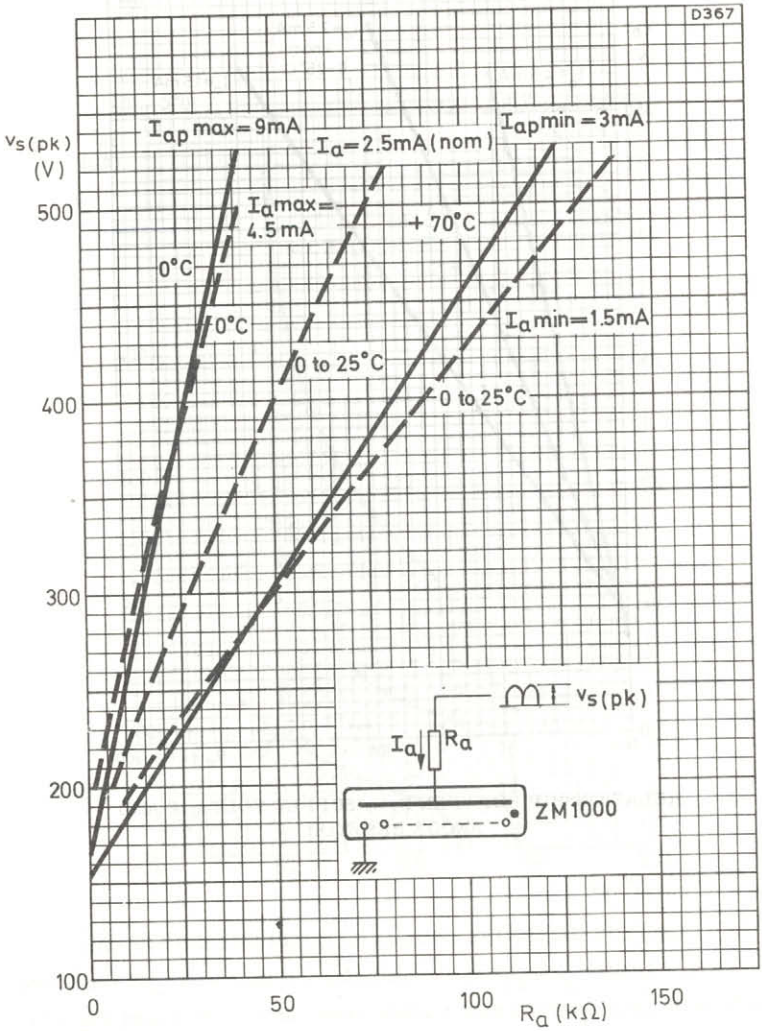
I_{kk} and ΣI_{kk} are proportional to the anode current within the operating range of I_a and with V_{kk} = 0 to 100V.

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

Reverse probe current is not permitted.



RELATIONSHIP BETWEEN D.C. SUPPLY VOLTAGE AND ANODE RESISTOR



RELATIONSHIP BETWEEN PULSE SUPPLY VOLTAGE AND ANODE RESISTOR

CHARACTER INDICATOR TUBES

ZM1001 ZM1001R

QUICK REFERENCE DATA

Cold cathode, side viewing character indicator tubes with long life expectancy to be used in conjunction with ZM1000 or ZM1000R numerical indicator tubes. The ZM1001R incorporates a red filter to improve the contrast of display.

Character height	10 to 14	mm
Characters		+, -, ∿, X, Y, Z
Cathode current, average	2.5	mA
maximum peak	12	mA
Minimum supply voltage	170	V

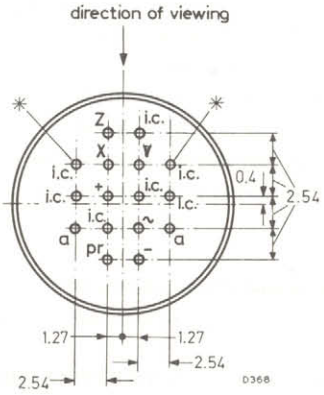
CHARACTERISTICS, OPERATING CONDITIONS AND RATINGS

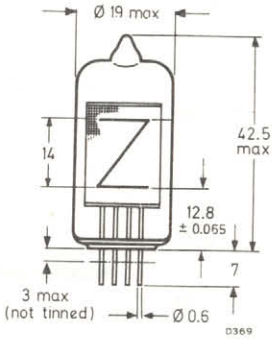
These are identical to type ZM1000

MOUNTING AND ACCESSORIES

These are the same as for type ZM1000

OUTLINE AND DIMENSIONS





All dimensions in mm

*Length of 2 pins marked * = 2.8mm max.

All pin centres lie within an area of 0.3mm diameter around the true geometrical position.

NUMERICAL INDICATOR TUBE

ZM1020
(formerly Z520M)

QUICK REFERENCE DATA

Cold cathode, neon-filled, end viewing indicator tube with long life expectancy. This tube incorporates a red filter to improve the contrast of display.

Numeral height	15.5 0.6	mm in
Numerals	0 1 2 3 4 5 6 7 8 9	
Cathode current	2.0	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN measured at room temperature.

Minimum anode-to-cathode voltage necessary for ignition (see note 1)	170	V
Anode-to-cathode maintaining voltage at 2mA (see page C1)	140 ± 10	V
Anode-to-cathode voltage below which all tubes will extinguish	120	V
D.C. operation (see page D4)		
Recommended cathode current	2.0	mA
Minimum positive bias on non-conducting cathodes (see note 2)	60	V
Half wave a.c. supply (see page D4)		
Recommended cathode current		
Average	1.5	mA
Peak	7.0	mA
Minimum positive bias on non-conducting cathodes (see note 2)	40	V

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 2)

Continuous display of one digit	> 5000	hr
Sequentially changing the display from one digit to the others, every 100 hours or less	> 30 000	hr

ABSOLUTE MAXIMUM RATINGS

Cathode current (Each digit)		
Maximum average (averaging time = 20ms)	2.5	mA
Maximum peak	10	mA
Minimum for d.c. operation	1.0	mA
Maximum negative current	0	mA
Bulb temperature		
Maximum	+ 70	°C
Minimum	- 50	°C

MOUNTING POSITION

Any

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

OPERATING NOTES

1. Bulb temperatures below 10°C result in a reduced life expectancy and changes in characteristics.
   For operation in equipment, to be used within a wide temperature range, the use of constant current operation (high supply voltage and high anode resistor) is recommended.

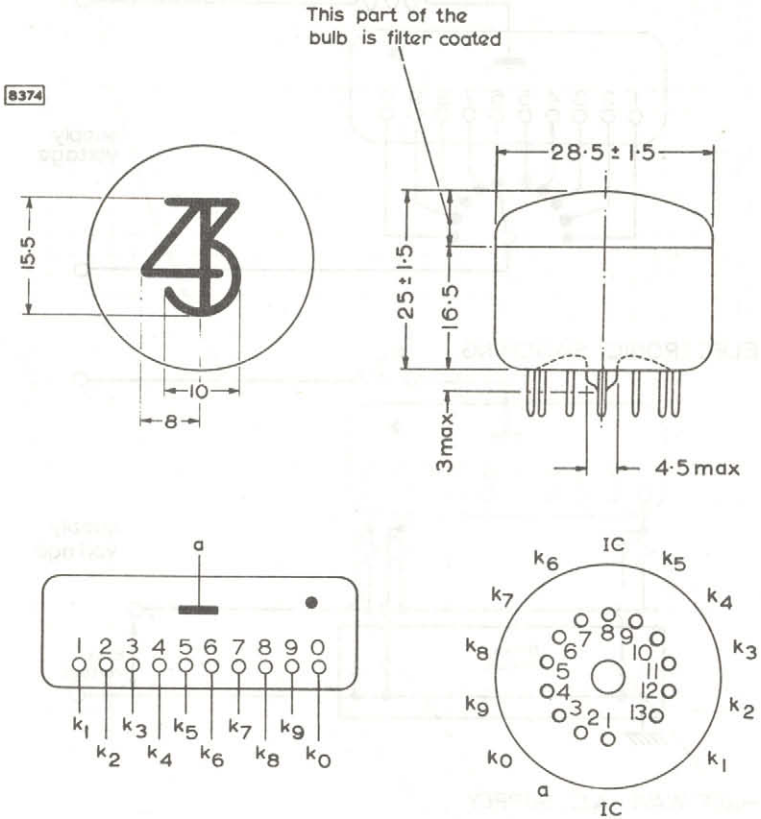
2. To obtain a good indication over life the voltage between the conducting and remaining cathodes should be greater than the values specified. These conditions are automatically satisfied when the non-conducting cathodes are isolated by, for example, mechanical contacts. It should be noted that when using curves on pages C2 and C3 that the probe current is not shared equally between non-illuminated cathodes.

ACCESSORY

Valve holder	B8 700 67

NUMERICAL INDICATOR TUBE

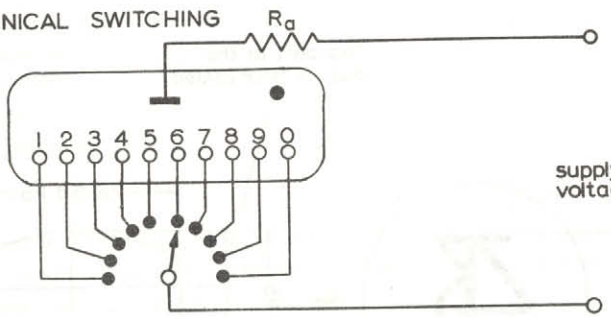
ZM1020
(formerly Z520M)



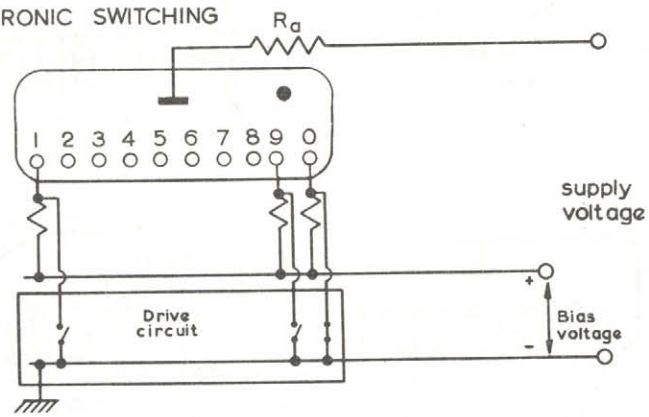
All dimensions in mm B13B Base

B2632

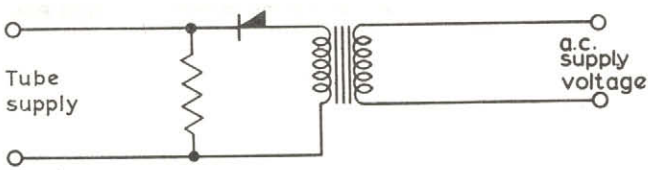
MECHANICAL SWITCHING



ELECTRONIC SWITCHING

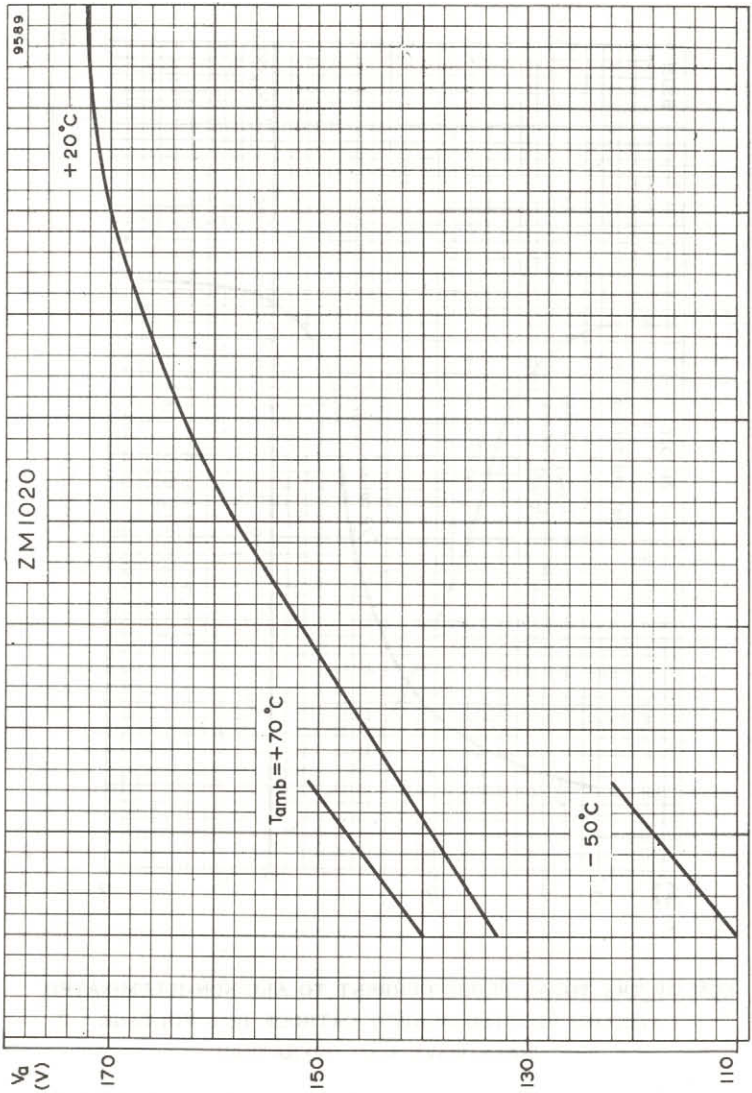


HALF WAVE A.C. SUPPLY

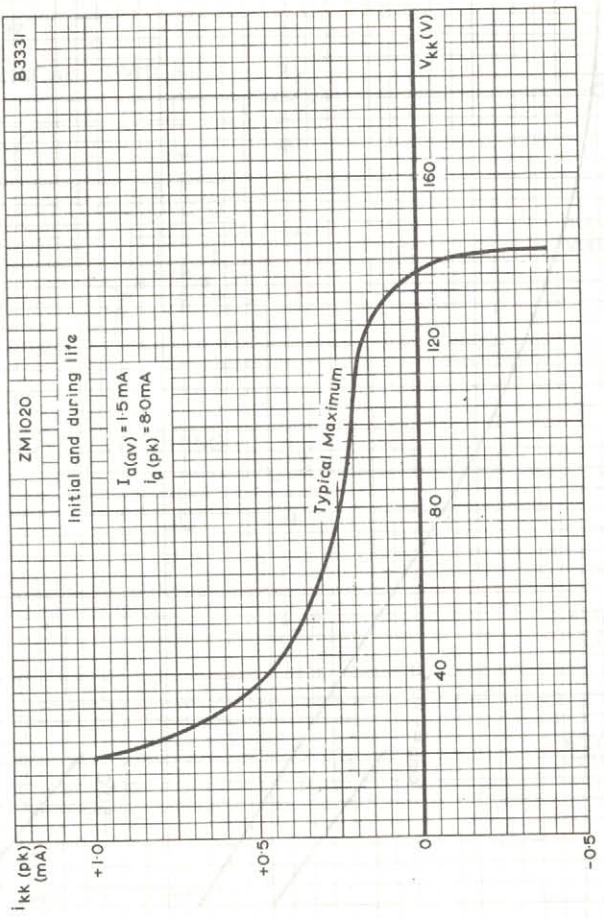


NUMERICAL INDICATOR TUBE

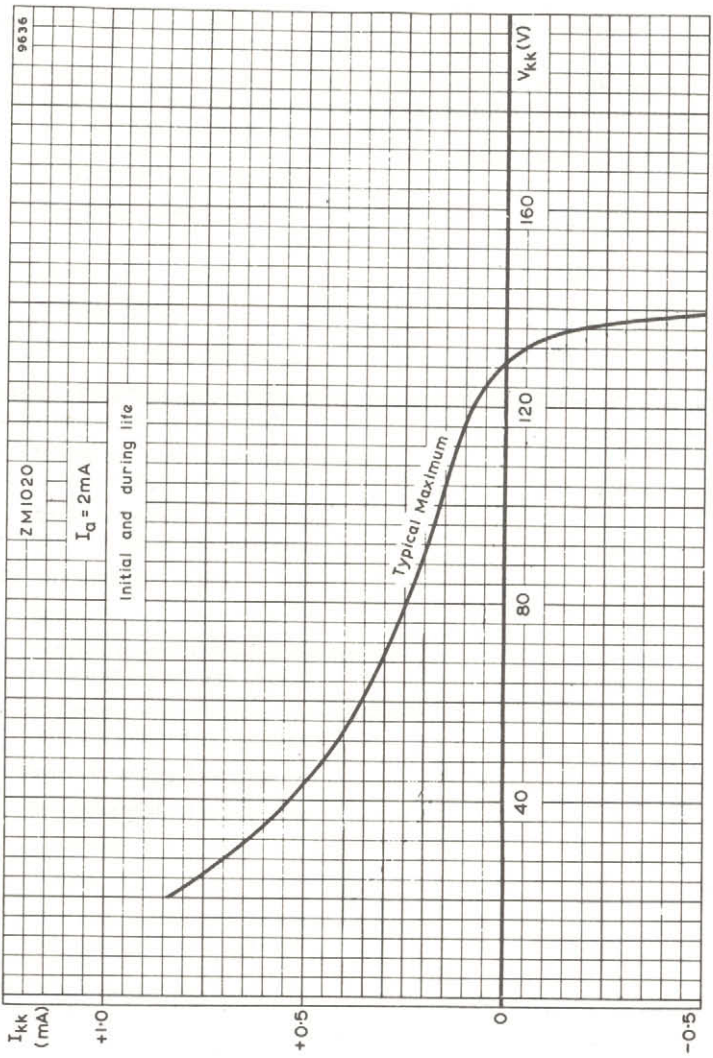
ZM1020
(formerly Z520M)



NOMINAL ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST ANODE CURRENT WITH AMBIENT TEMPERATURE AS PARAMETER



SUM OF THE TOTAL PROBE CURRENT TO ALL NON-ILLUMINATED CATHODES PLOTTED AGAINST CATHODE BIAS VOLTAGE (HALF-WAVE A.C. OPERATION)



SUM OF THE TOTAL PROBE CURRENT TO ALL NON-ILLUMINATED CATHODES PLOTTED AGAINST CATHODE BIAS VOLTAGE (D.C. OPERATION)

CHARACTER INDICATOR TUBES

ZM1021 ZM1023

QUICK REFERENCE DATA

Cold cathode, neon-filled, end viewing indicator tube with long life expectancy. The ZM1021 incorporates a red filter to improve visual contrast, and will form a compatible display with the ZM1020 numerical indicator tube. The ZM1023 is electrically identical with the ZM1021 but has no filter coating.

