Mullard technical handbook

Book two
Valves and tubes

Part two

Electro-optical devices
Radiation detectors

November 1973

ELECTRO-OPTICAL DEVICES, RADIATION DETECTORS

CONTENTS

Book 2 comprises the following parts—

Part 1 Receiving valves, television picture tubes.

Part 2 Electro-optical devices, radiation detectors.

Part 3 Gasfilled tubes.

Part 4 Transmitting and industrial heating tubes.

Part 5 Microwave tubes and components.

BOOK 2 (Part 2)

VALVES AND TUBES

Electro-optical devices

Radiation detectors

DATA HANDBOOK SYSTEM

The Mullard data handbook system is made up of three sets of books, each comprising several parts.

The three sets of books, easily identifiable by the colours of their covers, are as follows:

Book 1	(blue)	Semiconductor devices and integrated circuits
Book 2	(orange)	Valves and tubes
Book 3	(green)	Passive components, materials, and assemblies.

New editions will be issued at approximately yearly intervals.

The data contained in these books are as accurate and up to date as it is reasonably possible to make them at the time of going to press. It must however be understood that no guarantee can be given here regarding the availability of the various devices or that their specifications may not be changed before the next edition is published.

The devices on which full data are given in these books are those around which we would recommend equipment to be designed. Where appropriate, other types no longer recommended for new equipment designs, but generally available for equipment production are listed separately with abridged data. Data sheets for these types may be obtained on request. Older devices on which data may still be obtained on request are also included in the index of the appropriate part of each book.

Requests for information on the data handbook system and for individual data sheets should be made to

Central Technical Services
Mullard Limited
New Road
Mitcham
Surrey CR4 4XY.
Telephone: 01-648 3471   Telex: 22194

Information regarding price and availability of devices must be obtained from our authorised agents or from our representatives.

SELECTION GUIDE

SELECTION GUIDE—BOOK 2, PART 2

Section B—CATHODE RAY TUBES

Oscilloscope tubes

Screen Size (cm)	Description or application	Typical Deflection Sensitivity y (V/cm)	x (V/cm)	Typical H.T. (kV)	P.D.A. (kV)	Max. Overall Length (mm)	Type No.
Monoaccelerator tubes							
3 round	General purpose monitor Simple oscilloscopes	45·5	52·5	0·5	—	105	DH3-91
7 round	General purpose monitor Asymmetrical x deflection	21	37	0·5	—	172	DG7-31
7 round	General purpose monitor Symmetrical x deflection	21	37	0·5	—	172	DG7-32
7 round	Inexpensive oscilloscopes Monitoring devices	12	29	1·0	—	225	D7-190GH
10 round	Inexpensive oscilloscopes Read-out devices	14·5	33	1·5	—	260	D10-160GH
13 round	Inexpensive oscilloscopes Read-out devices	15	31	2·0	—	310	D13-480GH
Helical P.D.A. tubes							
7 round	Low heater consumption Transistor drive	4	11	0·3	1·2	296	{ DH7-11 { DP7-11
Mesh P.D.A. tubes							
10 round	Short length. High sensitivity	3·5	13	1·0	6·0	335	D10-170GH
8 × 10 rect.	Short length. High sensitivity	4·2	15·5	1·5	10	385	{ D14-120GH { D14-120GM
8 × 10 rect.	Short length. High sensitivity. Side connections to x and y	4·2	15·5	1·5	10	385	{ D14-121GH { D14-121GM
8 × 10 rect.	High sensitivity. Side connections to x and y. Internal graticule	4·1	15·2	1·5	10	417·5	D14-162GH/09

Flying spot scanner tubes

Screen Diameter (cm)	Description	Min. Resolution (lines)	Max. Anode Voltage (kV)	Type No.
13	Magnetic tube for monochrome TV	1000	27	Q13-110BA
13	Magnetic tube for colour TV	1000	27	Q13-110GU

Television monitor tubes

Screen Diagonal (cm)	Description	Min. Resolution (lines)	Deflection Angle (deg.)	Max. Anode Voltage (kV)	Max. Overall Length (mm)	Type No.
17	Viewfinder monitor	1100	70	16	234	M17-140W
17	Viewfinder monitor Bonded faceplate and band	1100	70	18	240	M17-141W

A preferred range of supersquare TV monochrome and colour picture tubes is also suitable for industrial applications. The following types are recommended:—

Monochrome—A44-120W/R, A50-120W/R, A61-120W/R

Colour—A56-120X, A66-120X

Data will be found in Book 2, Part 1.

Data display tubes

Preferred screen variants of television monitor tube types are available for data display applications.

Projection tubes

Screen Diameter (cm)	Description	Fluorescent Colour	Max. Anode Voltage (kV)	Type No.
13	Large area display, high brightness tubes for monochrome and colour TV	Green Blue Red White	55	MG13-38 MU13-38 MY13-38 MW13-38

Section C—CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

Incidence of Illumination	Max. Dissipation at 25°C. (mW)	Max. Cell Voltage (d.c. or peak) (V)	Nominal Cell Resistance at 50 lux (kΩ)	Type No.
End-on	200	110	2·4	ORP12
Side-on and end-on	400	200	1·2	ORP52
End-on	70	350	60	ORP60*
Side-on	70	350	60	ORP61
Side-on	100	350	45	ORP62
Side-on and end-on	100	350	30	ORP69
Side-on	500	100	0·4	RPY18
Side-on	1000	400	1·5	RPY20
End-on	75	50	2·5 at 25 lux	RPY33**
Side-on	100	50	0·6	RPY58A***
Side-on	50	50	4·5 at 10 lux	RPY71***

* Not suitable for matrix type arrays. Use ORP69 for this application.
** Cadmium sulpho-selenide.
*** Monograin.

Section D—INFRARED PHOTOCONDUCTIVE CELLS

Peak Spectral Response (μm)	Description	Typical Detectivity D* (λpk, 800, 1) cm $(Hz)^{\frac{1}{2}}$/W	Typical Responsivity at λpk (V/W)	Sensitive Area (mm)	Type No.
2·2	Evaporated lead sulphide at room temperature	4×10^{10}	8×10^4	6 × 6	61SV
2·5	Evaporated lead sulphide at room temperature	6×10^{10}	$1·2 \times 10^5$	6 × 6	62SV
1·8 to 2·2	Chemically deposited lead sulphide at room temperature. Flat plate construction	1×10^{10}	200mA/W	1 × 1	RPY75
1·8 to 2·2	As RPY75 but incorporating a germanium filter to cut off below 1·5μm	1×10^{10}	200mA/W	1 × 1	RPY75A
1·8 to 2·2	Chemically deposited lead sulphide at room temperature. TO-5 encapsulation	1×10^{10}	200mA/W	1 × 1	RPY76
1·8 to 2·2	As RPY76 but incorporating a germanium filter to cut off below 1·5μm	1×10^{10}	200mA/W	1 × 1	RPY76A
5·3	Indium antimonide at liquid nitrogen temperature	$5·5 \times 10^{10}$	$3·5 \times 10^4$	6 × 0·5	ORP13
6·0 to 6·3	Indium antimonide at room temperature	2×10^8	1·0	6 × 0·5	ORP10
6·0 to 6·3	Indium antimonide at room temperature	$1·5 \times 10^8$	5·0	2 × 2	RPY77
6·0 to 6·3	As RPY77 but with sapphire window	$1·5 \times 10^8$	5·0	2 × 2	RPY78

Longer wavelength and other infrared detectors are available.

A range of phototransistors and photodiodes will be found in Book 1, Part 3 (Semiconductor devices).

Section E—PHOTOEMISSIVE TUBES

General purpose photoemissive tubes

Photocathode Surface	Spectral Response Curve	Filling	Sensitivity (μA/lm) at (V)		Max. Anode Supply Voltage (V)	Type No.
Caesium antimony	A (S11)	Vacuum	45	100	100	90AV
Caesium antimony	A (S11)	Gasfilled	130	85	90	90AG
Caesium antimony	A (S11)	Vacuum	45	85	100	92AV
Caesium antimony	A (S11)	Gasfilled	130	85	90	92AG
Caesium on oxidised silver	C (S1)	Vacuum	20	50	250	90CV
Caesium on oxidised silver	C (S1)	Gasfilled	125	90	90	90CG

Ultra-violet sensitive photoemissive tube

Description	Type No.
Gasfilled photoemissive tube with end-on incidence, sensitive to ultra-violet radiation and intended for use as an on-off device in flame-failure circuits	155UG

Photoemissive tubes for photometry

Photocathode Surface	Spectral Response Curve	Colour Response	Typical Sensitivity (μA/lm)	Max. Anode Supply Voltage (V)	Type No.
Caesium on oxidised silver	C (S1)	Red	20	100	150CV
Caesium antimony	A (S11)	Blue	60	100	150AV

Type 150TV is also available with type T(S20) response.

Section F—PHOTOMULTIPLIER TUBES

Photo-cathode Diameter (mm)	Photocathode Surface	Description	No. of Stages	Average Anode Sensitivity Sens. at Vb		Type No.
				(A/lm)	(kV)	
14	Caesium, antimony	Scintillation counting, small size	10	250	1·8	XP1110
14	Caesium, antimony	Scintillation counting and optical uses, small size	10	250	1·8	XP1115
14	Caesium on oxidised silver	Rugged construction. For industrial infrared equipment	10	20	1·8	XP1116
14	Sodium, potassium, caesium, antimony	Rugged construction. For laser applications	9	100	1·8	XP1117
21·5×56 rect. window	Caesium, antimony	For very short light pulses of high luminous flux	6	0·45	3·5	XP1143
32	Caesium, antimony	General purpose	10	700	1·8	150AVP
32	Caesium on oxidised silver	For infrared telecom-munications and instruments	10	100	1·8	150CVP
32	Caesium, antimony	Low noise. X-ray and gamma ray spectrometry	10	700	1·8	XP1010
42	Caesium, antimony	Nuclear physics	14	6 500	2·2	56AVP
42	Potassium, caesium, antimony	Spectrometry	14	—	—	56DVP·
42	Potassium, caesium, antimony	Spectrometry, quartz window (ultra-violet)	14	—	—	56DUVP
42	Sodium, potassium, caesium, antimony	Laser applications	14	11 500	2·5	56TVP
42	Sodium, potassium, caesium, antimony	Telecommunications. Quartz window (ultra-violet)	14	11 500	2·5	56TUVP
42	Caesium, antimony	Very fast light pulse detector	10	450	4·0	XP1210
42	Potassium, caesium antimony	For applications requiring good time resolution	12	—	—	XP2020
44	Sodium, potassium, caesium, antimony	For laser applications	10	400	1·8	XP1002
44	Potassium, caesium, antimony	Venetian blind for nuclear applications	10	60	1·8	XP2000
69	Potassium, caesium, antimony	Venetian blind for nuclear applications	10	60	1·8	XP2030
110	Caesium, antimony	Nuclear physics. Curved window surface	14	7 000	2·4	58AVP*
110	Potassium, caesium, antimony	Nuclear physics	14	4 500	2·25	58DVP*
200	Potassium, caesium, antimony	Scintillation counting large size	12	—	—	60DVP
200	Potassium, caesium, antimony	As 60DVP except for plano-concave adaptor and metal envelope	12	—	—	60DVP/H

*This tube is supplied with a plano-concave acrylate window.

Universal photoscintillator housing assembly

Description	Type No.
A probe-like mechanical system with provisions for mounting a photo-multiplier tube, a voltage divider, a limiter and either a scintillator or a light guide	S5600 series

Section G—CAMERA TUBES

Plumbicon camera tubes: Broadcast quality

Diameter (mm)	Description	Type No.
25	TV pick-up tubes with separate mesh and anti-halation glass disc	XQ1070 XQ1070L XQ1070R XQ1070G XQ1070B
25	Similar to XQ1070 series but without anti-halation glass disc	XQ1070/01 XQ1070/01L XQ1070/01R XQ1070/01G XQ1070/01B
25	TV pick-up tubes with separate mesh, anti-halation glass disc, anti-comet-tail electron gun, lightpipe and precision optical alignment. Rear-loading into coil	XQ1080 XQ1080L XQ1080R XQ1080G XQ1080B
25	Similar to XQ1080 series but front-loading and without the precision optical alignment	XQ1090 XQ1090L XQ1090R XQ1090G XQ1090B
25	Similar to XQ1090 series but without the anti-halation glass disc	XQ1100 XQ1100L XQ1100R XQ1100G XQ1100B
30	TV pick-up tubes with separate mesh and anti-halation glass disc capable of operating at high beam currents	XQ1020 XQ1020L XQ1020R XQ1020G XQ1020B

30	Similar to XQ1020 series but with extended red response	XQ1023 XQ1023L XQ1023R
30	Similar to XQ1023 series but with an infrared reflection filter incorporated in the anti-halation glass disc	XQ1025 XQ1025L XQ1025R

Plumbicon camera tubes: Industrial quality

Diameter (mm)	Description	Type No.
25	Industrial version of XQ1070 series, the principal difference being in the blemish specification	XQ1071 XQ1071R XQ1071G XQ1071B
25	Similar to XQ1071 series, but without anti-halation glass disc	XQ1071/01 XQ1071/01R XQ1071/01G XQ1071/01B
25	Industrial version of XQ1080 series, the principal difference being in the blemish specification. Rear-loading	XQ1081 XQ1081R XQ1081G XQ1081B
25	Industrial version of XQ1090 series, the principal difference being in the blemish specification. Front-loading	XQ1091 XQ1091R XQ1091G XQ1091B
25	Similar to XQ1091 series but without the anti-halation glass disc	XQ1101 XQ1101R XQ1101G XQ1101B
30	Industrial version of XQ1020 series, the principal difference being in the blemish specification	XQ1021 XQ1021R XQ1021G XQ1021B
30	Similar to XQ1021 series but with extended red response	XQ1024 XQ1024R
30	Medical application version of XQ1020 series for use with X-ray image intensifiers	XQ1022

Section G (cont.)
Vidicon camera tubes

Diameter (mm)	Description	Type No.
17·7	Low cost integral mesh industrial grade vidicon	20PE11
17·7	Low cost separate mesh industrial grade vidicon	20PE13
17·7	Low cost separate mesh industrial grade vidicon with electrostatic focus and magnetic deflection	20PE14
25	Low cost separate mesh industrial grade vidicon	XQ1032
25	Ruggedised separate mesh vidicon with electrostatic focus and deflection	XQ1010

Section H—IMAGE INTENSIFIER AND IMAGE CONVERTER TUBES
Image intensifier tubes

Description	Screen Diameter (mm)	Tube Resolution (lines pairs/mm)	Type No.
Self-focusing electrostatic image intensifier tube with fibre-optic windows for general purpose applications	25	60	XX1050
High gain self-focusing image intensifier assembly for very low light level applications	25	30	XX1060
Version of XX1060 suitable for operation with an oscillator of controlled regulation for automatic brightness control	25	30	XX1060/01
Similar to XX1060 but incorporating an integral oscillator with automatic brightness control	25	30	XX1063

Channel image intensifier tubes
Apply for data of new types of these tubes.

Image converter tube

Description	Screen Diameter (mm)	Tube Resolution (line pairs/mm)	Type No.
Self-focusing electrostatic image converter tube sensitive to infrared	14·5	50	6929

Section J—CHANNEL ELECTRON MULTIPLIERS

Channel electron multipliers

Description	Input Dimensions (mm)	Nominal Resistance (Ω)	Nominal Gain	Output	Type No.
Planar spiral tube	1·25 dia.	3×10^9	$1·3 \times 10^8$ at 3 kV	Open-ended Closed	B310AL B310BL
Planar spiral tube with rectangular aperture	2×8	3×10^9	$1·3 \times 10^8$ at 3 kV	Open-ended Closed	B312AL B312BL
Planar spiral tube with round aperture	4·0 dia.	3×10^9	$1·3 \times 10^8$ at 3 kV	Open-ended Closed	B318AL B318BL
C-shaped tube	1·25 dia.	3×10^9	$1·5 \times 10^8$ at 3 kV	Open-ended Closed	B330AL B330BL
Planar spiral tube	2·2 dia.	3×10^9	$1·5 \times 10^8$ at 2·5 kV	Open-ended Closed	B410AL B410BL
Planar spiral tube with round aperture	9·1 dia.	3×10^9	$1·7 \times 10^8$ at 2·5 kV	Open-ended Closed	B419AL B419BL

Bakable versions are available with suffix /01 added to the type number e.g. B310AL/01

Channel electron multiplier plate

Description	Type No.
An array of channel electron multipliers fused into the shape of a disc. Channel diameter 40µm. Channel pitch 50µm. Disc diameter 53 mm. Disc thickness 1·6 mm.	G40-50

Section K—GEIGER-MULLER TUBES

End window beta tubes

Window Diameter (mm)	Window Thickness (mg/cm^2)	Recommended Working Voltage (V)	Type No.
9	2 to 3	500	MX147
17	2·5 to 3	420	MX168
17	1·5 to 2·5	420	MX168/01
17	2·5 to 3	420	MX168/02
17	1·5 to 2	550	MX190
19·8	1·5 to 2	575	MX148
24·1	1·5 to 2·5	600	MX123
27·8	2·5 to 3·5	575	MX149
51	3·5 to 4	900	MX167/01

Gamma sensitive tubes

Sensitive Length (mm)	Recommended Working Voltage (V)	Type No.
40	500	MX146
46	425	MX180
140	420	MX120/01
240	420	MX145

High current tubes

Gamma Sensitivity at 10 mR/h (^{60}Co source) (counts/min)	Recommended Working Voltage (V)	Wall Thickness (mg/cm^2)	Type No.
250	550	80 to 100	MX163
1200	575	80 to 100	MX151
2300	400	400	MX188
5700	600	400	MX119
7200	575	32 to 40	MX164

Liquid sample tubes

Liquid Capacity (ml)	Recommended Working Voltage (V)	Type No.
4·6 to 7	420	MX142
9 to 10	450	MX124/01

X-ray sensitive tube

Description	Recommended Working Voltage (V)	Type No.
Efficiency is over 50% for wavelengths between 0·12 and 0·25 nm (1·2 to 2·5 Å)	1250	MX118

Section K (cont.)
Low background and guard tubes

Description	Window Diameter (mm)	Type No.
End window tube	19·8	MX152
End window tube	27·8	MX166
Guard tube	—	MX155

Section L—VACUUM PRODUCTS
Ionisation gauges

Description	Tubulation*	Pressure Range (torr)	Gauge Factor	Type No.
Evaporation ion pump incorporating Bayard-Alpert gauge	W	10^{-3} to 10^{-10}	12	EIP–12
Single filament Bayard-Alpert gauge	K	10^{-3} to 10^{-10}	12	IOG–12
Wide bore tubulation version of IOG–12	K	10^{-3} to 10^{-10}	12	IOG–12W/UKG2
Nude version of IOG–12	M	10^{-3} to 10^{-10}	12	IOG–13T
Fine-wire collector Bayard-Alpert gauge (nude)	M	10^{-3} to 4×10^{-11}	12	IOG–18N
Ionisation gauge	W	10^{-3} to 5×10^{-8}	20	IOG–71

*K = "Kovar" type sealing glass
W = Tungsten sealing glass
M = "Kovar" type metal skirt

Appendage vacuum pump

Description	Tubulation*	Pumping Speed (l/s)	Pressure Range (torr)	Type No.
Evaporation ion pump	W	0·4	10^{-3} to 10^{-11}	EIP–12

*W — Tungsten sealing glass

GENERAL SECTION A

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	...	...	
Triode...	...	...	t	Heptode	...	...	
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

Direct Voltage	...	...	V
Alternating Voltage (r.m.s.)		$V_{r.m.s.}$
Alternating Voltage (mean)		V_{av}
Alternating Voltage (peak)		v_{pk}
Peak Inverse Voltage	...	P.I.V.

Current

Direct Current	...	...	I
Alternating Current (r.m.s.)	$I_{r.m.s.}$
Alternating Current (mean)	I_{av}
Alternating Current (peak)	i_{pk}
No Signal Current ...	...	I_0

Miscellaneous

Frequency	...	...	f
Amplification Factor	...	μ
Mutual Conductance	...	g_m
Conversion Conductance...	g_c
Distortion ...	...	...	D

Anode Efficiency	...	..	η
Sensitivity	...	...	...	S
Brightness	...	...	...	B
Temperature '	...	...	T
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	Anode Current (A.C. r.m.s.)	$I_{a(r.m.s.)}$
Control-Grid Voltage	V_{g1}	No Signal Anode Current	$I_{a(o)}$
Anode Supply Voltage	$V_{a(b)}$	Control-Grid Current	I_{g1}
Filament Voltage	V_f	Total Distortion	D_{tot}
Heater Voltage	V_h	3rd Harmonic Distortion	D_3
Anode Dissipation	p_a	Equivalent Noise	
Output Power	P_{out}	Resistance	R_{eq}
Drive Power	P_{drive}	Limiting Resistor	R_{lim}
Anode Current (D.C.)	I_a	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}	

Mullard

A new comprehensive type nomenclature system for transmitting and industrial valves and tubes has recently been introduced. In general, new Mullard devices will have type numbers in the 'new system', earlier devices will retain numbers in one of the 'old systems'.

NEW SYSTEM

The type number for valves or tubes used primarily in 'professional' applications (e.g. transmitters, navigation or communication equipment, industrial applications) consists of two letters followed by four figures. This system does not apply to receiving-type valves.

The first letter indicates a fundamental characteristic of the device:

X—photosensitive tube

Y—vacuum valve or tube (except photodevices)

Z—gasfilled valve or tube (except photodevices)

The second letter indicates the construction or application of the device :

A—diode

C—trigger tube

D—triode or double triode

G—miscellaneous

H—travelling wave tube

J—magnetron

K—klystron

L—tetrode, pentode, double tetrode or double pentode

M—cold cathode indicator or counter tube

P—photomultiplier tube or radiation counter tube

Q—camera tube

T—thyratron

X—ignitron, image intensifier or image converter

Y—rectifier

Z—voltage stabiliser or reference tube

The group of four figures is a serial number. The last figure is 0 for basic types; variants of the basic type are indicated by the figures 1 to 9.

Example

YL1030   Transmitting double tetrode

Receiving-type valves

The type number of receiving valves used primarily in 'professional' applications is similar to that for normal receiving valves except that there are four figures instead of two or three. The letters and first figure have the same significance as in the receiving valve type numbering system.

Example

EC1000   Triode for professional applications, special base, 6.3V heater

OLD SYSTEMS

Transmitting and large industrial valves and tubes

The type number generally consists of two or more letters followed by two sets of figures. These symbols provide information concerning the principal uses and ratings of the valves according to the following code.

The first letter indicates the general functional class of valve:

B—backward wave tube

J—magnetron

K—klystron

L—travelling wave tube

M—l.f. amplifying or modulator triode

P—r.f. power pentode

Q—r.f. power tetrode

R—power rectifier

T—r.f. power triode

X—large thyratron. (All hydrogen thyratrons and other thyratrons having max. mean anode current of 500mA or more.)

Note.—For valves having dual electrode systems, the code letters for both systems are used, e.g. 'QQ' for a double tetrode.

The second letter indicates some structural property in each class of valve:

(a) For transmitting valves and vacuum rectifiers, the type of cathode.

(b) For thyratrons and gasfilled rectifiers, the type of gas present.

(c) For microwave devices, a basic structural feature.

A—outputs up to 1W   ⎫ In backward wave and travelling

B—outputs of 1W and over ⎬   wave tubes

D—disc-seal construction

G—mercury-vapour filled

H—hydrogen-filled

N—external magnet required (in magnetrons)

P—packaged construction (in magnetrons)

R—inert-gas filled

S—reflex (single resonator) construction (in klystrons)

T—multiple resonator construction (in klystrons)

V—indirectly heated oxide-coated cathode

X—directly heated tungsten filament

Y—directly heated thoriated-tungsten filament

Z—directly heated oxide-coated filament

The third letter

Transmitting valves with a silica envelope have a third letter 'S'.
Thyratrons with a shield grid (tetrode construction) have a third letter 'Q'.
Microwave devices that are tunable have a third letter 'T'.

The first group of figures, immediately following the letters, indicates:

(a) The approximate anode voltage in kV for transmitting valves and rectifiers:

Thus 05 represents 0.5kV = 500V

2 represents 2kV = 2000V

For valves intended for pulse operation this figure is the peak anode voltage in kV.

(b) The approximate peak inverse voltage in kV for thyratrons.

(c) The approximate frequency of operation in Gc/s for magnetrons, klystrons, backward wave tubes and travelling wave tubes:

Thus 9 represents 9Gc/s = 9000Mc/s.

The second group of figures indicates:

(a) For transmitting valves, the maximum permissible anode dissipation in W. For dissipations of 10kW or more the dissipation in kW is given.

(b) For transmitting valves primarily intended for pulse operation this group is prefixed by the letter 'P' and the figures indicate the maximum peak current in amps.

(c) For backward wave and travelling wave tubes, the output power in mW or W depending on the second letter ('A' or 'B').

(d) For magnetrons, the pulse power output in kW.

(e) For klystrons, the power output in mW.

(f) For rectifiers, the approximate rectifier output current in mA.

(g) For thyratrons, the approximate maximum permissible mean anode current in mA. This group consists of at least three digits, the first one being 0 if the current is between 10 and 100mA. For currents of 10A or more the current in amps is given.

Thus 045 represents 45mA

6400 represents 6400mA = 6.4A

12 represents 12A

A final letter occasionally follows the second group of figures. This is usually a serial letter to denote a particular design or development. Types designed for water cooling are indicated by the letter 'W' and if these types also have a forced air-cooled version this is indicated by the letter 'A'.

Examples

JP9-7   Magnetron with packaged construction for operation at a frequency of approximately 9000Mc/s with pulse power output of 7kW.

KS9-20   Klystron of reflex construction for operation at a frequency of approximately 9000Mc/s with a power output of 20mW.

LA4-250   Travelling wave tube for operation at a frequency of approximately 4000Mc/s with an output of 250mW.

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QQV03-10   Double beam tetrode with indirectly heated oxide-coated cathode. Rated to work at 300V and to dissipate 10W continuously (5W at each anode).

QV20-P18   R.F. power tetrode with indirectly heated oxide-coated cathode. Designed for pulse operation with maximum peak anode voltage of 20kV and maximum peak anode current of 18A.

RG3-250   Mercury-vapour rectifier rated to work at 3kV and to give a maximum rectified output of 250mA.

XG5-500   Mercury-vapour thyratron having a rated peak inverse voltage of approximately 5kV and a maximum permissible mean anode current of approximately 500mA.

Cold cathode tubes

The type number for cold cathode tubes (excluding photocells and stabilisers) consists of one letter followed by a group of three figures which are followed by a second letter.

The first letter is always Z, indicating a cold cathode gasfilled tube.

The first figure indicates the type of base, the significance of the figure being the same as for Mullard receiving valves.

The second and third figures are serial numbers indicating a particular design or development.

The second letter indicates the function of the tube:

        A—*amplifier tube (continuous operation)*

        B—binary counter of switching tube

        C—multistage counter tube

        E—electrometer trigger or amplifier tube

        G—gating tube

        M—indicator (metering) tube

        S—multistage switching tube

        T—3-electrode trigger tube

        U—4-electrode trigger tube

        W—5-electrode trigger tube

Example

        Z803U   4-electrode cold cathode trigger tube with B9A base.

CATHODE RAY TUBES

B

Mullard cathode ray tubes are normally registered with Pro-Electron. The type number consists of a single letter followed by two sets of figures ending with one or two letters.

The first letter indicates the primary application of the tube:

A — television display tube for domestic applications.
D — oscilloscope tube—single trace.
E — oscilloscope tube—multiple trace.
F — radar display tube—direct viewing.
L — display storage tube.
M — professional television or display tube (except radar) —direct viewing.
P — professional display tube—projection.
Q — flying spot scanner.

The first group of figures indicates the diameter or diagonal of the lumines-cent screen in cm:

Thus   7 represents a 7cm (3in) screen.
13 represents a 13cm (5in) screen.
47 represents a 47cm (19in) screen.
59 represents a 59cm (23in) screen.

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

The second group of letters indicates the properties of the phosphor screen.

The first letter denotes the colour of the fluorescence (or phosphores-cence in the case of long or very long afterglow screens) according to the regions of the Kelly Chart of Colour Designations for Lights, where applicable:

A — Reddish-purple, purple, bluish-purple.
B — Purplish-blue, blue, greenish-blue.
D — Blue-green.
G — Bluish-green, green, yellowish-green.
K — Yellow-green.
L — Orange, orange-pink.
R — Reddish-orange, red, pink, purplish-pink, purplish-red, red-purple.
W — White.
X — Tri-colour screen.
Y — Greenish-yellow, yellow, yellowish-orange.