Character height	15.5	mm
	0.6	in
Characters	V A Ω ∿ + - %	
Cathode current	2.0	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND OPERATING CONDITIONS (measured at room temperature unless otherwise stated)

Minimum anode-to-cathode voltage necessary for ignition	170	V
Anode-to-cathode voltage below which all tubes will extinguish	120	V
D.C. operation (see page 4)		
Recommended cathode current	2.0	mA
Nominal anode-to-cathode maintaining voltage at 2.0mA (see page 5)	140	V
Minimum positive bias on non-conducting cathodes (see note 1 and page 6)	60	V
Half wave a.c. supply (see page 4)		
Recommended cathode current		
Average	1.5	mA
Peak	7.0	mA
Minimum positive bias on non-conducting cathodes (see note 1 and page 7)	40	V

LIFE EXPECTANCY (at recommended operating conditions and room temperature (see notes 1 and 2)

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each character)

Maximum average (averaging time = 20ms)	2.5	mA
Maximum peak	10	mA
Minimum for d.c. operation	1.0	mA
Maximum negative current	0	mA

Bulb temperature

Maximum	+70	^{o}C
Minimum (see note 2)	-50	^{o}C

MOUNTING POSITION

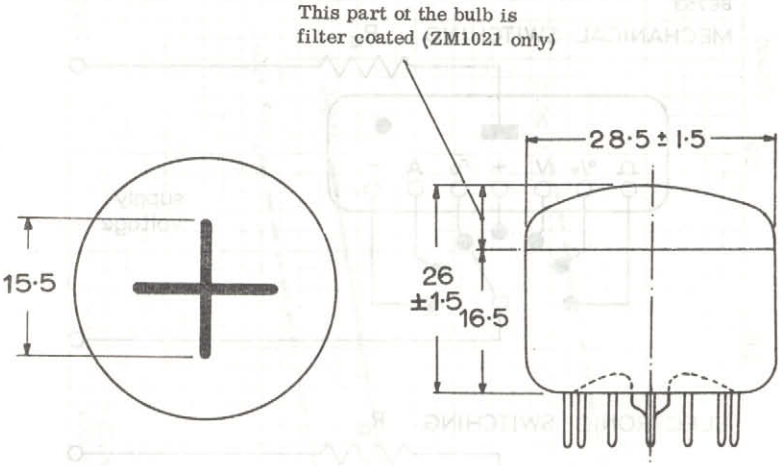
Any. The characters are viewed through the dome of the envelope. The characters will appear upright (within $\pm 1.5^{o}$) when the tube is mounted with the line through pins 1 and 8 vertical, pin 8 uppermost.

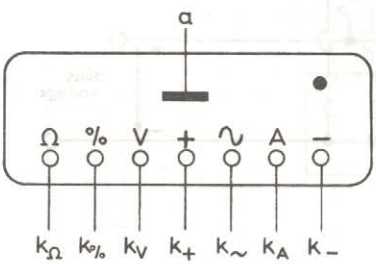
OPERATING NOTES

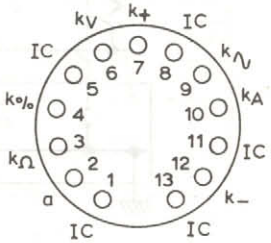
1. To obtain a good indication over life, the voltage between the conducting and remaining cathodes should be greater than the values specified. These conditions are automatically satisfied when the non-conducting cathodes are isolated by, for example, mechanical contacts. It should be noted when using the curves on pages 6 and 7 that the probe current is not shared equally between non illuminated cathodes.
2. Bulb temperatures below $10^{o}C$ result in a reduced life expectancy and changes in characteristics.
   For operation in equipment to be used within a wide temperature range, the use of constant current operation (high supply voltage and high anode resistor) is recommended.

ACCESSORY

Valve holder B8 700 67







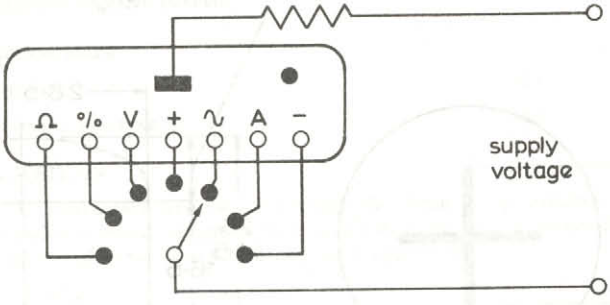
B13B Base

All dimensions in mm

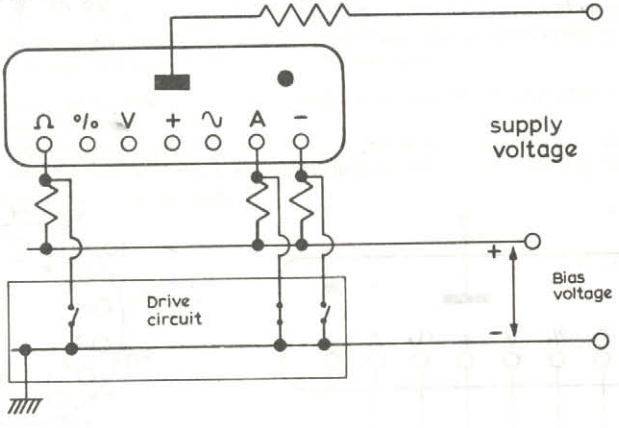
APPLICATION CIRCUITS

B6753

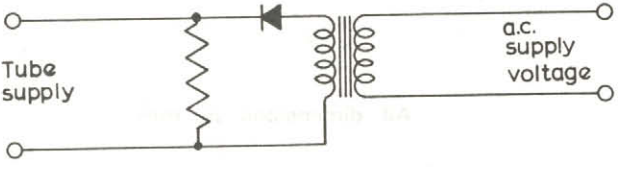
MECHANICAL SWITCHING

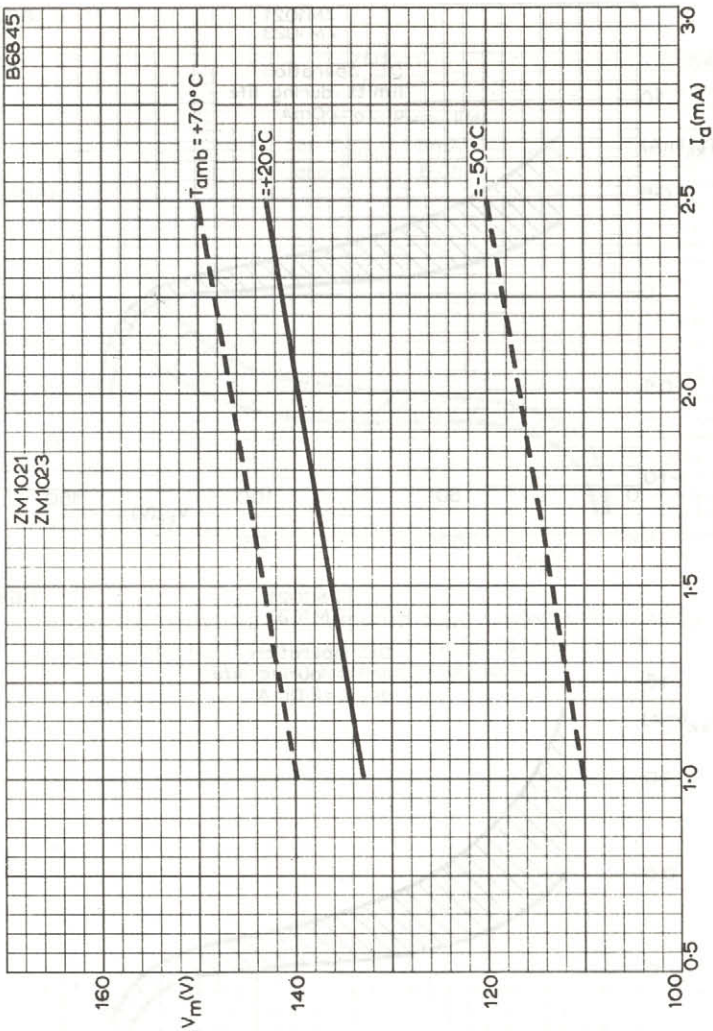


ELECTRONIC SWITCHING

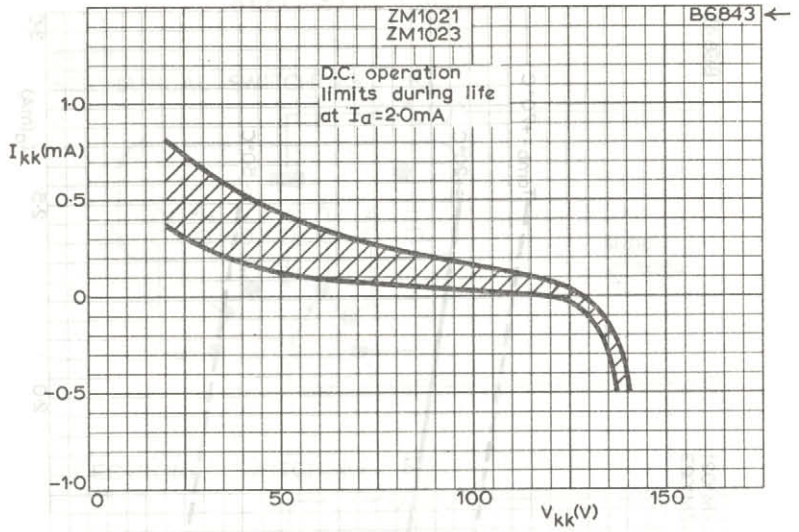


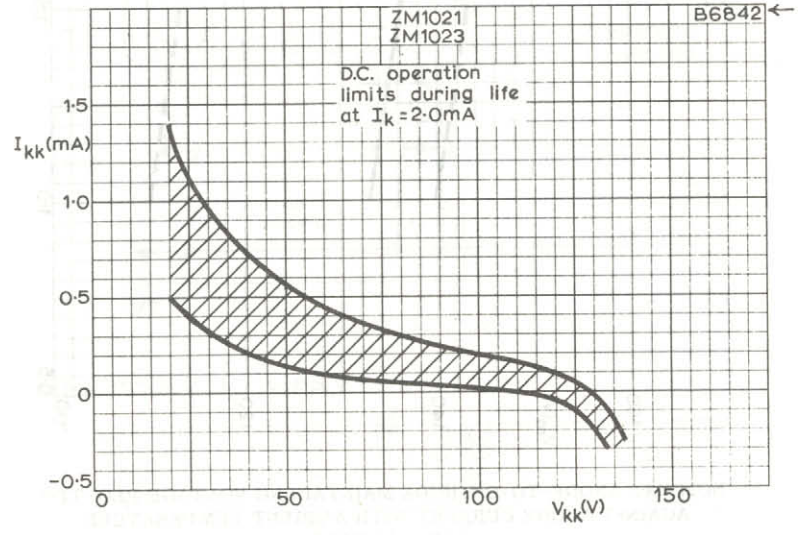
HALF WAVE A.C. SUPPLY



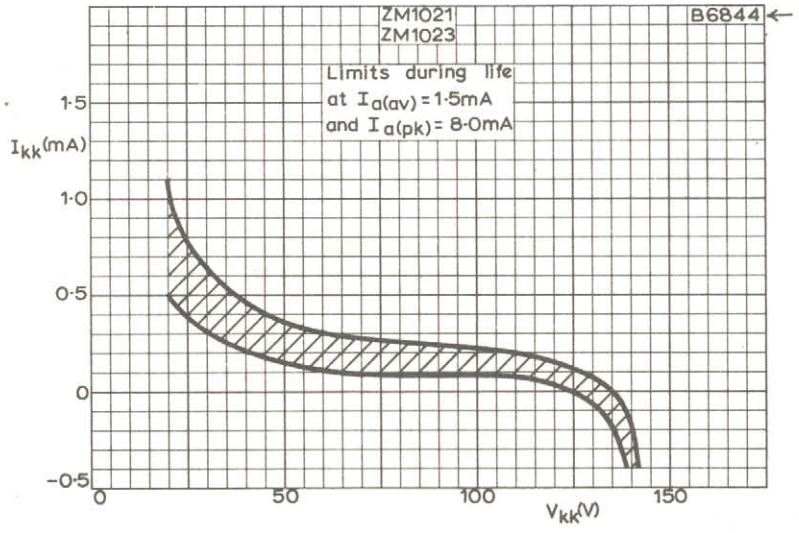


NOMINAL ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST ANODE CURRENT WITH AMBIENT TEMPERATURE AS PARAMETER





SUM OF THE TOTAL PROBE CURRENT TO ALL NON-ILLUMINATED CATHODES PLOTTED AGAINST CATHODE BIAS VOLTAGE (D.C. OPERATION)



SUM OF THE TOTAL PROBE CURRENT TO ALL NON-ILLUMINATED CATHODES PLOTTED AGAINST CATHODE BIAS VOLTAGE (HALF-WAVE A.C. OPERATION)

NUMERICAL INDICATOR TUBES

ZM1040 ZM1042

QUICK REFERENCE DATA

Cold cathode, neon-filled, side viewing indicator tubes with long life expectancy. The ZM1040 incorporates a red filter to improve the contrast of display. The ZM1042 is electrically identical to the ZM1040, but has no filter coating.

Numeral height	31	mm
	1.2	in
Numerals	0 1 2 3 4 5 6 7 8 9	
Cathode current	4.5	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN measured at room temperature.

Minimum anode-to-cathode voltage necessary for ignition (see note 1)	170	V
Anode-to-cathode maintaining voltage at 4.5mA (see page C1)	140 ± 10	V
Anode-to-cathode voltage below which all tubes will extinguish	120	V
D.C. operation		
Recommended cathode current	4.5	mA
Minimum positive bias on non-conducting cathodes (see note 2 and page C2)	60	V
Half-wave a.c. supply		
Recommended cathode current		
Average	2.5	mA
Peak	11	mA
Minimum positive bias on non-conducting cathodes (see note 2)	40	V

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 2)

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each digit)

Maximum average (averaging time = 20ms)	6.0	mA
Maximum peak	20	mA
Minimum for d.c. operation	3.0	mA
Maximum negative current	0	mA

Bulb temperature

Maximum	+70	^{o}C
Minimum (see note 1)	0	^{o}C

MOUNTING POSITION

Any

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

OPERATING NOTES

1. Bulb temperatures below $10^{o}C$ result in a reduced life expectancy and changes in characteristics.

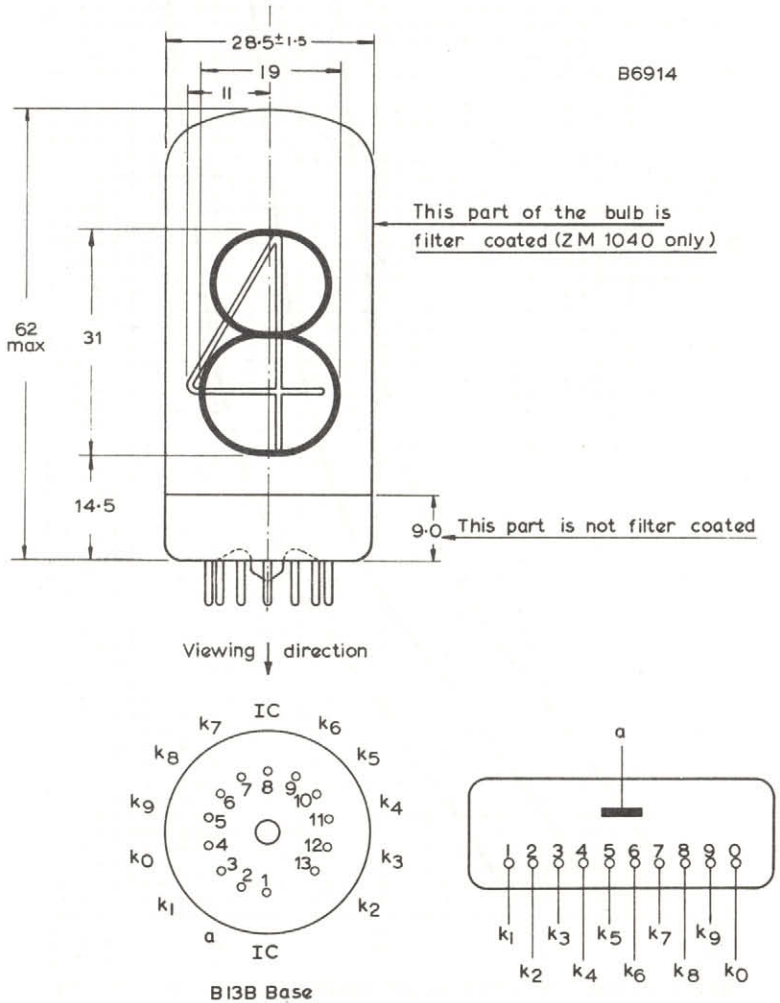
   For operation in equipment to be used within a wide temperature range, the use of constant current operation (high supply voltage and high anode resistor) is recommended.

2. To obtain a good indication over life, the voltage between the conducting and remaining cathodes should be greater than the value specified. These conditions are automatically satisfied when the non-conducting cathodes are isolated by, for example, mechanical contacts. It should be noted that when using the curve on page C2, the probe current is not shared equally between the non-illuminated cathodes.

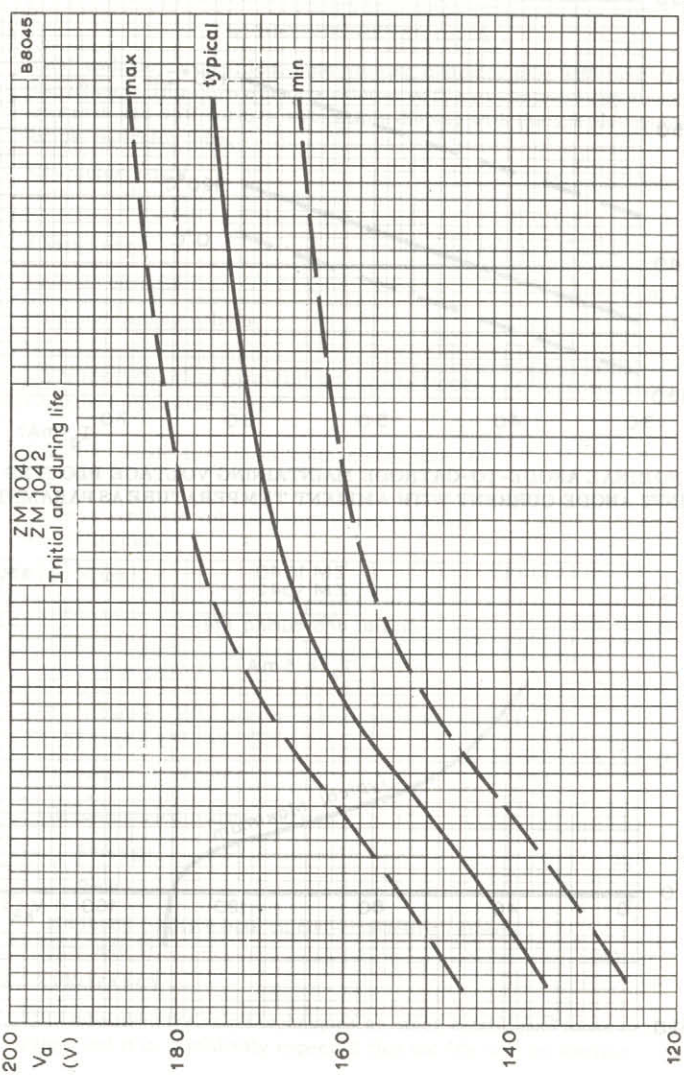
ACCESSORY

Valve holder	B8 702 28

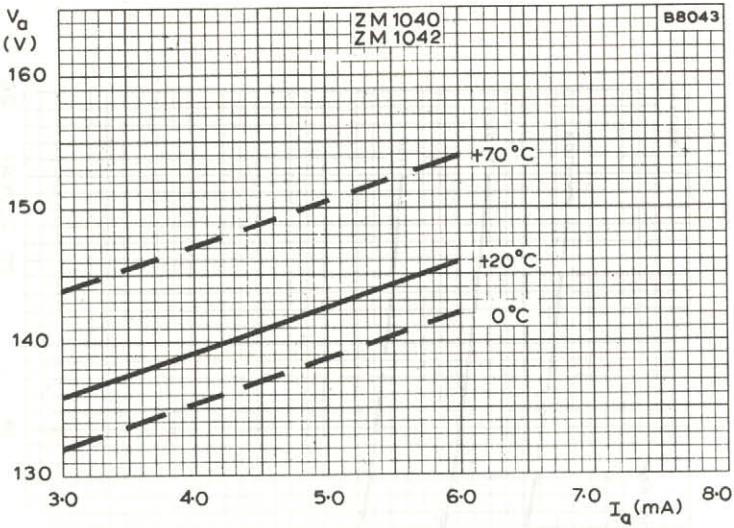
OUTLINE DRAWING



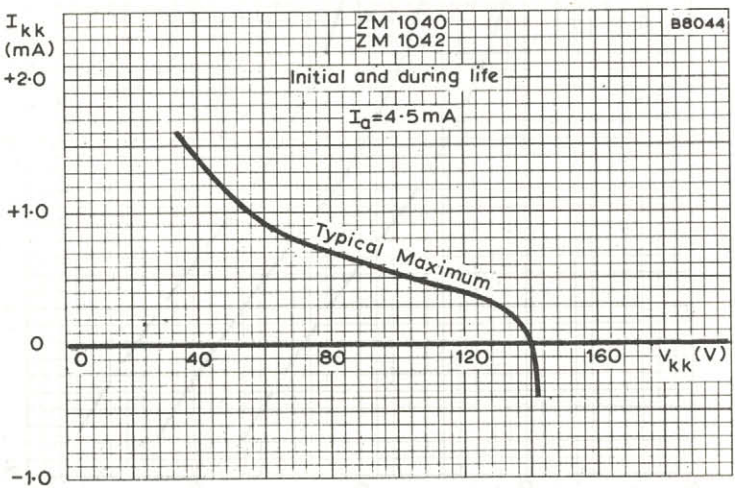
All dimensions in mm



NOMINAL ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST CATHODE CURRENT, WITH TYPICAL LIMITS



NOMINAL ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST ANODE CURRENT WITH AMBIENT TEMPERATURE AS PARAMETER



SUM OF THE TOTAL PROBE CURRENT TO ALL NON-ILLUMINATED CATHODES PLOTTED AGAINST CATHODE BIAS VOLTAGE (D.C. OPERATION)

CHARACTER INDICATOR TUBE

ZM1041

TENTATIVE DATA

QUICK REFERENCE DATA

Cold cathode, neon-filled, side viewing indicator tube with long life expectancy. This device incorporates a red filter to improve the visual contrast and will form a compatible display with the ZM1040 numerical indicator tube.

Character height	20		mm
	0.8		in
Characters	+	−	
Cathode current	4.5		mA
Minimum supply voltage	170		V

CHARACTERISTICS AND OPERATING CONDITIONS (measured at room temperature unless otherwise stated)

Minimum anode-to-cathode voltage necessary for ignition	170	V
Anode-to-cathode voltage below which all tubes will extinguish	120	V
D.C. operation		
Recommended cathode current	4.5	mA
Nominal anode-to-cathode maintaining voltage at 4.5mA (see page C1)	140	V
Minimum positive bias on non-conducting cathode (see note 1 and page C2)	60	V
Half-wave a.c. supply		
Recommended cathode current		
Average	2.0	mA
Peak	8.0	mA
Minimum positive bias on non-conducting cathode (see note 1)	40	V

LIFE EXPECTANCY

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each character)		
Maximum average (averaging time = 20ms)	6.0	mA
Maximum peak	20	mA
Minimum average during conduction	3.0	mA
Bulb temperature		
Maximum	+70	°C
Minimum (see note 2)	-50	°C

MOUNTING POSITION — Any

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

ACCESSORIES

Valve holder — B8 702 28

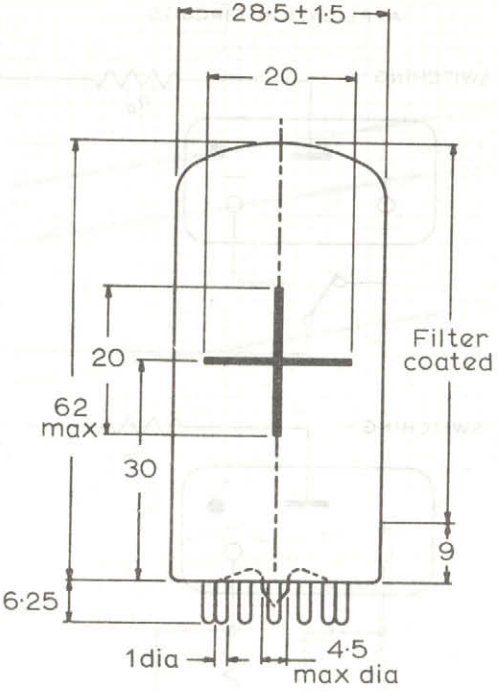
OPERATING NOTES

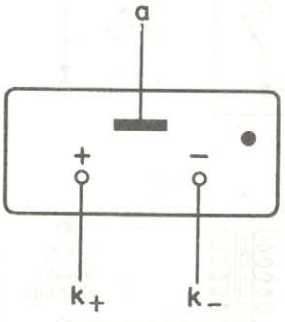
1. To obtain a good indication over life the voltage between the conducting and remaining cathode should be greater than the values specified. These conditions are automatically satisfied when the non-conducting cathode is isolated by, for example, mechanical contacts.

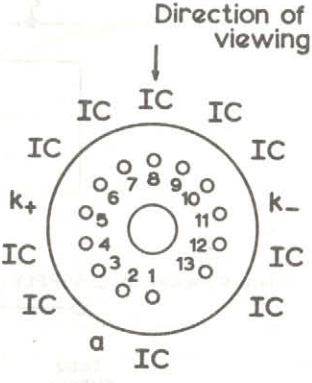
2. Bulb temperatures below 10°C result in a reduced life expectancy and changes in characteristics.
   For operation in equipment to be used within a wide temperature range, the use of constant current operation (high supply voltage and high anode resistor) is recommended.

CHARACTER INDICATOR TUBE

ZM1041







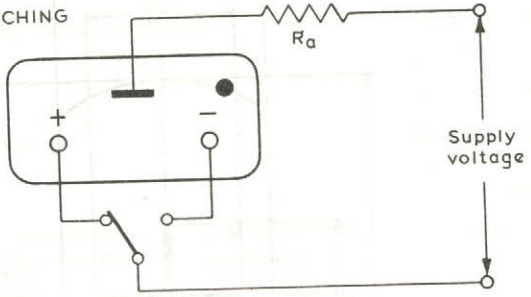
B13B Base

B4815

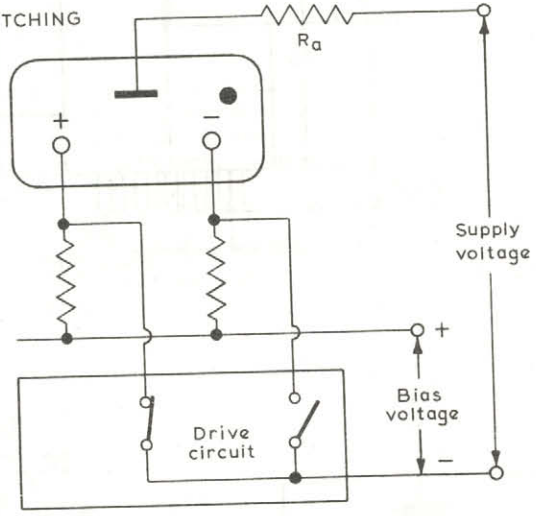
All dimensions in mm

APPLICATION CIRCUITS

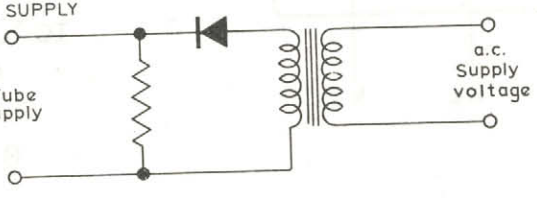
MECHANICAL SWITCHING



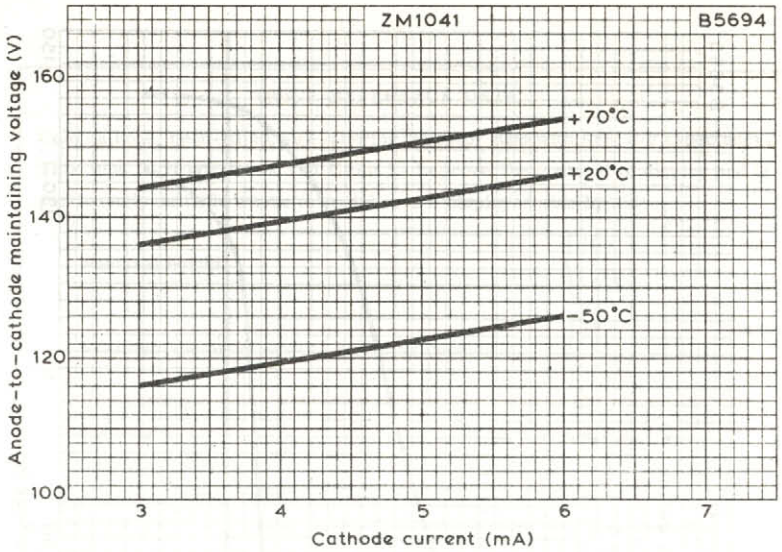
ELECTRONIC SWITCHING



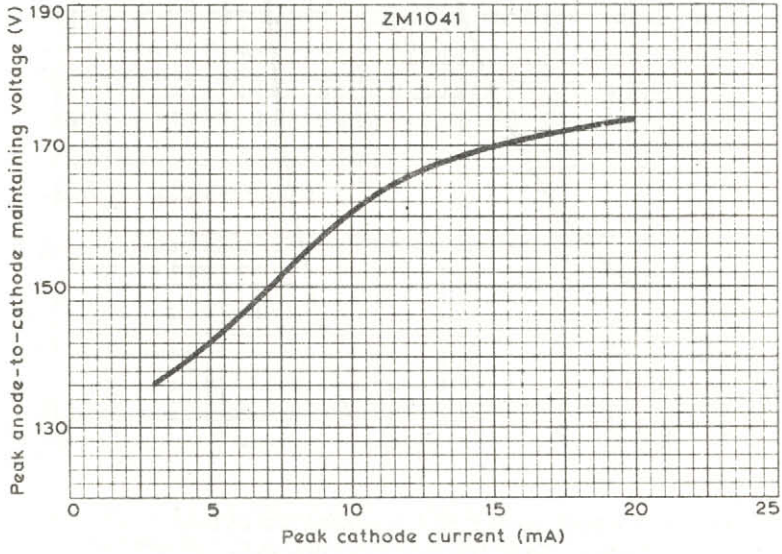
HALF-WAVE A.C. SUPPLY



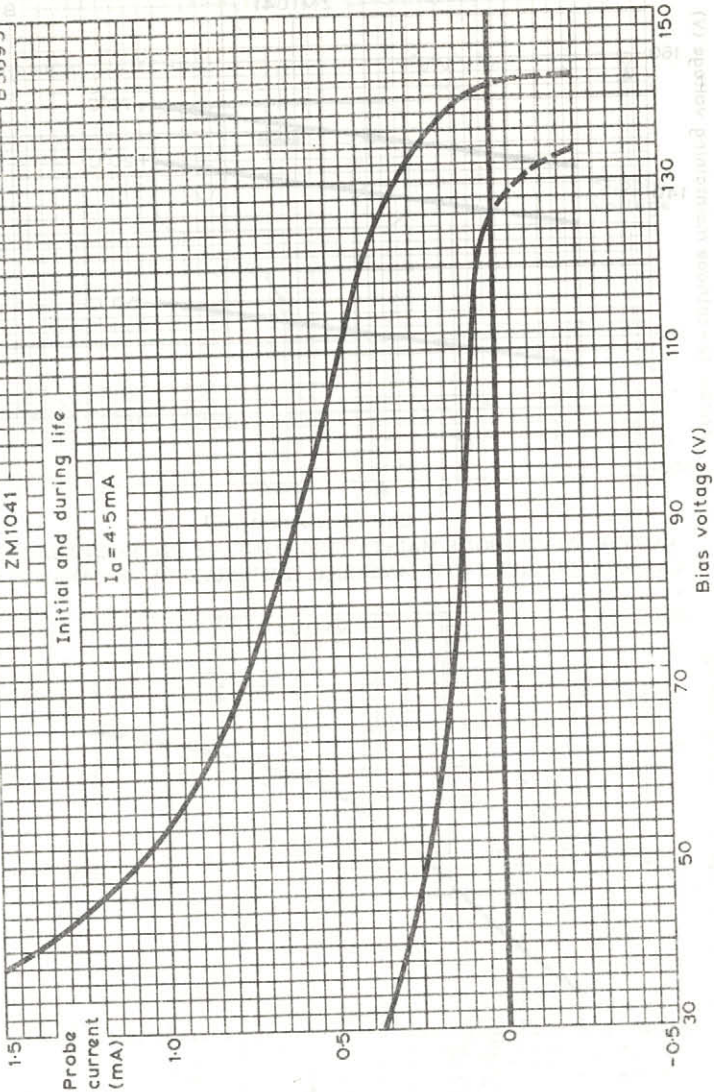
B5698



ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST CATHODE CURRENT WITH AMBIENT TEMPERATURE AS PARAMETER



PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST PEAK CATHODE CURRENT



PROBE CURRENT TO THE NON-ILLUMINATED CATHODE PLOTTED AGAINST CATHODE BIAS VOLTAGE (D.C. OPERATION)

NUMERICAL INDICATOR TUBE

ZM1080

QUICK REFERENCE DATA

Cold cathode, neon-filled, side-viewing indicator tube with long life expectancy. This tube incorporates a red filter to improve the contrast of display and is particularly suitable where many tubes are displayed side by side.

Numeral height	13	mm
	0.5	in
Minimum distance between mounting centres	19	mm
	0.75	in
Viewing angle	120	deg
Numerals	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	
Cathode current	2	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN (measured at 20 to 50 °C unless otherwise stated)

The values given state the range over which the tube will operate both initially and during life. No allowance has been made for supply voltage and component variations.

IGNITION REQUIREMENTS

Minimum anode to cathode voltage	170	V
Ignition delay time	see page C1	

CONDUCTION REQUIREMENTS

D.C. Operation

Maximum cathode current (see note 1)	3.5	mA
Minimum cathode current	1.5	mA
Nominal anode to cathode maintaining voltage at 2.0mA (see page C4)	140	V
Probe current to individual non-conducting cathodes (I_{kk})	see pages C2 and C3	

Pulse Operation		
Maximum cathode current, peak	12	mA
Maximum cathode current, average (Averaging time = 20ms)	2.5	mA
Minimum cathode current for satisfactory display, average	0.8	mA
Pulse duration		
Maximum	20	ms
Minimum	100	µs
Anode to cathode maintaining voltage	see page C4	
Probe current to individual non-conducting cathodes	see pages C2 and C3	

EXTINCTION REQUIREMENTS

Maximum anode to cathode voltage to ensure extinction	115	V

LIFE EXPECTANCY at recommended operating conditions and room temperature

Continuous display of one digit (see note 1)	>5000	h
Sequentially changing the display from one digit to the next every 100 hours or less	>30 000	h

LIMITING VALUES (ABSOLUTE)

Cathode current (each digit)		
Maximum average (Maximum averaging time = 20ms)	3.5	mA
Maximum peak	12	mA
Minimum average during conduction	1.5	mA
Bulb temperature		
Maximum	+70	°C
Minimum (see note 2)	-50	°C
MOUNTING POSITION	Any	

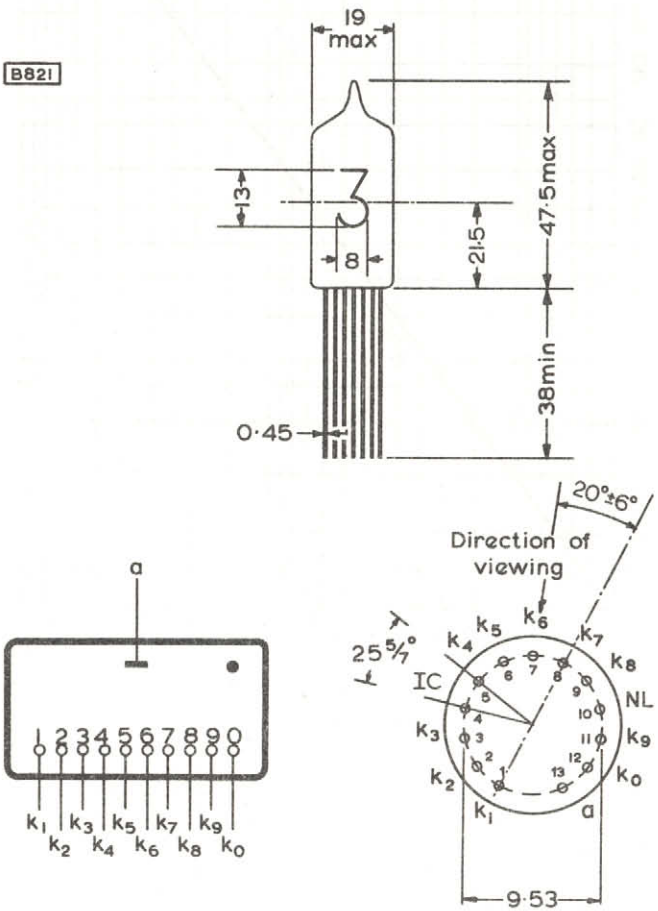
The numbers are viewed through the side of the envelope. The numbers will appear upright (within ±3°) when the tube is mounted vertically.

OPERATING NOTES

1. The life expectancy figures given above relate to operation with d.c. cathode currents between 1.5 to 2.5mA and at all permitted pulsed cathode currents. When a d.c. cathode current range of 1.5 to 3.5mA is used, the life expectancy exceeds 3000 hours with continuous display of one digit.
2. For bulb temperatures below 0 °C the life expectancy of the tube is substantially reduced.

3. The leads are tinned and may be dip-soldered to a minimum of 5mm from the seals at a solder temperature of 240°C for a maximum of 10 seconds.
4. Care should be taken not to bend the leads nearer than 1.5mm from the seals.
5. 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.