The second letter is a serial letter to denote particular phosphors. For the 'standard' television picture tube phosphors, the letters 'W' and 'X' are used without a second letter. The current Mullard phosphors are listed overleaf.

An **internal graticule** is indicated by a two-figure suffix separated from the final letter by an oblique stroke, for example, D13-450GH/01.

Examples:

A47-26W   Domestic television picture tube with 47cm (19in) screen.
D7-190GH   Single trace oscilloscope tube having 7cm screen with phosphor 'GH'.

OLD SYSTEM

Some earlier cathode ray tubes have type numbers consisting of two letters followed by two sets of figures.

The first letter indicates the method of deflection and focusing:

A — Electrostatic focusing, magnetic deflection.
D — Electrostatic focusing and deflection.
M — Magnetic focusing and deflection.

The second letter indicates a particular phosphor. Letters in use are listed below.

The first group of figures immediately following the letters, indicates the diameter or diagonal of the luminescent screen in cm.

The second group of figures is a serial number indicating a particular design or development.

Examples:

AW53-88   Cathode ray tube of 53cm screen diagonal having a 'W' phosphor and employing magnetic deflection and electrostatic focusing.

DH3-91   Cathode ray tube of 3cm screen diameter having an 'H' phosphor and employing electrostatic deflection and focusing.

DESIGNATION OF MULLARD PHOSPHORS

Pro-Electron designation	Old system	Fluorescent colour	Phosphorescent colour	Persistence	Equivalent JEDEC designation
BA	C	Purplish-blue	—	Very short	—
BC	V	Purplish-blue	—	Killed	—
BD	A	Blue	—	Very short	—
BE	B	Blue	Blue	Medium short	P11
BF	U	Blue	—	Medium short	—
GB	M	Purplish-blue	Yellowish-green	Long	P32
GE	K	Green	Green	Short	P24
GH	H	Green	Green	Medium short	P31
GJ	G	Yellowish-green	Yellowish-green	Medium	P1
GK	G*	Yellowish-green	Yellowish-green	Medium	—
GL	N	Yellowish-green	Yellowish-green	Medium short	P2
GM	P	Purplish-blue	Yellowish-green	Long	P7
GN	J	Blue	Green (Infra-red excited)	Medium short (fluorescence)	—
GP	—	Bluish-green	Green	Medium short	P2
KA	—	Yellow-green	Yellow-green	Medium	P20
LA	D	Orange	Orange	Medium	—
LB	E	Orange	Orange	Long	—
LC	F	Orange	Orange	Very Long	—
LD	L	Orange	Orange	Very Long	P33
W	W	White	—	—	P4
X	X	Tri-colour screen	—	—	P22
YA	Y	Yellowish-orange	Yellowish-orange	Medium	—

*Used in projection tubes.

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The following recommendations should be interpreted in conjunction with British Standard Code of Practice No. CP1005: (1962), 'The Use of Electronic Valves', upon which these notes have, in part, been based.

RATING SYSTEMS (in accordance with I.E.C. Publication 134)

Note: Limiting conditions may be either maxima or minima.

Absolute maximum rating system

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

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

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

Design-maximum rating system

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

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

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

Design-centre rating system

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

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

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

HEATER

Parallel operation

The heater voltage must be within ±7% of the rated value when the supply voltage is at its nominal rated value, and when a tube having the published heater character-istics is employed.

This figure is permissible only if the voltage variation is dependent upon more than one factor. In these circumstances the total tolerance may be taken as the square root of the sum of the squares of the individual deviations arising from the effects of the tolerances of the separate factors, providing no one of these deviations exceeds ±5%. Should the voltage variation depend on one factor only, the voltage variation must not exceed ±5%.

Series operation

The heater current must be within ±5% of the rated value when the supply voltage is at its nominal rated value, and when a tube having the published heater characteristics is employed.

This figure is permissible only if the current variation is dependent upon more than one factor. In these circumstances the total tolerance may be taken as the square root of the sum of the squares of the individual deviations arising from the effects of the tolerances of the separate factors, providing no one of these deviations exceeds ±3·5%. Should the total current variation depend upon one factor only, the current variation must not exceed ±3·5%.

When calculating the tolerances of associated components, the ratio of the change of heater voltage to the change of heater current in a typical series chain including a cathode ray tube is taken as 1·8, both deviations being expressed as percentages.

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

Mains variations

In addition to the tolerances quoted above, fluctuations in the mains supply voltage not exceeding ±10% are permissible. These conditions are, however, the worst which are acceptable and it is better practice to maintain the heater as close as possible to its published nominal.

Furthermore, in all types of equipment closer adjustment of heater voltage or current will react favourably upon valve and tube life and performance.

CATHODE

The potential difference between cathode and heater should be as low as possible and in any case must not exceed the limiting value given on the data sheets for individual tubes. Operation with the heater positive with respect to cathode is not recommended. In order to avoid excessive hum the a.c. component of the heater-to-cathode voltage

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should be as low as possible and should be less than $20V_{r.m.s.}$. When the heater is in a series chain or earthed, the 50Hz impedance between heater and cathode should not exceed 100kΩ. If the heater is supplied from a separate transformer winding the resistance between heater and cathode should not exceed 1MΩ.

INTERMEDIATE ELECTRODES (between cathode and final anode)

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

However, no electrode should be connected directly to a high energy source such as the h.t. line. When such a connection is required, it should be made via a series resistor of not less than 1kΩ.

Except where indicated for cathode drive service, voltages are with respect to cathode.

Grid cut-off voltages

The values showing the limits of grid cut-off voltage for specific values of first anode voltage are included in the data for individual tubes. The brightness control should be arranged so that it can handle any tube within limits shown at the appropriate first anode voltage (which is measured with respect to the cathode).

First accelerator voltage

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

Deflection blanking electrode voltage

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

Focusing voltage

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

Astigmatism control electrode voltage

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

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Beam centring electrode voltage

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

Deflection plate shield voltage

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

Geometry control electrode voltage

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

Deflection voltages

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

Raster distortion and its determination

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

Measuring procedure:—

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

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

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

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

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

(*f*) Pattern geometry correction will be adjusted for optimum performance in the sense of minimising simultaneously the deviation of the centre of x- respective to y-trace.

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Linearity

The linearity is defined as the difference between the sensitivity at a deflection of 75% of the useful scan and the sensitivity at a deflection of 25% of the useful scan. These sensitivities will not differ by more than the indicated value.

Post deflection shield voltage

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

Helix resistance

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

FINAL ACCELERATOR VOLTAGE

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

HIGH TENSION SUPPLY

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

LINE WIDTH

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

CAPACITANCES

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

LUMINESCENT SCREEN

To prevent damage to the screen material, care should be taken not to operate oscilloscope tubes with a stationary or slowly moving spot except at extremely low beam current. If measurements are to be made under high ambient light conditions it is advisable to use a contrast improving filter and/or a light hood.

TRACKING ERROR

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

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MOUNTING

Unless otherwise specified there is no restriction on the mounting position. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

SHIELDING

It is desirable that tubes should not be exposed to strong electrostatic and magnetic fields and a close fitting magnetic shield is generally necessary for electrostatic instrument tubes.

DIMENSIONS

Allowance should be made in the design of the equipment for the dimensional tolerances of the tube envelope and reliance should not be placed upon dimensions taken from individual tubes.

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE FOR TYPE BA
LUMINESCENT SCREEN

PERSISTENCE CHARACTERISTIC CURVE FOR TYPE BA
LUMINESCENT SCREEN

Mullard

D1605

LUMINANCE PLOTTED AGAINST CURRENT DENSITY
FOR TYPE BA LUMINESCENT SCREEN

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE BE LUMINESCENT SCREEN

Mullard

CATHODE RAY TUBE
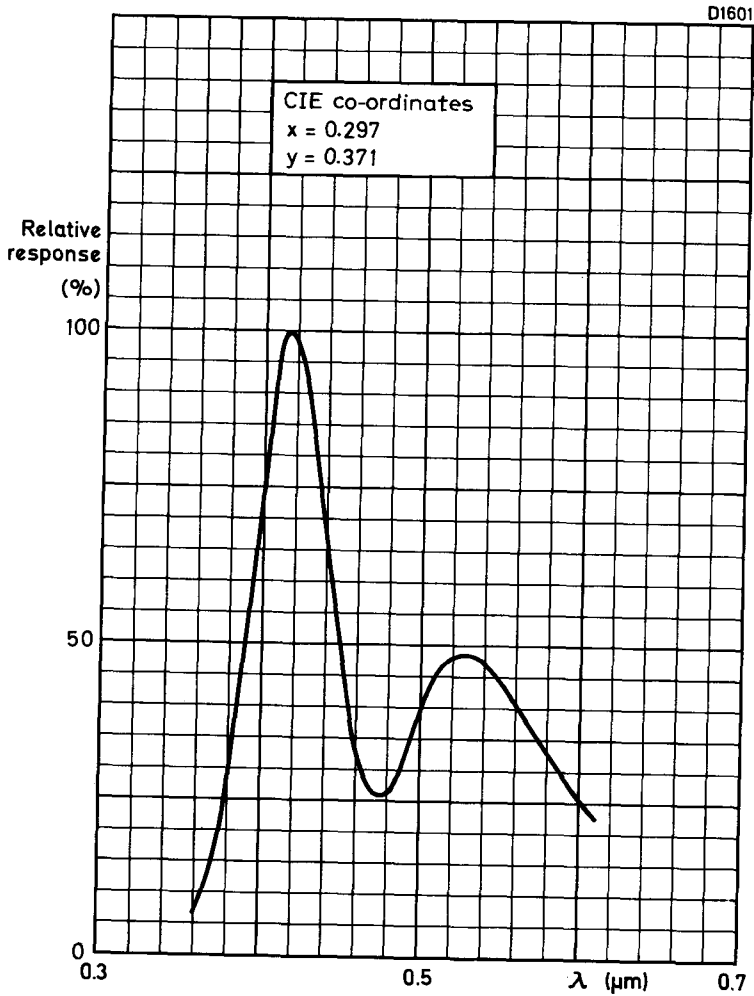# SCREEN TYPE BE(B)

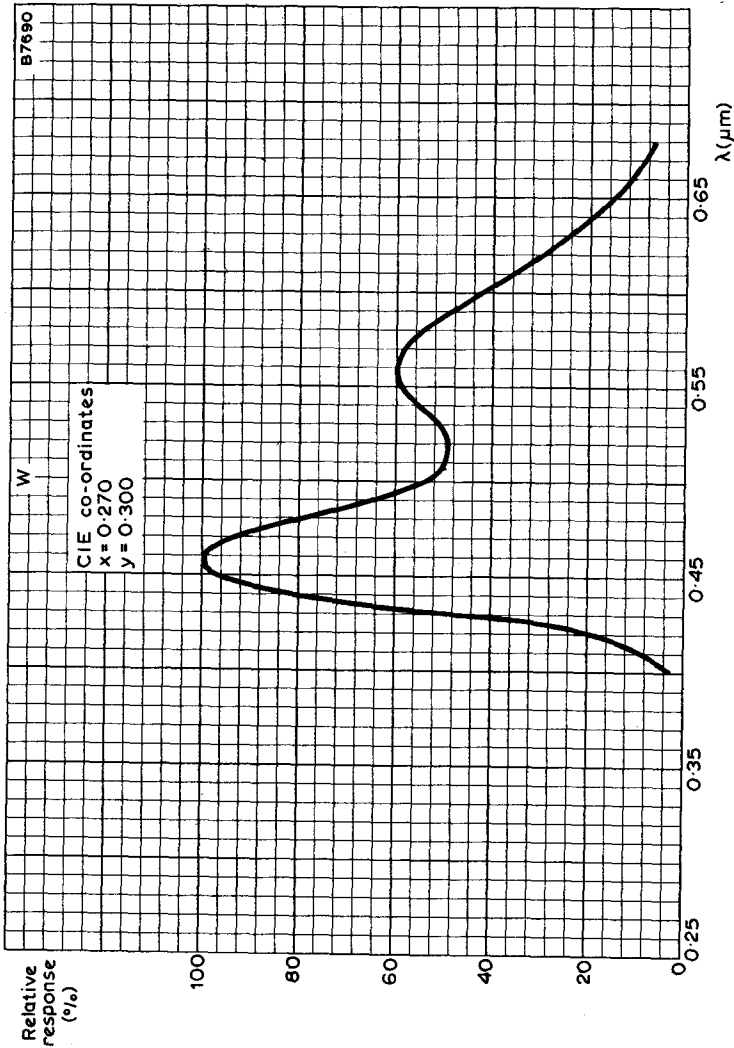B7683

BE

V screen : 1·5 to 5kV
I screen : 20μA peak
Excitation : Single focused spot
Pulse duration : 0·2μs
At lower screen voltage, lower
screen loading or longer
excitation time, the decay
time will be longer.

Relative luminance (%)

100   10   1   0·1   0·01

Time after cessation of excitation (μs)

10   10²   10³   10⁴   10⁵

PERSISTENCE CHARACTERISTIC CURVE
FOR TYPE BE LUMINESCENT SCREEN

Mullard

B7680

High brightness
CIE co-ordinates
x = 0·193
y = 0·420

Low brightness
CIE co-ordinates
x = 0·245
y = 0·523

—— High brightness

- - - Low brightness

$\lambda\,(\mu m)$

GH

Relative response (%)

**RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE GH LUMINESCENT SCREEN**

—————————— **Mullard** ——————————

CATHODE RAY TUBE
SCREEN TYPE GH(H)

B7681

V screen: 4kV
Excitation: Single focused spot
A) I screen: 20μA peak
   Pulse duration: 2μs
B) I screen: 1μA peak
   Pulse duration: 10ms
At lower screen voltage, lower
screen loading or longer excitation
time, the decay time will be longer.

GH

Relative luminance (%)

Time after cessation of excitation (μs)

PERSISTENCE CHARACTERISTIC CURVE
FOR TYPE GH LUMINESCENT SCREEN

Mullard

B7684

GJ

CIE co-ordinates
x = 0·218
y = 0·712

Relative response (%)

$\lambda (\mu m)$

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE GJ LUMINESCENT SCREEN

Mullard

CATHODE RAY TUBE
SCREEN TYPE GJ(G)

Graph labels:
- GJ
- B7685
- Vscreen=3kV
- Iscreen = 25μA(peak)
- Excitation=Single,focused spot
- The decay time is independent of screen voltage, screen loading and excitation

Y-axis: Relative luminance (%) — values 100, 10, 1, 0·1

X-axis: Time after cessation of excitation (ms) — values 0, 10, 20, 30, 40

PERSISTENCE CHARACTERISTIC CURVE
FOR TYPE GJ LUMINESCENT SCREEN

Mullard

B7686

GM

CIE co-ordinates
x = 0·151, 0·357
y = 0·032, 0·537

λ(μm)

0·65   0·55   0·45   0·35   0·25

Relative response (%)

100   80   60   40   20   0

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE GM LUMINESCENT SCREEN

Mullard

CATHODE RAY TUBE
SCREEN TYPE GM(P)

PERSISTENCE CHARACTERISTIC CURVE
FOR TYPE GM LUMINESCENT SCREEN

Mullard

B7688

GP

CIE Co-ordinates
x = 0·180
y = 0·365

λ (μm)

0·65 0·55 0·45 0·35 0·25

Relative response (%)

100 80 60 40 20 0

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE GP LUMINESCENT SCREEN

Mullard

CATHODE RAY TUBE
SCREEN TYPE GP

PERSISTENCE CHARACTERISTIC CURVE
FOR TYPE GP LUMINESCENT SCREEN

Mullard

D1601

CIE co-ordinates
x = 0.297
y = 0.371

Relative response (%)

100

50

0

0.3   0.5 λ (µm)   0.7

RELATIVE SPECTRAL ENERGY DISTRIBUTION
CURVE FOR TYPE GU LUMINESCENT SCREEN

Mullard

100

Relative
luminance
(%)

50

20

10

5

2

1

0   500   1000

Time after cessation of excitation (ns)

PERSISTENCE CHARACTERISTIC CURVE FOR TYPE
GU LUMINESCENT SCREEN

Mullard

B7690

CIE co-ordinates
x = 0·270
y = 0·300

W

Relative response (%)

λ (μm)

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE W LUMINESCENT SCREEN

Mullard

OSCILLOSCOPE TUBE   D7-190GH

QUICK REFERENCE DATA

7 cm (3.0 in) diameter, flat faced mono-accelerator oscilloscope tube, primarily intended for use in inexpensive oscilloscopes and read-out devices.

Final anode voltage	1.0	kV
Display area	50×60	mm
Deflection factor y	11.5	V/cm
Deflector factor x	29	V/cm

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode and astigmatism control electrode (see note 1)	$V_{a1,a3,s1}$	1000 ± 25	V
Focus electrode	V_{a2}	100 to 180	V
Control grid (for visual cut-off)	max.	-35	V
Average grid drive ($I_t = 10\mu A$) (approx.)	ΔV_g	10	V

Line width (see note 2)

$V_{a1,a3,s1}$	1.0	kV
V_{a2}	adjusted for optimum line width	
$V_{y1} = V_{y2}$	1.0	kV
V_{x1}	300	V
V_{x2}	700	V
I_{x2}	10	μA
V_g	adjusted for I_{x2} value stated	
*Line width	0.28	mm

*Measured by the shrinking raster method in the centre of the screen.

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Raster distortion

A graticule, consisting of concentric rectangles 50×40mm and 49×39.2mm is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage	V_y mean	1.0	kV
Mean x-plate voltage	V_x mean	1.0	kV
Vertical deflection factor	S_y av.	11.5	V/cm
	max.	12.5	V/cm
Horizontal deflection factor	S_x av.	29	V/cm
	max.	31	V/cm
Angle between x and y traces		90 ±1	deg

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than 1%.

CORRECTION POTENTIAL RANGES

Astigmatism control range	$\Delta V_{a1,a3,s1}$	±25	V

SCREEN

Phosphor		GH
Fluorescent colour		green
Phosphorescent colour		green
Persistence		medium short
Minimum useful screen diameter		64	mm

Minimum useful scan (at $V_{a1,a3,s1} = 1.0$kV)

$y_1 - y_2$	50	mm
$x_1 - x_2$	60	mm

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

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OSCILLOSCOPE TUBE   # D7-190GH

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a1,a3,s1}$ max.	2.2	kV
$V_{a1,a3,s1}$ min.	0.9	kV
V_{a2} max.	2.2	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	±125	V
p_t max.	3.0	mW/cm^2

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	~	4.0
g	all	~	5.5
x_1	all	x_2	4.0
x_2	all	x_1	4.0
y_1	all	y_2	3.5
y_2	all	y_1	3.0
x_1	x_2	all	1.6
y_1	y_2	all	1.1

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)	260	g

ACCESSORIES

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

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NOTES

1. The astigmatism control voltage should be adjusted for optimum spot shape. The range stated will apply if the mean x and y plate potentials are equal to $V_{a1,a3,s1}$, with no astigmatism adjustment.

2. As the construction of the tube does not permit a direct measurement of the beam current, this current should be determined as follows:

   (a) Under typical operating conditions display a small raster with no overscan, adjust V_g for a beam current of approximately $10\mu A$ and V_{a2} and $V_{a1,a3,s1}$ for optimum spot quality in the centre of the screen.

   (b) Remove the raster and adjust the deflection plate voltages to the values stated under 'Line width', thus directing the total beam current to x2. Measure I_{x2} and adjust V_g so that $I_{x2} = 10\mu A$.

   (c) Return to the conditions under (a) but without adjustment of V_g or $V_{a1,a3,s1}$. This results in a raster at a true beam current of $10\mu A$.

   (d) Adjust V_{a2} for optimum focus in the centre of the screen and measure the line width. Do not readjust $V_{a1,a3,s1}$.

Mullard

OSCILLOSCOPE TUBE

D7-190GH

OUTLINE DRAWING OF D7-190GH

B7550

All dimensions in mm.

Orientation of axes of deflection
as viewed from screen end

As viewed from base end
Special 14 pin base

Mullard

OSCILLOSCOPE TUBE
D10-160GH

QUICK REFERENCE DATA

10cm (4.0in) diameter, flat faced mono-accelerator oscilloscope tube, primarily intended for use in inexpensive oscilloscopes and read-out devices.

Final anode voltage	1.5	kV
Display area	60×80	mm
Deflection factor y	13.7	V/cm
Deflection factor x	32	V/cm

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode and astigmatism control electrode (see note 1)	$V_{a1,a3,s1}$	1500 ±30	V
Focus electrode	V_{a2}	140 to 275	V
Control grid (for visual cut-off)	V_g max.	~50	V
Average grid drive ($I_t = 10\mu A$) (approx.)	ΔV_g	10	V

Line width (see note 2)

$V_{a1,a3,s1}$	1.5	kV
V_{a2}	adjusted for optimum line width	
$V_{y1} = V_{y2}$	1.5	kV
V_{x1}	800	V
V_{x2}	1.2	kV
I_{x2}	10	μA
V_g	adjusted for I_{x2} value stated	
*Line width	0.27	mm

*Measured by the shrinking raster method in the centre of the screen.

Mullard

Raster distortion

A graticule, consisting of concentric rectangles $60 \times 50mm$ and $58.6 \times 49mm$ is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage	V_y mean		1.5	kV
Mean x-plate voltage	V_x mean		1.5	kV
Vertical deflection factor	S_y	av.	13.7	V/cm
		max.	14.5	V/cm
Horizontal deflection factor	S_x	av.	32	V/cm
		max.	34	V/cm
Angle between x and y traces			90 ±1	deg

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than 1%.

CORRECTION POTENTIAL RANGE

Astigmatism control range	$\Delta V_{a1,a3,s1}$	±30	V

SCREEN

Phosphor	GH	
Fluorescent colour	green	
Phosphorescent colour	green	
Persistence	medium short	
Minimum useful screen diameter	85	mm
Minimum useful scan (at $V_{a1,a3,s1} = 1.5kV$)		
$y_1 - y_2$	60	mm
$x_1 - x_2$	80	mm

The useful scan may be shifted vertically to a maximum of 5mm with respect to the geometric centre of the tube face.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a1,a3,s1}$ max.	2.2	kV
$V_{a1,a3,s1}$ min.	1.35	kV
V_{a2} max.	2.2	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	±125	V
p_t max.	3.0	mW/cm^2

Mullard

OSCILLOSCOPE TUBE

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	–	4.0
g	all	–	5.5
x_1	all	x_2	4.0
x_2	all	x_1	4.0
y_1	all	y_2	3.5
y_2	all	y_1	3.0
x_1	x_2	all	1.6
y_1	y_2	all	1.1

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)   400   g

ACCESSORIES

Socket (supplied with the tube)   55566

Mu-metal shield   55547

NOTES

1. The astigmatism control voltage should be adjusted for optimum spot shape. The range stated will apply if the mean x and y plate potentials are equal to $V_{a1,a3,s1}$, with no astigmatism adjustment.

2. As the construction of the tube does not permit a direct measurement of the beam current, this current should be determined as follows:

   (a) Under typical operating conditions display a small raster with no overscan, adjust V_g for a beam current of approximately $10\mu A$ and V_{a2} and $V_{a1,a3,s1}$ for optimum spot quality in the centre of the screen.

   (b) Remove the raster and adjust the deflection plate voltages to the values stated under 'Line width', thus directing the total beam current to x2. Measure I_{x2} and adjust V_g so that $I_{x2} = 10\mu A$.

   (c) Return to the conditions under (a) but without adjustment of V_g or $V_{a1,a3,s1}$. This results in a raster at a true beam current of $10\mu A$.

   (d) Adjust V_{a2} for optimum focus in the centre of the screen and measure the line width. Do not readjust $V_{a1,a3,s1}$.

Mullard

B7552

$\emptyset100$ ±2

40 ±10

117 ±5

$\emptyset61$

236 ±5

260 max.

$\emptyset51$ ±1.5

6·0 ±0·6

19 max

y_1
x_1
y_2
x_2
a_2
a_1, a_3, s_1
g
k h h

All dimensions in mm

y | trace

x_1 x_2 pin1
y_1
x trace
y_2
18° ±10°
pin 14

Orientation of axes of deflection
as viewed from screen end

x_1 k a_2 a_1, a_3, s_1
IC 6 7 8 9 y_1
  5 10
x_2 4 11 IC
g 3 12 y_2
IC 2 1 14 13 IC
  h h

As viewed from base end
Special 14 pin base

Mullard

D10-160GH Page 4

OSCILLOSCOPE TUBE

D10-170GH

<table>
<tr><td colspan="3" align="center">QUICK REFERENCE DATA</td></tr>
<tr><td colspan="3">10cm (4in) diameter flat-faced oscilloscope tube with mesh, intended for use in transistorised oscilloscopes up to 30MHz.</td></tr>
<tr><td>Final anode voltage (p.d.a.)</td><td>6.0</td><td>kV</td></tr>
<tr><td>Display area (at $V_{a4} = 6.0V_{a1,a3}$)</td><td>60 × 80</td><td>mm</td></tr>
<tr><td>Deflection factor y</td><td>3.5</td><td>V/cm</td></tr>
<tr><td>Deflection factor x</td><td>13</td><td>V/cm</td></tr>
</table>

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode + luminescent screen	V_{a4}	6.0	kV
Geometry control electrode and interplate shield (see note 1)	V_{s2}	1000 ±15	V
Deflection plate shield (see note 2)	V_{s1}	1000	V
Focus electrode	V_{a2}	170 to 230	V
First accelerator and astigmatism control electrode (see note 3)	$V_{a1,a3}$	1000 ±30	V
Control grid (for visual cut-off)	V_g	-16 to -40	V

Line width

V_{a4}	6.0	kV
V_{s2}	1.0	kV
V_{s1}	1.0	kV
$V_{a1,a3}$	1.0	kV
I_t	10	μA
*Line width	0.42	mm

*Measured by the shrinking raster method over the whole screen area.

Mullard

Raster distortion

A graticule consisting of concentric rectangles $60 \times 60\text{mm}$ and $58.6 \times 58.6\text{mm}$ is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage (see note 2)	V_y mean	1.0	kV
Mean x-plate voltage (see note 2)	V_x mean	1.0	kV
Vertical deflection factor	S_y	av. 3.5	V/cm
		max. 3.8	V/cm
Horizontal deflection factor	S_x	av. 13	V/cm
		max. 14	V/cm
Angle between x and y traces		$90^{\circ} \pm 45'$	

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

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

CORRECTION POTENTIAL RANGES

Astigmatism control range (see note 3)	$\Delta V_{a1,a3}$	± 30	V
Geometry control range (see note 1)	ΔV_{s2}	± 15	V

SCREEN

Phosphor	GH	
Fluorescent colour	green	
Phosphorescent colour	green	
Persistence	medium short	
Minimum useful screen diameter	85	mm
Minimum useful scan (at $V_{a4} = 6.0 V_{a1,a3}$)		
$y_1 - y_2$	60	mm
$x_1 - x_2$	80	mm

The useful scan may be shifted vertically to a maximum of 5mm with respect to the geometric centre of the tube face.

Mullard

OSCILLOSCOPE TUBE   D10-170GH

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a4} max. (p.d.a.)	6.6	kV
V_{a4} min.	4.0	kV
V_{s2} max.	2.2	kV
V_{s1} max.	2.2	kV
V_{a2} max.	2.2	kV
$V_{a1,a3}$ max.	2.2	kV
$V_{a1,a3}$ min.	900	V
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	±125	V
$v_{x(a1,a3)pk}$ max.	500	V
$v_{y(a1,a3)pk}$ max.	500	V
P_t max.	3.0	mW/cm^2
Ratio $V_{a4}/V_{a1,a3}$ max.	6.0	

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	-	5.0
g	all	-	6.0
x_1	all	x_2	7.0
x_2	all	x_1	7.0
y_1	all	y_2	5.0
y_2	all	y_1	5.0
x_1	x_2	all	2.5
y_1	y_2	all	1.5

Mullard

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT
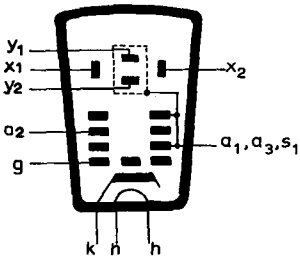
Tube alone (approx.)   500   g

ACCESSORIES

Socket (supplied with the tube)   55566

a4 connector (cavity connector CT8)   55563

Mu-metal shield   55548

NOTES

1. The tube is designed for optimum performance when operating at a ratio $V_{a4}/V_{a1,a3} \leq 6.0$. The geometry control electrode voltage (V_{s2}) should be adjusted between -15V and +15V with respect to the mean x-plate potential.

A negative control voltage will give some pin-cushion distortion with less background light, and a positive voltage will give some barrel distortion and a slight increase in background light.