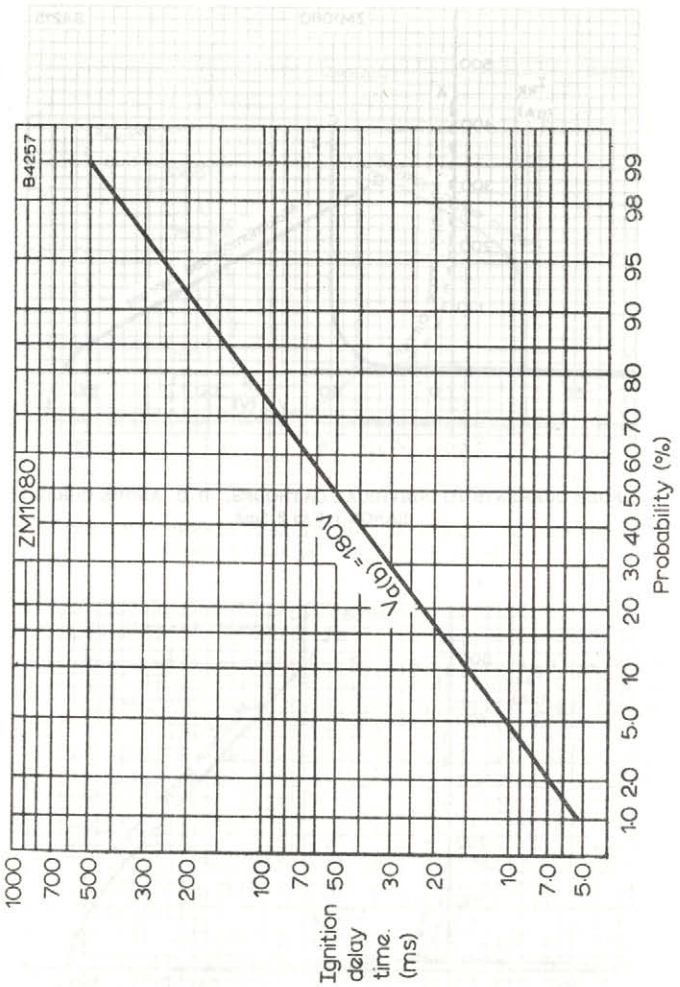
B821



All dimensions in mm

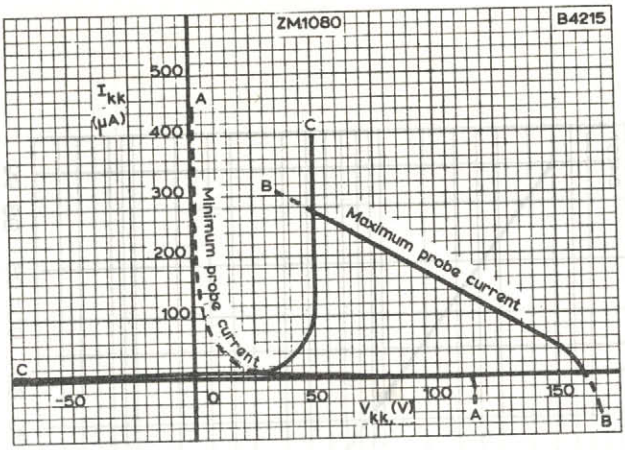
NUMERICAL INDICATOR TUBE

ZM1080

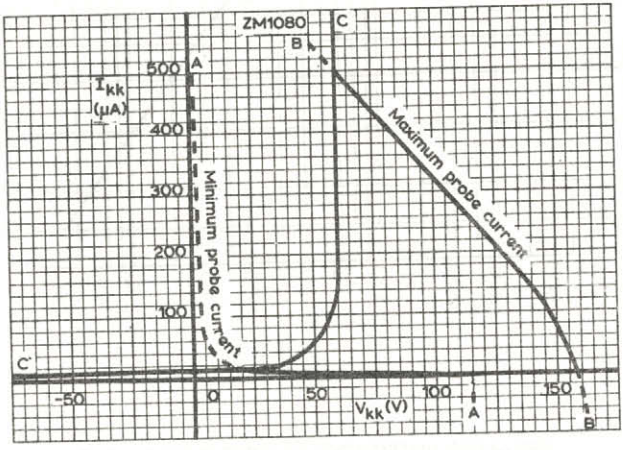


CUMULATIVE DISTRIBUTION OF IGNITION DELAY TIME

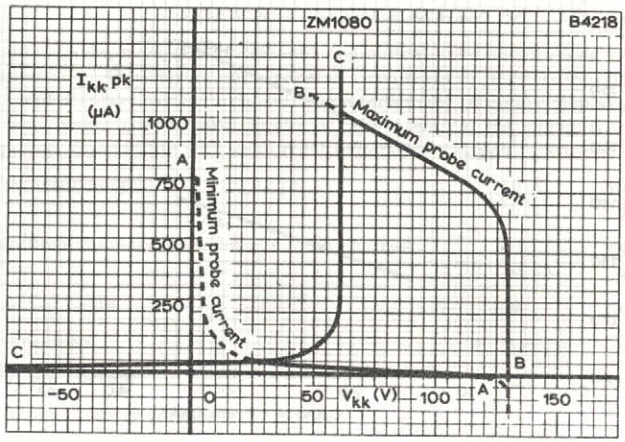
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few seconds. The ignition delay time will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage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



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



PEAK PROBE CURRENTS TO INDIVIDUAL CATHODES. PULSED ANODE CURRENT 10mA pk. 10% DUTY FACTOR

NOTE

PROBE CURRENT CURVES

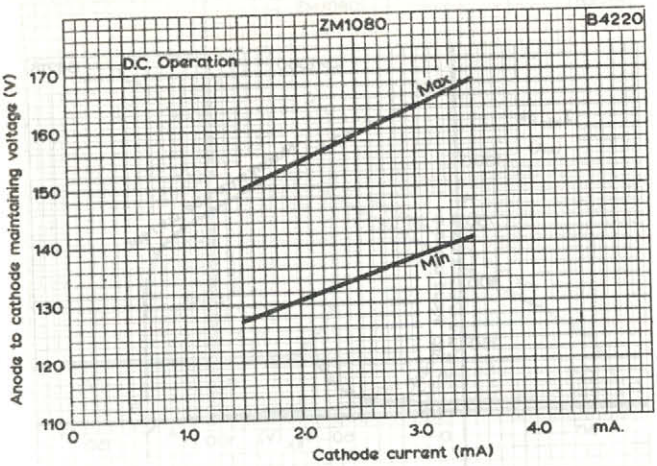
The boundaries A-A and B-B of the graphs represent, for the shown anode current ranges, the range of probe currents to individual non-conducting cathodes plotted against the voltage difference between the non-conducting cathodes and the conducting cathode.

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

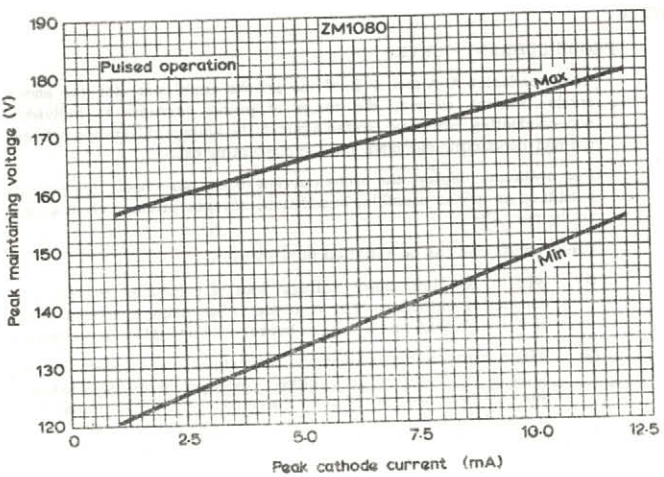
These conditions can be satisfied in two ways:-

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

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



ANODE TO CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST CATHODE CURRENT



PEAK MAINTAINING VOLTAGE PLOTTED AGAINST PEAK CATHODE CURRENT

NUMERICAL INDICATOR TUBE

ZM1082

This tube is identical to type ZM1080
but has no red contrast filter

CHARACTER INDICATOR TUBES

ZM1081 ZM1083

QUICK REFERENCE DATA

Cold cathode, neon-filled, side-viewing indicator tubes with long life expectancy. The ZM1081 incorporates a red filter to improve the contrast of display; particularly suitable where many tubes are displayed side by side. The ZM1083 is electrically identical but has no filter coating. Compatible with numerical indicators ZM1080, ZM1082.

Character height	10.5	mm
	0.4	in
Minimum distance between mounting centres	19	mm
	0.75	in
Viewing angle	120	deg
Characters	− + ∿	
Cathode current	2.0	mA
Minimum supply voltage	170	V

CHARACTERISTICS AND RANGE VALUES FOR EQUIPMENT DESIGN

(Measured at 20 to 50°C unless otherwise stated)

The values given state the range over which the tube will operate both initially and during life. No allowance has been made for supply voltage and component variations.

Minimum anode-to-cathode voltage necessary for ignition	170	V
Nominal anode-to-cathode maintaining voltage at 2.0mA (see page 3)	140	V
Anode-to-cathode voltage below which all tubes will extinguish	115	V

D.C. operation

Maximum cathode current	3.5	mA
Minimum cathode current	1.5	mA
Probe current to individual non-conducting cathodes (I_{kk})	See page 4	

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 1)

Continuous display of one character	>5000	h
Sequentially changing the display from one character to the others, every 100 hours or less	>15 000	h

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each character)

Maximum average (max. averaging time = 20ms)	3.5	mA
Maximum peak	12	mA
Minimum average during conduction	1.5	mA

Bulb temperature

Maximum	+70	^{o}C
Minimum (see note 2)	-50	^{o}C

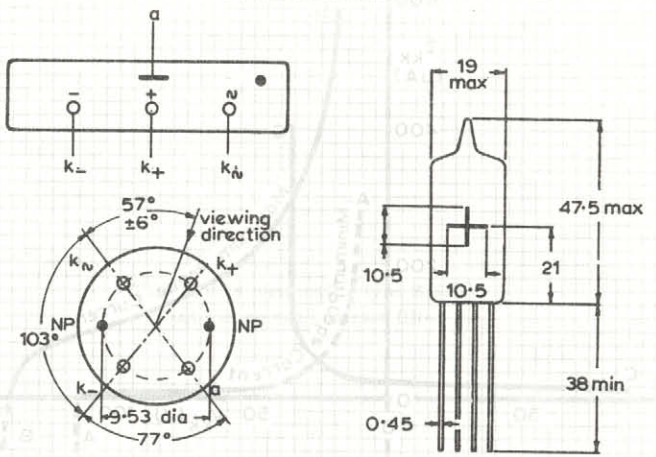
MOUNTING POSITION

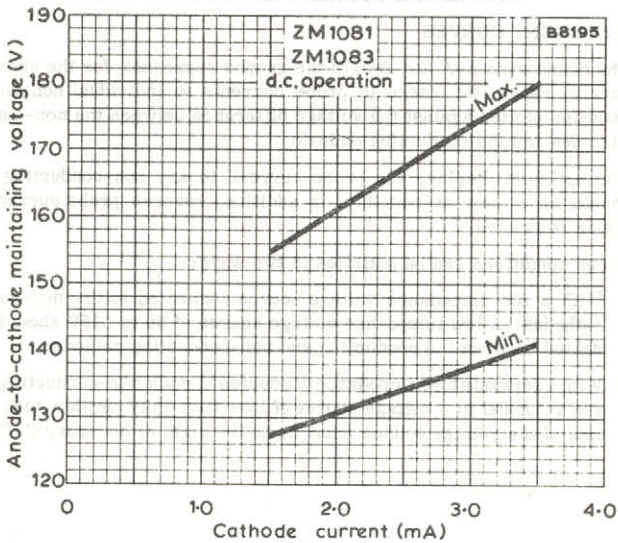
Any. The characters are viewed through the side of the envelope. The characters will appear upright (within $\pm 3^{o}$) when the tube is mounted vertically.

OPERATING NOTES

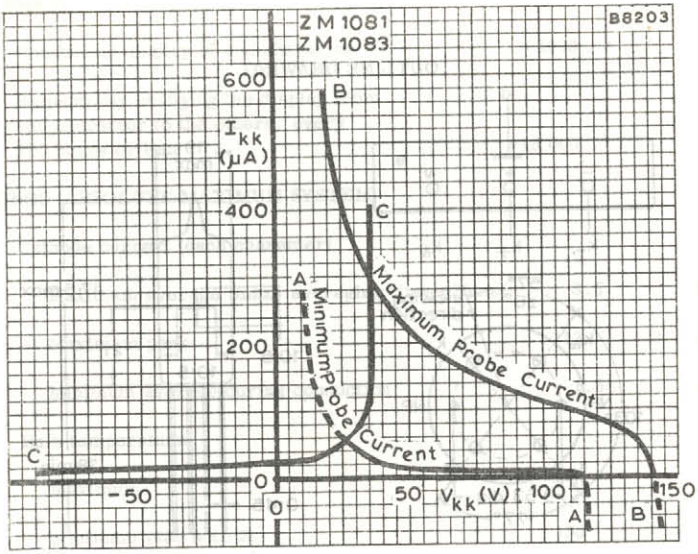
1. The life expectancy figures given above relate to operation with d.c. cathode currents between 1.5 and 2.5mA.
2. For bulb temperatures below $0^{o}C$ the life expectancy of the tube is substantially reduced.
3. The leads are tinned and may be dip-soldered to a minimum of 5mm from the seals at a solder temperature of $240^{o}C$ for a maximum of 10 seconds.
4. Care should be taken not to bend the leads nearer than 1.5mm from the seals.
5. 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.

OUTLINE DRAWING





ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST CATHODE CURRENT



PROBE CURRENTS TO INDIVIDUAL CATHODES
D.C. ANODE CURRENT RANGE 1.5 to 3.5mA

PROBE CURRENT CURVES

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

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

These conditions can be satisfied in two ways:-

1. With a low impedance voltage source connected to the non-conducting cathodes. A low impedance voltage source of 36 to 115V should be connected between the conducting and non-conducting cathodes.
2. With a separate high impedance connected to each non-conducting cathode and returned to a voltage source of less than 115V. In this case the load line of the voltage source must lie to the right of boundary C-C.

NUMERICAL INDICATOR TUBE

ZM1162

TENTATIVE DATA

QUICK REFERENCE DATA

Cold cathode, neon-argon filled rectangular end viewing numerical indicator tube with long life expectancy. The rectangular envelope allows for close tube-to-tube spacing, both in the horizontal and vertical axes.

Numeral height	15.5 0.6	mm in
Minimum distance between mounting centres	20 0.79	mm in
Viewing angle	90	deg
Numerals	1 2 3 4 5 6 7 8 9 0	
Cathode current	2.5	mA
Minimum supply voltage	170	V

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

Minimum anode-to-cathode voltage necessary for ignition	170	V
Ignition delay time		See page 3
Anode-to-cathode maintaining voltage		See page 4
Anode-to-cathode voltage below which all tubes will extinguish	115	V
Recommended cathode current, d.c.	2.5	mA
Minimum cathode current, d.c. (during any conduction period)	1.5	mA
D.C. operation		See pages 5 to 9

LIFE EXPECTANCY at recommended operating conditions and room temperature (see operating note)

Continuous display of one numeral	>5000	h
Sequentially changing the display from one numeral to another, every 100 hours or less	>20 000	h

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each digit)		
Maximum average (maximum averaging time = 20ms)	3.0	mA
Maximum peak (for 20ms maximum)	3.5	mA
Minimum (during any conduction period)	1.5	mA
Bulb temperature		°C
Maximum	+70	°C
Minimum (see operating note)	−10	°C

MOUNTING POSITION

Any. The numerals are viewed through the top of the envelope. The numerals will appear upright (within ±3°) when the tube is mounted with the line through pins 6 and 12 vertical, pin 6 uppermost.

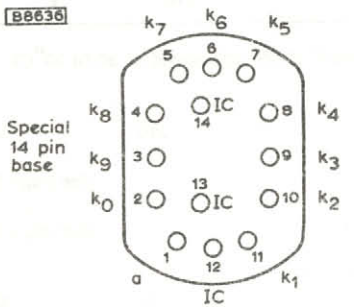
OPERATING NOTE

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

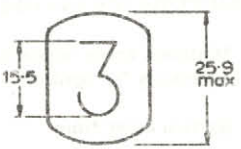
ACCESSORY (supplied as additional item)

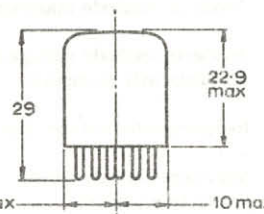
Socket 55705

B8636

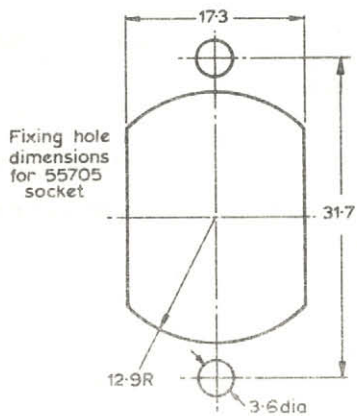


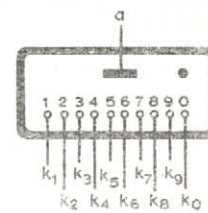
All dimensions in mm

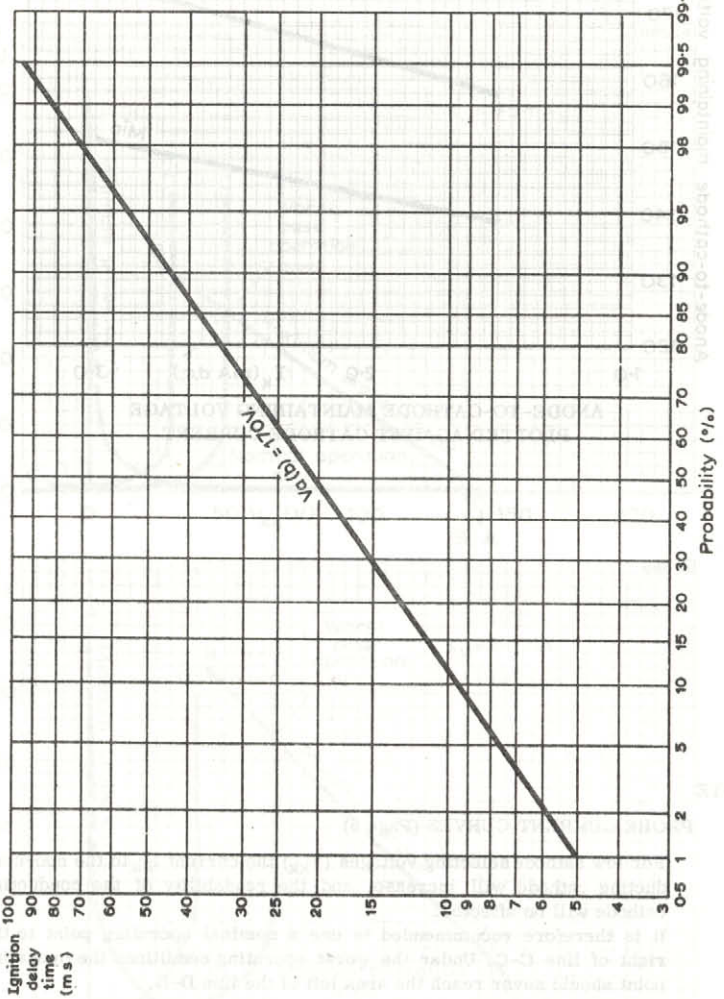




Centre line through pins 6 and 12. (Note: distance between centre lines of adjacent tubes must be at least 20mm)