2. The deflection plate shield voltage (V_{s1}) should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

3. The astigmatism control should be adjusted within the stated range for optimum spot shape.

OSCILLOSCOPE TUBE   D10-170GH

OUTLINE DRAWING OF D10-170GH

B8895

Cavity connector CT8

ø100 ±2
28 ±5
40 ±10
173 ±10
ø61
311·5 ±4·5
335 max
ø51 ±1·5
6·0 ±0·6
19 max

All dimensions in mm

a4
y1
x1
y2 s1
a2
g
s2
x2
a1, a3
k h h

y trace
0° ± 10°
a4
x1   x2
y1
y2
pin 1
x trace
18 ± 10°
pin 14

Orientation of axes of deflection
as viewed from screen end

x1 k a2
IC
a1, a3
y1
s2
x2
y2
g
s1 h h IC

As viewed from base end
Special 14 pin base

Mullard

OSCILLOSCOPE TUBE   **D13-480GH**

QUICK REFERENCE DATA

13cm (5.0in) diameter, flat faced mono-accelerator oscilloscope tube, primarily intended for use in inexpensive oscilloscopes and read-out devices.

Final anode voltage	2.0	kV
Display area	80 × 100	mm
Deflection factor y	14.4	V/cm
Deflection factor x	31.3	V/cm

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	.6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode and astigmatism control electrode (see note 1)	$V_{a1,a3,s1}$	2000 ±50	V
Focus electrode	V_{a2}	220 to 370	V
Control grid (for visual cut-off)	V_g max.	−65	V
Average grid drive ($I_t = 10\mu A$) (approx.)	ΔV_g	10	V

Line width (see note 2)

$V_{a1,a3,s1}$	2.0	kV
V_{a2}	adjusted for optimum line width	
$V_{y1} = V_{y2}$	2.0	kV
V_{x1}	1.3	kV
V_{x2}	1.7	kV
I_{x2}	10	μA
V_g	adjusted for I_{x2} value stated	
*Line width	0.3	mm

*Measured by the shrinking raster method in the centre of the screen.

Mullard

Raster distortion

A graticule, consisting of concentric rectangles 85 × 70mm and 83 × 68.8mm is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage	V_y mean		2.0	kV
Mean x-plate voltage	V_x mean		2.0	kV
Vertical deflection factor	S_y	av.	14.4	V/cm
		max.	15.5	V/cm
Horizontal deflection factor	S_x	av.	31.3	V/cm
		max.	33	V/cm
Angle between x and y deflection			90 ±1	deg

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

The sensitivity at a deflection of less than 75% of the useful scan will not differ from the sensitivity at a deflection of 25% of the useful scan by more than 1%.

CORRECTION POTENTIAL RANGES

Astigmatism control range	$\Delta V_{a1,a3,s1}$	±50	V

SCREEN

Phosphor	GH	
Fluorescent colour	green	
Phosphorescent colour	green	
Persistence	medium short	
Minimum useful screen diameter	114	mm
Minimum useful scan (at $V_{a1,a3,s1} = 2.0$kV)		
$y_1 - y_2$	80	mm
$x_1 - x_2$	100	mm

The useful scan may be shifted vertically to a maximum of 6mm with respect to the geometric centre of the tube face.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a1,a3,s1}$ max.	2.2	kV
$V_{a1,a3,s1}$ min.	1.5	kV
V_{a2} max.	2.2	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	±125	V
p_t max.	3.0	mW/cm^2

Mullard

OSCILLOSCOPE TUBE   D13-480GH

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	–	4.0
g	all	–	5.5
x_1	all	x_2	4.0
x_2	all	x_1	4.0
y_1	all	y_2	3.5
y_2	all	y_1	3.0
x_1	x_2	all	1.6
y_1	y_2	all	1.1

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)   650   g

ACCESSORIES

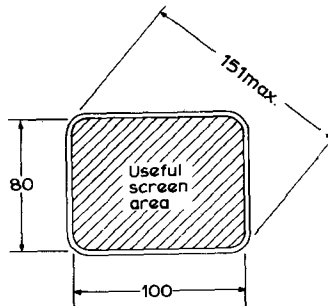Socket (supplied with tube)   55566

Mu-metal shield   55580

NOTES

1. The astigmatism control voltage should be adjusted for optimum spot shape. The range stated will apply if the mean x and y plate potentials are equal to $V_{a1,a3,s1}$, with no astigmatism adjustment.

2. As the construction of the tube does not permit a direct measurement of the beam current, this current should be determined as follows:

   (a) Under typical operating conditions display a small raster with no overscan, adjust V_g for a beam current of approximately $10\mu A$ and V_{a2} and $V_{a1,a3,s1}$ for optimum spot quality in the centre of the screen.

   (b) Remove the raster and adjust the deflection plate voltages to the values stated under 'Line width', thus directing the total beam current to x2. Measure I_{x2} and adjust V_g so that $I_{x2} = 10\mu A$.

   (c) Return to the conditions under (a) but without adjustment of V_g or $V_{a1,a3,s1}$. This results in a raster at a true beam current of $10\mu A$.

   (d) Adjust V_{a2} for optimum focus in the centre of the screen and measure the line width. Do not readjust $V_{a1,a3,s1}$.

Mullard

All dimensions in mm

Orientation of axes of deflection
as viewed from screen end

As viewed from base end
Special 14 pin base

Mullard

OSCILLOSCOPE TUBES

D14-120GH
D14-120GM

```
                    QUICK REFERENCE DATA

12 × 10cm (4.7 × 4.0 in) flat-faced oscilloscope tubes with mesh and metal
backed screen. Primarily intended for use in 25 to 30MHz transistorised
oscilloscopes.
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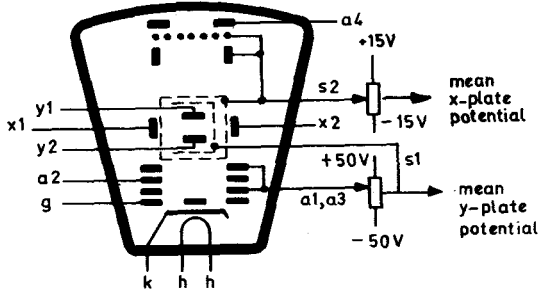
Final anode voltage (p.d.a.)	10	kV
Display area (at $V_{a4} = 6.7 V_{a1,a3}$)	80 × 100	mm
Deflection factor y	4.2	V/cm
Deflection factor x	15.5	V/cm

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h		6.3	V
I_h		300	mA

OPERATING CONDITIONS

Beam forming

Final anode + luminescent screen	V_{a4}	10	kV
Geometry control electrode and interplate shield (see note 1)	V_{s2}	1500 ±15	V
Deflection plate shield (see note 2)	V_{s1}	1500	V
Focus electrode	V_{a2}	250 to 350	V
First accelerator and astigmatism control electrode (see note 3)	$V_{a1,a3}$	1500 ±50	V
Control grid (for visual cut-off)	V_g	-20 to -60	V
Average grid drive ($I_t = 10\mu A$) (approx.)	ΔV_g	12	V

Line width

V_{a4}	10	kV
V_{s2}	1.5	kV
V_{s1}	1.5	kV
$V_{a1,a3}$	1.5	kV
I_t	10	μA

*Line width

at screen centre	0.40	mm
over the whole screen area (average)	<0.45	mm

*Measured by the shrinking raster method.

Mullard

Raster distortion

A graticule consisting of concentric rectangles 95×75mm and 93×73.6mm is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage (see note 2)	$V_{y(mean)}$		1.5	kV
Mean x-plate voltage (see note 2)	$V_{x(mean)}$		1.5	kV
Vertical deflection factor	S_y	av.	4.2	V/cm
		max.	4.6	V/cm
Horizontal deflection factor	S_x	av.	15.5	V/cm
		max.	16	V/cm
Angle between x and y traces			90 ±1	deg
Angle between x trace and horizontal axis of tube face (max.) (see note 4)			5	deg

Both x and y plates are intended for symmetrical deflection.

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

Linearity of deflection

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

CORRECTION POTENTIAL RANGES

Astigmatism control range (see note 3)	$\Delta V_{a1,a3}$	±50	V
Geometry control range (see note 1)	ΔV_{s2}	±15	V

SCREEN

	GH	GM
Phosphor		
Fluorescent colour	green	purplish-blue
Phosphorescent colour	green	yellowish-green
Persistence	medium short	long

Minimum useful scan (at $V_{a4} = 6.7 V_{a1,a3}$)

$y_1 - y_2$	80	mm
$x_1 - x_2$	100	mm

The useful scan may be shifted vertically and horizontally to a maximum of 6.0mm with respect to the geometric centre of the tube face.

OSCILLOSCOPE TUBES

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a4} max. (p.d.a.)	11	kV
V_{a4} min.	9.0	kV
V_{s2} max.	2.2	kV
V_{s1} max.	2.2	kV
V_{a2} max.	2.2	kV
$V_{a1,a3}$ max.	2.2	kV
$V_{a1,a3}$ min.	1.35	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	±125	V
$v_{x\sim(a1,a3)pk}$ max.	500	V
$v_{y\sim(a1,a3)pk}$ max.	500	V
p_t max.	3.0	mW/cm^2
Ratio $V_{a4}/V_{a1,a3}$ max.	6.7	

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	–	4.5
g	all	–	5.5
x_1	all	x_2	6.5
x_2	all	x_1	6.5
y_1	all	y_2	5.0
y_2	all	y_1	5.0
x_1	x_2	all	2.2
y_1	y_2	all	1.7

Mullard

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.
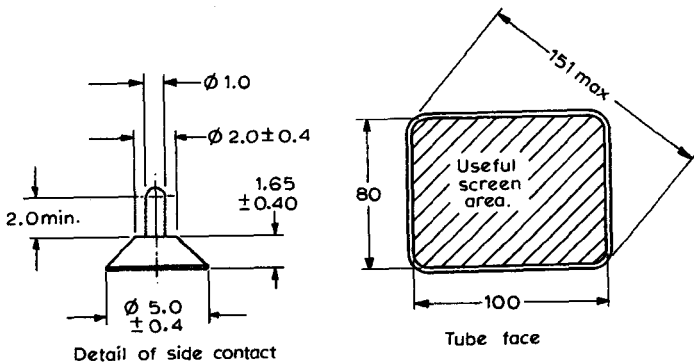
WEIGHT

Tube alone (approx.)   900   g

ACCESSORIES

Socket (supplied with the tube)   55566

a4 connector (cavity connector CT8)   55563

Mu-metal shield   55581

NOTES

1. The tube is designed for optimum performance when operating at a ratio $V_{a4}/V_{a1,a3} \leq 6.7$. The geometry control electrode voltage (V_{s2}) should be adjusted between $-15V$ and $+15V$ with respect to the mean x-plate potential.
A negative control voltage will give some pin-cushion distortion with less background light, and a positive voltage will give some barrel distortion and a slight increase in background light.

2. The deflection plate shield voltage (V_{s1}) should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

3. The astigmatism control should be adjusted within the stated range for optimum spot shape.

4. In order to align the x trace with the horizontal axis of the screen, the whole picture can be rotated by means of a rotation coil. This coil will require 50 ampere-turns for the maximum image rotation of 5 degrees, and should be positioned as shown on the outline drawing.
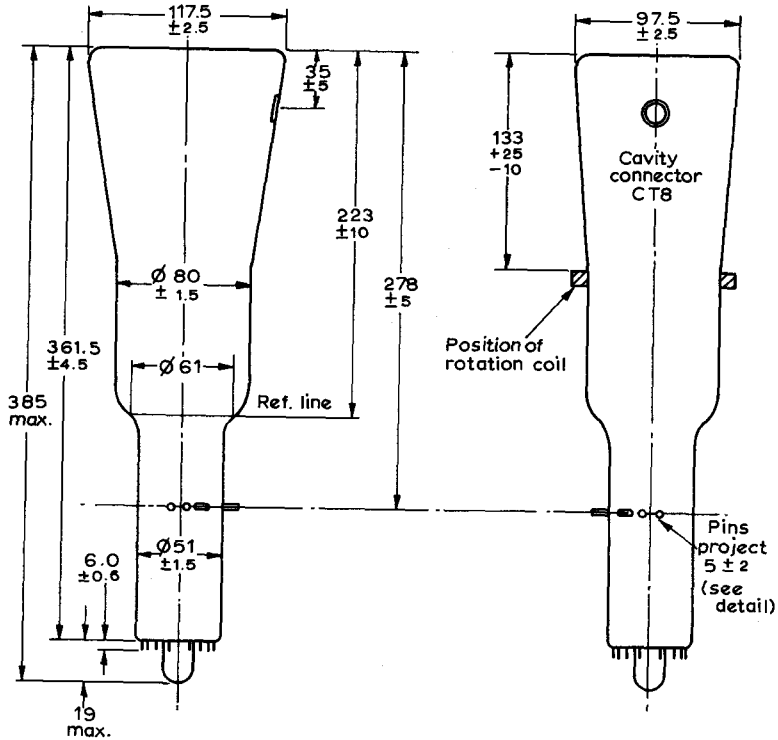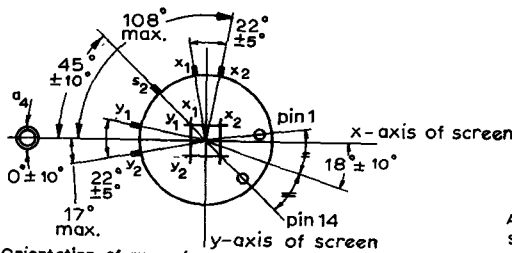

All dimensions in mm

Mullard

OSCILLOSCOPE TUBES

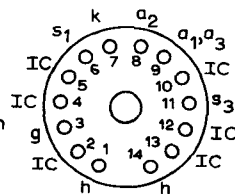# D14-120GH
D14-120GM

OUTLINE DRAWING OF D14-120GH AND D14-120GM

B9094

All dimensions in mm

Orientation of axes of deflection
as viewed from screen end

As viewed from base end
Special 14 pin base

Mullard

The diagram shows base connection labels:

- a4
- +15V
- s2
- mean x-plate potential
- -15V
- y1
- x1
- x2
- y2
- +50V
- s1
- a2
- g
- a1,a3
- mean y-plate potential
- -50V
- k h h

OSCILLOSCOPE TUBES

QUICK REFERENCE DATA

12 × 10cm (4.7 × 4.0in) flat-faced oscilloscope tubes with mesh and metal backed screen. Side connections to the x and y plates. For use in transistorised oscilloscopes up to 50MHz.

Final anode voltage (p.d.a.)	10	kV
Display area ($V_{a4} = 6.7V_{a1,a3}$)	80 × 100	mm
Deflection factor y	4.2	V/cm
Deflection factor x	15.5	V/cm

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h		6.3	V
I_h		300	mA

OPERATING CONDITIONS

Beam forming

Final anode + luminescent screen	V_{a4}	10	kV
Geometry control electrode (see note 1)	V_{s3}	1500 ± 100	V
Post deflection and interplate shield	V_{s2}	1500	V
Background illumination control (see note 1)	ΔV_{s2}	0 to −15	V
Deflection plate shield (see note 2)	V_{s1}	1500	V
Focus electrode	V_{a2}	250 to 350	V
First accelerator and astigmatism control electrode (see note 3)	$V_{a1,a3}$	1500 ± 50	V
Control grid (for visual cut-off)	V_g	−20 to −60	V
Average grid drive for $I_t = 10\mu A$ (approx.)	ΔV_g	12	V

Line width

V_{a4}	10	kV
V_{s2}	1.5	kV
V_{s1}	1.5	kV
$V_{a1,a3}$	1.5	kV
I_t	10	μA
*Line width (approx.) at screen centre	0.4	mm
over the whole screen area (average)	<0.45	mm

*Measured by the shrinking raster method.

Mullard

Raster distortion

A graticule consisting of concentric rectangles 95×75mm and 93×73.6mm is aligned with the electrical x-axis of the tube. The edges of a raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage (see note 2)	$V_{y(mean)}$		1.5	kV
Mean x-plate voltage (see note 2)	$V_{x(mean)}$		1.5	kV
Vertical deflection factor	S_y	av.	4.2	V/cm
		max.	4.6	V/cm
Horizontal deflection factor	S_x	av.	15.5	V/cm
		max.	16	V/cm
Angle between x and y traces			90 ± 1	deg
Angle between x trace and horizontal axis of tube face (see note 4)		max.	5	deg

Both x and y plates are intended for symmetrical deflection.

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

Linearity of deflection

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

CORRECTION POTENTIAL RANGES

Astigmatism control range	$\triangle V_{a1,a3}$	± 50	V
Geometry control range (see note 1)	$\triangle V_{s3}$	± 100	V
Background illumination control range (see note 1)	$\triangle V_{s2}$	0 to -15	V

SCREEN

Phosphor	GH	GM
Fluorescent colour	green	purplish–blue
Phosphorescent colour	green	yellowish–green
Persistence	medium short	long

Minimum useful scan (at $V_{a4} = 6.7V_{a1,a3}$)

$y_1 - y_2$	80	mm
$x_1 - x_2$	100	mm

The useful scan may be shifted vertically and horizontally to a maximum of 6.0mm with respect to the geometric centre of the tube face.

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OSCILLOSCOPE TUBES

DI4-121GH
DI4-121GM

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a4} max. (p.d.a.)	11	kV
V_{a4} min.	9.0	kV
V_{s3} max.	2.2	kV
V_{s2} max.	2.2	kV
V_{s1} max.	2.2	kV
V_{a2} max.	2.2	kV
$V_{a1,a3}$ max.	2.2	kV
$V_{a1,a3}$ min.	1.35	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	20	V
V_{h-k} max.	± 125	V
$v_{x-(a1,a3)pk}$ max.	500	V
$v_{y-(a1,a3)pk}$ max.	500	V
p_t max.	3.0	mW/cm^2
Ratio $V_{a4}/V_{a1,a3}$ max.	6.7	

CAPACITANCES (measured on three terminal capacitance bridge)

High Potential	Low Potential	Earthed	Capacitance (pF)
k	all	–	4.5
g	all	–	5.5
x_1	all	x_2	5.5
x_2	all	x_1	5.5
y_1	all	y_2	4.0
y_2	all	y_1	4.0
x_1	x_2	all	2.2
y_1	y_2	all	1.7

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MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)   900   g

ACCESSORIES

Socket (supplied with tube)	55566
a4 connector (cavity connector CT8)	55563
Side contact connector	55561
Mu-metal shield	55581A

NOTES

1. The tube is designed for optimum performance when operating at a ratio $V_{a4}/V_{a1,a3} \leq 6.7$. The geometry control electrode voltage (V_{s3}) should be adjusted between $-100V$ and $+100V$ with respect to the mean x-plate potential. A negative voltage on s_2, also with respect to the mean x-plate potential, will cause some pin-cushion distortion with less background light, and a positive voltage will give some barrel distortion and a slight increase of background light.
   By varying V_{s2} and V_{s3} it is possible to find a compromise between background light and raster distortion.

2. The deflection plate shield voltage (V_{s1}) should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

3. The astigmatism control should be adjusted within the stated range for optimum spot shape.

4. In order to align the x trace with the horizontal axis of the screen, the whole picture can be rotated by means of a rotation coil. This coil will require 50 ampere-turns for the maximum image rotation of 5 degrees, and should be positioned as shown on the outline drawing.

Detail of side contact

Tube face

All dimensions in mm

OSCILLOSCOPE TUBES

OUTLINE DRAWING OF D14-121GH AND D14-121GM

117.5 ±2.5

35 ±5

97.5 ±2.5

133 +25 −10

Cavity connector C T8

223 ±10

278 ±5

∅ 80 ± 1.5

Position of rotation coil

361.5 ±4.5

∅ 61

Ref. line

385 max.

6.0 ±0.6

∅51 ±1.5

Pins project 5 ± 2 (see detail)

19 max.

All dimensions in mm

108° max.

22° ±5°

45° ±10°

x₁

x₂

s₂

a₄

y₁

x₁

x₂

pin 1

0 ± 10°

y₁

y₂

18° ± 10°

17° max.

22° ±5°

y₂

pin 14

x-axis of screen

y-axis of screen

Orientation of axes of deflection as viewed from screen end.

s₁ k a₂ a₁ a₃

IC   IC

IC   IC

g   IC

IC   IC

h   h

As viewed from base end
Special 14 pin base.

D289

Mullard

OSCILLOSCOPE TUBE   D14-162GH/09

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┌──────────────────────────────────────────────────────────────────┐
│                        QUICK REFERENCE DATA                        │
│                                                                    │
│  12 × 10cm flat-faced oscilloscope tube with mesh and metal backed │
│  screen. The tube has side connections to x and y plates and an    │
│  internal graticule.                                               │
│                                                                    │
│  Final anode voltage                              10       kV      │
│  Display area ($V_{a4}$ = 6.7$V_{a1,a3}$)        80 × 100  mm      │
│  Deflection factor y                              4.1      V/cm    │
│  Deflection factor x                              15.2     V/cm    │
└──────────────────────────────────────────────────────────────────┘
```

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode + luminescent screen	V_{a4}	10	kV
Geometry control electrode (see note 1)	V_{s3}	1500 ± 100	V
Interplate shield (see note 1)	V_{s2}	1500 ± 15	V
Deflection plate shield (see note 2)	V_{s1}	1500	V
Focus electrode	V_{a2}	450 to 550	V
First accelerator and astigmatism control electrode (see note 3)	$V_{a1,a3}$	1500 ± 50	V
Control grid (for visual cut-off)	V_g	-25 to -60	V
Average grid drive (I_t = 10μA) (approx.)	ΔV_g	20	V

Line width

V_{a4}	10	kV
V_{s2}	1.5	kV
V_{s1}	1.5	kV
$V_{a1,a3}$	1.5	kV
I_t	10	μA

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OPERATING CONDITIONS (contd.)

* Line width

at screen centre	0.3	mm
over the whole screen area (average)	<0.35	mm

*Measured by the shrinking raster method.

Raster distortion

A graticule consisting of concentric rectangles 95 × 75mm and 93 × 73.6mm is aligned with the electrical x-axis of the tube. The edges of the raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage (see note 2)	$V_{y(mean)}$	1.5	kV
Mean x-plate voltage (see note 2)	$V_{x(mean)}$	1.5	kV
Vertical deflection factor	S_y	4.1 to 4.4	V/cm
Horizontal deflection factor	S_x	15.2 to 16	V/cm
Angle between x and y traces		90±1	deg
Angle between x trace and horizontal axis of tube face (max.) (see note 4)			

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

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

CORRECTION POTENTIAL RANGES

Astigmatism control range (see note 3)	$\Delta V_{a1,a3}$	±50	V
Geometry control range (see note 1)	ΔV_{s3}	±100	V
Interplate shield control range (see note 1)	ΔV_{s2}	±15	V

SCREEN

Tube face diagonal	14	cm
Phosphor	GH	
Fluorescent colour	green	
Phosphorescent colour	green	
Persistence	Medium short	
Minimum useful screen dimensions	80 × 100	mm

OSCILLOSCOPE TUBE $\quad$ D14-162GH/09

SCREEN (contd.)

Minimum useful scan (at $V_{a4} = 6.7V_{a1,a3}$)

$y_1 - y_2$	80	mm
$x_1 - x_2$	100	mm

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a4} max. (p.d.a.)	13	kV
V_{a4} min.	9	kV
V_{s3} max.	2.2	kV
V_{s2} max.	2.2	kV
V_{s1} max.	2.2	kV
V_{a2} max.	2.2	kV
$V_{a1,a3}$ max.	2.2	kV
$V_{a1,a3}$ min.	1.35	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
Grid drive (d.c. or average) max.	30	V
V_{h-k} max.	± 125	V
$v_{x-(a1,a3)pk}$ max.	500	V
$v_{y-(a1,a3)pk}$ max.	500	V
p_t max.	3	mW/cm^2
Ratio $V_{a4}/V_{a1,a3}$ max.	6.7	

CAPACITANCES (measured on three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	-	4.0
g	all	-	5.5
x_1	all	x_2	5.5
x_2	all	x_1	5.5
y_1	all	y_2	3.5
y_2	all	y_1	3.5
x_1	x_2	all	2.0
y_1	y_2	all	1.6

Mullard

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)　　1.3　　kg

ACCESSORIES

Socket (supplied with tube)　　55566

a4 connector (cavity connector CT8)　　55563

Mu-metal shield (see note 5)　　55585

NOTES

1. The tube is designed for optimum performance when operating at a ratio $V_{a4}/V_{a1,a3} \leq 6.7$. The geometry control electrode voltage (V_{s3}) should be adjusted between -100V and +100V with respect to the mean x plate potential.
   A negative voltage on s_2, also with respect to the mean x plate potential, will cause some pin-cushion distortion with less background light, and a positive voltage will give some barrel distortion and a slight increase of background light. By varying V_{s2} and V_{s3} it is possible to find a compromise between back-ground light and raster distortion.

2. The deflection plate shield voltage (V_{s1}) should be equal to the mean y-plate potential. The mean x- and y-plate potentials should be equal for optimum spot quality.

3. The astigmatism control should be adjusted within the stated range for optimum spot shape.

4. In order to align the x trace with the horizontal axis of the screen, the whole picture can be rotated by means of the rotation coil supplied.

5. To avoid damage to the side contacts the narrower end of the shield should have an internal diameter not less than 65mm.

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OSCILLOSCOPE TUBE   D14-162GH/09

CORRECTION COILS

The D14-162GH/09 is provided with a coil unit (see Fig. 1) consisting of a pair of coils L1 and L2 for image rotation (aligning the x trace with the x lines of the grat-icule).

Fig. 1

Image rotation

The image rotation coil winding is concentric with the tube neck. Under typical operating conditions 50 ampere turns are required for the maximum rotation of 5°. Both coils have 850 turns. This means that a maximum current of 30mA per coil is required which can be obtained from a 24V supply when the coils are con-nected in series or a 12V supply when they are in parallel.

Connecting the coils

The coils have been connected to the 4 soldering tags according to Fig. 2.

Base view   05849

All dimensions in millimetres   Fig. 2

D5848

120
115

40
30

100
95

Cavity
connector
CT8

158
123

233
213

283
273

∅ 95max

407.5
max

388.5
376.5

∅61

Ref. line

Position of
rotation coil

∅52.5
49.5

6.6
5.4

∅1.0

∅2.0
±0.4

2.0min

Pins project 5±2
(see detail)

19 max.

∅ 5.0
±0.4

1.65
±0.40

All dimensions in mm

Detail of side contact

108°
max

22°
+5°

45°
±10°

x₁   x₂

s₂   x₁ x₂

y₁   y₁

22°
±5°

y₂   y₂

0°±10°

17°max

pin 1

x-axis of screen

18°±10°

pin 14

y-axis of screen

Orientation of axes of deflection
as viewed from screen end

k   a2

s1   a1,a3

IC   7 8   IC
   5 6   9
IC   4   10   s3
   3   11
g   2   12   IC
      1 14 13
IC   IC

h   h

As viewed from base end
Special 14 pin base

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OSCILLOSCOPE TUBE D14-162GH/09

+100V

mean x−plate potential −100V

s3

y1
x1
y2
a2
g

a4

s2

x2 −15V

+50V s1

a1,a3 −50V

mean x−plate potential

mean y−plate potential

k h h

151 max

Useful screen area

80

100

Tube face
All dimensions in mm

10 x 10 = 100

2

8 x 10 = 80

line width 0.15mm   sub-division 2 mm
dot diameter 0.3mm

D1211

OSCILLOSCOPE TUBES

DG7-31
DG7-32

QUICK REFERENCE DATA

7cm (3in) diameter low voltage oscilloscope tubes for monitoring purposes. DG7-31 has asymmetrical x-deflection whereas DG7-32 has symmetrical x-deflection. Both types have symmetrical y-deflection.

Final anode voltage	500	V
Display area	Full scan in both directions	
Deflection factor y	21	V/cm
Deflection factor x	37	V/cm

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with

GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

TYPE NOMENCLATURE

Following the introduction of the suffixes /01, /02 etc. to type numbers denoting various internal graticules, it has been found necessary to cancel some of the older type numbers which used similar suffixes. The following list relating the old and new type numbers also includes the equivalent CV numbers.

Old Mullard Type Number	New Mullard Type Number	CV Number
DG7-31	–	CV5418
DG7-31/01	DG7-31	CV8330
DG7-32	–	CV2431
DG7-32/01	DG7-32	CV8959

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Beam forming

Final anode	$V_{a1,a3}$	500	V
Focus electrode	V_{a2}	0 to 120	V
Control grid (for visual cut-off)	V_g	-50 to -100	V
Focusing electrode current	I_{a2}	-15 to + 10	μA

Line width

V_{a1+a3}	500	V
I_t	0.5	μA
*Line width	0.4	mm

*Measured on a circle of 50mm diameter

Raster distortion

A graticule, consisting of concentric rectangles 43.2 × 43.2mm and 40 × 40mm is aligned with the electrical x axis of the tube. The edges of a raster will fall between these rectangles with optimum correction potentials applied.