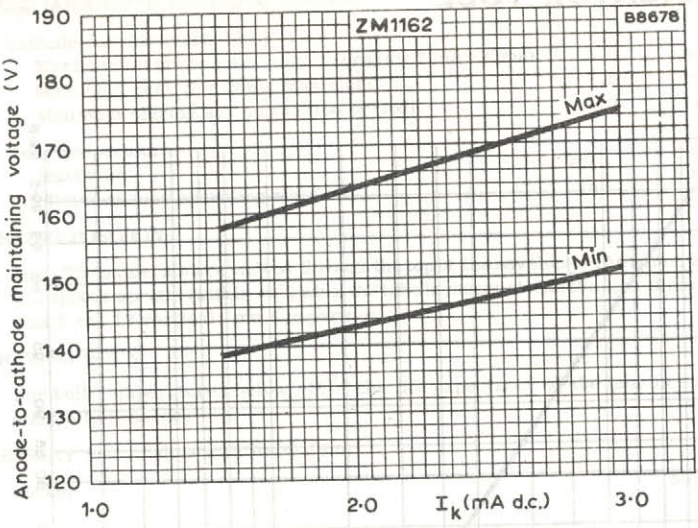






CUMULATIVE DISTRIBUTION OF IGNITION DELAY TIME

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



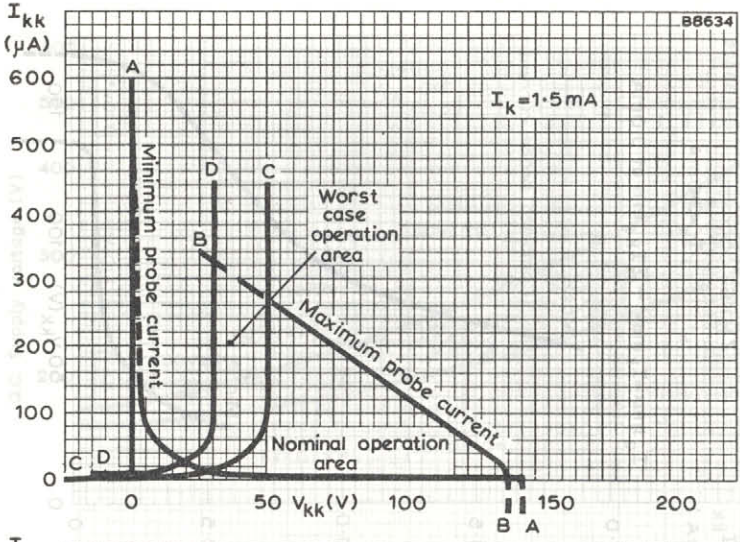
ANODE-TO-CATHODE MAINTAINING VOLTAGE PLOTTED AGAINST CATHODE CURRENT

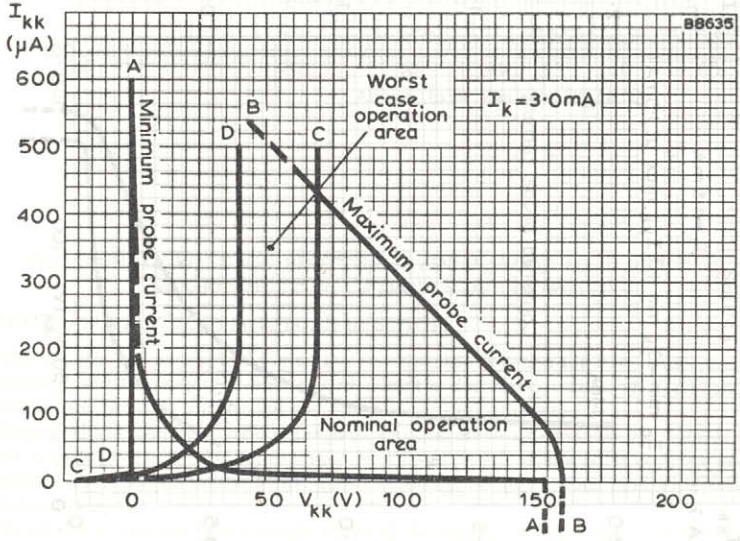
NOTE

PROBE CURRENT CURVES (Page 5)

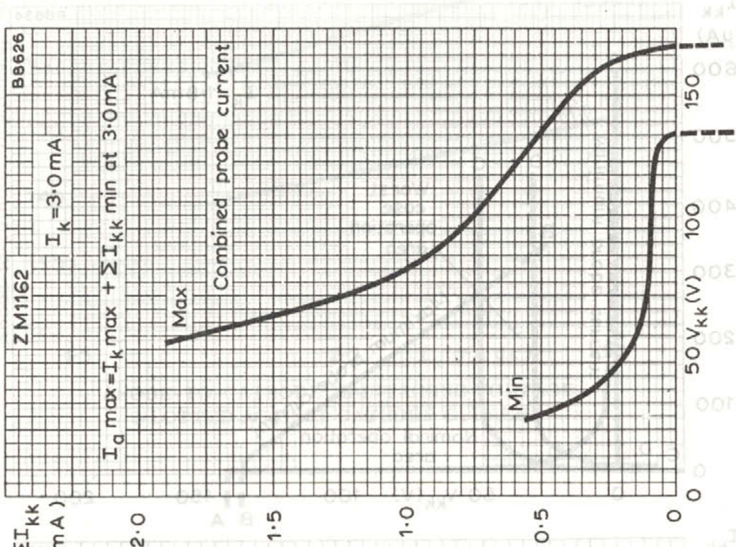
For low cathode selecting voltages (V_{kk}) the current I_{kk} to the non-conducting cathode will increase, and the readability of the conducting cathode will be affected.

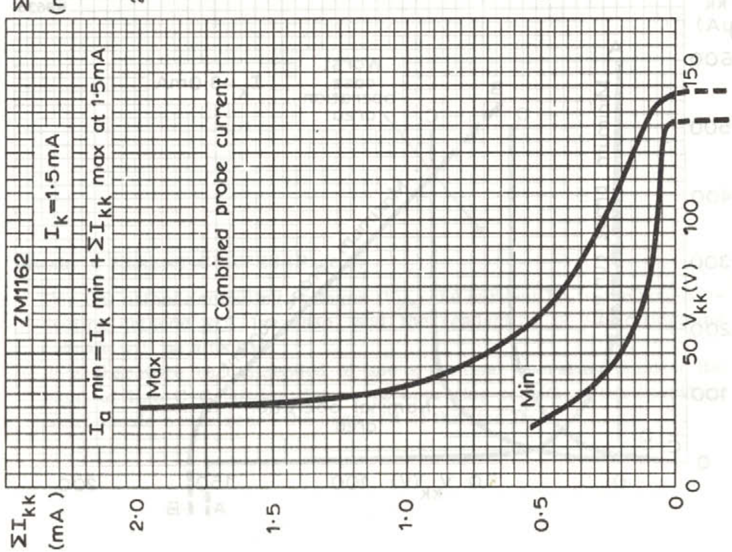
It is therefore recommended to use a nominal operating point to the right of line C-C. Under the worst operating conditions the operating point should never reach the area left of the line D-D.



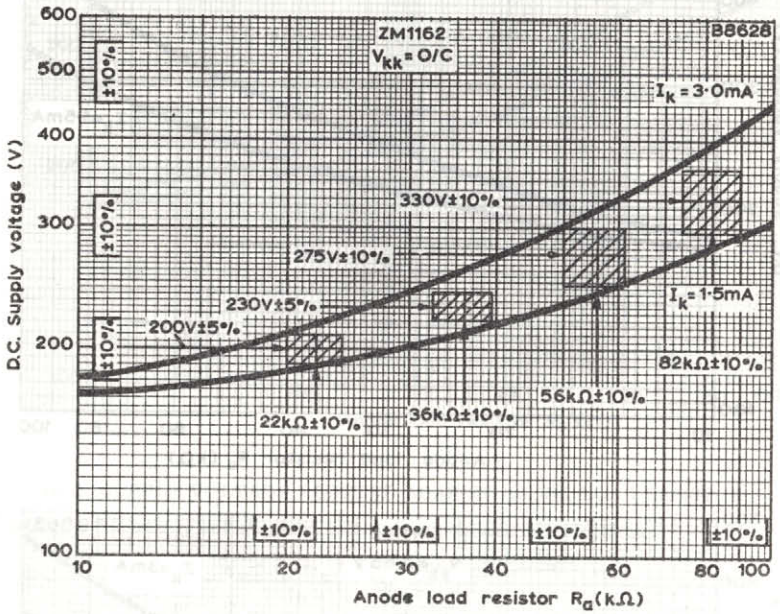


PROBE CURRENTS TO INDIVIDUAL NON-CONDUCTING CATHODES





COMBINED PROBE CURRENT TO ALL NON-CONDUCTING CATHODES



D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR: NON-CONDUCTING CATHODES OPEN CIRCUIT

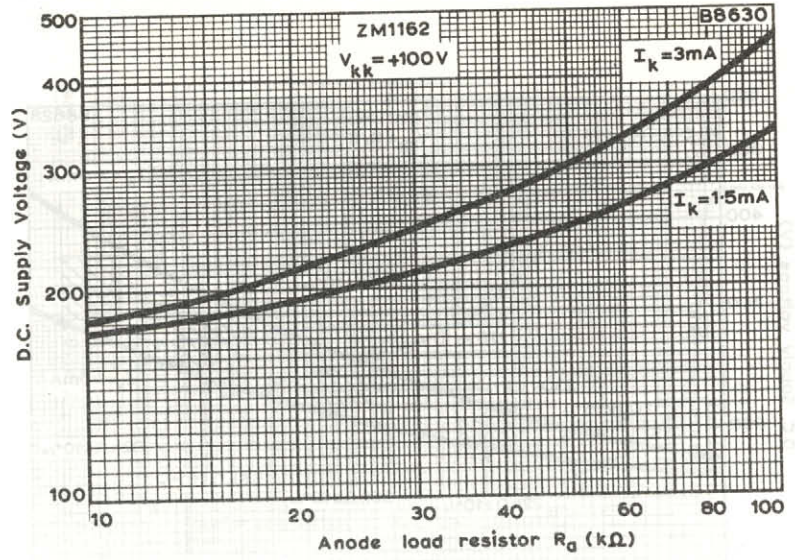
NOTE - SUPPLY VOLTAGE/LOAD RESISTOR

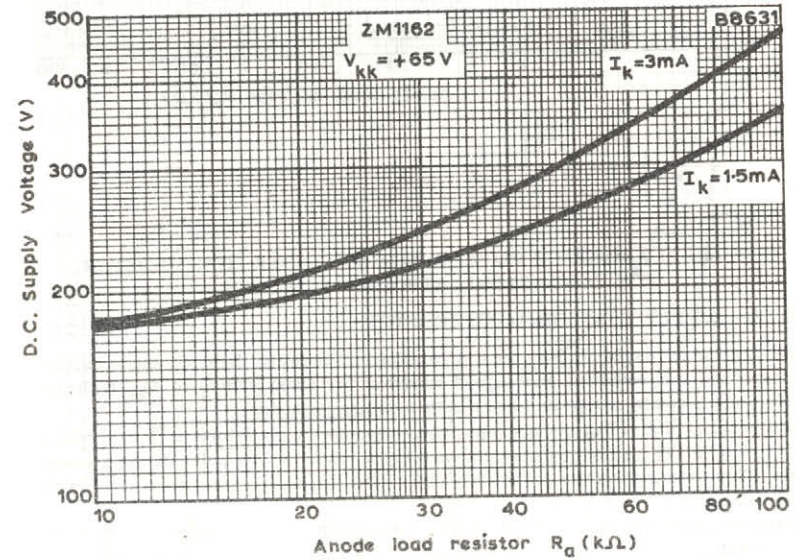
The graphs on pages 7 to 9 give the relationship between the d.c. anode supply voltage and the required anode load resistor for fixed values of V_{kk} (voltage difference between conducting and non-conducting cathodes).

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.

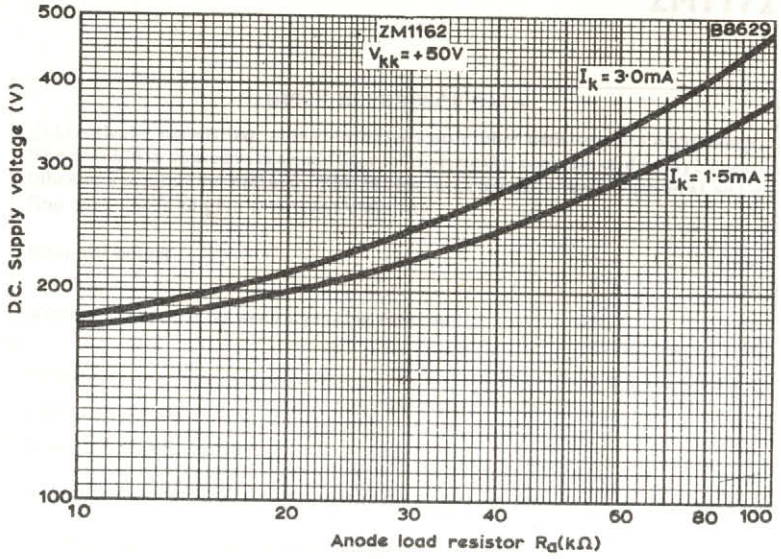
Examples are shown on the graph above of the supply voltages and load resistors with tolerances expressed as a percentage so as to remain within the recommended operating region.

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 PLOTTED AGAINST ANODE LOAD RESISTOR



D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

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

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

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

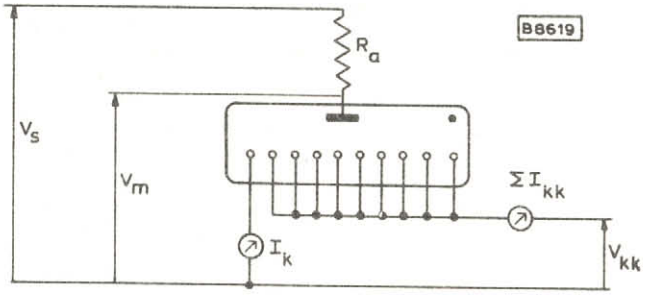
The value of ΣI_{kk} will depend on the bias voltage V_{kk}.

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

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

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

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



NUMERICAL INDICATOR TUBES

ZM1170 ZM1172

QUICK REFERENCE DATA

Cold cathode, neon filled, side viewing indicator tubes with long life expectancy. The ZM1170 is coated with a red filter to improve the contrast of display. These tubes are similar to ZM1080, ZM1082 but incorporate a larger numeral and a fine wire anode to give improved visibility.

Numeral height	15.5	mm
	0.6	in
Minimum distance between mounting centres	19	mm
	0.75	in
Numerals	1 2 3 4 5 6 7 8 9 0	
Cathode current	2.5	mA
Minimum supply voltage	170	V

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

Minimum anode-to-cathode voltage necessary for ignition	170	V
Ignition delay time	See page 4	
Anode-to-cathode maintaining voltage	See page 5	
Anode-to-cathode voltage below which all tubes will extinguish	115	V
Cathode current		
Maximum peak	12	mA
Maximum average (averaged over any 10ms) (see note 1)	3.5	mA
Minimum average (averaged over any 10ms) (see note 1)	0.8	mA
Minimum average (averaged over any conduction period) (see note 1)	1.5	mA
Recommended average (during any d.c. conduction period)	2.5	mA
Probe current		
Probe current to individual non-conducting cathodes (I_{kk})	See pages 6 and 11	
Probe current to combined non-conducting cathodes (ΣI_{kk})	See pages 7, 11 and 12	

D.C. operation

See pages 5 to 10

Pulse operation

Minimum pulse duration	100	μs

See pages 5, 11, 12 and 13

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 2)

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each digit)		
Maximum average (averaged over any 10ms)	3.5	mA
Maximum peak	12	mA
Minimum average (averaged over any conduction period)	1.5	mA
Bulb temperature		
Maximum	+70	°C
Minimum (see note 2)	-50	°C

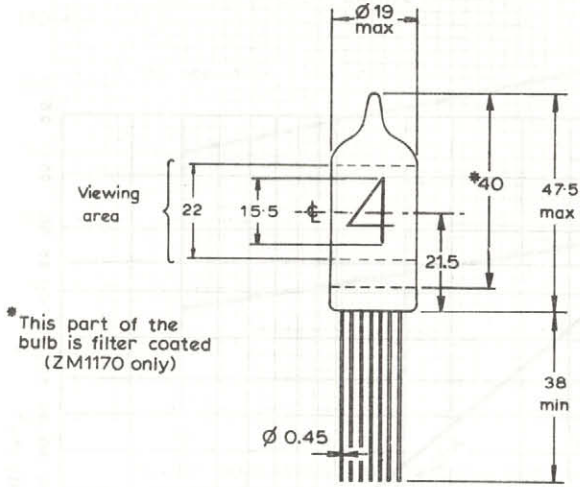
MOUNTING POSITION

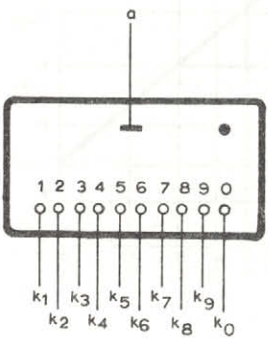
Any. The numerals are viewed through the side of the envelope. The numerals will appear upright (within ±3°) when the tube is mounted vertically, base down.

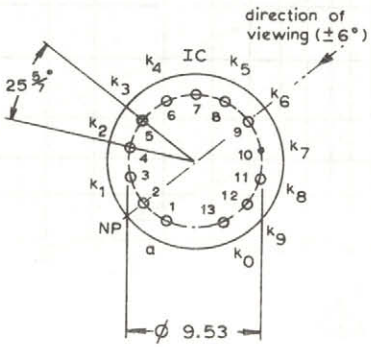
OPERATING NOTES

1. The minimum average current (averaged over any 10ms) of 0.8mA is necessary for adequate light output without flicker in applications other than d.c. The minimum average current (averaged over any conduction period) of 1.5mA is necessary to ensure complete cathode coverage initially and throughout life.
2. For bulb temperatures below 0°C the life expectancy of the tube is substantially reduced.
3. 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.
4. The leads are tinned and may be dip-soldered to a minimum of 5mm from the seals at a solder temperature of 240°C for a maximum of 10 seconds.
5. Care should be taken not to bend the leads nearer than 1.5mm from the seals.

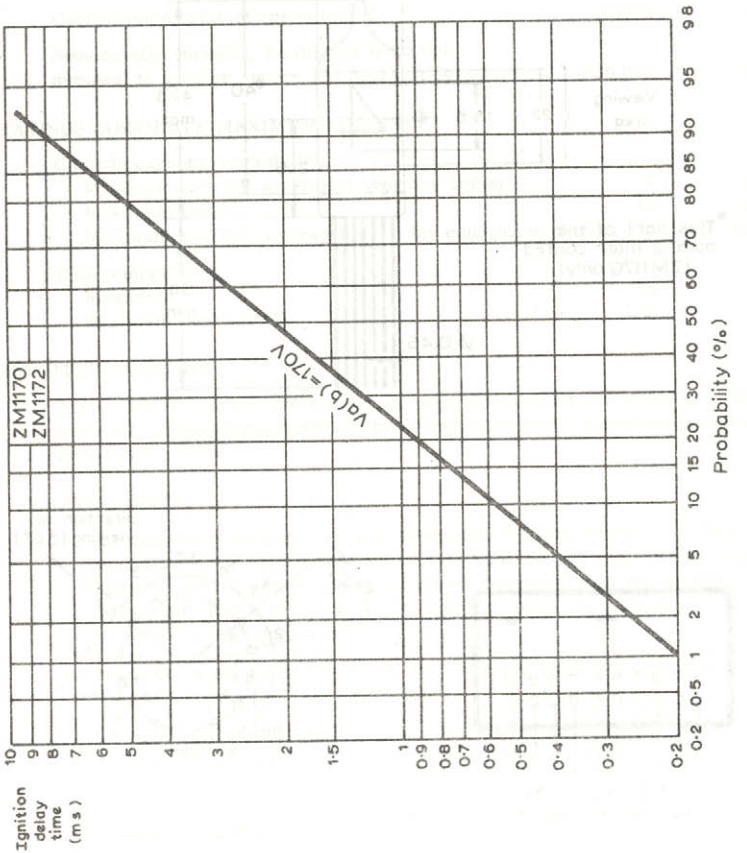
OUTLINE AND DIMENSIONS





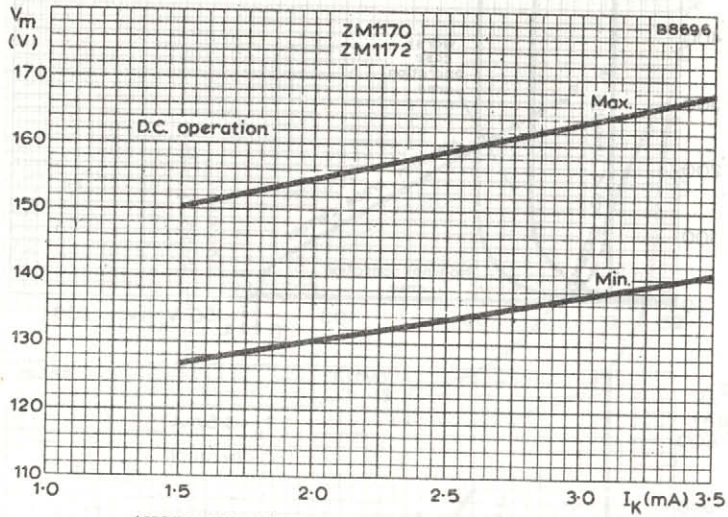


All dimensions in mm

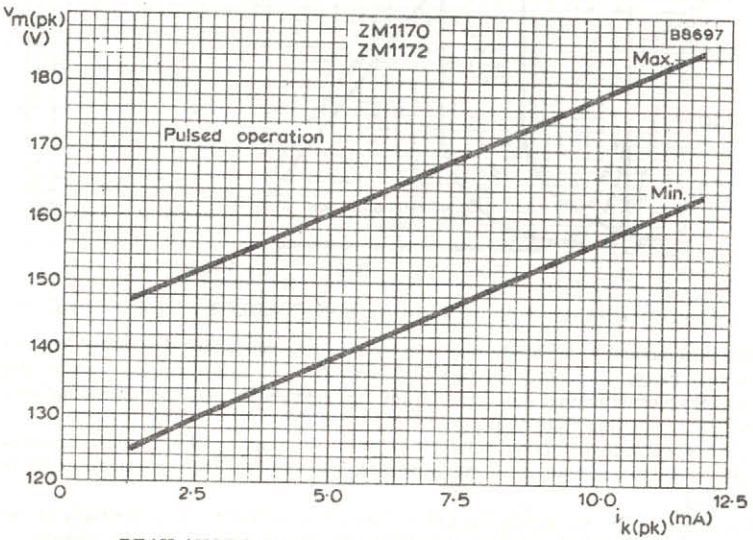


CUMULATIVE DISTRIBUTION OF IGNITION DELAY TIME

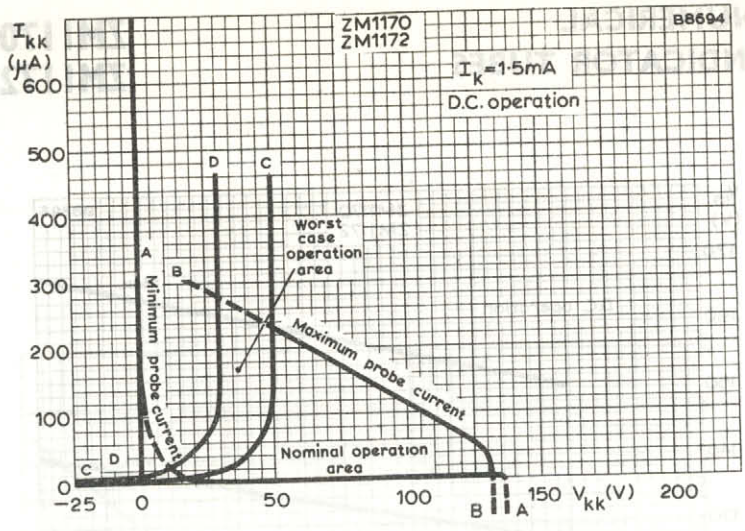
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few seconds. The ignition delay time will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage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

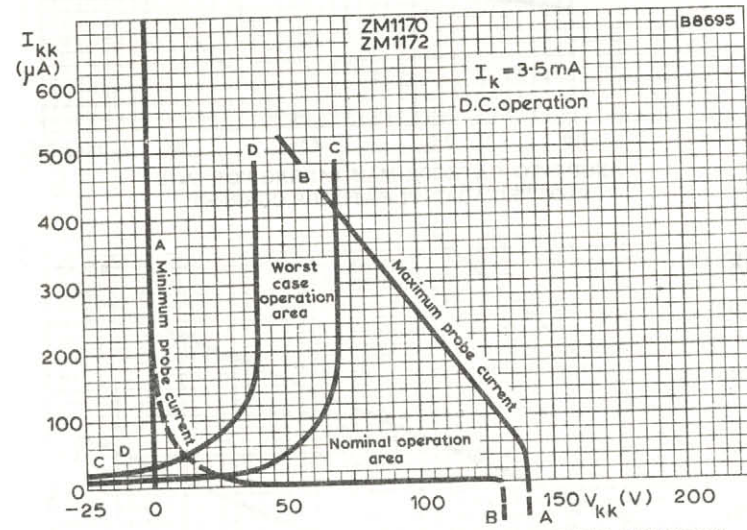


ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST CATHODE CURRENT



PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST PEAK CATHODE CURRENT



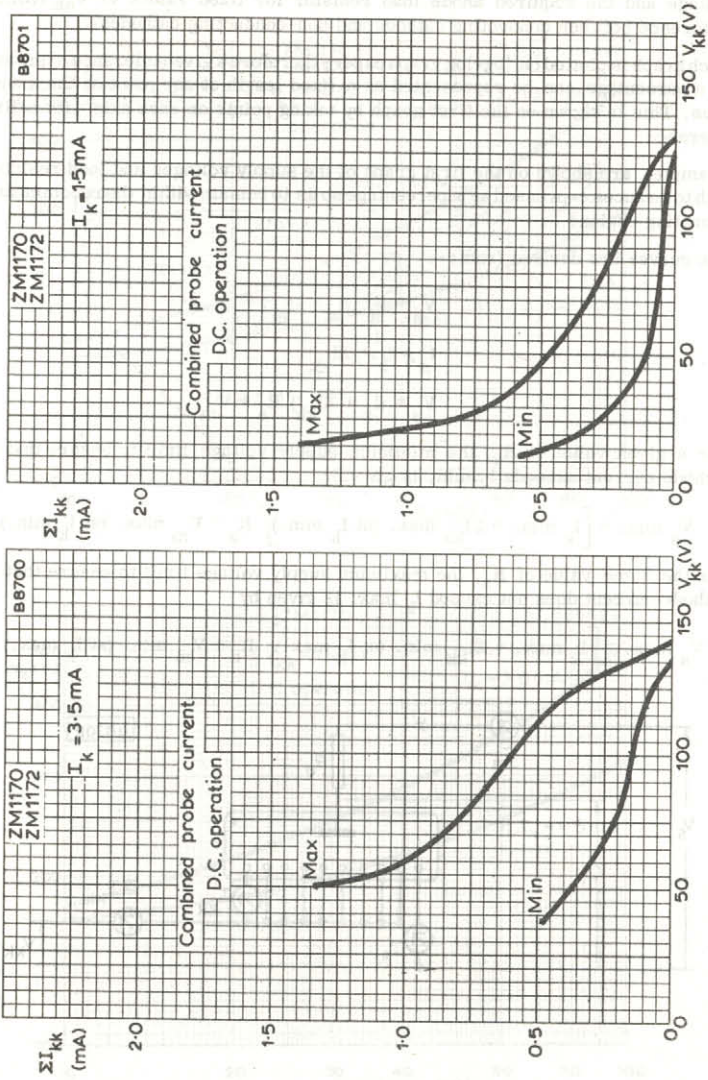


PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

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 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.



COMBINED PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

Sum of the probe currents to the non-conducting cathodes (ΣI_{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 9, 10 and 13 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 tolerances expressed as a percentage so as to remain within the recommended operating region.

The curves are derived from:-

$$V_s = I_a . R_a + V_m$$

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

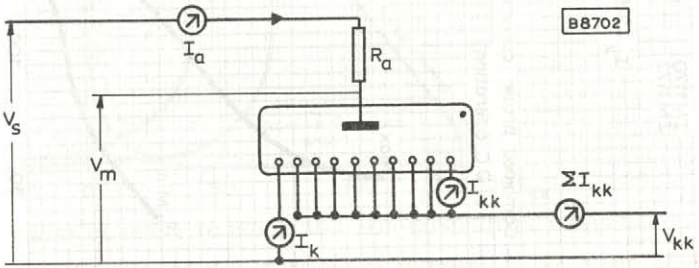
$$V_s = (I_k + \Sigma I_{kk}) R_a + V_m$$

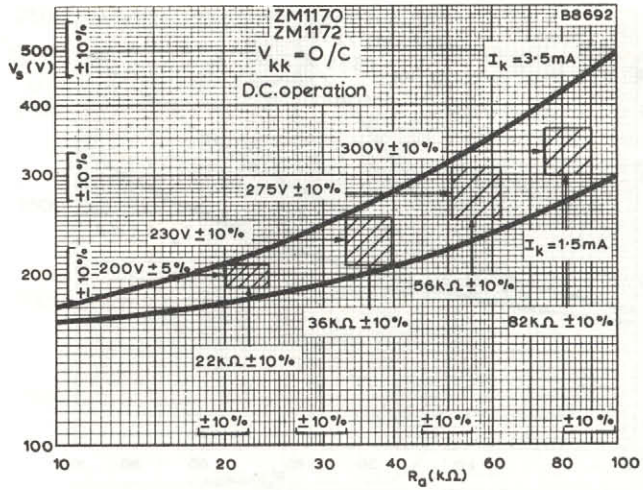
For a given value of R_a, the minimum supply voltage limit to ensure that the cathode current exceeds I_k min. is given by:

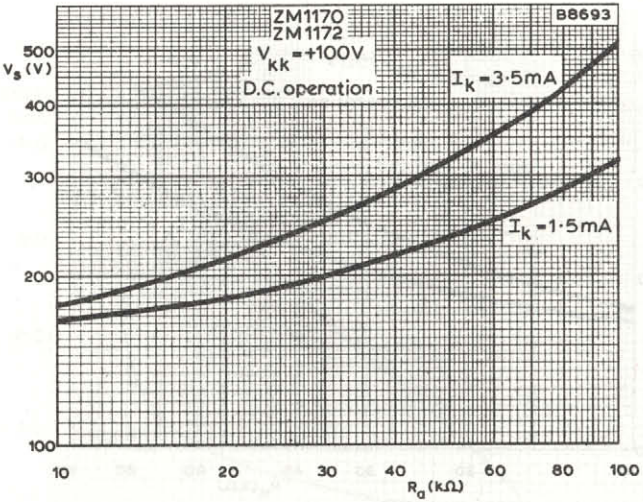
$$V_s \text{ min.} = \left[I_k \text{ min.} + \Sigma I_{kk} \text{ max. (at } I_k \text{ min.)} \right] R_a + V_m \text{ max. (at } I_k \text{ min.)}$$

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:

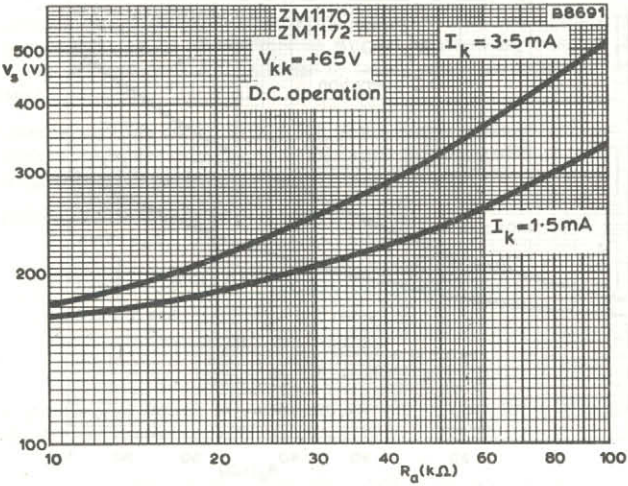
$$V_s \text{ max.} = \left[I_k \text{ max.} + \Sigma I_{kk} \text{ min. (at } I_k \text{ max.)} \right] R_a + V_m \text{ min. (at } I_k \text{ max.)}$$

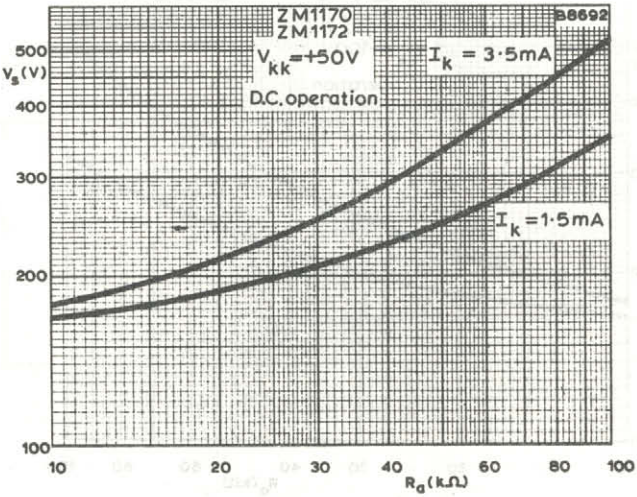




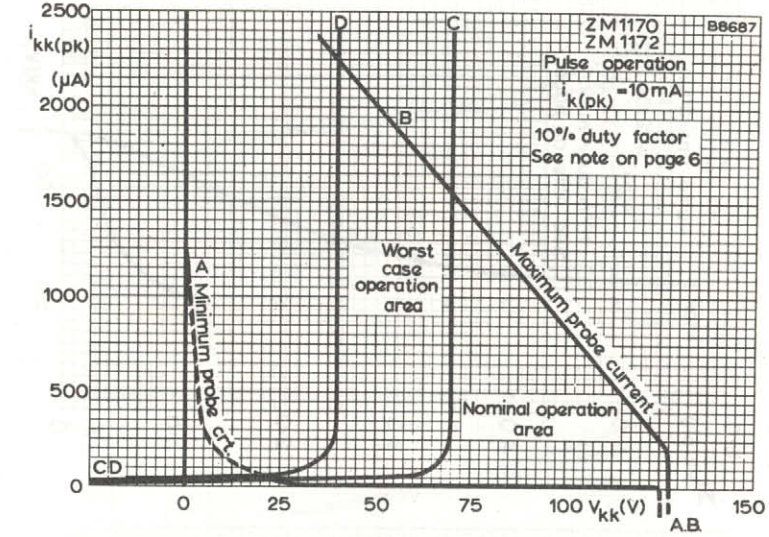


D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

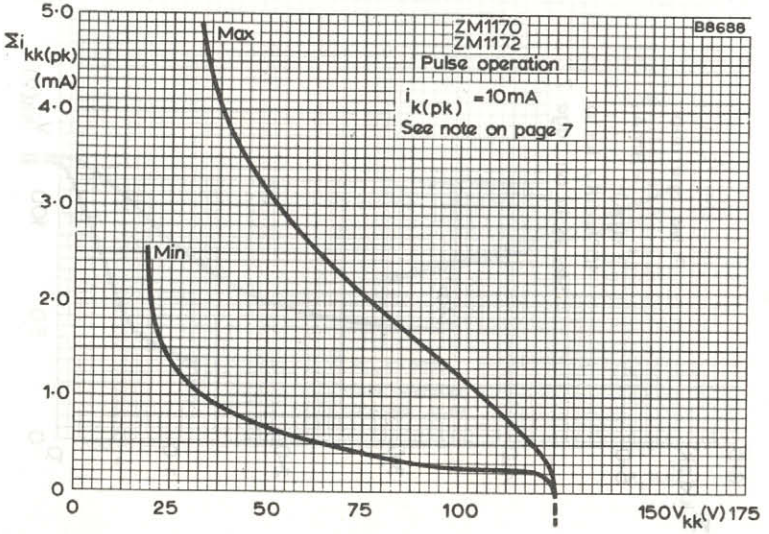




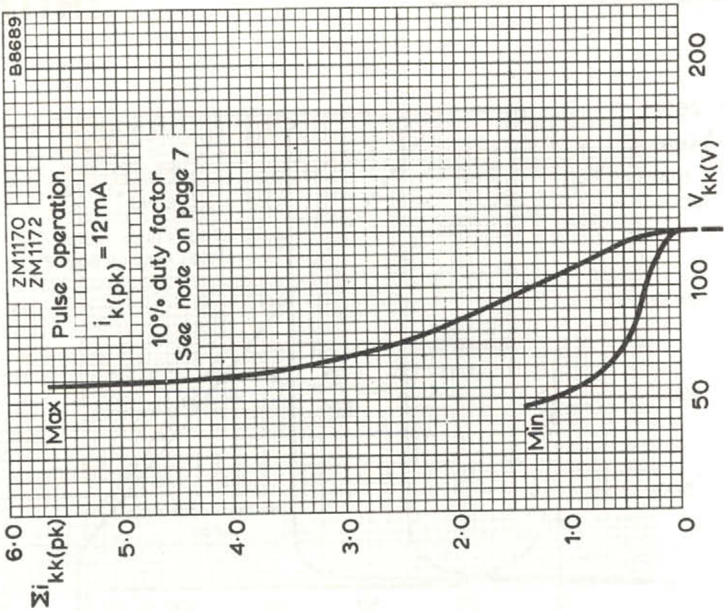
D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

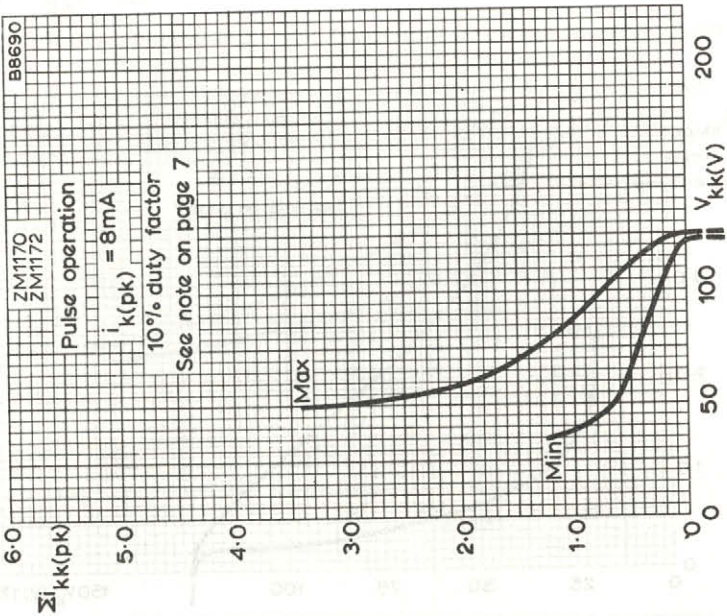


PEAK PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

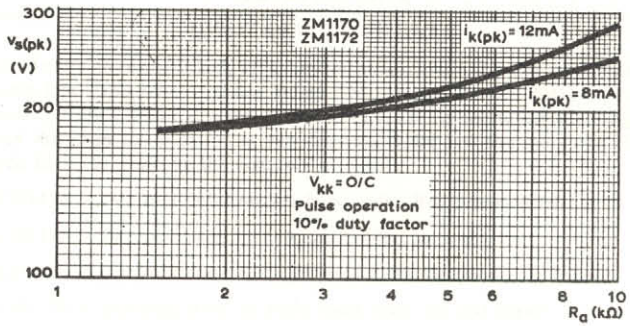


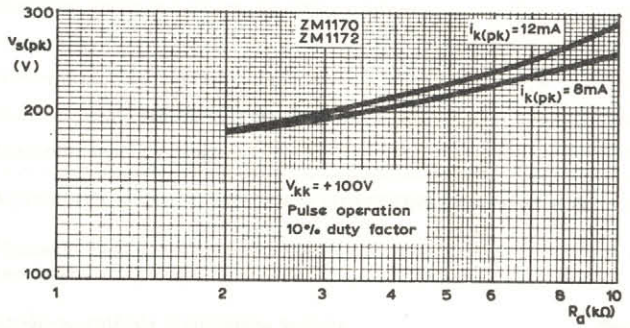
COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

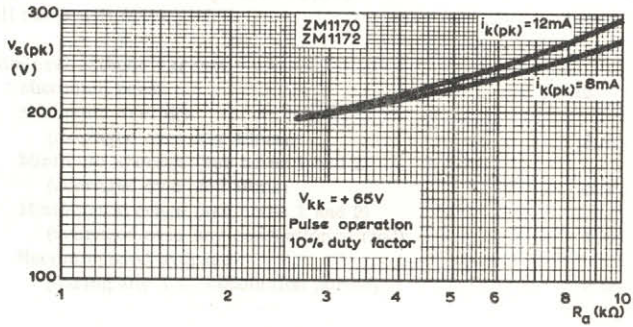




COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES







PEAK SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

NUMERICAL INDICATOR TUBES

ZM1174 ZM1175 ZM1176 ZM1177

TENTATIVE DATA

QUICK REFERENCE DATA

Cold cathode, neon filled, side viewing numerical indicator tubes with long life expectancy. These tubes are similar to the ZM1172, but incorporate a decimal point. The four types are electrically identical, but differ in the position of the decimal point and the inclusion of a red filter to improve the contrast of display.