Note:

A contrast improving transparent conductive coating connected to a_1, a_3 is present between the glass and the fluorescent layer. This makes possible the application of a high potential to a_1, a_3 with respect to earth, without the risk of picture distortion if the face plate is touched.

DEFLECTION

Double electrostatic

Mean y-plate voltage	V_y mean	500	V
Mean x-plate voltage	V_x mean	500	V
Vertical deflection factor	S_y	18.8 to 23.2	V/cm
Horizontal deflection factor	S_x	33.3 to 41.5	V/cm
Angle between x and y deflection		90 ± 1.5	deg

DG7 - 31

The x-plates are intended for asymmetrical deflection.
The y-plates are intended for symmetrical deflection.

DG7 - 32

Both x - and y - plates are intended for symmetrical deflection.

SCREEN

Phosphor	G(GJ)
Fluorescent colour	yellowish – green
Phosphorescent colour	yellowish – green
Persistence	medium
Minimum useful screen diameter	65 mm

Minimum useful scan (at $V_{a1,a3} = 500V$)

$y_1 - y_2$	Full scan
$x_1 - x_2$	Full scan

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OSCILLOSCOPE TUBES

DG7-31
DG7-32

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a1,a3}$max.		800	V
$V_{a1,a3}$min.		400	V
V_{a2} max.		200	V
$-V_g$ max.		200	V
$+V_g$ max.		0	V
$+v_{g(pk)}$ max.		2.0	V
V_{h-k} max.	Cathode positive	200	V
	Cathode negative	125	V
p_t max.		3.0	mW/cm^2
R_{g-k} max.		500	kΩ
$R_{x-(a1,a3)}$max.		5.0	MΩ
$R_{y-(a1,a3)}$max.		5.0	MΩ

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	–	3.2
g	all	–	7.6
x_1	all	x_2	3.7
x_2	all	x_1	3.0
y_1	all	y_2	2.5
y_2	all	y_1	2.5
x_1	x_2	all	1.7
y_1	y_2	all	1.0

EQUIPMENT DESIGN RANGE

Focusing electrode voltage	V_{a2}	0 to 240	V/kV of $V_{a1,a3}$
Grid cut-off voltage	V_g	-100 to -200	V/kV of $V_{a1,a3}$
Deflection factor			
vertical	S_y	37.6 to 46.4	V/cm/kV of $V_{a1,a3}$
horizontal	S_x	67 to 83	V/cm/kV of $V_{a1,a3}$

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

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WEIGHT

Tube alone (approx.)   120   g

ACCESSORIES

Socket   2422 516 00001

Mu-metal shield   55530

OUTLINE DRAWING OF DG7-31 AND DG7-32

All dimensions in mm

Orientation of axes of deflection
as viewed from screen end

As viewed from base end
B12A base

OSCILLOSCOPE TUBE

DH3-91

<div style="border:1px solid">

QUICK REFERENCE DATA

3 cm (1 in) dia. simple oscilloscope tube for low voltage applications.

Anode voltage	500	V
Display area	full scan	
Deflection factor y	49	V/cm
Deflection factor x	56.5	V/cm

</div>

This data should be read in conjunction with GENERAL OPERATIONAL
RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

Final anode	$V_{a1,a3,y2}$	500	V
*Control grid (for visual cut-off)	V_g	-8.0 to -27	V

Line width

$V_{a1,a3,y2}$	500	V
I_t	0.5	μA
**Line width	0.6	mm

*In no circumstances must the grid be allowed to become positive.

**Measured on a circle of 25mm diameter.

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DEFLECTION

Double electrostatic

Vertical deflection factor	S_y	35 to 63	V/cm
Horizontal deflection factor	S_x	41 to 72	V/cm

The x plates are intended for symmetrical deflection.

The y plates are intended for asymmetrical deflection.

For optimum focus with symmetrical operation the average potential of the x plates and $V_{a1,a3,y2}$ should be equal. With asymmetrical operation the potential on any one deflection plate should not differ from $V_{a1,a3,y2}$ by more than the deflection voltage.

SCREEN

Phosphor	H	
Fluorescent colour	green	
Persistence	medium short	
Minimum useful screen diameter	28	mm

Minimum useful scan

$y_1 - y_2$	full scan
$x_1 - x_2$	full scan

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a1,a3,y2}$ max.	1.0	kV
$V_{a1,a3,y2}$ min.	350	V
$-V_g$ max.	200	V
$+V_g$ max.	0	V
$+v_{g\,(pk)}$ max.	2.0	V
V_{h-k} max.		
cathode positive	200	V
cathode negative	125	V
p_t max.	3.0	mW/cm^2
R_{g-k} max.	1.0	MΩ
R_{y-a3} max.	5.0	MΩ
R_{x-a3} max.	5.0	MΩ

Mullard

OSCILLOSCOPE TUBE

DH3-91

CAPACITANCES (measured on a three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
g	all	–	5.6
x_1	all	x_2	4.5
x_2	all	x_1	4.5
y_1	all	a_1, a_3, y_2	3.5
x_1	x_2	all	1.0

EQUIPMENT DESIGN RANGE

Grid cut-off voltage	V_g	–16 to –54	V/kV of $V_{a1,a3,y2}$
Deflection factor			
vertical	y	38.5 to 52.5	V/cm/kV of $V_{a1,a3,y2}$
horizontal	x	90 to 120	V/cm/kV of $V_{a1,a3,y2}$

MOUNTING POSITION

Any. This tube may be supported by the base alone but care must be taken to minimise the effects of sudden acceleration and shock.

WEIGHT

Tube alone (approx.)   39   g

ACCESSORIES

Socket   2422 501 05001

Mu-metal shield   55525

NOTE

A contrast improving transparent conductive coating connected to a_1, a_3, y_2 is present between the glass and fluorescent layer. This makes possible the application of a high potential to a_1, a_3, y_2 with respect to earth, without the risk of picture distortion if the face plate is touched.

Mullard

B6910

Pin5

$90°±10°$

x_1 x_2
y_1
y_2

x trace

Orientation of axes of deflection
as viewed from screen end.

30max

65R

90
max
105
max

31max

y_1
x_1 x_2
a_1, a_3, y_2
g

k, a_2 h h

x_2 g
y_1 x_1
4 5
3 6
2 7
1 8
a_1, a_3, y_2
k, a_2
h h

B8G Base

All dimensions in mm

Mullard

OSCILLOSCOPE TUBE

DH3-91

CIRCUIT NOTES FOR DH3-91

In view of the simplicity of the operating requirements no additional supplies may be required when the tube is incorporated in some equipment. An arrangement suitable for use in such a case is shown in Fig. 1. Fixed bias is provided by the cathode resistor R3 which may be by-passed if necessary by a $0.5\mu F$ capacitor. Although tubes may not be identical in respect of their 'brightness-grid voltage' characteristic this method of auto-bias produces almost constant brilliance in changing from tube to tube.

Fig. 1

Owing to the presence of a transparent conducting film connected to anode between the screen of the tube and the glass, the tube may be operated with its cathode at earth potential without any oscillogram distortion when an earthed body is brought near the screen.

Depending on the individual application, the simple arrangement shown may be un-suitable for a variety of reasons. Two of the commonest drawbacks, with suggestions for overcoming them, are:

1. If various patterns are to be displayed on the same tube it is probable that different beam currents will be required to produce the same brightness on each oscillogram. A modified variable brilliance control can be provided merely by using a variable cathode bias resistor. Alternatively, if it is re-quired to 'black-out' the trace a combination of tube current and bleed can be used. In either case it is desirable to incorporate a limiting resistor in order to prevent excessive beam current being drawn.

2. Since the deflector plates are essentially at h.t. potential it is not normally possible to incorporate d.c. coupling to them. Should this be required it is necessary to run the tube anode at the mean potential of the deflector plates, which usually involves tapping the anode across the h.t. supply. If there is no point from which the d.c. signal can be taken which allows the necessary mini-mum h.t. to be obtained, it is recommended that a negative supply be utilised. This may already be incorporated in the apparatus.

Note – If it is required to run the y plate only from a d.c. signal the anode tap can be used as a centring device.

Fig. 2 shows the two modifications listed above. In it the y plates are shown d.c. connected and the x plates a.c. connected. No x shift network is included. V1 is the actual working voltage of the tube.

Fig. 2

Mullard

OSCILLOSCOPE TUBES

+---+
| QUICK REFERENCE DATA |
| |
| 7cm (3.0in) diameter, flat faced oscilloscope tubes with helical p.d.a. For |
| use in transistorised equipment. |
| |
| Final anode voltage (p.d.a.)   1.2   kV |
| Display area (at $V_{a4} = 4.0V_{a3}$)   45 × 60   mm |
| Deflection factor y   3.65   V/cm |
| Deflection factor x   10.7   V/cm |
+---+

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	95	mA

OPERATING CONDITIONS

Beam forming

Final anode + luminescent screen	V_{a4}	1.2	kV
Geometry control electrode (see note 1)	V_{s1}	300 ±30	V
Astigmatism control electrode (see note 2)	V_{a3}	$300 \pm^{40}_{15}$	V
Focus electrode	V_{a2}	20 to 150	V
First accelerator	V_{a1}	1.2	kV
Control grid (for visual cut-off)	V_g	−30 to −80	V
Focus electrode current	I_{a2}	−15 to +10	μA

Line width

V_{a4}	1.2	kV
V_{a3}	300	V
V_{a1}	1.2	kV
I_t	10	μA
*Line width	0.65	mm

*Measured by the shrinking raster method in the centre of the screen.

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Raster distortion

A graticule, consisting of concentric rectangles 40.8×40.8mm and 39.2×39.2mm is aligned with the electrical x-axis of the tube. The edges of the raster will fall between these rectangles, with optimum correction potentials applied.

DEFLECTION

Double electrostatic

Mean y-plate voltage	V_y mean	300	V
Mean x-plate voltage	V_x mean	300	V
Vertical deflection factor	S_y	3.2 to 4.1	V/cm
Horizontal deflection factor	S_x	9.4 to 12	V/cm
Angle between x and y deflection		90 ±1	deg

Both x and y plates are intended for symmetrical deflection. If use is made of the full deflection capabilities of the tube the deflection plates will intercept part of the electron beam near the edge of the scan. Therefore a low impedance deflection plate drive is necessary.

Linearity of deflection

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

CORRECTION POTENTIAL RANGES

Astigmatism control range	$\triangle V_{a3}$	+40 / −15	V
Geometry control range	$\triangle V_{s1}$	±30	V

SCREEN

	H	P	
Phosphor	H	P	
Fluorescent colour	green	purplish-blue	
Phosphorescent colour	green	yellowish-green	
Persistence	medium-short	long	
Minimum useful screen diameter		68	mm

Minimum useful scan (at $V_{a4} = 4V_{a3}$)

$y_1 - y_2$	45	mm
$x_1 - x_2$	60	mm

Mullard

OSCILLOSCOPE TUBES

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a4} max. (p.d.a.)	5.0	kV
V_{a4} min.	1.2	kV
V_{s1} max.	2.2	kV
V_{a3} max.	2.1	kV
V_{a3} min.	300	V
V_{a2} max.	1.0	kV
V_{a1} max.	1.6	kV
V_{a1} min.	800	V
$-V_g$ max.	200	V
$+V_g$ max.	0	V
$+v_{g(pk)}$ max.	2.0	V
V_{h-k} max.		
cathode positive	100	V
cathode negative	15	V
$v_{x-a3(pk)}$ max.	500	V
$v_{y-a3(pk)}$ max.	500	V
p_t max.	3.0	mW/cm^2
Ratio V_{a4}/V_{a3} max.	4.0	
R_{g-k} max.	1.5	$M\Omega$
R_{x-a3} max.	50	$k\Omega$
R_{y-a3} max.	50	$k\Omega$

HELIX RESISTANCE

Minimum p.d.a. helix resistance	40	$M\Omega$

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CAPACITANCES (measured on three terminal capacitance bridge)

High potential	Low potential	Earthed	Capacitance (pF)
k	all	–	3.0
g	all	–	5.7
x_1	all	x_2	4.0
x_2	all	x_1	4.0
y_1	all	y_2	3.5
y_2	all	y_1	3.5
x_1	x_2	all	1.9
y_1	y_2	all	1.7

EQUIPMENT DESIGN RANGE

Focus electrode voltage	V_{a2}	35 to 165	V/kV of V_{a3}
Grid cut-off voltage	V_g	30 to 60	V/kV of V_{a1}

Deflection factor ($V_{a4} = 4V_{a3}$)

vertical	10.7 to 13.7	V/cm/kV of V_{a3}
horizontal	31.3 to 40	V/cm/kV of V_{a3}

MOUNTING POSITION

Any. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

WEIGHT

Tube alone (approx.)	370	g

ACCESSORIES

Socket (supplied with tube)	40467
a4 connector (cavity connector CT8)	55563
Mu-metal shield	55532

NOTES

1. The tube is designed for optimum performance when operating at a ratio $V_{a4}/V_{a3} = 4$. Operation at any other ratio may result in changes in deflection uniformity and geometry distortion. The geometry control electrode voltage should be adjusted within the stated range for optimum performance.

2. The astigmatism control should be adjusted within the stated range for optimum spot shape.

OUTLINE DRAWING

Orientation of axes of
deflection as viewed
from screen end

As viewed from base end
Special 14 pin base

All dimensions in mm

D2232

Mullard

<div style="border:1px solid">

QUICK REFERENCE DATA

17cm (7in) flat-faced rectangular direct viewing television tube with metal backed screen, primarily intended for use as a viewfinder in television cameras.

Deflection angle	70	deg
Focusing	Electrostatic	
Resolution	>1100	lines
Maximum overall length	234	mm

</div>

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

V_{a2+a4}	14	kV
V_{a3} (focus electrode control range)	0 to 400	V
V_{a1}	400	V
V_g for visual extinction of focused raster	–30 to –62	V

SCREEN

Metal backed

Fluorescent colour	White
Useful screen area	See page 5

RESOLUTION

Resolution at screen centre (see note 1)	>1000	>1100	lines

Measured at:

V_{a2+a4}	14	16	kV
V_{a1}	400	600	V
I_t	50	50	μA
Brightness	500	600	cd/m^2 (nits)

FOCUSING

Electrostatic
The range of focus voltage shown in 'OPERATING CONDITIONS' results in optimum overall focus at a beam current of 50μA.

DEFLECTION

Magnetic

Diagonal deflection angle	70	deg

The deflection coils should be designed so that their internal contour is in accordance with the reference line gauge shown on page 6.

CAPACITANCES

c_{g-all}	7.0	pF
c_{k-all}	5.0	pF
$c_{a2+a4-M}$	300	pF

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be connected to chassis, and the capacitance of this coating to the final anode is used to provide smoothing for the e.h.t. supply. The electrical connection to this coating must be made within the area specified on the tube outline drawing.

REFERENCE LINE GAUGE

See page 6

MOUNTING POSITION

Any.
The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.
The tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the pins whilst handling the tube. It is advisable to keep this pin protector on the base until it can be replaced by the socket after the installation of the tube in any equipment.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a2+a4} max. (at $I_{a2+a4} = 0$) (see note 2)	16	kV
V_{a2+a4} min.	12	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
V_{a1} max.	800	V
V_{a1} min.	300	V
V_{h-k} (cathode positive)		
d.c. max.	250	V
pk max. (see note 3)	300	V
V_{h-k} (cathode negative)		
d.c. max.	135	V
pk max.	180	V

NOTES

1. Measured by the shrinking raster method. If necessary the resolution can be improved by the use of a beam centring magnet. This magnet can be supplied on request, together with instructions for its use.

2. With the high voltage used with this tube high voltage flashovers may occur, which may destroy the cathode. Therefore it is necessary to provide protective circuits using spark gaps. The spark gaps must be connected as follows:

short connections to electrodes

to chassis ← short connections to external conductive coating

No other connections between external conductive coating and chassis are permissible.

3. During a warm-up period not exceeding 15 seconds the heater may be 410V negative with respect to the cathode.

WARNING

X-ray shielding is advisable to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operating above 14kV.

ACCESSORIES

Final accelerator connector (CT8 cavity connector)	55563
Beam centring magnet	3322 142 11401

Mullard

B8760

143±2

External conductive coating (M)

60±5

50±6

93±6

Reference line

16±3

227±7

Determined by the plane of the upper edge of the step on the reference line gauge, page 6, when the gauge is resting on the cone.

27·8min
*Neck dia

* The maximum dimension is determined by the reference line gauge.

111±2

This side of the bulb is free of external conductive coating

a2 + a4
Recessed cavity connector CT8

All dimensions in mm

10 R

124 min

B8761

93 min

Useful screen area
shown shaded.

155 min

176 max

Bulb dimensions

9°

a2 + a4

9°

a3

NP

a1

g

g

k

h   h

B8H Base

.a2 + a4

a3

g

a1

k h   h

All dimensions in mm

Mullard

Engineering drawing — Reference line gauge. All dimensions in mm.

B8873

- 96·8 ± 0·4 dia
- 88·9 ± 0·4 dia
- 82·5 ± 0·1 dia
- 53·9 ± 0·05 dia
- 30·75 ± 0·07 dia

R = 1·0 ± 0·4

14·3 ± 0·1

6·4 ± 0·4

90°

Reference Line

20·7 ± 0·1

16·9 ± 0·1

R = 12·7 ± 0·4

R = 12·7 ± 0·1

15·57 ± 0·10

6°

77·8 ± 0·4

29·67 +0·07 −0·00 dia

Reference line gauge

All dimensions in mm

43 ± 0·4 dia

TELEVISION MONITOR TUBE

M17-141W

QUICK REFERENCE DATA

17cm (7in) flat-faced rectangular direct viewing television tube with metal backed screen, primarily intended for use as a viewfinder in television cameras. This tube is provided with a bonded faceplate and a metal mounting band.

Deflection angle	70	deg
Focusing	Electrostatic	
Resolution	>1100	lines
Maximum overall length	240	mm

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

Suitable for parallel operation only

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

V_{a2+a4}	14	16	kV
V_{a3} (focus electrode control range)	0 to 400	0 to 400	V
V_{a1}	400	600	V
V_g for visual extinction of focused raster	-30 to -62	-40 to -90	V

SCREEN

Metal backed

Fluorescent colour	White
Useful screen area	See page 5

RESOLUTION

Resolution at screen centre (see note 1)	> 1000	> 1100	lines

Measured at :

V_{a2+a4}	14	16	kV
V_{a1}	400	600	V
I_t	50	50	μA
Brightness	500	600	cd/m^2 (nits)

FOCUSING

Electrostatic
The range of focus voltage shown in 'OPERATING CONDITIONS' results in optimum overall focus at a beam current of 50μA.

DEFLECTION

Magnetic

Diagonal deflection angle	70	deg

The deflection coils should be designed so that their internal contour is in accordance with the reference line gauge shown on page 6.

CAPACITANCES

c_{g-all}	7.0	pF
c_{k-all}	5.0	pF
$c_{a2+a4-M}$	240	pF
$c_{a2+a4-B}$	135	pF

EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating, M, which must be connected to chassis, and the capacitance of this coating to the final anode is used to provide smoothing for the e.h.t. supply. The electrical connection to this coating must be made within the area specified on the tube outline drawing.

REFERENCE LINE GAUGE

See page 6

MOUNTING POSITION

Any.

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.
The tube is fitted with a pin protector in order to avoid damage to the glass base due to bending of the pins whilst handling the tube. It is advisable to keep this pin protector on the base until it can be replaced by the socket after the installation of the tube in any equipment.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{a2+a4} max. (at $I_{a2+a4} = 0$) (see note 2)	18	kV
V_{a2+a4} min.	12	kV
$+V_{a3}$ max.	1.0	kV
$-V_{a3}$ max.	500	V
V_{a1} max.	800	V
V_{a1} min.	300	V
V_{h-k} (cathode positive)		
d.c. max.	250	V
pk max. (see note 3)	300	V
V_{h-k} (cathode negative)		
d.c. max.	135	V
pk max.	180	V

NOTES

1. Measured by the shrinking raster method. If necessary the resolution can be improved by the use of a beam centring magnet. This magnet can be supplied on request, together with instructions for its use.

2. With the high voltage used with this tube high voltage flashovers may occur, which may destroy the cathode. Therefore it is necessary to provide protective circuits using spark gaps. The spark gaps must be connected as follows:

No other connections between external conductive coating and chassis are permissible.

3. During a warm-up period not exceeding 15 seconds the heater may be 410V negative with respect to the cathode.

4. The metal band (B) must be connected directly to the chassis by, for example, a spring contact.

WARNING

X-ray shielding is advisable to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube when operating above 14kV.

ACCESSORIES

Final accelerator connector (CT8 cavity connector)	55563
Beam centring magnet	3322 142 11401

External
conductive
coating (M)

148 +0.5 −1.0

B8763

25±0.5

7.0min

98±7

44±4

Reference line

16±3   See rim
detail

Determined by the plane
of the upper edge of
the step on the reference
line gauge, page 6, when
the gauge is resting on
the cone.

232
± 8

27.8 min
∗Neck dia

∗ The maximum dimension
is determined by the
reference line gauge.

117 +0.5 −1.0

54±7

This side of the
bulb is free of
external
conductive
coating.

a2 + a4
Recessed cavity
connector CT8

3.0
2.5

9.0

1.0

Rim detail

All dimensions in mm

5·0 R

B8876

93 min

80 ±2

Useful screen area shown shaded.

124 min

155 min

9°

9°

a2+a4

a3

NP

a1

g

g

k

h   h

B8H Base

a2+a4

g

a3

a1

k h   h

All dimensions in mm

Mullard

B8873

96·8 ± 0·4 dia

88·9 ± 0·4 dia

82·5 ± 0·1 dia

53·9 ± 0·05 dia

30·75 ± 0·07 dia

R = 1·0 ± 0·4

14·3 ± 0·1

6·4 ± 0·4

90°

Reference Line

20·7 ± 0·1

16·9 ± 0·1

R = 12·7 ± 0·4

R = 12·7 ± 0·1

15·57 ± 0·10

77·8 ± 0·4

6°

29·67 +0·07 −0·00 dia

Reference line gauge

All dimensions in mm

43 ± 0·4 dia

Mullard

PROJECTION TUBES

QUICK REFERENCE DATA

13cm (5in) diameter projection tubes designed to provide high brightness, large area displays for colour and monochrome television.

Type	MG13-38	MU13-38	MY13-38	MW13-38
Fluorescent colour	green	blue	red	white
Deflection angle			47	deg
Focusing				Magnetic
Operating voltage			50	kV

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

For series or parallel operation

V_h 6.3   V

I_h 300   mA

OPERATING CONDITIONS

V_a 50   kV

V_g for visual extinction of focused raster   −100 to −170   V

$i_{a(pk)}$ max.   2.5   mA

SCREEN

Type	Fluorescent colour	Colour point x	Colour point y
MG13-38	Green	0.19	0.72
MU13-38	Blue	0.17	0.13
MY13-38	Red	0.661	0.331
MW13-38	White	–	–
Minimum useful screen area		92×69	mm

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BRIGHTNESS

Measured at

V_a	50	kV
I_a	500	μA
Raster size (see note 1)	92×69	mm
MG13-38	20 000	cd/m^2(nits)
MU13-38	2900	cd/m^2(nits)
MY13-38	6000	cd/m^2(nits)
MW13-38	8700	cd/m^2(nits)

FOCUSING

Magnetic

The focusing coil should be at a distance of 240mm from the centre of the air gap to the front of the screen. It is necessary to centre the focusing coil to get optimum sharpness.

DEFLECTION

Double magnetic

Deflection angle	47	deg

CAPACITANCES

C_{g-all} max.	10	pF
C_{k-all} max.	9	pF

REFERENCE LINE

Reference line is determined by the position where a gauge 38.1 $^{+0.05}_{-0.00}$ mm diameter and 50mm long will rest on bulb cone.

MOUNTING POSITION

Any, except vertical with the screen downwards, the axis of the tube making an angle of less than 50° with the vertical. The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

The bottom circumference of the base shell will fall within a circle having a diameter of 50mm which is concentric with the cone axis.

Mullard

PROJECTION TUBES

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_a max. (see note 2)	55	kV
V_a min.	40	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
$+v_{g(pk)}$ max.	0	V
I_a max. (see note 3)	500	μA
$v_{h-k(pk)}$ max. (cathode positive)	100	V
$v_{h-k(pk)}$ max. (cathode negative, see note 4)	50	V
R_{h-k} max.	20	kΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. (f = 50Hz)	500	kΩ
Minimum raster size (see note 1)	69×72	mm
Magnification max. (for MW13-38 only)	40	X

TUBE PROTECTION

It is essential that means be provided for the instantaneous removal of the beam current, in the event of a failure of either one or both of the time-bases. Unless such a safety device is incorporated, a failure of this type will result in the immediate destruction of the screen of the tube.

WARNING

X-ray shielding equivalent to a lead thickness of 1mm is required to give protection against possible danger of personal injury arising from prolonged exposure at close range to this tube.

Mullard

NOTES

1. The screen should be air-cooled by a continuous airflow of $0.06\text{m}^3/\text{s}$.

2. A 50kΩ resistor should be included in the e.h.t. lead in order to avoid damage to the tube due to a momentary internal arc.

3. In order to prevent the possible occurrence of a cracked tube face when operating with localised high brightness areas the mean anode current must be less than $500\mu\text{A}$. This is especially the case for stationary raster patterns.

4. In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible (< 20V r.m.s.).

5. Before removing the tube from an equipment the screen and cone should be discharged.

6. The spark trap and the outer coating of the tube must be connected to earth.

7. It is recommended that the connection to the final anode be made with the e.h.t. connector supplied with the tube.

WEIGHT

Tube alone (approx.)	950	g

ACCESSORIES

Socket	5912/20
Anode connector	supplied with tube

PROJECTION TUBES

D421

∅ 131±1.5

∅ 115 min

3±1

90°±10°

69

92

R=207 ±4.5

External insulating coating

55 ±4

123.5 ±3

27° ±7°

215 ±4

Ref. line (see page 2)

12±4

27.5 max

364 ±10

NC   NC

NP   NP

NP   NP

NP   NP

a NP

g

75°±10° h   h   k

B12A Base
As viewed from base end

Protective sleeve

∅ 36.5 ±1.5

5 nom

110 ±4

181.5 ±4

External conductive coating

Top centre of grid

a

g

spark trap

k h   h

spark trap

All dimensions in mm

Mullard

MG13-38 - Page 5

FLYING SPOT SCANNER TUBES

Q13-110BA
Q13-110GU

QUICK REFERENCE DATA

13cm (5 in) diameter flying spot scanner cathode ray tubes.
Type Q13-110BA is intended for monochrome television and other applications.
Type Q13-110GU is primarily intended for colour television applications.

Anode voltage	25	kV
Deflection angle	40	deg
Resolution	>1000	lines

Unless otherwise stated data is applicable to both types

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - CATHODE RAY TUBES

HEATER

For series or parallel operation

V_h	6.3	V
I_h	300	mA

OPERATING CONDITIONS

V_a	25	kV
I_a	50 to 150	μA
V_g for cut-off	-50 to -100	V
Resolution at centre of screen using focusing coil AT1997	>1000	lines

SCREEN

Metal backed

Persistence	very short	
Fluorescent colour		
Q13-110BA	purplish-blue	
Q13-110GU	white	
Minimum useful screen diameter	108	mm

For spectral energy distribution and other graphs see "Screen type BA" and "Screen type GU" data sheets.

Mullard

FOCUSING

Magnetic

DEFLECTION

Magnetic

Deflection angle	40	deg

CAPACITANCES

c_{g-all}	6.5	pF
c_{k-all}	6.5	pF
c_{a-M}	250 to 450	pF

SPARK TRAP AND EXTERNAL CONDUCTIVE COATING

This tube has an external conductive coating (M) around the neck of the tube, and the capacitance of this to the anode may be used to provide smoothing for the e.h.t. supply.

The insulating coating around the cone of the tube should not be in close proximity to any metal parts.

Incorporated within the tube is a spark trap so positioned that it prevents any internal flashover taking place between the anode and the grid.

The spark trap and external conductive coating around the neck of the tube must be connected to the chassis.

REFERENCE LINE GAUGE

See page 3

MOUNTING POSITION

Any, except with screen downwards and the axis of the tube making an angle of less than 50° with the vertical.