ZM1174 - Decimal point on left hand side. Red contrast filter.

ZM1175 - Decimal point on left hand side. No red filter.

ZM1176 - Decimal point on right hand side. Red contrast filter.

ZM1177 - Decimal point on right hand side. No red filter.

Numeral height	15.5	mm
Minimum distance between mounting centres	19	mm
Numerals	1 2 3 4 5 6 7 8 9 0	
Numeral cathode current	2.5	mA
Decimal point cathode current (nom.)	0.5	mA
Minimum supply voltage	170	V

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

Minimum anode-to-cathode voltage necessary for ignition	170	V
Anode-to-cathode maintaining voltage	See page 4	
Anode-to-cathode voltage below which all tubes will extinguish	115	V
Numeral cathode current		
Maximum peak	12	mA
Maximum average (averaged over any 10ms)	3.5	mA
Minimum average (see notes 1 and 2) (averaged over any 10ms)	0.8	mA
Minimum average (see notes 1 and 2) (averaged over any conduction period)	1.5	mA
Recommended average (during any d.c. conduction period)	2.5	mA

Decimal point cathode current (see note 3)		
Maximum peak	2.5	mA
Minimum average (averaged over any conduction period)	0.05	mA
Recommended average (during any d.c. conduction period)	0.5	mA
Minimum pulse duration (pulsed operation)	100	μs

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 4)

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Numeral cathode current (each digit)		
Maximum average (averaged over any 10ms)	3.5	mA
Maximum peak	12	mA
Minimum average (averaged over any conduction period)	1.5	mA
Bulb temperature		
Maximum	+70	°C
Minimum (see note 4)	-50	°C

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.

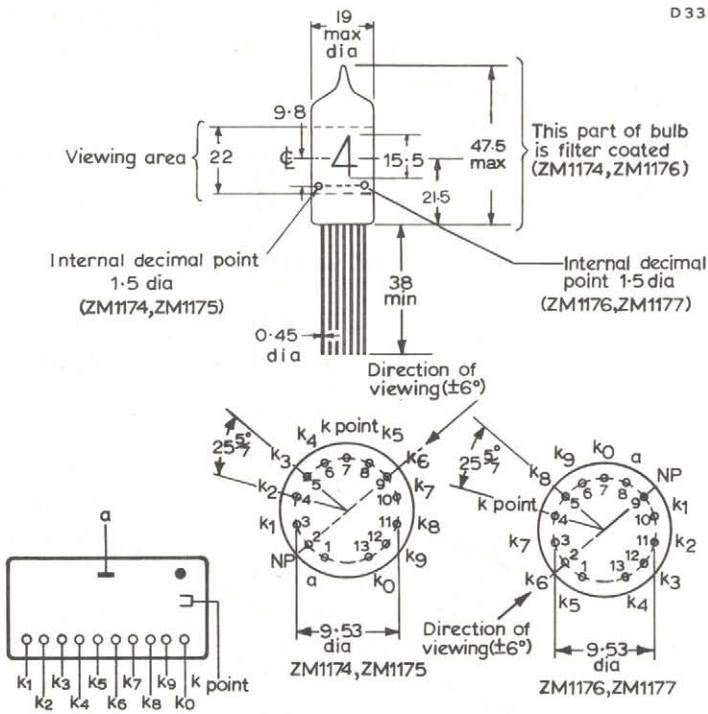
OPERATING NOTES

1. This value applies, irrespective of whether the decimal point is running or not.
2. The minimum average current (averaged over any 10ms) of 0.8mA is necessary for adequate light output without flicker in applications other than d.c. The minimum average (averaged over any conduction period) of 1.5mA is necessary to ensure adequate cathode coverage, initially and throughout life.
3. 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 maximum decimal point current is 0.15mA at a numeral cathode current of 1.5mA.
4. For bulb temperatures below 0°C the life expectancy of the tube is substantially reduced.

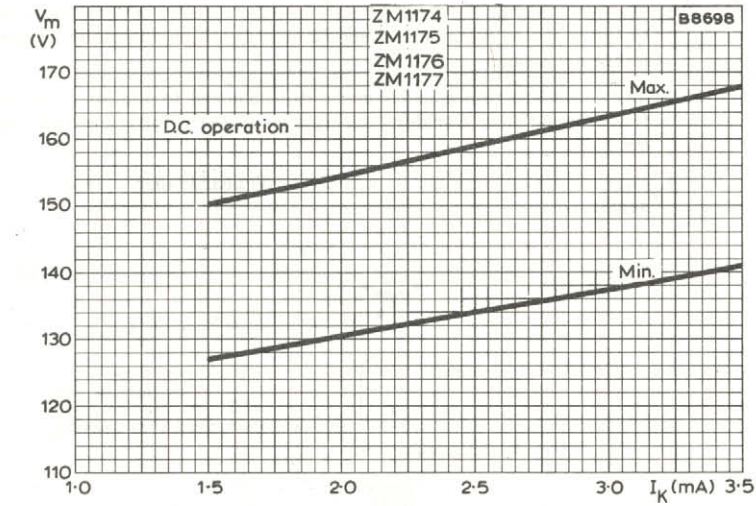
5. The tube may be soldered directly into the circuit, but heat conduction to the glass-to-metal seals should be kept to a minimum by the use of a thermal shunt.

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

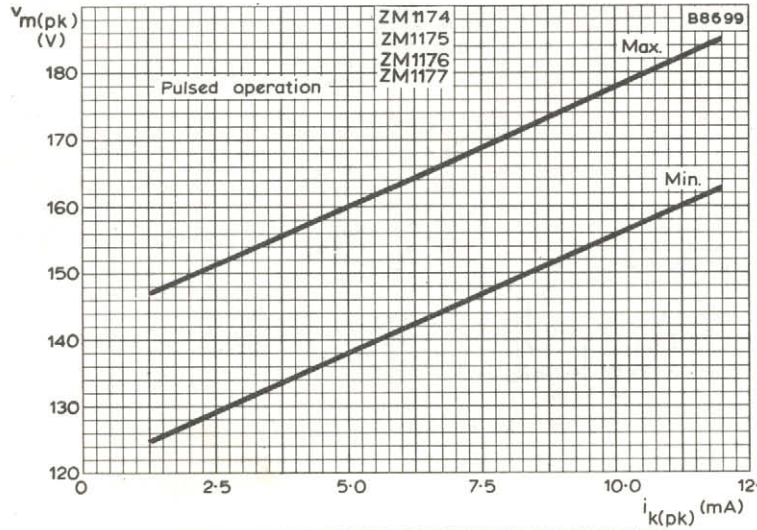
7. Care should be taken not to bend the leads nearer than 1.5mm from the seals.



All dimensions in mm



ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST CATHODE CURRENT



PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST PEAK CATHODE CURRENT

NUMERICAL INDICATOR TUBES

ZM1230 ZM1232

QUICK REFERENCE DATA

Cold cathode, neon filled, side viewing indicator tubes with long life expectancy. The ZM1230 is coated with a red filter to improve contrast of display. These tubes are similar to ZM1170, ZM1172 but are inverted with leads mounted at the top.

Numeral height	15.5	mm
	0.6	in
Minimum distance between mounting centres	19	mm
	0.75	in
Numerals	1 2 3 4 5 6 7 8 9 0	
Cathode current	2.5	mA
Minimum supply voltage	170	V

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

Minimum anode-to-cathode voltage necessary for ignition	170	V
Ignition delay time	See page 4	
Anode-to-cathode maintaining voltage	See page 5	
Anode-to-cathode voltage below which all tubes will extinguish	115	
Cathode current		
Maximum peak	12	mA
Maximum average (averaged over any 10ms) (see note 1)	3.5	mA
Minimum average (averaged over any 10ms) (see note 1)	0.8	mA
Minimum average (averaged over any conduction period) (see note 1)	1.5	mA
Recommended average (during any d.c. conduction period)	2.5	mA
Probe current		
Probe current to individual non-conducting cathodes (I_{kk})	See pages 6 and 11	
Probe current to combined non-conducting cathodes (ΣI_{kk})	See pages 7, 11 and 12	

D.C. operation

See pages 5 to 10

Pulse operation

Minimum pulse duration	100	μs

See pages 5, 11, 12 and 13

LIFE EXPECTANCY at recommended operating conditions and room temperature (see note 2)

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

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Cathode current (each digit)		
Maximum average (averaged over any 10ms)	3.5	mA
Maximum peak	12	mA
Minimum average (averaged over any conduction period)	1.5	mA
Bulb temperature		
Maximum	+70	°C
Minimum (see note 2)	-50	°C

MOUNTING POSITION

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

OPERATING NOTES

1. The minimum average current (averaged over any 10ms) of 0.8mA is necessary for adequate light output without flicker in applications other than d.c. The minimum average current (averaged over any conduction period) of 1.5mA is necessary to ensure complete cathode coverage initially and throughout life.

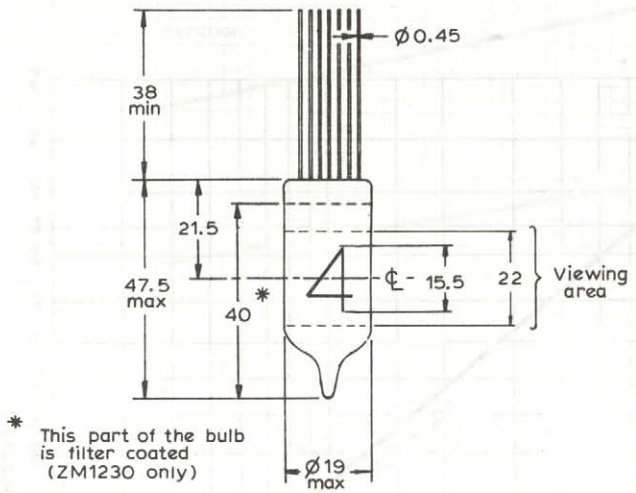
2. For bulb temperatures below 0°C the life expectancy of the tube is substantially reduced.

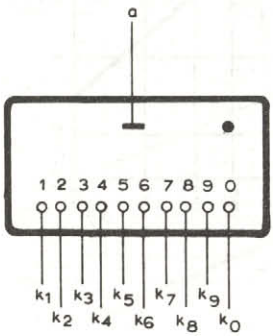
3. The tube may be soldered directly into the circuit, but heat conduction to the glass-to-metal seals should be kept to a minimum by the use of a thermal shunt.

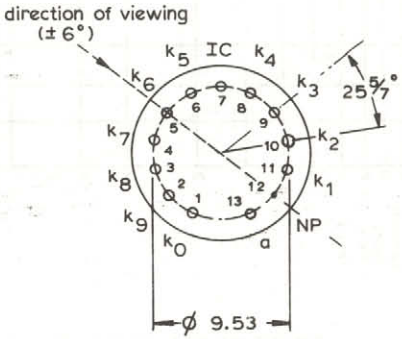
4. The leads are tinned and may be dip-soldered to a minimum of 5mm from the seals at a solder temperature of 240°C for a maximum of 10 seconds.

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

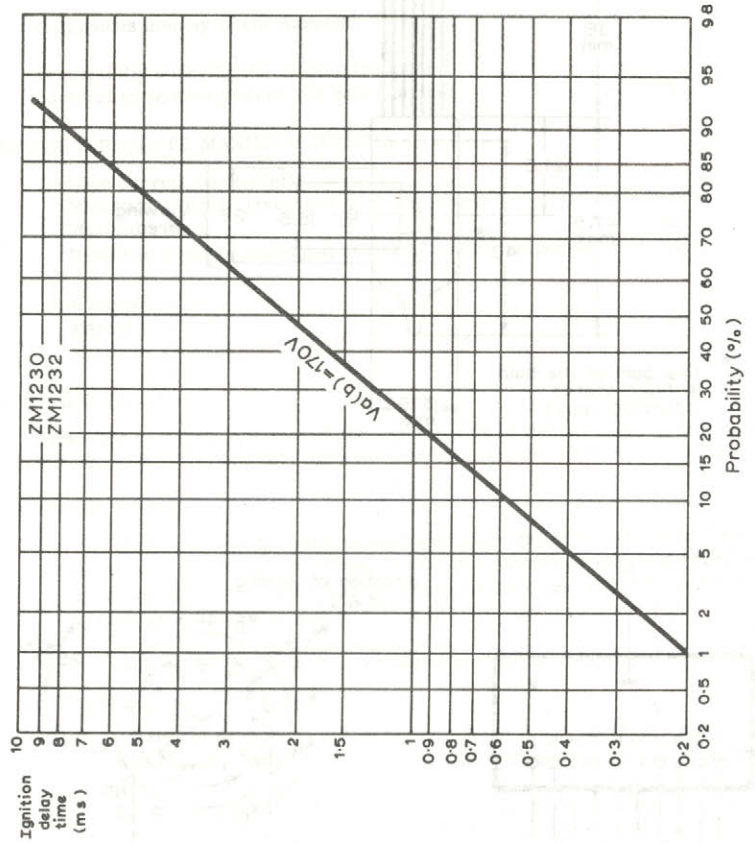
OUTLINE AND DIMENSIONS





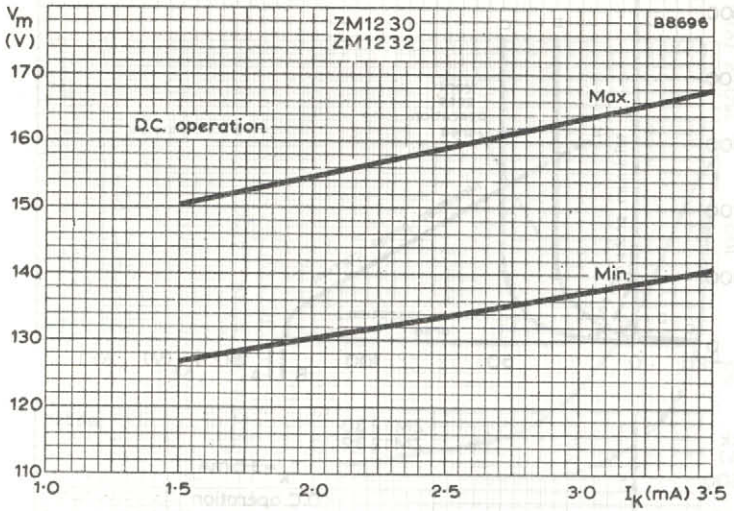


All dimensions in mm

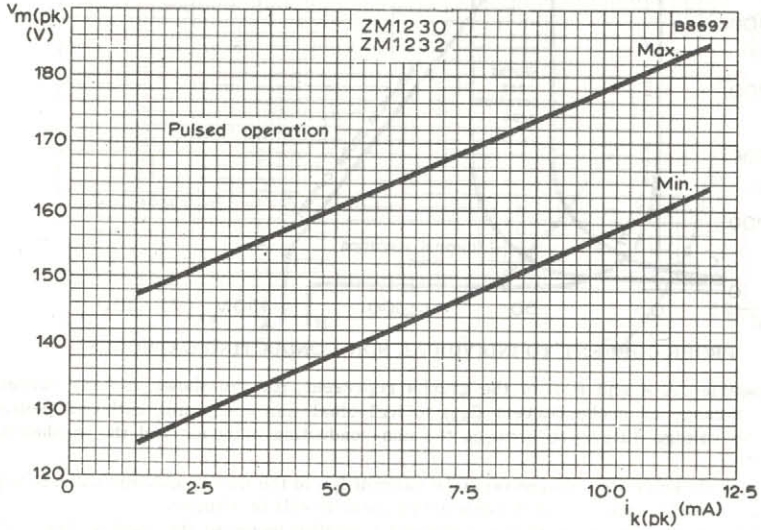


CUMULATIVE DISTRIBUTION OF IGNITION DELAY TIME

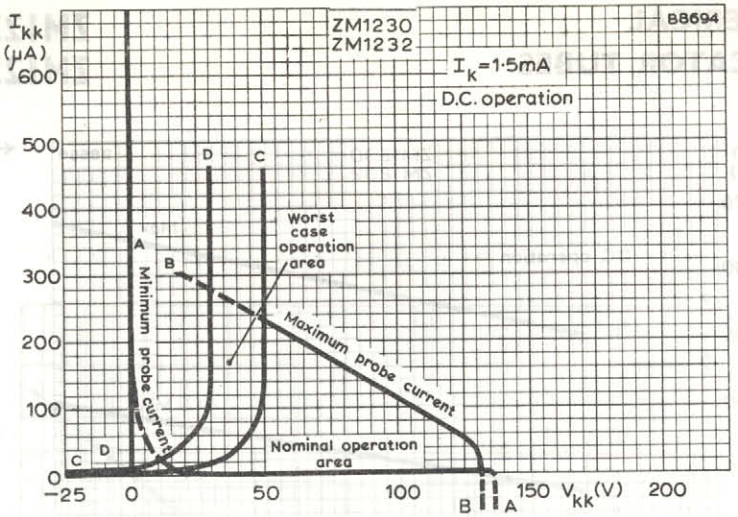
This curve shows the probability that a tube will ignite in less than the time shown after a non-conduction period of a few seconds. The ignition delay time will be appreciably reduced when the interval between conduction periods is less than 100 milliseconds. In general, an increase in the supply voltage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