ACCESSORIES

Focusing coil	type AT1997

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_a max.	27	kV
V_a min.	20	kV
$-V_g$ max.	200	V
$+V_g$ max.	0	V
$+v_{g(pk)}$ max.	2	V

RATINGS (contd.)

I_k max.	150	μA
V_{h-k} max. (see note 1)		
cathode negative	125	V
cathode positive	200	V
peak cathode positive (see note 2)	410	V
R_{h-k} max.	1.0	MΩ
R_{g-k} max.	1.5	MΩ
Z_{g-k} max. at 50Hz	0.5	MΩ

NOTES

1. In order to avoid excessive hum the a.c. component of V_{h-k} should be as low as possible ($<20V_{r.m.s.}$).
2. During a warm-up period not exceeding 45s.

TUBE PROTECTION

It is essential that means be provided for the instantaneous removal of the beam current in the event of a failure of either one or both of the timebases. Unless such a safety device is incorporated a failure of this type will result in immediate destruction of the screen of the tube.

X-RADIATION PROTECTION

Shielding equivalent to a lead thickness of 0.5mm is required to protect the observer against X-radiation.

REFERENCE LINE GAUGE

All dimensions in mm   D1596

OUTLINE DRAWING

Ø127±3

Ø108 min.

Useful screen area

Cavity connector CT8

30±6

a

117.5±5

Insulating coating

40°

Ø50

Reference line

(determined by the plane of the upper edge of the gauge when the gauge is resting on the cone).

31 max

100   338±9

External conductive coating (M).

Centre of magnetic length of focus unit

Ø36.5±1.5

a
g

Spark trap

k h h

NC   NC

NP   NP
NP   NP
a
NP   Spark trap
NP

g   k
h   h
90°±10°

B12A Base

All dimensions in mm

D1595

Mullard

ANODE CURRENT PLOTTED AGAINST GRID VOLTAGE

Mullard

CADMIUM SULPHIDE
PHOTOCONDUCTIVE CELLS

C

CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL EXPLANATORY NOTES

1. DESCRIPTION

Cadmium sulphide (CdS) cells are two-terminal light–sensitive resistors enclosed in a protective envelope of glass or plastic. They are made by sintering photoconductive cadmium sulphide powder into ceramic–like tablets of the required shape. Cadmium sulphide, when suitably prepared, is an insulator in the dark, but becomes a conductor when light falls upon it, due to the release of electrons within the material. The resistance varies roughly in inverse proportion to the illumination, and its range may cover up to six decades.

Electrodes are deposited upon the tablet surface, and are made of materials which give an ohmic contact, but with low resistance compared with that of the cadmium sulphide. The electrodes are usually inter–digital, i.e. in the form of interlinked fingers or combs. The design of the electrode system affects the resistance and voltage rating of the cell, so that different resistances and voltage ratings can be achieved on a tablet of given size. A device with a small number of widely spaced electrodes will have a higher resistance and voltage rating than a device using the same tablet with a large number of closely spaced electrodes.

2. DATA PRESENTATION

In general the data is divided into four main sections: quick reference data, cell characteristics, ratings and shock and vibration resistance.

2.1 Quick reference data

This section contains the main characteristics of the cell to allow rapid comparison with other cells. The information for circuit design should be obtained from the succeeding sections of the data. The characteristics usually given in the quick reference data are: maximum power dissipation at an ambient temperature of $25^{\circ}C$, maximum cell voltage, nominal cell resistance at 50 lux illumination, sensitive area of the cell, maximum overall dimensions and any special features.

2.2 Cell characteristics

The electrical properties of cadmium sulphide cells are dependent on many factors, such as illumination, colour temperature of the source, cell voltage and current, temperature, time of operation in the circuit, and operation during the 24 hours prior to measurement. The characteristics given in the data are therefore only checkpoints of the electrical properties, measured under specified conditions and at start of life. They are based on the device being uniformly illuminated by a tungsten lamp operated at a specified colour temperature, usually $2700^{\circ}K$. An explanation of colour temperature is given in section 6.2.

The cell resistance at a fixed level of illumination is affected by the colour temperature or colour content of the illumination. A curve of the spectral response of Mullard cadmium sulphide cells is given on page 8 of these notes.

More detailed information on cell characteristics is given in section 3.

2.3 Ratings

The ratings of Mullard cadmium sulphide cells are given according to the absolute maximum system, as defined below:

2.3.1 I.E.C. definition (International Electrotechnical Commission)

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

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

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

2.3.2 Absolute maximum cell surge voltage

The absolute maximum cell surge voltage is, unless otherwise stated, twice the absolute maximum cell voltage given in the data. A surge is defined as an occasional over-voltage due to supply transients.

2.3.3 Maximum power dissipation

The value of maximum power dissipation given in the data applies to uniform illumination of the cell. If only part of the tablet is illuminated the maximum power should be reduced in proportion to the area used. Therefore it is generally preferable to reduce the illumination on the cell by interposing a filter, instead of reducing the illuminated area by means of an iris or shutter.

2.4 Shock and vibration resistance

The conditions for shock and vibration given in the data sheets are intended only to give an indication of the mechanical quality of the cells. It is not advisable to subject a cell to such conditions.

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3.   CELL CHARACTERISTICS

3.1   Illuminated resistance

When the illumination incident on a cell is changed the resistance changes
to a value which is a function of the new illumination. The change is not
immediate, and the resistance may overshoot as shown below:

3.2   Illuminated resistance (a.c. operation)

When a cell is operated from an a.c. supply the effective resistance
measured as $|V/I|$ is usually greater than the resistance measured under
d.c. conditions. Where a.c. resistance characteristics are not fully
described, the a.c. resistance values at 50Hz are approximately 1 to 1.3
times those for d.c.

When using h.f. supplies there will be some change in impedance accom-
panied by a phase shift between the applied voltage and the cell current.

3.3   Definitions

The following terms are used in the data:

Illuminated resistance ~ the resistance of the cell when illuminated.

Initial illuminated resistance – the first virtually constant value of illumin-
ated resistance after a change in illumination, usually after a change
following 16 hours in complete darkness. (After 16 hours in darkness,
changes in the cadmium sulphide material are still occurring, but have an
insignificant effect on subsequent measurements.)

Equilibrium illuminated resistance – the illuminated resistance after such
a time that the rate of change of illuminated resistance is less than 0.2%
per minute.

Illuminated current – the current which flows when a specified voltage is
applied to the illuminated cell.

<u>Initial illuminated current</u> – the first virtually constant value of illuminated current after a change of illumination, usually after a change following 16 hours in complete darkness.

<u>Equilibrium illuminated current</u> – the illuminated current after such a time that the rate of change of illuminated current is less than 0.2% per minute.

<u>Dark resistance</u> – the resistance of the cell in complete darkness.

<u>Initial dark resistance</u> – the dark resistance at a specified time after a specified history.

<u>Equilibrium dark resistance</u> – the dark resistance after such a time that the rate of change of dark resistance is less than 0.2% per minute.

<u>Dark current</u> – the current which flows when a specified voltage is applied to the cell in complete darkness.

<u>Initial dark current</u> – the dark current at a specified time after a specified history.

<u>Equilibrium dark current</u> – the dark current after such a time that the rate of change of dark current is less than 0.2% per minute.

<u>Resistance rise time</u> – the time taken for the resistance of the cell to rise to a specified value after switching off a specified illumination after a specified history.

<u>Resistance decay time</u> – the time taken for the resistance of the cell to fall to a specified value, measured from the instant of switching on a specified illumination after a specified history.

<u>Current decay time</u> – the time taken for the current through the cell to fall to 10% of its value at the instant of switching off a specified illumination after a specified history.

<u>Current rise time</u> – the time taken for the current through the cell to rise to 90% of its initial illuminated current, measured from the instant of switching on a specified illumination after a specified history.

<u>Illumination sensitivity</u> – the illuminated current divided by the incident illumination.

<u>Temperature coefficient of illuminated resistance (current)</u> – the relationship between illuminated resistance (current) and variation of ambient temperature, under conditions of constant illumination and applied voltage. Within the normal operating range of the cells the temperature coefficient of illuminated resistance is typically -0.2% per degC.

<u>Initial drift</u> – the difference between the equilibrium and initial illuminated current, expressed as a percentage of the initial illuminated current.

<u>Illumination response</u> – the relationship between the initial illuminated resistance (R) and the illumination (E), defined as $\dfrac{\Delta \log R(\text{initial})}{\Delta \log E}$

Gamma – the relationship between change in resistance and corresponding change in illumination, defined as $\dfrac{\log R1/R2}{\log E2/E1}$ where R1 = resistance at illumination E1 and R2 = resistance at illumination E2.

4. THERMAL DATA

4.1 Ambient temperature

The ambient temperature is the temperature of the air surrounding the cell in its practical situation, which means that all other devices in the same space or apparatus must have their normal maximum dissipation and the normal apparatus envelope must be used.

The ambient temperature can normally be measured by means of a mercury thermometer with a blackened bulb, placed 5mm from the cell in the horizontal plane through the centre of the effective area of the cadmium sulphide tablet. The thermometer should be exposed to substantially the same radiant energy as that incident on the cadmium sulphide tablet.

4.2 Thermal resistance

The thermal resistance of a cell is defined as the temperature difference between the hottest point of the cell and the dissipating medium, divided by the power dissipated in the device.

5. MECHANICAL CONSIDERATIONS

5.1 Mounting position

Unless otherwise stated in the published data, cells can be mounted in any position.

5.2 Soldering and wiring recommendations

Most photoconductive cells can be soldered directly into the circuit, as indicated in the published data. Heat conducted to the seals should be kept to a minimum by the use of a thermal shunt. Unless otherwise stated, cells may be dip-soldered at a solder temperature of $240^{\circ}C$ for a maximum of 10 seconds up to a point 5mm from the seals. Care should be taken not to bend the leads nearer than 1.5mm from the seals.

5.3 Storage

It is recommended that cells are stored in the dark. In any case direct sunlight should be avoided.

5.4 Outline drawings

All dimensions are given in millimetres.

Mullard

6. CELL ILLUMINATION

6.1 Light units

Cadmium sulphide cells are sensitive mainly in the visible region of the spectrum, so units associated with visible light are used in the data sheets. The four preferred units are defined below.

Cadmium sulphide data is usually given in terms of the illumination on the cell.

6.1.1 Luminous intensity - candela (cd)

Luminous intensity is the term used to express the light giving power of a source.

The candela is 1/60th of the luminous intensity, in a direction normal to the surface, of one square centimetre of a black body at the temperature of solidification of platinum.

6.1.2 Luminous flux - lumen (lm)

Luminous flux is the term used to express the total amount of light emitted or received by a given surface, or passing through a given area.

The lumen is the luminous flux radiating from a point source of uniform luminous intensity 1 candela, and contained within a solid angle of 1 steradian.

A steradian is the solid angle subtended at the centre of a sphere of radius r by an area r^2 on the surface of the sphere. As the surface area of a sphere is $4\pi r^2$, a complete sphere comprises 4π steradians, so the total luminous flux from a point source of 1 candela is 4π lumens.

6.1.3 Illumination - lux (lx)

Illumination is the term used to express the amount of luminous flux falling on a given surface.

The lux is the illumination produced when 1 lumen of flux falls on a surface of area 1 square metre. It will be seen that an illumination of 1 lux is produced on an area of 1 square metre at a distance of 1 metre from a point source of 1 candela.

6.1.4 Luminance - candela/square metre (cd/m^2)

Luminance is a measure of the brightness of a surface whether illuminated or self-luminous.

The preferred unit is the candela per square metre, previously known as the nit.

6.2 Colour temperature

The normal way of specifying the colour of a light source is by means of its colour temperature. This is the temperature to which a black body would have to be raised to give a similar colour sensation to that produced by the light source under examination. Certain light sources (e.g. the sky) have a colour which cannot in practice be obtained by heating a black body, and to quote equivalent colour temperatures in these cases involves theoretical extrapolations. The colour temperature of the sky may be as high as $20\,000^{\circ}$K, but it is possible to simulate the colour source by the use of conventional tungsten lamps in conjunction with filters.

6.2.1 C.I.E. Standard (Commission Internationale de l'Eclairage)

The C.I.E. standard illumination source A has a colour temperature of 2854°K. To obtain a good test lamp stability, Mullard cadmium sulphide cells are normally measured at the slightly lower colour temperature of 2700°K, and the published characteristics are given for this illumination. The cell resistance with an illumination of 2854°K is approximately 5% higher than the resistance at 2700°K. For other light sources the cell resistance should be multiplied by the following approximate factors:

Source of illumination	Factor
Incandescent radiation at colour temperature of:	
1500°K	1/2
*2000°K	2/3
Sunlight	4/3
White fluorescent light	2

*2000°K corresponds to light from an oil fired burner flame (yellow flame).

RELATIVE SPECTRAL SENSITIVITY OF CADMIUM
SULPHIDE PHOTOCONDUCTIVE CELLS

Mullard

PHOTOCONDUCTIVE CELL   ORP12

<div style="border:1px solid">

QUICK REFERENCE DATA

Cadmium sulphide photoconductive cell for end-on incidence of illumination. Intended for general purpose applications and automatic contrast and brightness control of television receivers.

Maximum power dissipation (T_{amb} = 25°C)	200	mW
Absolute maximum cell voltage	110	V
Cell resistance (at 50 lux)	2.4	kΩ
Sensitive area	0.6	cm^2

</div>

This data should be read in conjunction with 'OPERATING NOTES' given on page 2.

CHARACTERISTICS

.   (measured under d.c. conditions, at start of life, with T_{amb} = 25°C)

Cell resistance at 1000 lux and		
lamp colour temperature 2700°K		
Typical	75 to 300	Ω
Minimum ultimate dark resistance at 110V d.c.	10	MΩ
(see pages 3 and 4)		
*Nominal resistance rise time	75	ms
**Nominal resistance fall time	350	ms

*When an illumination of 50 lux is removed, the resistance rise time is the time taken for the cell resistance to rise to 24kΩ.

**When an illumination of 50 lux is applied to a cell that was in the dark the resistance fall time is the time taken for the resistance to fall from its dark value to 5.3kΩ.

ABSOLUTE MAXIMUM RATINGS

V_{cell} max. (d.c. or a.c. pk)	110	V
P_{cell} max. with uniform illumination (see curve on page 6)		
at T_{amb} = 25°C	200	mW
T_{amb}		
Maximum	+60	°C
Minimum	-10	°C

Mullard

OPERATING NOTES

1. This data is based on the device being uniformly illuminated.

2. For sources of illumination other than a lamp of colour temperature 2700°K, the cell resistance should be multiplied by the following approximate factors.

Source of illumination	Factor
Incandescent radiation at colour temperature of:	
1500°K	1/2
2000°K	2/3
Sunlight	4/3
White fluorescent	2

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

4. When the cell illumination is changed the cell resistance changes to a transient value and then over a period of approximately 10 minutes assumes an equilibrium value. The transient usually overshoots the final equilibrium resistance.

5. The cell should not be subjected to high relative humidity at ambient temperatures above 50°C.

6. The cell may be soldered directly into the circuit but heat conducted to the cell body should be kept to a minimum by the use of a thermal shunt.

Direction of light

Sensitive area

Cell lead I

Cell lead II

The polarity of the
supply is not important

Tinned copper
leads 23 s.w.g.
(0·6 dia)

All dimensions in mm

14 max

8·6 max

8±1

2±1

9·6

7473

ORP12 Page 2

CELL RESISTANCE PLOTTED AGAINST ILLUMINATION

Mullard

NOMINAL RESISTANCE RISE-TIME CURVES WITH
ILLUMINATION AS PARAMETER

ORP12

lamp colour temperature = 2700°K

Following 10 s dark period

Following 5 min dark period

Cell resistance (Ω)

B3326

1 lux

10 lux

10^2 lux

10^3 lux

Time in light

NOMINAL RESISTANCE FALL-TIME CURVES FROM DARKNESS
WITH ILLUMINATION AS PARAMETER

Mullard

ORP12

B4059

Cell dissipation (mW)

200

150

100

Permissible area of operation

50

-50   0 T_{amb}(°C)   50   100

MAXIMUM CELL DISSIPATION PLOTTED AGAINST AMBIENT
TEMPERATURE

Mullard

ORP12

B3284

Response (%) vs Wavelength (μm)

SPECTRAL RESPONSE CURVE

PHOTOCONDUCTIVE CELL ORP52

QUICK REFERENCE DATA

Cadmium sulphide photoconductive cell for end-on or side incidence, intended for use in industrial on-off applications such as flame failure equipment. The cell is tropic proof, shock and vibration resistant.

Maximum power dissipation ($T_{amb} = 25^{o}C$)	400	mW
Maximum cell voltage (d.c. and repetitive peak)	200	V
Cell resistance (at 50 lux, 2700K colour temperature)	1.2	kΩ
Maximum overall dimensions	44 × 15.9 dia	mm

This data should be read in conjunction with GENERAL EXPLANATORY NOTES-
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many factors, such as illumination, colour temperature of the source, cell voltage and current, temperature, time of operation in the circuit, and operation during the 24 hours prior to measurement. The following characteristics are therefore only checkpoints of the electrical properties, measured under specified conditions and at start of life.

CHARACTERISTICS (measured under d.c. conditions, at start of life, with T_{amb} =25°C illumination colour temperature = 2700K)

	Min.	Typ.	Max.	
Dark resistance (200V applied in series with 1MΩ (see note 1)				
after 20s in darkness	4.0	–	–	MΩ
after 30min in darkness	100	–	–	MΩ
Illuminated resistance (50 lux illumination, 10V applied voltage)				
initially after 16h in darkness (see note 2)	0.75	1.2	3.0	kΩ
after 15min under the measuring conditions	0.75	1.5	4.1	kΩ
Current rise time (time to reach 90% of the max. value, measured from the instant of switching on 50 lux illumination after 16h in darkness, 10V applied voltage)	–	–	2.0	s
Current decay time (time to reach 10% of the max. value, measured from the instant of switching off the illumination, after 16h in darkness and 10s at 50 lux, 10V applied voltage)	–	–	0.2	s

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CHARACTERISTICS (Continued)

	Typ.	Max.	
Sensitivity (50 lux illumination, 10V applied voltage)	0.17	–	mA/lux
Temperature coefficient of illuminated resistance	–0.2	–0.5	%/degC
$\dfrac{\text{Resistance with 0.5V applied voltage}}{\text{Resistance with 10V applied voltage}}$	1.05	–	

THERMAL CHARACTERISTIC

Thermal resistance from cadmium sulphide tablet to ambient device free in air	150	degC/W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	200	V
$V_{cell(pulse)}$ max. (maximum period 5ms, maximum repetition frequency 1pulse/min)	500	V
P_{cell} max.	See page 4	
$P_{cell(pulse)}$ max.	$5 \times P_{cell}$ max.	
I_{cell} max. (d.c. and repetitive peak)	100	mA
Maximum illumination	50 000	lux
T_{tablet} max.	+85	^{o}C
T_{amb} max. (storage) (see note 3)	+50	^{o}C
T_{amb} max. (operating) (see note 3)	+70	^{o}C
T_{amb} min. (storage and operating)	–40	^{o}C

DESIGN CONSIDERATIONS

Apparatus using cadmium sulphide cells should designed so that changes in resistance of the cells during life from –30% to +70% do not impair the circuit performance. Direct sunlight should be avoided.

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25 g (peak), 10 000 shocks in one of the three positions of the cell.

Vibration

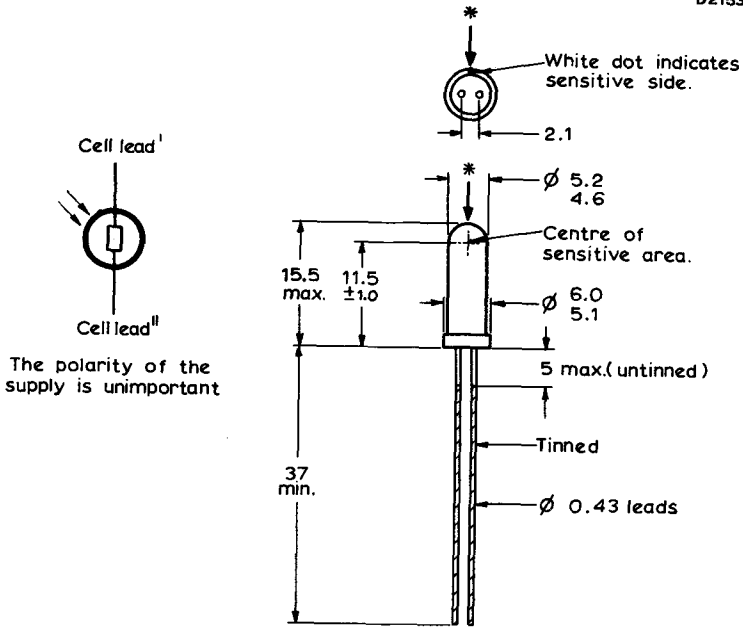2.5 g (peak), 50Hz, 32 hours in each of the three positions of the cell.

Mullard

PHOTOCONDUCTIVE CELL ORP52

NOTES

1. The spread of dark resistance is large, and values higher than 100MΩ and 10 000 MΩ are possible for the initial and equilibrium dark resistance respectively.

2. After 16 hours in darkness changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illuminated resistance and the resistance decay time.

3. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

4. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

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

OUTLINE AND DIMENSIONS

Incident radiation

B9207
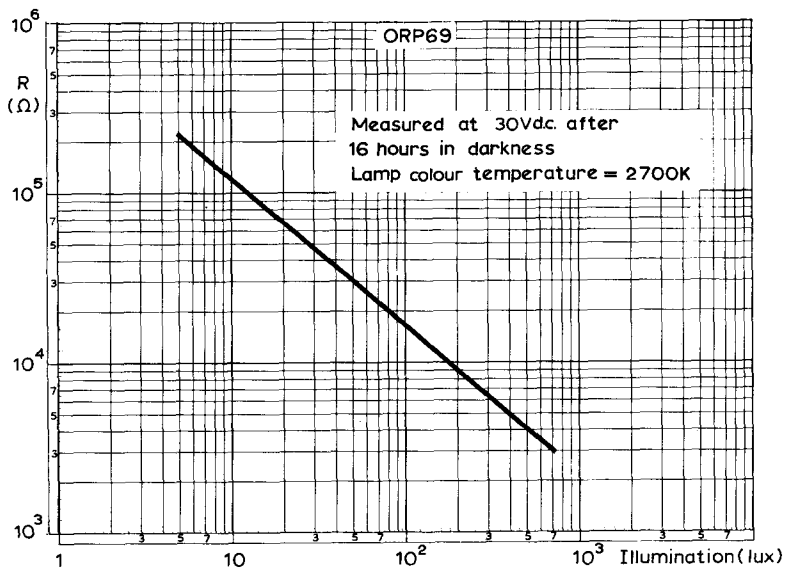
15·9max.

Cell lead'

45°

12 dia

36 max.

26 ±2

Cell lead"

The polarity of the supply is not important

10 max. (untinned)

8·0 max.
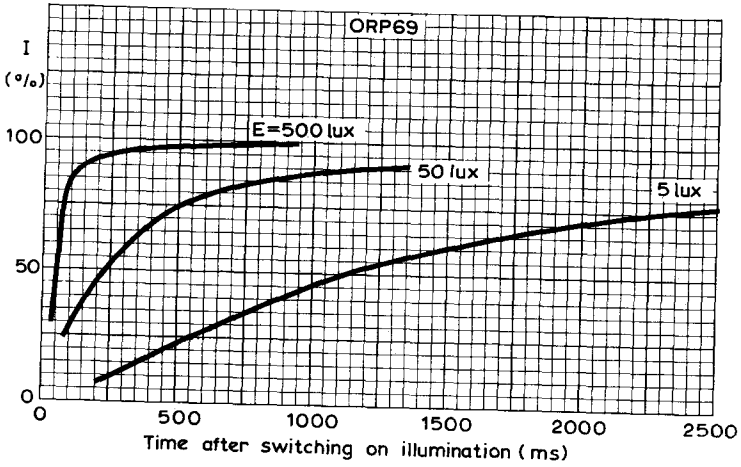
37 min.

tinned

All dimensions in mm

Mullard

INITIAL CELL RESISTANCE PLOTTED AGAINST ILLUMINATION

MAXIMUM POWER DISSIPATION
PLOTTED AGAINST AMBIENT TEMPERATURE

Mullard

PHOTOCONDUCTIVE CELLS   ORP60
ORP61

QUICK REFERENCE DATA

Cadmium sulphide photoconductive cells intended for use in flame control and other industrial applications, and for automatic brightness and contrast control in television receivers. The cells are shock and vibration resistant. ORP60 is for end-on incidence, ORP61 is for side incidence.

Maximum power dissipation $(T_{amb} = 25^{\circ}C)$	70	mW
Maximum cell voltage (d.c. and repetitive peak)	350	V
Cell resistance (at 50 lux, 2700K colour temperature)	60	kΩ
Maximum overall dimensions	16.5 × 6.0 dia mm	

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with GENERAL EXPLANATORY NOTES – CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many factors, such as illumination, colour temperature of the source, cell voltage and current, temperature, time of operation in the circuit, and operation during the 24 hours prior to measurement. The following characteristics are therefore only checkpoints of the electrical properties, measured under specified conditions and at start of life.

CHARACTERISTICS (Measured under d.c. conditions, at start of life, with $T_{amb} = 25^{\circ}C$, illumination colour temperature = 2700K, unless otherwise stated)

	Min.	Typ.	Max.	
Initial dark current (300V applied in series with 1MΩ, after 20s in darkness)	–	–	1.5	μA
Initial illuminated current (30V applied voltage, 50lux illumination after 16h in darkness) (see note 1)	200	500	800	μA
Sensitivity (50lux illumination, 30V applied voltage)	–	10	–	μA/lux

END OF LIFE CHARACTERISTICS (Measured under d.c. conditions, with $T_{amb} = 25^{O}C$, illumination colour temperature = 2700K)

None of the following end of life characteristics are expected to be reached before 2500 operating hours under the following conditions:

Illumination = 50 to 100lux

Colour temperature ≏ 2500K

Power dissipation = 60mW

$T_{amb} = 35^{O}C$

Initial dark current (300V applied voltage, after 20s in darkness)	≤3.0	μA
Change of intial illuminated current during life (30V applied voltage, 50lux illumination, after 16h in darkness)	≤60	%

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	350	V
P_{cell} max.	See page 4	
I_{cell} max. (d.c. and repetitive peak)	7.5	mA
T_{amb} max. (storage) (see note 2)	+50	^{O}C
T_{amb} max. (operating) (see note 2)	+70	^{O}C
T_{amb} min. (storage and operating)	–40	^{O}C

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25g (peak), 3000 shocks in one of the three positions of the cell.

Vibration

2.5g (peak), 50Hz, 32 hours in each of the three positions of the cell.

PHOTOCONDUCTIVE CELLS ORP60
ORP61

NOTES

1. After 16 hours in darkness changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illuminated resistance and the resistance decay time.

2. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

3. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

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

OUTLINE AND DIMENSIONS

Sensitive area = 0.25mm^2

CELL VOLTAGE PLOTTED AGAINST CELL CURRENT
WITH ILLUMINATION AS PARAMETER

MAXIMUM POWER DISSIPATION PLOTTED AGAINST
AMBIENT TEMPERATURE

Mullard

PHOTOCONDUCTIVE CELL ORP62

This data should be read in conjunction with GENERAL EXPLANATORY
NOTES - CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many
factors, such as illumination, colour temperature of the source, cell volt-
age and current, time of operation in the circuit, and opera-
tion during the 24 hours prior to measurement. The following characteris-
tics are therefore only checkpoints of the electrical properties, measured
under specified conditions and at start of life.

CHARACTERISTICS (measured under d.c. conditions, at start of life, with
$T_{amb} = 25^oC$, illumination colour temperature = 2700K)

	Min.	Typ.	Max.	
Initial dark resistance (300V applied in series with 1MΩ, after 20s in darkness) (see note 1)	150	-	-	MΩ
Illuminated resistance (30V applied voltage, 50 lux illumination) initially after 16h in darkness (see note 2)	30	45	100	kΩ
after 15 min under the measuring conditions	30	60	170	kΩ
Current rise time	See page 5			
Current decay time	See page 5			
Sensitivity (50 lux illumination, 30V applied voltage)	-	13	-	μA/lux
Temperature coefficient of illuminated resistance	-	-0.2	-0.5	%/degC
$\dfrac{\text{Resistance with 0.5V applied voltage}}{\text{Resistance with 30V applied voltage}}$	-	1.4	-	

Mullard

THERMAL CHARACTERISTIC

Thermal resistance from cadmium sulphide tablet to ambient, device free in air	600	degC/W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	350	V
$V_{cell(pulse)}$ max. (maximum period 5ms, maximum repetition frequency 1 pulse/min)	1.0	kV
P_{cell} max.	See page 4	
$P_{cell(pulse)}$ max.	$5 \times P_{cell}$ max.	
T_{tablet} max.	+85	^{o}C
T_{amb} max. (storage) (see note 3)	+50	^{o}C
T_{amb} max. (operating) (see note 3)	+70	^{o}C
T_{amb} min. (storage and operating)	−40	^{o}C

DESIGN CONSIDERATIONS

Apparatus using cadmium sulphide cells should be designed so that changes in resistance of the cells during life from −30% to +70% do not impair the circuit performance. Direct sunlight should be avoided.

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25g (peak), 10 000 shocks in one of the three positions of the cell.

Vibration

2.5 g (peak), 50Hz, 32 hours in each of the three positions of the cell.

NOTES

1. The spread of dark resistance is large, and values higher than 1000MΩ are possible for the initial dark resistance.

2. After 16 hours in darkness changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illuminated resistance and the current rise time.

3. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

4. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

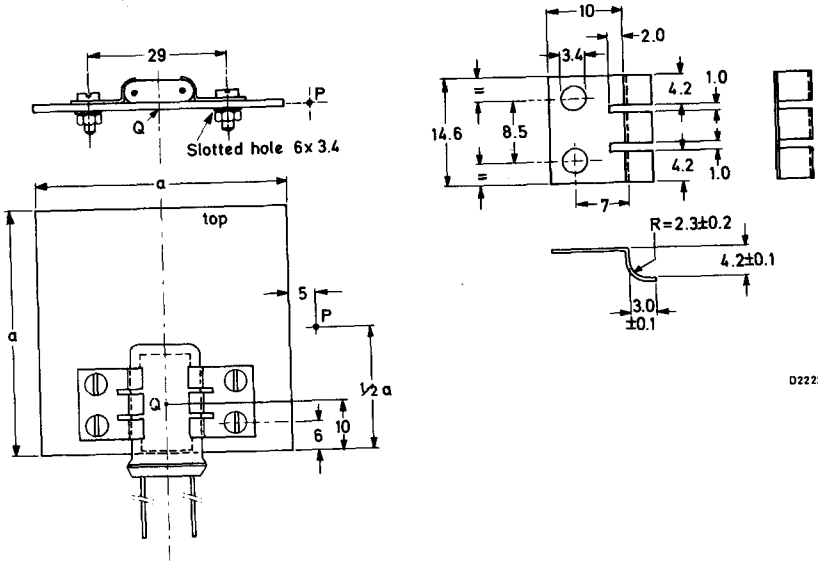6. Care should be taken not to bend the leads nearer than 1.5mm from the seals.

PHOTOCONDUCTIVE CELL ORP62

OUTLINE AND DIMENSIONS

Cell lead^I

Cell lead^{II}

The polarity of the
supply is unimportant.

Incident
radiation.

B9167

Red dot indicates
sensitive side.

2·1

5·2 dia.
max.

Centre of
sensitive area.

6·0 dia.
max.

15.5
max.

12
±2

5·0 max.(untinned.)

37
min.

Tinned.

0·43 dia.

All dimensions in mm.

Sensitive area = 2mm × 2.5mm

Mullard

INITIAL ILLUMINATED RESISTANCE PLOTTED AGAINST ILLUMINATION

MAXIMUM POWER DISSIPATION PLOTTED AGAINST
AMBIENT TEMPERATURE

Mullard

PHOTOCONDUCTIVE CELL ORP62

CURRENT RISE TIME WITH ILLUMINATION AS PARAMETER

CURRENT DECAY TIME WITH ILLUMINATION AS PARAMETER

Mullard

PHOTOCONDUCTIVE CELL ORP69

```
QUICK REFERENCE DATA

Cadmium sulphide photoconductive cell for end-on or side incidence
intended for use in industrial on-off applications such as flame failure
circuits. The cell is tropic proof, shock and vibration resistant.

Maximum power dissipation ($T_{amb} = 25^{o}C$)          100      mW

Maximum cell voltage (d.c. and repetitive peak)          350      V

Cell resistance (at 50 lux, 2700K colour temperature)    30       $k\Omega$

Maximum overall dimensions                    6.0 dia $\times$ 15.5  mm
```

This data should be read in conjunction with GENERAL EXPLANATORY NOTES –
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many
factors, such as illumination, colour temperature of the source, cell vol-
tage and current, temperature, time of operation in the circuit, and opera-
tion during the 24 hours prior to measurement. The following characteris-
tics are therefore only checkpoints of the electrical properties, measured
under specified conditions and at start of life.

CHARACTERISTICS (measured under d.c. conditions, at start of life, with T_{amb}
$= 25^{o}C$, illumination colour temperature $= 2700K$)

	Min.	Typ.	Max.	
Initial dark resistance (300V applied in series with 1MΩ after 20s in darkness) (see note 1)	100	–	–	MΩ
Illuminated resistance (30V applied voltage, 50 lux illumination)				
initially after 16h in darkness (see notes 2 and 3)	20	30	60	kΩ
after 15min under the measuring conditions (see note 3)	27	46	115	kΩ
$\dfrac{\text{Resistance with side incidence}}{\text{Resistance with end-on incidence}}$	0.7	1.0	1.8	
Current rise time	See page 5			
Current decay time	See page 5			
Sensitivity (50 lux illumination, 30V applied voltage) (see note 3)	–	17	–	μA/lux
Temperature coefficient of illuminated resistance	–	–0.2	–0.5	%/degC
$\dfrac{\text{Resistance with 0.5V applied voltage}}{\text{Resistance with 30V applied voltage}}$	–	1.4	–	

THERMAL CHARACTERISTIC

Thermal resistance from cadmium sulphide tablet to ambient, device free in air	600	degC/W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	350	V
$V_{cell\ (pulse)}$ max. (maximum period 5ms, maximum repetition frequency 1 pulse/min)	700	V
P_{cell} max.	See page 4	
$P_{cell\ (pulse)}$ max.	$5 \times P_{cell}$ max.	
T_{tablet} max.	+85	^{o}C
T_{amb} max. (storage) (see note 4)	+50	^{o}C
T_{amb} max. (operating) (see note 4)	+70	^{o}C
T_{amb} min. (storage and operating)	-40	^{o}C

DESIGN CONSIDERATIONS

Apparatus using cadmium sulphide cells should be designed so that changes in resistance of the cells during life from -30% to +70% do not impair the circuit performance. Direct sunlight should be avoided.

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25g (peak), 10 000 shocks in one of the three positions of the cell.
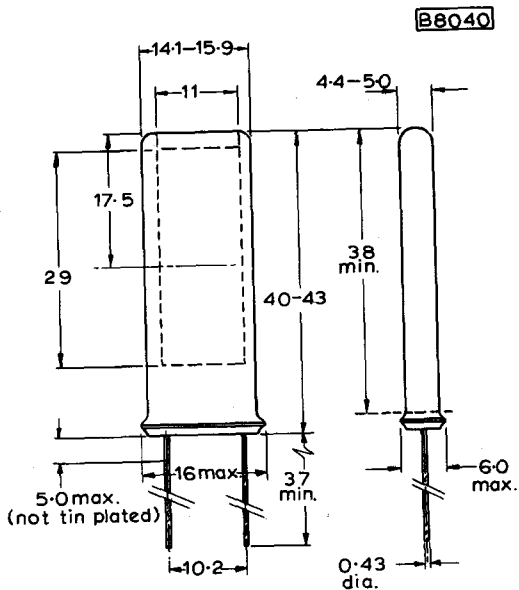
Vibration

2.5g (peak), 50Hz, 32 hours in each of the three positions of the cell.

NOTES

1. The spread of dark resistance is large, and values higher than 1000MΩ are possible for the initial dark resistance.

2. After 16 hours in darkness changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illuminated resistance and the current rise time.

3. Measured with end-on incidence.

4. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

5. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

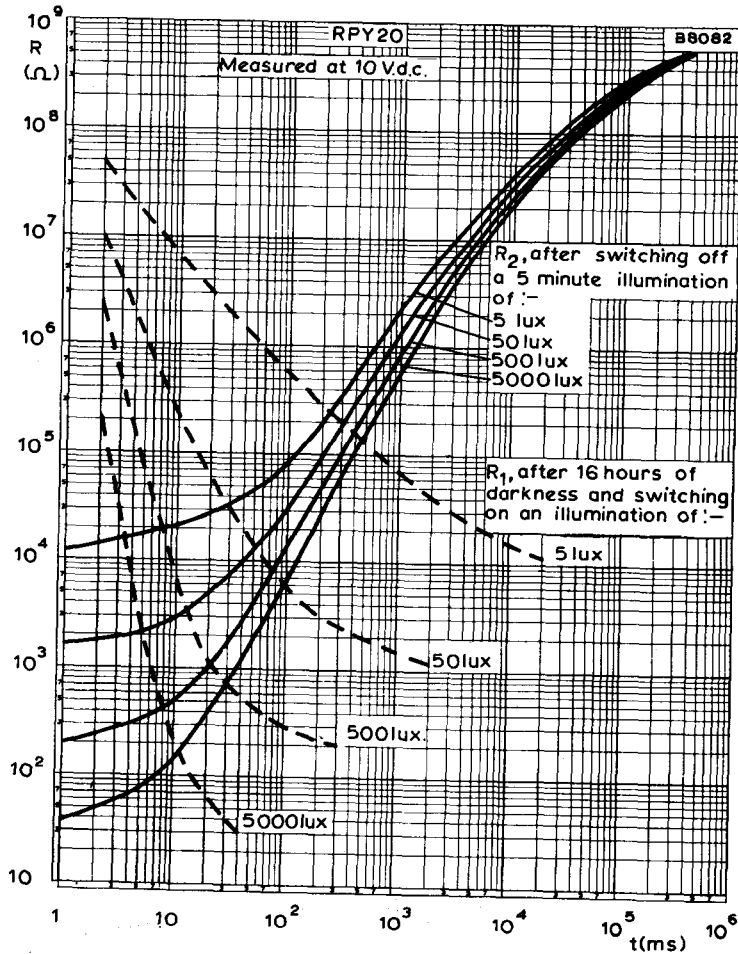7. Care should be taken not to bend the leads nearer than 1.5mm from the seals.

PHOTOCONDUCTIVE CELL ORP69

OUTLINE AND DIMENSIONS

D2153

White dot indicates
sensitive side.

2.1

Cell lead¹

∅ 5.2
4.6

Centre of
sensitive area.

15.5 max. 11.5 ±1.0

∅ 6.0
5.1

Cell lead¹¹

The polarity of the
supply is unimportant

5 max.(untinned)

Tinned

37 min.

∅ 0.43 leads

*Alternative directions for incident radiation

All dimensions in mm

Mullard

INITIAL ILLUMINATED RESISTANCE PLOTTED AGAINST ILLUMINATION

MAXIMUM POWER DISSIPATION PLOTTED AGAINST
AMBIENT TEMPERATURE

Mullard

PHOTOCONDUCTIVE CELL ORP69

CURRENT RISE TIME WITH ILLUMINATION AS PARAMETER

CURRENT DECAY TIME WITH ILLUMINATION AS PARAMETER

Mullard

PHOTOCONDUCTIVE CELL   RPY18

QUICK REFERENCE DATA

Flat cadmium sulphide photoconductive cell for side incidence intended for use in general control circuits. The cell is tropic proof, shock and vibration resistant.

Maximum power dissipation ($T_{amb} = 25^{\circ}C$)	0.5	W
Maximum power dissipation with a heatsink with thermal resistance 5.0 degC/W ($T_{amb} = 25^{\circ}C$)	2.0	W
Maximum cell voltage (d.c. and repetitive peak)	100	V
Cell resistance (at 50 lux, 2700K colour temperature)	400	Ω
Sensitive area	10 × 15	mm
Maximum overall dimensions	27 × 16.3 × 6.0	mm

This data should be read in conjunction with GENERAL EXPLANATORY NOTES - CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many factors, such as illumination, colour temperature of the source, cell voltage and current, temperature, time of operation in the circuit, and operation during the 24 hours prior to measurement. The following characteristics are therefore only checkpoints of the electrical properties, measured under specified conditions and at start of life.

CHARACTERISTICS (measured under d.c. conditions, at start of life, with $T_{amb} = 25^{\circ}C$, illumination colour temperature = 2700K)

	Min.	Typ.	Max.	
Dark resistance (100V applied in series with 1MΩ) (see note 1)				
after 20s in darkness	5.6	–	–	MΩ
after 30min in darkness	50	–	–	MΩ
Initial illuminated resistance (after 16h in darkness) (see note 2)				
at 50 lux, 10V applied voltage	235	400	1200	Ω
at 5000 lux, 1V applied voltage (see note 3)	–	25	35	Ω
Equilibrium illuminated resistance (after 15min under the measuring conditions)				
at 50 lux, 10V applied voltage	235	480	1560	Ω
at 5000 lux, 1V applied voltage (see note 3)	–	–	35	Ω

Mullard

CHARACTERISTICS (contd.)	Typ.	Max.	
Resistance decay time (time to reach 50Ω, measured from the instant of switching on 5000 lux illumination after 16h in darkness)	5.0	25	ms
Resistance rise time (time to reach 2kΩ, measured from the instant of switching off 5000 lux illumination after 5min or more illumination)	40	200	ms
Sensitivity (50 lux illumination, 10V applied voltage)	0.5	–	mA/lux
Temperature coefficient of illuminated resistance	–0.2	–0.5	%/degC
$\dfrac{\text{Resistance with 0.5V applied voltage}}{\text{Resistance with 10V applied voltage}}$	1.1	–	

THERMAL CHARACTERISTICS

Thermal resistance from cadmium sulphide tablet to ambient, device free in air		120	degC/W
*Thermal resistance from cadmium sulphide tablet to heatsink		25	degC/W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	100	V
$V_{cell\ (pulse)}$ max. (maximum period 5ms, maximum repetition frequency 1 pulse/min)	250	V
P_{cell} max.	See page 6	
$P_{cell\ (pulse)}$ max.	$5 \times P_{cell}$ max.	
I_{cell} max. (d.c. and repetitive peak)	250	mA
Maximum illumination	50 000	lux
T_{tablet} max. (see note 4)	+85	^{o}C
T_{amb} max. (storage) (see note 5)	+50	^{o}C
T_{amb} max. (operating) (see note 5)	+70	^{o}C
T_{amb} min. (storage and operating)	–40	^{o}C

DESIGN CONSIDERATIONS

Apparatus using cadmium sulphide cells should be designed so that changes in resistance of the cells during life from –30% to +70% do not impair the circuit performance. Direct sunlight should be avoided.

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock – 25 g (peak), 10 000 shocks in one of the three positions of the cell.
Vibration – 2.5 g (peak), 50Hz, 32 hours in each of the three positions of the cell.

*The temperature of the heatsink is measured near the centre of the cell, when the cell is properly clamped on a heatsink as shown on page 4.

Mullard

PHOTOCONDUCTIVE CELL   RPY18

NOTES

1. The spread of dark resistance is large, and values higher than 15MΩ and 2000MΩ are possible for the initial and equilibrium dark resistance respectively.

2. After 16 hours in darkness, changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illuminated resistance and the resistance decay time.

3. Maximum during life 40Ω.

4. If no forced air cooling is used the envelope temperature opposite the centre of the sensitive area is about 83°C when the temperature of the cadmium sulphide tablet is 85°C. This temperature can be measured, for example, by means of a thermocouple fastened on the envelope.

5. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

6. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

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

OUTLINE AND DIMENSIONS

All dimensions in mm

The spacing of the leads is compatible with
the standard 2.54mm (0.1in) printed wiring grid

Mullard

29

Slotted hole 6×3.4

top

P

5

½a

6 10

10

2.0

3.4

14.6 8.5

4.2 1.0

4.2 1.0

7

R=2.3±0.2

4.2±0.1

3.0 ±0.1

D2222

Clamping strip
thickness 0.3mm

All dimensions in mm

The thermal resistance Θ_h of the heatsink is defined as the temperature difference between the point Q at the back of the heatsink and the ambient at point P. It is measured as per watt dissipation in the device, the heatsink being placed in a cubical enclosure of internal edges $5 \times a$ mm with point Q in the centre of the cube, the plane of the heatsink being vertical with the edge shown as 'top' uppermost.

A heatsink as shown in the drawing has a thermal resistance of

$$\Theta_h = 19 \text{ degC/W when } a = 50\text{mm}$$

and $\Theta_h = 7.5$ degC/W when a = 100mm

With smaller enclosure dimensions a higher value of Θ_h may be expected.

Mounting instructions

To achieve the above mentioned Θ_h values, it is essential that the RPY18 be installed in the following manner:

1. Mount one clamp on the heatsink, using the side with round holes.

2. Push the RPY18 under that clamp.

3. Press the second clamp firmly against the RPY18, using the slot holes.

Mullard

RESISTANCE RISE AND FALL TIME CURVES
WITH ILLUMINATION AS PARAMETER

Mullard

RPY18

B9079

10^5
R
(Ω)

Measured at 10 V d.c.
Lamp colour temperature = 2700K

10^4

10^3

10^2

10

1   10 10^2 10^3 Illumination (lux)

INITIAL CELL RESISTANCE PLOTTED
AGAINST ILLUMINATION

D2233

2.5
$P_{cell\ max}$
(W)

2

III

Averaging time = 2s
Curve I : in free air
Curve II : on a heatsink with θ_h = 19 deg C/W
Curve III : on a heatsink with θ_h = 7.5 deg C/W

1.5

II

1

0.5

I

0
0   10   20   30   40   50   60   70
$T_{amb}(^{\circ}C)$

MAXIMUM POWER DISSIPATION PLOTTED AGAINST
AMBIENT TEMPERATURE

Mullard

PHOTOCONDUCTIVE CELL RPY20

QUICK REFERENCE DATA

Flat cadmium sulphide photoconductive cell for use in general control applications such as twilight switches and flame failure equipment. The cell is tropic proof, shock and vibration resistant.

Maximum power dissipation ($T_{amb} = 25^{o}C$)	1.0	W
Maximum cell voltage (d.c. and repetitive peak)	400	V
Cell resistance (at 50lux, $2700^{o}K$ colour temperature)	1.5	kΩ
Sensitive area	3.2	cm^2

This data should be read in conjunction with GENERAL EXPLANATORY NOTES-
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

GENERAL

The electrical properties of cadmium sulphide cells are dependent on many factors, such as illumination, colour temperature of the source, cell voltage and current, temperature, time of operation in the circuit, and operation during the 24 hours prior to measurement. The following characteristics are therefore only checkpoints of the electrical properties, measured under specified conditions and at start of life.

CHARACTERISTICS (measured under d.c. conditions, at start of life, with $T_{amb} = 25^{o}C$, lamp colour temperature = $2700^{o}K$)

	Min.	Typ.	Max.	
Dark resistance (300V applied in series with 1MΩ) See note 1				
after 20s in darkness	6.5	-	-	MΩ
after 30min in darkness	120	-	-	MΩ
Illuminated resistance (50lux illumination, 10V applied voltage)				
initially after 16h darkness (See note 2)	0.7	1.5	3.3	kΩ
after 15min illumination	0.7	1.9	4.5	kΩ
Resistance decay time (time to reach 10kΩ, measured from the instant of applying 50lux illumination after 16h darkness, 10V applied voltage)	-	-	0.2	s
Resistance rise time (time to reach 1MΩ, measured from the instant of switching off 50lux illumination after 5min or more illumination, 10V applied voltage)	-	0.9	1.5	s

CHARACTERISTICS (Continued)

	Typ.	Max.	
Sensitivity (50lux illumination, 10V applied voltage)	0.15	–	mA/lux
Temperature coefficient of illuminated resistance	–0.2	–0.5	%per degC
Resistance with 0.5V applied voltage / Resistance with 10V applied voltage	1.05	–	

THERMAL CHARACTERISTIC

Thermal resistance from cadmium sulphide tablet to ambient, device free in air	60	degC/W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	400	V
I_{cell} max. (d.c. and repetitive peak)	500	mA
P_{cell} max.		See page 6
Maximum illumination	50 000	lux
Maximum temperature of cadmium sulphide tablet (see note 3)	+85	^{o}C
T_{amb} max. (storage) (see note 4)	+50	^{o}C
T_{amb} max. (operating) (see note 4)	+70	^{o}C
T_{amb} min. (storage and operating)	–40	^{o}C

TYPICAL TWILIGHT SWITCHING CIRCUIT

V.D.R.   Voltage dependent resistor, 10mA at 180V, 2W.

F   Absorption filter to be used to correct circuit spreads and to adjust the switching level (10 to 70lux). Light transmission 5 to 20%.

RLA   D.C. relay, 20kΩ, ratio $I_{on}/I_{off} < 2.7$ (e.g. $I_{on} = 2$mA, $I_{off} = 0.8$mA).

DESIGN CONSIDERATIONS

Apparatus with cadmium sulphide cells should be designed so that changes in resistance of the cells during life from –30% to +70% do not impair the circuit performance. Direct sunlight should be avoided.

Mullard

PHOTOCONDUCTIVE CELL RPY20

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

25g (peak), 10 000 shocks in one of the three positions of the cell.

Vibration

2.5g (peak), 50Hz, 32 hours in each of the three positions of the cell.

NOTES

1. The spread of dark resistance is large, and values higher than 100MΩ and 10 000MΩ are possible for the initial and equilibrium dark resistance respectively.

2. After 16 hours in darkness changes in the cadmium sulphide material are still occurring, but have an insignificant effect on the illumination resistance and the resistance decay time.

3. If no forced air cooling is used, the envelope temperature opposite the centre of the sensitive area is about 83°C when the temperature of the cadmium sulphide tablet is 85°C. This temperature can be measured, for example, by means of a thermocouple fastened on the envelope.

4. Operation of the cell counteracts the deteriorating effect of long periods at high temperature. The maximum operating temperature is therefore higher than the maximum storage temperature.

5. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

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

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

Mullard

OUTLINE AND DIMENSIONS

B8040

141-15·9

11

4·4 – 5·0

17·5

29

40-43

38 min.

5·0 max.
(not tin plated)

16 max.

37 min.

10·2

6·0 max.

0·43 dia.

All dimensions in mm.

The spacing of the leads is compatible with
the standard printed wiring grid 2.54mm (0.1in)

PHOTOCONDUCTIVE CELL RPY20

RESISTANCE RISE AND FALL TIME CURVES
WITH ILLUMINATION AS PARAMETER

Mullard

MAXIMUM POWER DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

INITIAL CELL RESISTANCE PLOTTED AGAINST ILLUMINATION

Mullard

PHOTOCONDUCTIVE CELL   RPY33

QUICK REFERENCE DATA

Cadmium sulpho–selenide photoconductive cell for end–on incidence intended for use in exposure meters, light control equipment and for general industrial use. The cell is tropic proof, shock and vibration resistant. The envelope is hermetically sealed and has a plane glass window.

Maximum power dissipation	as a measuring device	10	mW
	for general use	75	mW
Maximum cell voltage (d.c. and repetitive peak)		50	V
Cell resistance (at 25 lux, 2854K colour temperature)		2.5	kΩ
Sensitive area		4.9 × 3	mm
Maximum overall dimensions		∅9.4 × 3.4	mm

This data should be read in conjunction with GENERAL EXPLANATORY NOTES–CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

CHARACTERISTICS (measured under d.c. conditions, at start of life, with $T_{amb}=25^{o}C$)

The cell is pre–conditioned for at least 1 hour with 300 lux illumination (fluorescent light)

	Min.	Typ.	Max.	
Initial dark resistance (50V applied voltage, 20s after switching off an illumination of 25.6 lux)	100	–	–	kΩ
Initial illuminated resistance (25.6 lux illumination, 2854K colour temperature, 1 V applied voltage)	1.68	–	5.1	kΩ
Current decay time (time to reach 10% of the current at the instant of switching off 5 lux illumination)	–	3.0	–	s
Gamma over the illumination range 0.4 to 25.6 lux (see note 1)	0.60	0.72	0.84	
Illuminated current drift (over 10min period, 50 lux illumination)	–	–	10	%
Pre–conditioning factor (see note 2)	0.9	–	1.2	
<u>Illumination at 2700K</u> Illumination at 4700K (for the same cell resistance)	–	0.9	–	

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)		50	V
P_{cell} max.	for use as a measuring device	10	mW
	for general use	75	mW
T_{amb} max.		+60	°C
T_{amb} min.		−40	°C

SHOCK AND VIBRATION

Samples taken from normal production are submitted to shock and vibration tests as below. More than 95% of the devices pass these tests without perceptible damage.

Shock

50g (peak), 5 shocks in each of the three positions of the cell.

Vibration

2.5g (peak), 50Hz, 32 hours in each of the three positions of the cell.

NOTES

1. Gamma = $\dfrac{\log R1/R2}{\log E2/E1}$ where R1 = resistance at illumination E1
and R2 = resistance at illumination E2

2. Pre–conditioning factor = $\dfrac{\text{Cell current at } 0.4 \text{ lux after 3 days in darkness}}{\text{Cell current at } 0.4 \text{ lux after 1 hour pre–conditioning}}$
at 300 lux (fluorescent light)

3. The cell may be soldered directly into the circuit, but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

4. The cell may be dip–soldered at a solder temperature of 245°C for a maximum of 10 seconds up to a point 5mm from the seals, or for a maximum of 3 seconds up to a point 1.5mm from the seals.
At a solder temperature between 245 and 400°C the maximum soldering time is 5 seconds up to a point 5mm from the seals.

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

Mullard

PHOTOCONDUCTIVE CELL

RPY33

OUTLINE AND DIMENSIONS

D257

∅ 8.1 ±0.05

∅ 9.4 max.

Sensitive area

3·4 / 2·9

2

0.85 / 0.55

0.3 max.

Cell lead'

∅ 1.6 / 1.4

∅ 0.50 / 0.35

37 ±0.5

Cell lead"

5 ±0·2

Sensitive area

45°

0.9 / 0.7

0.9 / 0.7

4.9

All dimensions in mm

∅ 6.1 / 5.9

3.0

Mullard

RELATIONSHIP BETWEEN RESISTANCE AT 0.4 LUX AND 25.6 LUX SHOWING POSSIBLE RANGE OF VALUES

SPECTRAL RESPONSE CURVE

Mullard

QUICK REFERENCE DATA

Monograin cadmium sulphide photoconductive device for side incidence in plastic encapsulation. The device consists of two cells connected in series, and is intended for general applications.

Maximum power dissipation ($T_{amb} \leq 25^\circ C$)	100	mW
Maximum cell voltage (d.c. and repetitive peak)	50	V
Cell resistance (at 50 lux, 2700K colour temperature)	600	Ω
Maximum overall dimensions	5.3 x 5.3 x 1.4	mm

This data should be read in conjunction with GENERAL EXPLANATORY NOTES - CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

CHARACTERISTICS

Measured under d.c. conditions, at start of life, with $T_{amb} = 25^\circ C$, illumination colour temperature = 2700K, and with PRECONDITIONING of at least one hour illumination with 300 lux (fluorescent light).

	Min.	Typ.	Max.	
Initial dark resistance (50V applied in series with 1MΩ, after 20s in darkness)	200	-	-	kΩ
Initial illuminated resistance (1V applied voltage, 50 lux illumination, after 16h in darkness)	0.35	0.6	1.4	kΩ
Initial drift (see 3.1 of Gen. Expl. Notes)	-	0	-	%
$\dfrac{\text{Resistance at 2856K colour temperature}}{\text{Resistance at 4700K colour temperature}}$ (at constant illumination)	-	0.83	-	

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max (d.c. and repetitive peak)	50	V
$V_{cell(pulse)}$ max. (maximum period 5ms, maximum repetition frequency 1 pulse/min)	100	V
P_{cell} max. ($T_{amb} \leq 25^\circ C$)	100	mW
I_{cell} max. (d.c. and r.m.s.)	25	mA
T_{amb} max. (storage)	+50	$^\circ C$
T_{amb} min. (storage and operating)	-40	$^\circ C$
T_{cell} max. (operating)	+70	$^\circ C$

Mullard

CLIMATIC DATA

After exposure to test C: Damp heat test (long term exposure):
temperature $40^{\circ}C \pm 2^{\circ}C$; relative humidity between 90 and 95%; severity VII of
Publication 68-2 of the International Electrotechnical Commission (IEC) the changes
in illumination resistance are within +50 and -30%.

A high humidity does not harm the cell but care should be taken not to put the cell
into operation when wet. Four hours under normal room conditions make it suffi-
ciently dry, also after it has been exposed to high humidity conditions for a long
time.