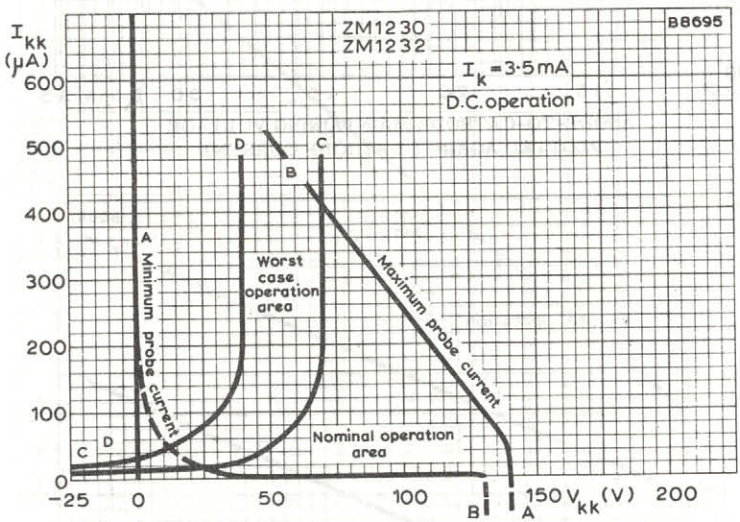


ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST CATHODE CURRENT



PEAK ANODE-TO-CATHODE MAINTAINING VOLTAGE
PLOTTED AGAINST PEAK CATHODE CURRENT



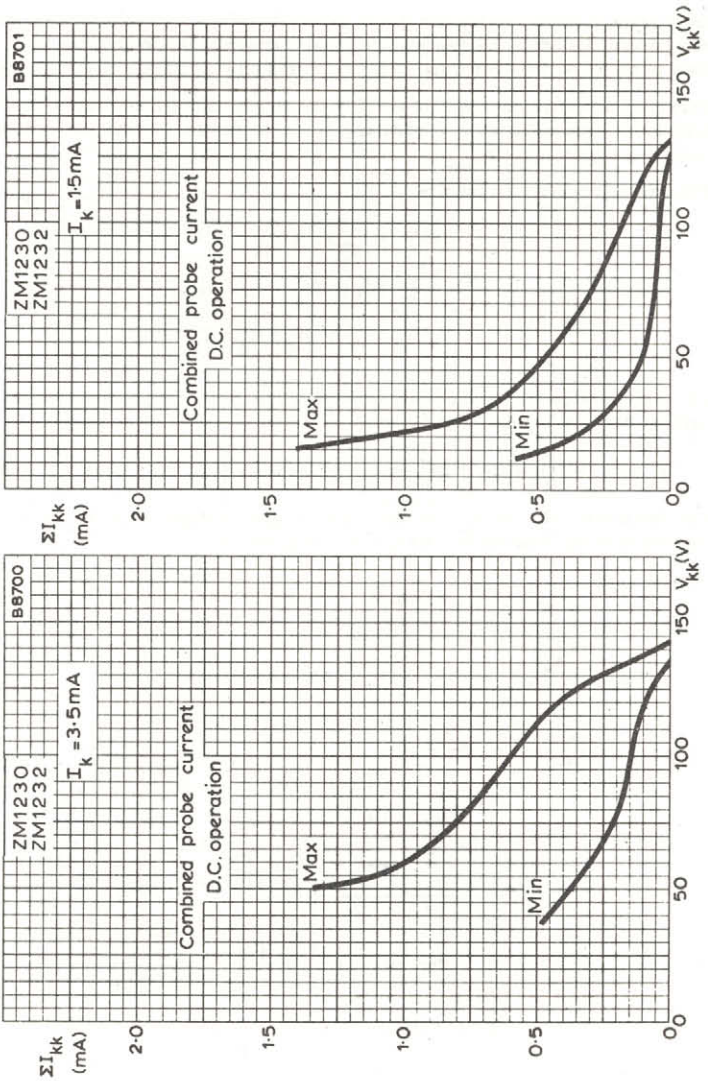


PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

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 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.



COMBINED PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

Sum of the probe currents to the non-conducting cathodes (ΣI_{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 9, 10 and 13 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 tolerances expressed as a percentage so as to remain within the recommended operating region.

The curves are derived from:-

$$V_s = I_a . R_a + V_m$$

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

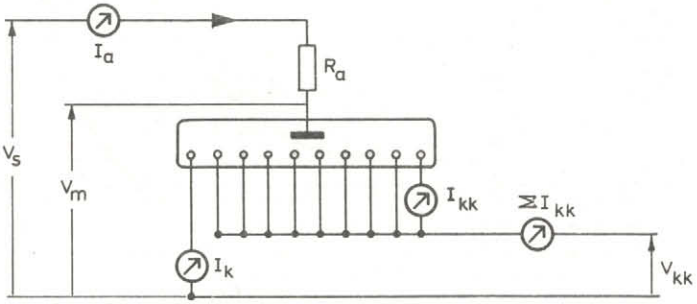
$$V_s = (I_k + \Sigma I_{kk}) R_a + V_m$$

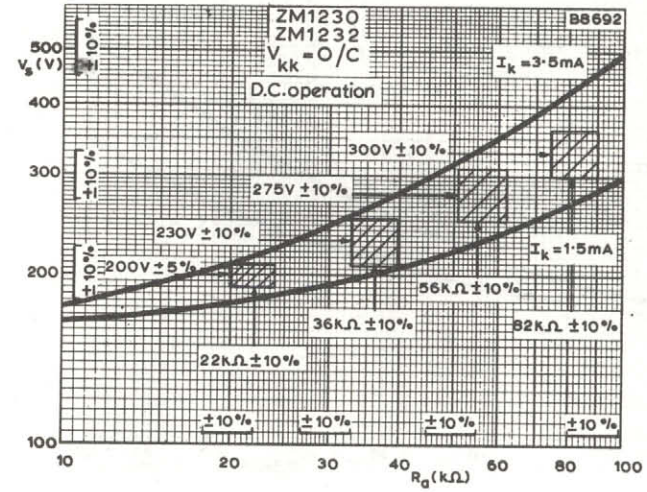
For a given value of R_a, the minimum supply voltage limit to ensure that the cathode current exceeds I_k min. is given by:

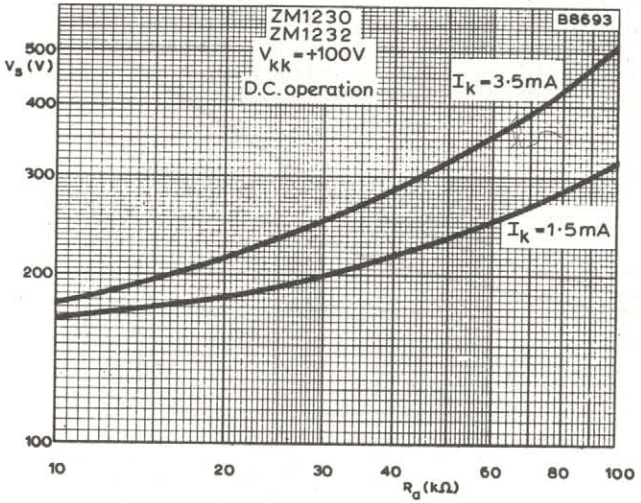
$$V_s \text{ min.} = \left[I_k \text{ min.} + \Sigma I_{kk} \text{ max. (at } I_k \text{ min.)} \right] R_a + V_m \text{ max. (at } I_k \text{ min.)}$$

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:

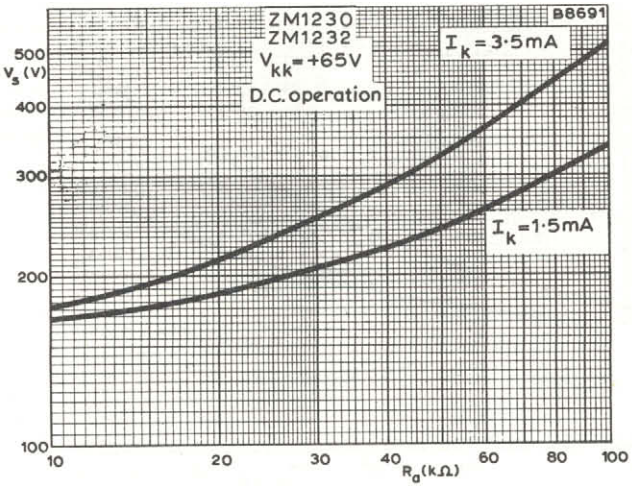
$$V_s \text{ max.} = \left[I_k \text{ max.} + \Sigma I_{kk} \text{ min. (at } I_k \text{ max.)} \right] R_a + V_m \text{ min. (at } I_k \text{ max.)}$$

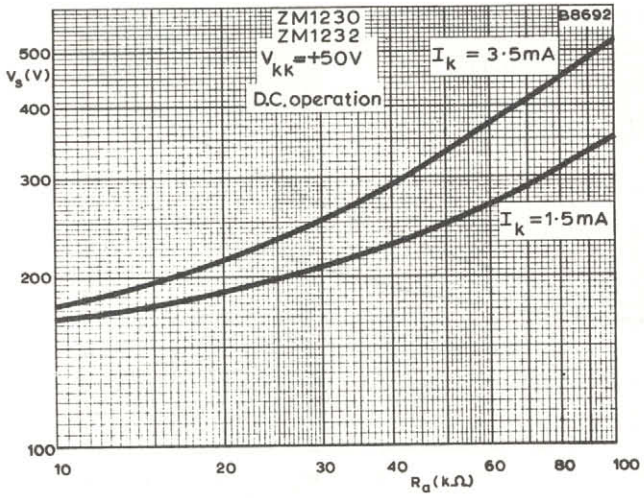




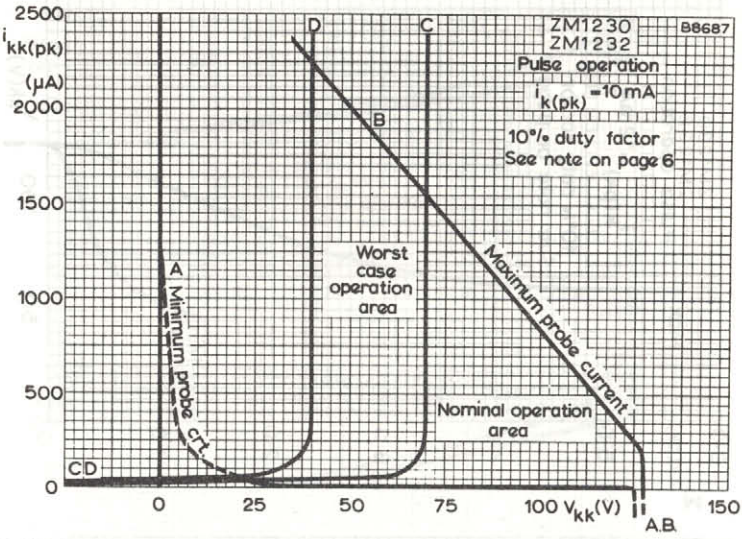


D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

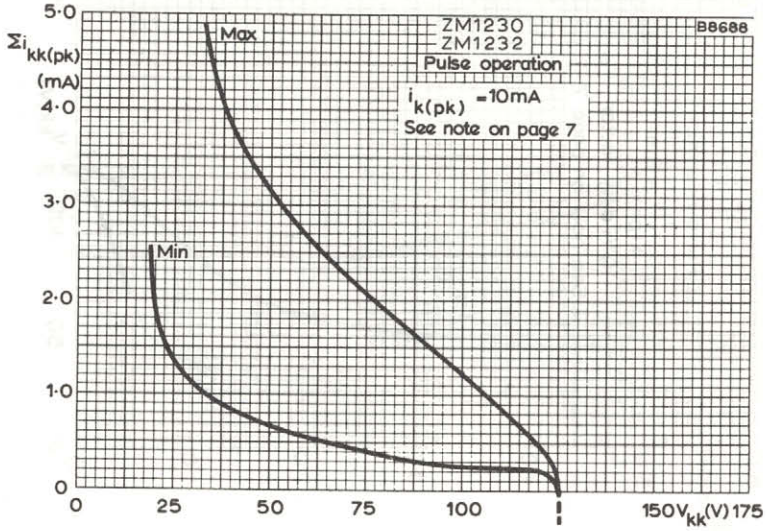




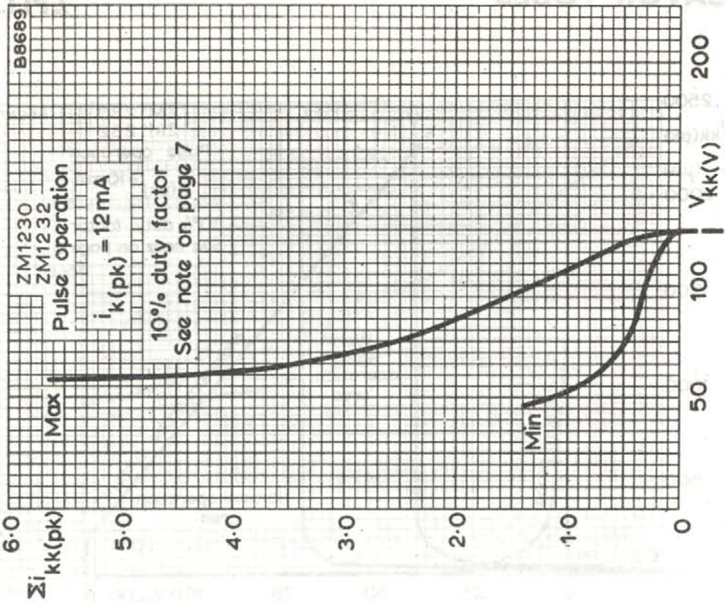
D.C. SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

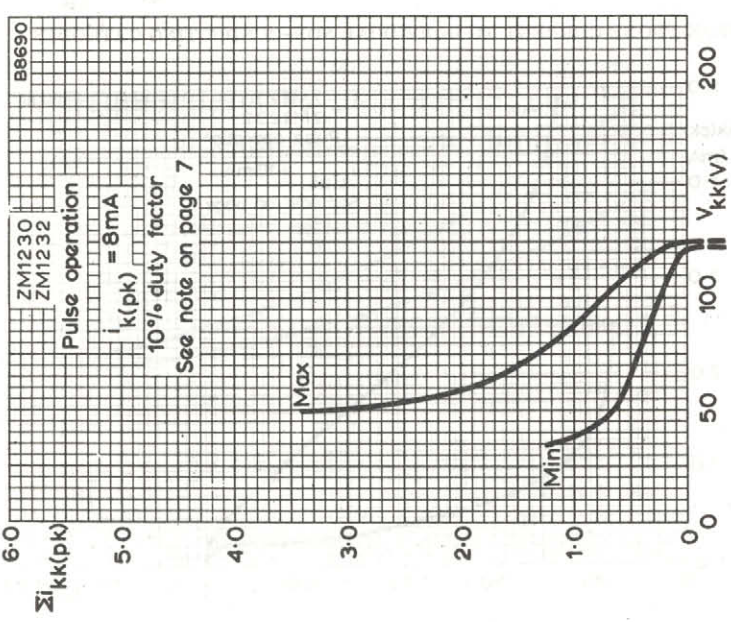


PEAK PROBE CURRENT TO INDIVIDUAL NON-CONDUCTING CATHODES

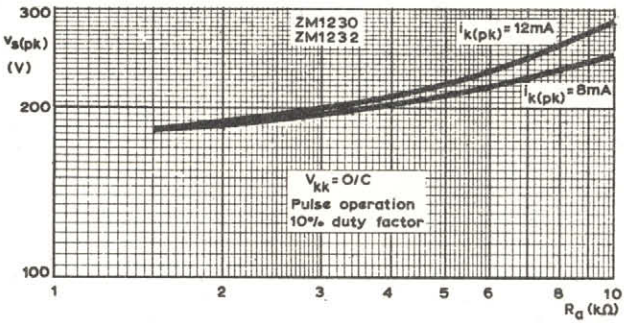


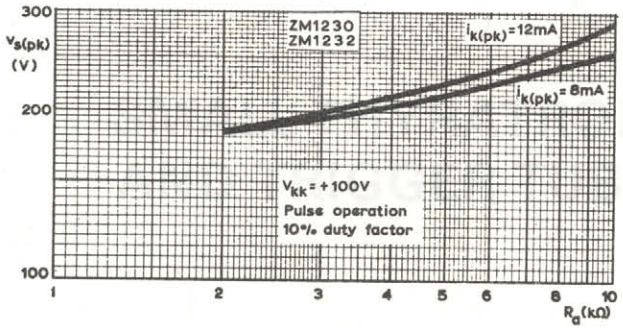
COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES

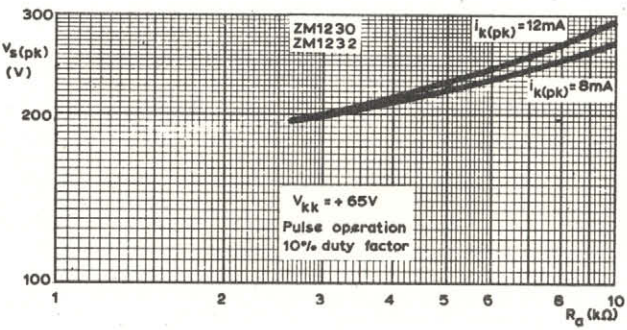




COMBINED PEAK PROBE CURRENT TO ALL NON-CONDUCTING CATHODES







PEAK SUPPLY VOLTAGE PLOTTED AGAINST ANODE LOAD RESISTOR

INDEX TO BOOK 2 PART 3

GASFILLED TUBES

Reference to sections :—

Section B—Switching Diodes, Reed Inserts
Section C—Voltage Stabiliser and Reference Tubes
Section D—Counting Tubes
Section E—Numerical and Character Indicating Tubes
Section F—Small Thyratrons and Trigger Tubes
Section G—Large Thyratrons
Section H—Ignitrons
Section J—Power Rectifiers
Section K—Accessories

*—Data for these types are available on request.

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Type No.	Section	Type No.	Section
Z900T	F	ZM1232	E
ZA1001	*	ZT1000	*
ZA1002	B	ZT1011	G
ZA1004	B	ZX1051	H
ZA1005	*	ZX1052	H
ZM1000	E	ZX1053	H
ZM1000R	E	ZX1061	H
ZM1020	E	ZX1062	H
ZM1021	E	ZZ1000	C
ZM1022	E	75C1	C
ZM1023	E	83A1	C
ZM1024	*	85A2	C
ZM1040	E	90C1	C
ZM1041	E	108C1	C
ZM1042	E	150B2	C
ZM1050	*	150C2	C
ZM1080	E	150C4	C
ZM1081	E	5644	*
ZM1082	E	55701	K
ZM1083	E	55702	K
ZM1162	E	55703	K
ZM1170	E	55704	K
ZM1172	E	55705	K
ZM1174	E	56022	K
ZM1175	E	101063	*
ZM1176	E	101064	*
ZM1177	E	101065	K
ZM1230	E		