OUTLINE AND DIMENSIONS

Incident radiation

The spacing of the leads is
compatible with the standard
2.54 mm (0.1 in) printed wiring grid

cell leads

The polarity of the supply
is not important

All dimensions in mm   D2113a

Colour identification - gold/brown

NOTES

1. The device consists of two photoconductive cells connected in series. The resist-
ance of the device is mainly governed by the resistance of the cell receiving the
lower luminous flux.
If for any application it is required to partially shade the device, the shadow line
should be perpendicular to the axis of the device (i.e. horizontal if the cell is
positioned as in the drawing above).

2. Since heat produced in the cell is removed mainly by conduction along the leads,
short leads may improve the performance.

3. The device may be soldered directly into the circuit, but heat conducted to the
tablet should be kept to a minimum by the use of a thermal shunt. It may be dip-
soldered at a solder temperature of $270^{\circ}C$ for a maximum of 2 seconds up to a
point 6mm from the envelope.

4. Care should be taken not to bend the leads nearer than 2mm from the seals.

These cells are manufactured by a technique which does not employ sintering or
high temperatures, but is based on cadmium sulphide monograin layers. The
result is an extremely small device with good power dissipation and stability over
life.

Mullard

MAXIMUM POWER DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

Measured at 1V d.c.
2700K colour temperature
after 16 hours in darkness

INITIAL CELL RESISTANCE PLOTTED AGAINST ILLUMINATION

Mullard

RELATIVE SPECTRAL RESPONSE

Mullard

PHOTOCONDUCTIVE DEVICE   RPY71

QUICK REFERENCE DATA

Linear monograin cadmium sulphide photoconductive device in plastic encap-
sulation. The device consists of two cells in series, and is intended for use in
cameras, exposure meters, light control equipment and for general industrial
use. The device features gamma equal to unity.

Maximum power dissipation	50	mW
Maximum cell voltage (d. c. and repetitive peak)	50	V
Cell resistance (at 10 lux, 2700K colour temperature)	3 to 6	kΩ
Maximum overall dimensions	$5.3 \times 5.3 \times 1.4$	mm

This data should be read in conjunction with GENERAL EXPLANATORY NOTES -
CADMIUM SULPHIDE PHOTOCONDUCTIVE CELLS

CHARACTERISTICS

Measured under d.c. conditions, at start of life, with $T_{amb} = 25^{\circ}C$, illumination
colour temperature = 2700K, and with PRECONDITIONING of at least one hour
illumination with 300 lux (fluorescent light).

	Min.	Typ.	Max.	
Initial dark resistance (50V d. c. applied in series with 1MΩ, 20s after switching off an illumination of 10 lux)	600	-	-	kΩ
Initial illumination resistance (10 lux illumination, 1V d. c. applied voltage)	2.4	-	6.0	kΩ
Illumination response (Gamma) over the illumination range 0.1 to 10 lux measured at 1V d. c. (see note 1)	0.94	-	1.12	
Pre-conditioning factor (see note 2)	0.9	-	1.1	
$\dfrac{\text{Illumination at 2700K}}{\text{Illumination at 4700K}}$ (referred to the same cell current)	0.9	-	1.1	
Negative temperature coefficient of illuminated resistance (1V applied voltage, 1.0 lux illumination, between -10 and +40°C)	-	-	0.5 %/degC	

THERMAL DATA

Thermal resistance from cell to a point on the leads 2mm from the cell	35	deg C/W

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RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{cell} max. (d.c. and repetitive peak)	50	V
P_{cell} max.	50	mW
I_{cell} max. (d.c. and repetitive peak)	20	mA
T_{amb} max. (storage and operating)	+70	^oC
T_{amb} min. (storage and operating)	-40	^oC

NOTES

1. $\text{Gamma} = \dfrac{\log R_1 - \log R_2}{\log E_2 - \log E_1}$ where R_1 = resistance at illumination E_1

   and R_2 = resistance at illumination E_2

2. $\text{Pre-conditioning factor} = \dfrac{\text{Cell current at 1.0 lux after 3 days in darkness}}{\text{Cell current at 1.0 lux after 1 hour pre-conditioning at 300 lux (fluorescent light)}}$

   measured when a stable current is reached.

3. The device may be soldered directly into the circuit, but heat conducted to the seals should be kept at a minimum by the use of a thermal shunt. It may be dip-soldered at a solder temperature of 270^oC for a maximum of 2s up to a point 6mm from the seals.

OUTLINE AND DIMENSIONS

Incident radiation

The spacing of the leads is compatible with the standard 2.54 mm (0.1 in) printed wiring grid

cell leads

The polarity of the supply is not important

All dimensions in mm   D2113a

Colour identification - green.

PHOTOCONDUCTIVE DEVICE

RPY71

GENERAL

The device consists of two photoconductive cells connected in series. The resistance of the device is mainly governed by the resistance of the cell receiving the lower luminous flux.

If for any application it is required to partially shade the device, the shadow line should be perpendicular to the axis of the device (i. e. horizontal if the cell is positioned as in the outline drawing on page 2).

The RPY71 cell is manufactured by a completely new technique which does not employ sintering or high temperatures, but is based on cadmium sulphide monograin layers. In this process a single layer of cadmium sulphide grains (one grain being approximately 40μm thick) is embedded into a sheet of synthetic material so that each crystal protrudes at both sides. Gold contacts are provided by evaporation and the device is encapsulated with a special plastic.

The result is an extremely small device with good power dissipation and stability over life.

INITIAL CELL RESISTANCE PLOTTED
AGAINST ILLUMINATION

Mullard

MAXIMUM POWER DISSIPATION
PLOTTED AGAINST AMBIENT TEMPERATURE

RELATIVE SPECTRAL RESPONSE

Mullard

INFRARED
PHOTOCONDUCTIVE CELLS

D

PHOTOCONDUCTIVE CELL   ORP10

QUICK REFERENCE DATA

Indium antimonide photoconductive element mounted on a copper heatsink. Recommended for operation at a temperature of 20°C. Sensitive to infrared radiation extending to 7.5μm and intended for use with modulated or pulsed radiation.

Wavelength at maximum response	6.0 to 6.3	μm
Operating temperature	20	°C
D* (6.0μm, 800, 1), typical	2.0×10^8	cm$(Hz)^{1/2}$/W
Time constant (approx.)	0.1	μs
Element dimensions	6.0×0.5	mm

CHARACTERISTICS (at 20°C under conditions specified in note 1)

Wavelength at maximum response	6.0 to 6.3	μm
Spectral response range (see page 6)	visible to 7.5	μm
Cell resistance		
maximum	120	Ω
minimum	30	Ω
Time constant (approx.)	0.1	μs

BLACK BODY PERFORMANCE (see notes 1 and 2)

Responsivity (to 500K radiation), typical	0.3	V/W
D* (500K, 800, 1), typical	6.0×10^7	cm$(Hz)^{1/2}$/W
N.E.P. (500K, 800, 1), typical	2.5×10^{-9}	W

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MONOCHROMATIC PERFORMANCE (see notes 1 and 2)

Responsivity (to $6.0\mu m$ radiation)

minimum	0.4	V/W
typical	1.0	V/W

D* ($6.0\mu m$, 800, 1)

minimum	8.5×10^7	cm(Hz)$^{1/2}$/W
typical	2.0×10^8	cm(Hz)$^{1/2}$/W

N.E.P. ($6.0\mu m$, 800, 1)

typical	8.6×10^{-10}	W
maximum	2.0×10^{-9}	W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Maximum bias current (at 20°C)	100	mA
Maximum operating ambient temperature	+70	^{o}C
Storage temperature		
maximum	+70	^{o}C
minimum	-50	^{o}C

NOTES

1. Test conditions

The detector is attached to a heatsink which is maintained at a temperature of 20°C and a bias current of 50mA is applied. A parallel beam of monochromatic radiation of wavelength $4.4\mu m$, which would produce a steady irradiance of $68\mu W/cm^2$ at the sensitive element, is square wave modulated at 800Hz. The actual r.m.s. power at the element is therefore reduced to

$$\frac{68}{2.2} = 31\mu W/cm^2$$

Measurements of the detector output are made with an amplifier tuned to 800Hz and with a bandwidth of 50Hz, and are referred to open circuit conditions, i.e., correction is made for the shunting effects of the bias supply impedance and the amplifier input impedance. Under these test conditions, the ORP10 will exhibit a minimum signal-to-noise ratio of 45 and typical of 105. The detectivities quoted at the wavelength at maximum response and under black body conditions are calculated from these measurements, assuming the detector to have a typical response curve.

The figures in brackets which follow responsivity, D* and N.E.P. refer to the test conditions, for example, D* ($6.0\mu m$, 800, 1) denotes monochromatic radiation incident on the detector of wavelength $6.0\mu m$, modulation frequency 800Hz, an electronic bandwidth of 1Hz.

2. D* and N.E.P.

These are figures of merit for the materials of detectors and are fully discussed in most textbooks on infrared, e.g., 'Infrared Physics' by J.T. Houghton and S.D. Smith (O.U.P. 1966) and 'Elements of Infrared Technology' by Kruse, McGlauchlin and McQuistan (John Wiley, New York 1962). D* is defined in the expression:

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$$D^* = \frac{\frac{V_s}{V_n} \times \left[A(\Delta f)\right]^{1/2}}{W}$$

where
V_s = Signal voltage across detector terminals
V_n = Noise voltage across detector terminals
A = Detector area
(Δf) = Bandwidth of measuring amplifier
W = Radiation power incident on detector sensitive element in r.m.s. watts

The Noise Equivalent Power (N.E.P.) is related to D^* by the expression:

$$N.E.P. = \frac{(A)^{1/2}}{D^*}$$

3. Variation of performance with bias current

Both signal and noise vary with bias current in this type of cell. Typical curves are shown on page 8. At high currents the noise increases more rapidly than the signal, and therefore the signal-to-noise ratio has a peak value at some optimum current, which will vary slightly from cell to cell. A typical value is 50mA. In addition the ohmic heating caused by bias currents above 60mA causes the temperature of the element to become significantly greater than the substrate so that the signal decreases as described in note 4.

4. Variation of performance with element temperature

As with all semiconductor photocells, the performance depends on the temperature of the sensitive element. In the case of the ORP10 this is influenced by the ambient temperature and ohmic heating caused by the d.c. bias current. To minimise fluctuations, the element is mounted on a copper base from which it is insulated by a layer of aluminium oxide, and can readily be attached to a large heatsink.

A typical variation of performance with temperature is given on page 9. The curve on page 8 shows the decrease in signal caused by the high current raising the temperature of the element.

On cooling, indium antimonide exhibits improved detectivity and increased resistance. Below 15°C this is impractical with the ORP10 unless special precautions are taken to prevent condensation and icing on the exposed element. Detectors designed for low temperature operation, such as the ORP13, are therefore contained in an evacuated dewar vessel and fitted with a sapphire window.

5. Warning

The sensitive surface is unprotected and should not be touched. It is stable in normal atmospheres but should not be exposed to high concentrations of the vapours of organic solvents. Care should be taken to avoid strain when attaching cells to heatsinks.

Recommended circuit for use with radiation chopped at 800Hz.

Circuit notes

Transformer - Fortiphone type MM634. This component should be adequately screened to prevent stray pick-up.

The resistor R should be wire wound to minimise noise. It must be substantially larger than the cell resistance and its actual value will depend upon the supply voltage and the cell currents required.

The 560pF capacitor tunes the secondary to approximately 800Hz but since the 'Q' is low, the actual value is not highly critical.

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PHOTOCONDUCTIVE CELL ORP10

OUTLINE DRAWING OF ORP10

2 fixing holes
Ø 3.0

Direction
of
radiation

2.0 (approx)

10

9.5

Ø 0.5

37
min

5.0 min
tinned

17

6.0

0.5

1.5

Sensitive area

All dimensions in mm

D 1522

Mullard

ORP 10
B4462

Relative response (%) (y-axis)
Wavelength (μm) (x-axis)

SPECTRAL RESPONSE CURVE

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PHOTOCONDUCTIVE CELL ORP10

TYPICAL VARIATION OF DETECTIVITY WITH WAVELENGTH

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ORP10 PARAMETERS PLOTTED AGAINST BIAS CURRENT

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NORMALISED RESISTANCE AND OPEN-CIRCUIT SIGNAL AT 6.0μm
PLOTTED AGAINST TEMPERATURE OF ORP10

Mullard

SIGNAL-TO-NOISE RATIO, NOISE AND SIGNAL PLOTTED AGAINST
BIAS CURRENT (See circuit on page 4)

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PHOTOCONDUCTIVE CELL ORP13

QUICK REFERENCE DATA

Indium antimonide photoconductive element mounted in a glass dewar vessel and cooled by liquid nitrogen or liquid air. Sensitive to infrared radiation extending to 5.6μm and intended for use with modulated or pulsed radiation.

Wavelength at maximum response	5.3	μm
Operating temperature	77	K
D* (500K, 800, 1) min.	5×10^9	$cm(Hz)^{1/2}/W$
Time constant, typical	5	μs
Element dimensions	6.0×0.5	mm

CHARACTERISTICS (cooled to 77K under conditions specified in note 1)

Wavelength at maximum response	5.3	μm
Spectral response range (see page 7)	visible to 5.6	μm
Cell resistance		
maximum	60	$k\Omega$
minimum	20	$k\Omega$
Time constant (see note 2), typical	5	μs
Boil off time of bulk liquid nitrogen		
minimum	90	min
typical	120	min

BLACK BODY PERFORMANCE, 500K (see note 1)

Responsivity (500K, 800)		
minimum	4×10^3	V/W
typical	7×10^3	V/W
D* (500K, 800, 1)		
minimum	5×10^9	$cm(Hz)^{1/2}/W$
typical	7.5×10^9	$cm(Hz)^{1/2}/W$
N.E.P. (500K, 800, 1)		
typical	2.3×10^{-11}	W
maximum	3.5×10^{-11}	W

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MONOCHROMATIC PERFORMANCE (see note 1)

Responsivity (5.3μm, 800), typical	3.5×10^4	V/W
D* (5.3μm, 800, 1), typical	5.5×10^{10}	$cm(Hz)^{1/2}/W$
N.E.P. (5.3μm, 800, 1), typical	3.2×10^{-12}	W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Maximum bias current (at 77K)	30	mA
Storage temperature	-55 to +55	^{o}C

NOTES

1. Test conditions

The detector is cooled to 77K by filling the dewar vessel with liquid nitrogen, or by use of a liquid transfer system. An optimum bias of 250 to 500μA is applied. The sensitive element is situated at a distance of 264mm from a black body source limited by an aperture of 3mm diameter.

The radiation path is interrupted at 800Hz by a chopper blade at ambient temperature. Under these conditions the r.m.s. power at the element (chopping factor 2.2) is 4.5μW/cm².

Measurements of the detector output are made with an amplifier tuned to 800Hz with a bandwidth of 50Hz, and referred to open-circuit conditions, i.e., correction is made for the shunting effects of the bias supply impedance and the amplifier impedance.

The figures in brackets which follow responsivity, D* and N.E.P. refer to the test conditions, for example, D* (5.3μm, 800, 1) denotes monochromatic radiation incident on the detector of wavelength 5.3μm, modulation frequency 800Hz, an electronic bandwidth of 1Hz.

D* and N.E.P.

These are figures of merit for the materials of detectors and are fully discussed in most textbooks on infrared, e.g., 'Infrared Physics' by J.T. Houghton and S.D. Smith (O.U.P. 1966) and 'Elements of Infrared Technology' by Kruse, McGlauchlin and McQuistan (John Wiley, New York 1962). D* is defined in the expression:

$$D^* = \frac{\frac{V_s}{V_n} \times \left[A(\Delta f)\right]^{1/2}}{W}$$

where

V_s = Signal voltage across detector terminals

V_n = Noise voltage across detector terminals

A = Detector area

(Δf) = Bandwidth of measuring amplifier

W = Radiation power incident on detector sensitive element (r.m.s. value, in watts)

The Noise Equivalent Power (N.E.P.) is related to D* by the expression:

$$N.E.P. = \frac{(A)^{1/2}}{D^*}$$

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Variation of performance with bias current

Both signal and noise vary with bias current in this type of cell. Typical curves are shown on page 8. At high currents the noise increases more rapidly than the signal, and therefore the signal to noise ratio has a peak value at some optimum current, which will vary slightly from cell to cell.

2. Time constant

Detector time constant figures are based on the response to a step function in the incident radiation. Quoted times indicate the interval between the moment the radiation is cut off and the output falling to 63% of its peak value.

3. Warnings

a. The resistance of the cell at room temperature is three orders of magnitude less than at the operating temperature (77K). Care should therefore be taken to ensure that the device is not allowed to reach room temperature while still biased, if any form of low impedance biasing is employed.

b. If provision is made for cells to be plugged into the bias current and amplifier, steps must be taken to limit the current available from the amplifier input capacitor. This current can be excessive at the instant of plugging in the cell.

A zener diode can be used to limit the voltage developed across the input capacitor as shown in the diagram.

c. The dewar vessel must always be completely dry before being refilled with liquid nitrogen. In humid conditions, water vapour may condense at the top of the dewar. Should this occur, the remaining liquid nitrogen should be allowed to boil off, the ice should be removed carefully and precautions taken to avoid a recurrence. In very humid conditions the window should be purged with a clean dry gas.

4. Low Frequency Noise

This will be minimised by use of non-absorbent cotton wool placed in the bottom of the dewar. The recommended quantity is 40mg.

OUTLINE DRAWING OF ORP13

D214

6.0

0.5

∅ 16.5 (window)

∅ 37 max

5.5
max

9.0 max

129 max

∅ 35.5 max

The polarity of the
supply is not important

∅ 10.0
  ±0.5 (dewar opening)

25.0
±0.5

All dimensions in mm

∅ 6.0 max

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D 213

Terminals

Leads

Metal encapsulation

Glass dewar vessel

Sensitive area on
alumina substrate

Sapphire window

Incident
radiation

Surface aluminised
mirror

Mullard

37

16   3

58   16   45°

12

32

MIRROR   37

D215

All dimensions in mm

MIRROR ATTACHMENT – TYPE 13

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SPECTRAL RESPONSE CURVE

Mullard

RESPONSIVITY, DETECTIVITY AND NOISE PLOTTED AGAINST BIAS CURRENT

Mullard

PHOTOCONDUCTIVE CELLS

RPY75
RPY75A
RPY76
RPY76A

QUICK REFERENCE DATA

Lead sulphide, chemically deposited, photoconductive cells recommended for room temperature operation. The RPY75 is made in the form of a flat plate, and the RPY76 is encapsulated in a hermetically sealed TO-5 envelope with an end viewing window.

These detectors are also available as RPY75A and RPY76A which incorporate a germanium filter to cut off radiation at wavelengths below 1.5μm.

Wavelength at maximum response	1.8 to 2.2	μm
Operating temperature	20	°C
Current responsivity (500K, 800) min.	2.0	mA/W
Current responsivity (2.0μm, 800) min.	200	mA/W
D* (500K, 800, 1) min.	1.0×10^8	cm(Hz)$^{1/2}$/W
Time constant typical	250	μs
Sensitive area	1.0×1.0	mm

Unless otherwise stated data is applicable to all types

CHARACTERISTICS at 20°C (see notes 1 and 2)

Wavelength at maximum response	1.8 to 2.2	μm
Spectral response range (see curves on page 5)		
RPY75, RPY76	0.5 to 3.0	μm
RPY75A, RPY76A	1.5 to 3.0	μm
Cell resistance		
minimum	200	kΩ
typical	600	kΩ
Time constant (see note 3)		
typical	250	μs
maximum	400	μs

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BLACK BODY PERFORMANCE (500K)

Current responsivity (500K, 800) min.	2.0	mA/W
D* (500K, 800, 1) min.	1.0×10^{8}	$cm(Hz)^{1/2}/W$
N.E.P. (500K, 800, 1) max.	1.0×10^{-9}	W

MONOCHROMATIC PERFORMANCE (2.0µm radiation)

Current responsivity (2.0µm, 800) min.	200	mA/W
D* (2.0µm, 800, 1) min.	1.0×10^{10}	$cm(Hz)^{1/2}/W$
N.E.P. (2.0µm, 800, 1) max.	1.0×10^{-11}	W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Maximum power dissipation	20	mW
Storage temperature	–20 to +50	^{o}C
Operating temperature	–20 to +50	^{o}C

NOTES

1. **Test conditions**

The cell is operated at a temperature of $20^{o}C$. The sensitive element is situated at a distance of 264mm from a black body source limited by an aperture of 3mm diameter.

The radiation path is interrupted at 800Hz by a chopper blade at ambient temperature. Under these conditions the r.m.s. power at the element (chopping factor 2.2) is $4.5µW/cm^{2}$.

A bias voltage of 24V is applied to the cell. Measurements of the detector output are made using a low value resistive load, followed by a current pre-amplifier, as shown in figure 1. The output is fed into an amplifier tuned to 800Hz with a bandwidth of 50Hz.

The figures in brackets, which follow current responsivity, D* and N.E.P. refer to the test conditions, for example, D* (2.0µm, 800, 1) denotes monochromatic radiation incident on the detector of wavelength 2.0µm, modulation frequency 800Hz, an electronic bandwidth of 1Hz.

D* and N.E.P.

These are figures of merit for the materials of detectors and are fully discussed in most textbooks on infrared, e.g., 'Infrared Physics' by J.T. Houghton and S. D. Smith (O.U.P. 1966) and 'Elements of Infrared Technology' by Kruse, McGlauchlin and McQuistan (John Wiley, New York 1962). D* is derived from the expression:

PHOTOCONDUCTIVE CELLS

NOTES (contd.)

$$D^* = \frac{\frac{I_s}{I_n} \times \left[A(\Delta f) \right]^{1/2}}{W}$$

where

I_s = Signal current

I_n = Noise current

A = Detector area

(Δf) = Bandwidth of measuring amplifier

W = Radiation power incident on detector
sensitive element (r.m.s. value in watts)

The Noise Equivalent Power (N.E.P.) is related to D^* by the expression:

$$N.E.P. = \frac{(A)^{1/2}}{D^*}$$

2. Variation of performance with bias

Both signal and noise vary with bias in this type of cell. At bias levels at which the cell dissipation is less than 2.5mW the maximum level of D^* is maintained. At higher levels the noise increases more rapidly than the signal so that although the responsivity increases, D^* falls. The maximum responsivity typically occurs at a dissipation level of 10mW, beyond which heating occurs with a consequent reduction in responsivity.

Variation of performance with temperature/life

Responsivity and D^* are dependent on the previous temperature/life history of the cell. The quoted values are the minimum which may be expected after storage or operation up to 35°C. These values may decrease by 50% after storage or operation at temperatures up to the absolute maximum temperature of 50°C.

3. Time constant

Detector time constant figures are based on the response to a step function of incident radiation. Quoted times indicate the interval between the moment of application and the output pulse reaching 63% of its peak value.

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4. Recommended operating conditions

In order to minimise the effects of parameter variations with temperature and life it is recommended that a form of constant voltage bias is used. A suitable circuit is shown in fig. 1. With this mode of operation the signal is the short-circuit current, which is related to the open-circuit cell voltage by the expression:

$$V_{oc} = I_{sc} \times R_{cell}$$

5. Warning

Prolonged exposure to visible radiation should be avoided.

Fig. 1

OUTLINE AND DIMENSIONS

All dimensions in mm

RPY75 and RPY75A

RPY76 and RPY76A
(TO-5 with end window)

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PHOTOCONDUCTIVE CELLS

RELATIVE SPECTRAL RESPONSE OF RPY75 AND RPY76

RELATIVE SPECTRAL RESPONSE OF RPY75A AND RPY76A

Mullard

PHOTOCONDUCTIVE CELLS

QUICK REFERENCE DATA

Indium antimonide photoconductive element mounted in modified SOT-15 encapsulation. Recommended for operation at room temperatures. Sensitive to infrared radiation extending to 7μm and intended for use with modulated or pulsed radiation. The RPY77 is without window, while RPY78 has a sapphire window giving element protection in adverse environments.

Wavelength at maximum response	5.0 to 7.0	μm
Operating temperature	20	^{o}C
Typical D* (6.0μm, 800, 1)	1.5×10^8	cm(Hz)$^{1/2}$/W
Time constant	<0.1	μs
Element dimensions	2.0 × 2.0	mm
Field of view	120	deg

Unless otherwise stated, data is applicable to both types

CHARACTERISTICS at 20°C (see note 1)

	RPY77	RPY78	
Wavelength at maximum response	5.0 to 6.5	5.0 to 6.5	μm
Spectral response range (see page 5)	visible to 7.5	visible to 7.0	μm
Cell resistance			
minimum	500	500	Ω
typical	650	650	Ω
maximum	1500	1500	Ω
Time constant (see note 2)	<0.1	<0.1	μs

BLACK BODY PERFORMANCE (see note 1)

	RPY77	RPY78	
Responsivity (to 500K radiation)			
minimum	1.2	1.1	V/W
typical	1.7	1.7	V/W
D* (500K, 800, 1)			
minimum	3.2×10^7	3.0×10^7	$cm(Hz)^{1/2}/W$
typical	7.0×10^7	7.0×10^7	$cm(Hz)^{1/2}/W$
N.E.P. (500K, 800, 1)			
typical	4.0×10^{-9}	4.0×10^{-9}	W
maximum	7.0×10^{-9}	7.0×10^{-9}	W

MONOCHROMATIC PERFORMANCE (see note 1)

	RPY77	RPY78	
Responsivity (6.0μm, 800)			
minimum	3.5	3.3	V/W
typical	5.0	5.0	V/W
D* (6.0μm, 800, 1)			
minimum	1.0×10^8	9.5×10^7	$cm(Hz)^{1/2}/W$
typical	1.5×10^8	1.5×10^8	$cm(Hz)^{1/2}/W$
N.E.P. (6.0μm, 800, 1)			
typical	1.3×10^{-9}	1.3×10^{-9}	W
maximum	2.0×10^{-9}	2.1×10^{-9}	W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Maximum bias current	25	mA
Operating temperature	–55 to +70	^{o}C
Storage temperature	–55 to +70	^{o}C

NOTES

1. The detector is attached to a heatsink which is maintained at a temperature of $20^{o}C$ and a bias current of 10mA is applied. A parallel beam radiation of known irradiance $E(\mu W/cm^2)$ at the sensitive element, is square wave modulated at 800Hz. The actual r.m.s. power at the element is therefore reduced to

$$\frac{E}{2.2} = \mu W/cm^2$$

Measurements of the detector output are made with an amplifier tuned to 800Hz and with a bandwidth of 50Hz, and are referred to open circuit conditions, that is, correction is made for the shunting effects of the bias supply impedance and the amplifier input impedance. The figures in brackets which follow responsivity, D* and N.E.P. refer to the test conditions, for example, D* (6.0μm, 800, 1) denotes monochromatic radiation incident on the detector of wavelength 6.0μm, modulation frequency 800Hz, an electronic bandwidth of 1Hz.

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NOTES (contd.)

D* and N.E.P.

These are figures of merit for the materials of detectors and are fully discussed in most textbooks on infrared for example, 'Infrared Physics' by J.T. Houghton and S.D. Smith (O.U.P. 1966) and 'Elements of Infrared Technology' by Kruse, McGlauchlin and McQuistan (John Wiley, New York, 1962). D* is defined in the expression:

$$D^* = \frac{\frac{V_s}{V_n} \times \left[A(\Delta f)\right]^{\frac{1}{2}}}{W}$$

where V_s = signal voltage across detector terminals

V_n = noise voltage across detector terminals

A = detector area

Δf = bandwidth of measuring amplifier

W = radiation power incident on detector sensitive element (r.m.s. value, in watts)

The Noise Equivalent Power (N.E.P.) is related to D* by the expression:

$$N.E.P. = \frac{(A)^{\frac{1}{2}}}{D^*}$$

Variation of performance with bias current

Both signal and noise vary with bias current in this type of cell. Typical curves for relative changes in resistance, D*, open circuit responsivity and short circuit responsivity with bias current at several temperatures are shown on pages 6 and 7. At high currents the noise increases more rapidly than the signal, and therefore the signal-to-noise ratio has a peak value at some optimum current, which will vary slightly from cell to cell. A typical value is 10mA. In addition the heating caused by bias currents above 15mA causes the temperature of the element to become significantly greater than the substrate so that the signal decreases as described below.

Variation of performance with element temperature

As with all semiconductor photocells, the performance depends on the temperature of the sensitive element. In the case of the RPY77 and RPY78 this is influenced by the ambient temperature and heating caused by the d.c. bias current. To minimise fluctuations, the device can be attached to a large heatsink. A typical variation of performance with temperature is given on page 6.

On cooling, indium antimonide exhibits improved detectivity and increased resistance. If performance is desired significantly below room temperature, it is suggested that the window version of this detector (RPY78) be used with precautions to avoid condensation on the window.

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NOTES contd .

2. Time constant

Time constant is defined as the time taken for the cell output to fall to $\frac{1}{e}$ of the value it had before the square wave radiation pulse decrement.

3. Warnings

The sensitive surface of the RPY77 is unprotected and should not be touched. It is stable in normal atmospheres but must not be exposed to high concentrations of solvent vapours or corrosive gases. Condensation of water vapour on the sensitive area must not be allowed while the bias current is on. It is advisable to protect the cell from air currents which may give rise to spurious signals.

Care should be taken when attaching cells to heatsinks. It is recommended that a high conductivity epoxy resin, with a cure temperature of less than 60°C, is used. The sensitive area of the RPY77 should be protected by means of a temporary cover, from resin vapours which occur during the curing cycle.

A thermal shunt should be used when making soldered connections to the leads.

OUTLINE DRAWING OF RPY77 AND RPY78

Field of view
100° x 100° min.

RPY78
Sapphire window
0.12 / 0.18 thick

2.0 max.

0.1

0.8

6.8 max.

5.0 min.

6.8 max.

0.35

1.25

Sensitive area
2.0 x 2.0

3.0

All dimensions in mm

Mullard

PHOTOCONDUCTIVE CELLS RPY77 RPY78

LOW NOISE AMPLIFIER FOR RPY77 AND RPY78

Mullard

Relative resistance — D1797

1·5
1·0
0·5
0

$T_{case} = 15°C$
$= 20°C$
$= 30°C$
$= 40°C$
$= 50°C$

0   5   10   15   20   25
Bias current (mA)

Relative D* — D1798

1·5
1·0
0·5
0

$T_{case} = 15°C$
$= 20°C$
$= 30°C$
$= 40°C$
$= 50°C$

0   5   10   15   20   25
Bias current (mA)

Mullard

PHOTOCONDUCTIVE CELLS

Relative responsivity — Open circuit condition

$T_{case} = 15°C$, $=20°C$, $=30°C$, $=40°C$, $=50°C$

Bias current (mA)

Relative responsivity — Short circuit condition

$T_{case} = 15°C$, $=20°C$, $=30°C$, $=40°C$, $=50°C$

Bias current (mA)

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Frequency (Hz)

PHOTOCONDUCTIVE CELLS 61SV 62SV

QUICK REFERENCE DATA

Evaporated lead sulphide photoconductive cells with sensitive element mounted in a glass dewar. The cells are normally supplied in the encapsulated version for room temperature operation, but an unencapsulated version is also available for cooled operation.

Spectral response from 0.3 to 3.5μm and intended for use with pulsed or modulated radiation.

	61SV	62SV	
Wavelength at maximum response	2.2	2.5	μm
Resistance	1.5	1.5	MΩ
Responsivity (2.0μm radiation)	8.0×10^4	1.2×10^5	V/W
D* (2.0μm, 800, 1)	4.0×10^{10}	6.0×10^{10}	$cm(Hz)^{1/2}/W$
Time constant	100	175	μs
Sensitive area	6.0×6.0	6.0×6.0	mm

Unless otherwise stated, data is applicable to both types

CHARACTERISTICS (at $T_{amb} = 20^o C$ under conditions specified in note 1)

		61SV	62SV	
Wavelength at maximum response		2.2	2.5	μm
Spectral response range (see page 5)		0.3 to 3.5	0.3 to 3.5	μm
Cell resistance	min.	1.0	1.0	MΩ
	typ.	1.5	1.5	MΩ
	max.	4.0	4.0	MΩ
Time constant (see note 2)	typ.	100	175	μs
Noise voltage	typ.	8.5	8.5	μV

BLACK BODY PERFORMANCE (see note 1)

		61SV	62SV	
Responsivity (to 500K radiation)	min.	2.0×10^2	1.0×10^3	V/W
	typ.	1.3×10^3	2.0×10^3	V/W
D* (500K, 800, 1)	min.	2.0×10^8	6.0×10^8	$cm(Hz)^{1/2}/W$
	typ.	6.5×10^8	1.0×10^9	$cm(Hz)^{1/2}/W$
N.E.P. (500K, 800, 1)	typ.	9.2×10^{-10}	6.0×10^{-10}	W
	max.	3.0×10^{-9}	1.0×10^{-9}	W

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MONOCHROMATIC PERFORMANCE (see note 1)

		61SV	62SV	
Responsivity (to 2.0μm radiation)	typ.	8.0×10^4	1.2×10^5	V/W
D* (2.0μm, 800, 1)	typ.	4.0×10^{10}	6.0×10^{10}	cm(Hz)$^{\frac{1}{2}}$/W
N.E.P. (2.0μm, 800, 1)	typ.	1.5×10^{-11}	1.0×10^{-11}	W

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Electrical

V_{cell} max.	250	V
I_{cell} max.	0.5	mA

Temperature (see note 3)

T_{amb} max. (storage and operating)	+60	^{o}C
T_{amb} min. (storage and operating)		
Encapsulated version	-55	^{o}C
Cooled version	-80	^{o}C

NOTES

1. Test conditions

Characteristics are measured with the cell biased from a 200V d.c. supply in series with a 1.0MΩ load resistor. No correction is made for the loading effect of the 1.0MΩ resistor, i.e. open circuit characteristics are not given.

The sensitive element is situated at a distance of 264mm from a black body source limited by an aperture of 3mm. The radiation path is interrupted at 800Hz by a chopper blade at ambient temperature. Under these conditions the r.m.s. power at the element (chopping factor 2.2) is 4.5μW/cm^2.

Measurements of the detector output are made with an amplifier tuned to 800Hz with a bandwidth of 50Hz.

The figures in brackets which follow responsivity, D* and N.E.P. refer to the test conditions, for example, D* (2.0μm, 800, 1) denotes monochromatic radiation incident on the detector of wavelength 2.0μm, modulation frequency 800Hz, an electronic bandwidth of 1Hz.

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NOTES (contd.)

D* and N.E.P.

These are figures of merit for the materials of detectors and are fully discussed in most textbooks on infrared e.g. 'Infrared Physics' by J.T. Houghton and S.D. Smith (O.U.P. 1966) and 'Elements of Infrared Technology' by Kruse, McGlauchlin and McQuistan (John Wiley, New York 1962). D* is defined in the expression:

$$D* = \frac{\frac{V_s}{V_n} \times [A(\Delta f)]^{\frac{1}{2}}}{W}$$

where V_s = Signal voltage across detector terminals

V_n = Noise voltage across detector terminals

A = Detector area

(Δf) = Bandwidth of measuring amplifier

W = Radiation power incident on detector sensitive element (r.m.s. value, in watts)

The Noise Equivalent Power (N.E.P.) is related to D* by the expression:

$$N.E.P. = \frac{(A)^{\frac{1}{2}}}{D*}$$

Variation of performance with bias current

Both signal and noise vary with bias current in this type of cell. Typical curves are shown on page 6. At high currents the noise increases more rapidly than the signal and therefore the signal-to-noise ratio has a peak value at some optimum current, which will vary from cell to cell.

2. Time constant

Detector time constant figures are based on the response to a step function in the incident radiation. Quoted times indicate the interval between the moment the radiation is cut off and the output falling to 63% of its peak value.

3. Variation of performance with ambient temperature

The performance of the cell is dependent on the ambient temperature. Correction factors for the variation of performance are given on page 8.

4. Warning

Prolonged exposure to visible radiation should be avoided.

Mullard

OUTLINE DRAWING OF 61SV AND 62SV

D301

The polarity of
the supply is
not important

All dimensions in mm

ENCAPSULATED
VERSION

COOLED
VERSION

SOCKET

A suitable socket for the encapsulated version is Belling–Lee type 789/CS.

Mullard

PHOTOCONDUCTIVE CELLS

61SV
62SV

TYPICAL SPECTRAL RESPONSE AT 20°C

TYPICAL VARIATION OF DETECTIVITY WITH WAVELENGTH

Mullard

**DETECTIVITY, RESPONSIVITY AND NOISE
PLOTTED AGAINST CELL CURRENT**

The values given are for a typical cell (1.5MΩ) in series with a 1MΩ resistor, and are relative to the values at $V_{supply} = 200V$, corresponding to a cell current of 80μA.

DETECTIVITY PLOTTED AGAINST FREQUENCY

Mullard

PHOTOCONDUCTIVE CELLS

61SV
62SV

RELATIVE NOISE PLOTTED AGAINST FREQUENCY

RELATIVE RESPONSE PLOTTED AGAINST FREQUENCY

Mullard

RELATIVE VALUES OF DETECTIVITY, RESISTANCE AND RESPONSIVITY
PLOTTED AGAINST AMBIENT TEMPERATURE

RELATIVE RESPONSE PLOTTED AGAINST
BLACK BODY TEMPERATURE

Mullard

10^{13}
D^*
$(\lambda \mu m, 800, 1)$
$\left[\dfrac{cm(Hz)^{1/2}}{W} \right]$

61SV
Typical values
$I_{cell} \approx 25 \mu A$

B9257

−76°C
−40°C
0°C
20°C

Wavelength (μm)

DETECTIVITY PLOTTED AGAINST WAVELENGTH
WITH CELL TEMPERATURE AS A PARAMETER
FOR COOLED VERSION OF 61SV

Mullard

PHOTOEMISSIVE TUBES

E

1. GENERAL

Photoemissive tubes are photoelectric devices of the emissive type, as distinct from barrier layer and photoconductive cells. They may be divided into two main groups:

a)   High vacuum tubes

b)   Gas-filled tubes

Each of these groups can be sub-divided into red sensitive and blue sensitive photo tubes; the spectral response depends upon the photocathode material. Blue sensitive tubes have a type 'A' or type 'U' cathode (caesium antimony), type 'U' having a quartz window to extend the response into the ultra-violet region. Red sensitive tubes have a type 'C' cathode (caesium on oxidised silver).

Spectral response curves for each type of cathode are given at the end of these notes. These curves are for guidance only, and should not be taken as exact.

2.   OPERATING CHARACTERISTICS

For a vacuum photo tube the anode current at a fixed illumination is reasonably constant at voltages above a certain low value known as the "saturation voltage".

Gas-filled photo tubes contain a quantity of inert gas, the ionising potential of which is generally somewhat higher than the saturation voltage of an equivalent vacuum photo tube, so that the anode current is substantially constant between the saturation voltage and the voltage at which ionisation commences. Above this voltage range, ionisation increases, resulting in a progressive increase in anode current.

Since the gas-filled photo tube operates at a higher voltage than the ionising potential, it will have a greater sensitivity than a similar vacuum photo tube. Within the operating ranges of both groups of photo tube the anode current is directly proportional to the quantity of light incident on the cathode surface.

2.1   **Luminous sensitivity**

The response of a photo tube to light falling on its cathode is termed its luminous sensitivity; this is expressed in micro-amperes per lumen. The sensitivity of all types of photo tube is dependent upon the colour temperature of the light source and in some cases upon the portion of the cathode that is illuminated.

The sensitivity of gas-filled photo tubes, moreover, is dependent upon the anode voltage; the sensitivity of vacuum photo tubes in the "saturation region", in which region the tube mainly operates, is practically independent of the anode voltage.

2.1 Luminous sensitivity (cont'd)

Unless otherwise stated, the values given in the data sheets have been obtained by illuminating the total useful cathode area with an incandescent lamp having a colour temperature of 2700°K.

The values given for sensitivity on the data sheets are the initial values for average photo tubes. The ratio between the maximum and minimum initial sensitivity of photo tubes of a given type will not exceed 3 to 1.

2.2 Dark current

This is the current which flows between the photocathode and anode when the photo tube is in total darkness. The tube is in total darkness when no radiation within the spectral sensitivity curve of the photocathode is present. This current is caused mainly by electrical leakage and thermionic emission from the photocathode and will therefore increase with temperature and voltage.

2.3 Frequency response

The sensitivity of a vacuum photo tube is constant for frequencies of light modulation up to those generally met in practice. Only at very high frequencies, at which transit time limitations occur, the sensitivity becomes dependent upon the frequency.

The sensitivity of gas-filled photo tubes, however, decreases with increasing frequency. At a frequency of 15 000Hz this decrease is about 3dB, as shown in the accompanying curve.

3. THERMAL DATA

Ambient temperature

The temperature of the photocathode must not be too high otherwise evaporation of the emissive cathode layer may result, with consequent reduction in sensitivity and life. As it is difficult to measure this temperature the limiting value for the ambient temperature is given in the published data sheets.

It must be considered, however, that even when the ambient temperature in the immediate vicinity of the photo tube is not beyond the limit, an excessive temperature rise of the photocathode can still be caused, for example, by infra-red heat radiation. If the possibility of this radiation exists a suitable filter should be inserted in the optical path to minimise this effect.

4. OPERATIONAL NOTES

4.1 Stability during life

Where a gas-filled photo tube is continuously operated at its maximum rated voltage, its sensitivity may fall by as much as 50% during 500 hours.

Vacuum photo tubes on the other hand are inherently more stable.

The stability of both types of photo tube will be improved if the current density at the photocathode is reduced (for example by reducing the incident light or increasing the illuminated area of the photocathode). Particularly in the case of gas-filled photo tubes reduction of the anode voltage will improve the stability.

In the inoperative periods, also, photo tubes must not be exposed to strong radiation such as strong sunlight. A loss of sensitivity of both vacuum and gas-filled photo tubes during operation will be wholly or partially restored during inoperative periods.

4.2 Prevention of glow discharge

Gas-filled photo tubes must not be operated above the published maximum voltage since the glow discharge, indicated by a faint blue glow in the bulb, may occur, and this may adversely affect the good operation of the photo tube and can even result in rapid destruction of the photocathode. If accidental overrunning can be expected the anode resistance should have a value of at least $0.1M\Omega$. When it is necessary to approach the maximum operating voltage a stabilised supply is recommended.

5. MOUNTING

If no restrictions are made on the individual published data sheets, photo tubes may be mounted in any position.

6. STORAGE

It is necessary for photo tubes to be always stored in the dark.

7. RATINGS

The ratings of photo tubes are given according to the absolute maximum rating system.

8. OUTLINE DIMENSIONS

The outline dimensions are given in millimetres.

9. TYPE NOMENCLATURE

The type nomenclature for Mullard photoemissive tubes consists of two or three figures followed by two letters. These symbols provide information concerning the class of tube and the type of photocathode.

The figures are a serial number indicating a particular design or development.

The first letter indicates the type of spectral response (see section 1)

A - Type A (S11) response (caesium antimony)

C - Type C (S1) response (caesium on oxidised silver)

U - Type U (S13) response (caesium antimony, quartz window)

The second letter indicates the class of tube

G - Gas-filled

V - High vacuum

Example:- 150AV

150	A	V
Serial number	Type A (S11) phtotcathode	High vacuum

RELATIVE SPECTRAL SENSITIVITY FOR TYPE A (S11) PHOTOCATHODE

RELATIVE SPECTRAL SENSITIVITY FOR TYPE C (S1) PHOTOCATHODE

Mullard

RELATIVE SPECTRAL SENSITIVITY FOR TYPE U (S13) PHOTOCATHODE

FREQUENCY RESPONSE OF GAS-FILLED PHOTOEMISSIVE TUBES

GAS-FILLED PHOTOCELL

Gas-filled photocell particularly sensitive to day-
light and to radiation having a blue predominance.
It is suitable for use in sound reproducing systems
where a dye-image sound track is used in conjunction with an incandescent light source.

90AG

CATHODE

Surface	Caesium antimony	
Projected area	4.0	cm^2

MOUNTING POSITION

Any

CAPACITANCE

c_{a-k}	0.7	pF

CHARACTERISTICS (Measured at 85V)

I_{dark}	<0.1	µA
* S	130	µA/lumen
A_g max.	7.0	

* Measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K and with a series resistor of 1MΩ.

RECOMMENDED OPERATING CONDITIONS

$V_{a(b)}$	85	V

LIMITING VALUES (Absolute ratings)

$V_{a(b)}$ max.	90	V
I_k max.	2.5	µA
$T_{ambient}$ max.	70	°C

Mullard

90AG

GAS-FILLED PHOTOCELL

Gas-filled photocell particularly sensitive to day-light and to radiation having a blue predominance.
It is suitable for use in sound reproducing systems where a dye-image sound track is used in conjunction with an incandescent light source.

19 mm. max.

6 mm.

54 mm. max.

34 mm.

13 mm.

47 mm. max.

Sensitive cathode area shown shaded

Direction of light

The cathode connection should be made to pins 1, 2, 6 & 7 connected together and the anode connection to pins 3, 4 & 5 connected together.

B7G BASE

158

GAS-FILLED PHOTOCELL

90AG

*Gas-filled photocell particularly sensitive to day-
light and to radiation having a blue predominance.
It is suitable for use in sound reproducing systems
where a dye-image sound track is used in conjunction with an incandescent light source.*

ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE

Mullard

VACUUM PHOTOCELL

Vacuum photocell, particularly sensitive to daylight and to light radiation with a blue predominance. The use of the B7G miniature all-glass base permits a rigid construction and maximum cathode area for a cell of this size.

90AV

CATHODE

Surface	Caesium antimony
Projected area	4.0 cm²

MOUNTING POSITION

Any

CAPACITANCE

c_{a-k}	0.7 pF

CHARACTERISTICS (measured at Va=100V)

I_{dark}	<0.05	μA
* S	45	μA/lumen

* Measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K and with a series resistor of 1MΩ

LIMITING VALUES (Absolute ratings)

$V_{a(b)}$ max.	100	V
I_k max.	5	μA
$T_{ambient}$ max.	70	°C

Mullard

90AV

VACUUM PHOTOCELL

Vacuum photocell, particularly sensitive to daylight and to light radiation with a blue predominance. The use of the B7G miniature all-glass base permits a rigid construction and maximum cathode area for a cell of this size.

Sensitive cathode
area shown shaded

Direction of light

The cathode connection should be made to pins 1,2,6 & 7 connected together and the anode connection to pins 3,4 & 5 connected together.

B7G BASE

158

VACUUM PHOTOCELL

Vacuum photocell, particularly sensitive to daylight and to light radiation with a blue predominance. The use of the B7G miniature all-glass base permits a rigid construction and maximum cathode area for a cell of this size.

90AV

ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE
WITH TOTAL ILLUMINATION AS PARAMETER

Mullard

GAS-FILLED PHOTOEMISSIVE TUBE   90CG

QUICK REFERENCE DATA

Gas-filled photoemissive tube, particularly sensitive to incandescent light sources and to near infra-red radiation.

Anode supply voltage	90	V
Luminous sensitivity	125	μA/lm
Spectral response curve		Type C (S1)

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - PHOTOEMISSIVE TUBES

PHOTOCATHODE

Surface	Caesium on oxidised silver	
Spectral response curve	Type C (S1)	
Projected sensitive area	3.0	cm^2

CHARACTERISTICS

Anode supply voltage	90	V
Anode series resistor	1.0	$M\Omega$
Luminous sensitivity (measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K)	125	μA/lm
Dark current	$\leq$0.1	μA

CAPACITANCE

c_{a-k}	1.1	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a(b)}$ max.	90	V
I_k max.	2.0	μA
T_{amb} max.	100	°C

OUTLINE AND SCHEMATIC DRAWING
OF 90CG

19 dia max

11 min

B9243

54 max

47·6 max

30·5 min

8·5 max

Incident radiation

a

k

IC   a   IC

o o
o 3 4 5 o
k o2   6 o k
o 1 7 o
k   IC

B7G Base

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

I_a (µA)

B9242   90CG R_a=1MΩ

10MΩ 5MΩ 4MΩ 3MΩ 2MΩ

0·025 lm
0·02 lm
0·015 lm
0·01 lm
0·005 lm

3

2

1

0
0   20   40   60   80 V_a (V)   100

ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE
WITH ILLUMINATION AS PARAMETER

Mullard

VACUUM PHOTOEMISSIVE TUBE 90CV

QUICK REFERENCE DATA

Vacuum photoemissive tube, particularly sensitive to incandescent light sources and to near infra-red radiation.

Anode supply voltage (max.)	250	V
Luminous sensitivity	20	μA/lm
Spectral response curve	Type C (S1)	

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - PHOTOEMISSIVE TUBES

PHOTOCATHODE

Surface	Caesium on oxidised silver	
Spectral response curve	Type C (S1)	
Projected sensitive area	3.0	cm^2

CHARACTERISTICS

Anode supply voltage	50	V
Anode series resistor	1.0	MΩ
Luminous sensitivity (measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K)	20	μA/lm
Dark current (at $V_a = 100V$)	≤ 0.05	μA

CAPACITANCE

c_{a-k}	0.8	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a(b)}$ max.	250	V
I_k max.	10	μA
T_{amb} max.	100	°C

OUTLINE AND SCHEMATIC DRAWING
OF 90CV

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE
WITH ILLUMINATION AS PARAMETER

Mullard

GAS-FILLED PHOTOEMISSIVE TUBE 92AG

QUICK REFERENCE DATA

Gas-filled photoemissive tube, particularly sensitive to daylight and to radiation having a blue predominance.

Anode supply voltage (max.)	90	V
Luminous sensitivity	130	μA/lm
Spectral response curve	Type A (S11)	

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - PHOTOEMISSIVE TUBES

PHOTOCATHODE

Surface	Caesium antimony	
Spectral response curve	Type A (S11)	
Projected sensitive area	2.1	cm^2

CHARACTERISTICS

Anode supply voltage	85	V
Anode series resistor	1.0	$M\Omega$
Luminous sensitivity (measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K)	130	μA/lm
Dark current	≤ 0.1	μA

CAPACITANCE

c_{a-k}	0.9	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a(b)}$ max.	90	V
I_k max.	12.5	nA/mm^2
T_{amb} max.	70	°C

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

**ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE
WITH ILLUMINATION AS PARAMETER**

Mullard

VACUUM PHOTOEMISSIVE TUBE $\qquad$ 92AV

QUICK REFERENCE DATA		
Vacuum photoemissive tube, particularly sensitive to daylight and to radiation having a blue predominance.		
Anode supply voltage (max.)	100	V
Luminous sensitivity	45	μA/lm
Spectral response curve	Type A (S11)	

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES – PHOTOEMISSIVE TUBES

PHOTOCATHODE

Surface	Caesium antimony	
Spectral response curve	Type A (S11)	
Projected sensitive area	2.1	cm^2

CHARACTERISTICS

Anode supply voltage	85	V
Anode series resistor	1.0	MΩ
Luminous sensitivity (measured with the whole cathode area illuminated by a lamp of colour temperature 2700°K)	45	μA/lm
Dark current	$\leq$ 0.05	μA

CAPACITANCE

c_{a-k}	0.9	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

$V_{a(b)}$ max.	100	V
I_k max.	25	nA/mm^2
T_{amb} max.	70	$^{\circ}$C

Mullard

OUTLINE AND SCHEMATIC DRAWINGS
OF 92AV

The cathode connection may be made to pins 1, 2, 6 and 7 connected together and the anode connection to pins 3, 4 and 5 connected together.

ANODE CURRENT PLOTTED AGAINST ANODE VOLTAGE
WITH ILLUMINATION AS PARAMETER

Mullard

VACUUM PHOTOEMISSIVE TUBES 150AV
150CV
150UV

QUICK REFERENCE DATA

Vacuum photoemissive tubes with high stability and linearity, intended for use in high precision photometry (up to 1 lux) and for measurements of quickly changing light phenomena (up to approx. 1000 lux).

The 150AV is particularly sensitive to light having a blue predominance
The 150CV is particularly sensitive to light having a red predominance
The 150UV is particularly sensitive to blue light and has a response which extends into the ultra-violet region.

	150AV	150CV	150UV	
Anode voltage	6 to 90	6 to 90	6 to 90	V
Maximum average current	50	35	50	nA
Maximum peak current	35	25	35	μA
Sensitivity	60	20	60	μA/lm
Rise time	14	14	14	ns
Spectral response curve	A (S11)	C (S1)	U (S13)	

Unless otherwise stated, data is applicable to all types
This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - PHOTOEMISSIVE TUBES

PHOTOCATHODE	150AV	150CV	150UV	
*Surface	Caesium antimony	Caesium on oxidised silver	Caesium antimony	
**Spectral response curve	A (S11)	C (S1)	U (S13)	
Luminous sensitivity (Measured using a tungsten lamp of colour temperature 2850°K)				
typical	60	20	60	μA/lm
minimum	35	14	35	μA/lm

Each tube is marked with its sensitivity. An angle of 15° between the axis of the tube and the direction of the incident light decreases the sensitivity by not more than 5%.

*The cathode material is deposited on the inner surface of the window, which is optically plane and polished. This allows the luminous source to be at a close and repeatable distance from the cathode.

**The spectral response curve is a nominal one, and considerable variation between individual tubes may be expected.

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CHARACTERISTICS

Saturation voltage

luminous flux = 0.05 lm	< 6.0	V
luminous flux = 1.0 lm	< 70	V

Anode voltage	6 to 90	V

Dark current

150AV, 150UV	< 1.0	pA
150CV	< 1.0	nA

*Linearity	10^{-4}	
Insulation resistance	$> 10^{15}$	Ω
Rise time	14	ns

*Tube current is proportional to luminous flux within measuring errors, provided that the anode voltage is higher than the saturation voltage.

CAPACITANCE

c_{a-k}	13	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_a max.	100	V

I_k max. (per unit area)

peak	50	nA/mm^2
average (averaging time = 1s)	70	pA/mm^2

I_k max. (cathode uniformly illuminated)
peak

150AV, 150UV	35	μA
150CV	25	μA

average (averaging time = 1s)

150AV, 150UV	50	nA
150CV	35	nA

T_{bulb} max.	+60	^oC
T_{bulb} min.	−90	^oC

LIFE EXPECTANCY

At the maximum average current the sensitivity will not decrease by more than 10% of its initial value between start of life and 500 operating hours. At lower cathode currents a higher stability may be expected.

NOTES

The cathode should not be exposed to direct sunlight.
In cases where low frequency noise influences the measuring results, this source of noise may be reduced by cooling the tube to -90^oC.

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VACUUM PHOTOEMISSIVE TUBES   150AV 150CV 150UV

OUTLINE DRAWINGS

Anode and cathode terminals are CT1 caps

All dimensions in millimetres

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APPLICATION NOTES

The currents allowed through this tube are so small that amplification will always be necessary. To maintain the accuracy of the signal from the tube is often the main problem. This problem may be divided into four parts.

1. **Distortion due to capacitive shunting**
   The signal at the input of the amplifier is

   $$v = \frac{i}{\sqrt{\frac{1}{R^2} + \omega^2 C^2}}$$

   where v = signal in volts
       i = current through photoemissive tube, in amps
       R = series resistance across which signal is taken, in ohms
       ω = $2\pi f$ (f = signal frequency in Hz)
       C = total capacitance of cathode of photoemissive tube
           + input capacitance of amplifier + stray capacitance,
           in farads. The value of C will probably be at least
           20pF.

   Given a maximum allowable distortion, the maximum signal frequency will limit the value of R, and therefore also the value of v.

2. **Noise**

   The signal level at the input to the amplifier must exceed the noise level. The three main sources of noise are:

   a. **Shot noise in the photoemissive tube**, which follows the formula:

   $$I_{noise} = \sqrt{2eiB} \text{ (amps r.m.s.)}$$
   $$V_{noise} = R I_{noise}$$

   where e = electronic charge (1.6×10^{-19} coulomb)
       i = current through photoemissive tube, in amps
       B = bandwidth in Hz
       R = series resistance across which signal is taken, in ohms

   b. **Resistance noise**, which follows the formula:

   $$V_{noise} = \sqrt{4kTRB}$$

   where k = Boltzmann's constant (1.38×10^{-23} Nm/degK)
       T = temperature in $^{\circ}$K
       R = series resistance across which signal is taken, in ohms
       B = bandwidth in Hz

   c. **Input noise of the amplifier**

   When a thermionic valve is used in the input stage of the amplifier, the noise voltage follows the formula:

   $$V_{noise} = \sqrt{\Sigma V_{eq}^2 \Delta B}$$

   V_{eq} varies with frequency, and has a different value for each valve type. For frequencies above 1kHz V_{eq} does not change much with frequency, so that the formula may be approximated to:

   $$V_{noise} = V_{eq}\sqrt{B}$$

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APPLICATION NOTES (cont'd)

In this case V_{eq} can be approximated within a factor of 2 or 3 by:

$$V_{eq} = \frac{3 \times 10^{-9} \sqrt{I_a}}{gm}$$

where I_a = the anode current of the valve, in amps

gm = the mutual conductance in amps/volt.

3. **Amplifier input current**

The input current to the amplifier should be low compared with the signal current through the photoemissive tube.

4. **Amplifier linearity**

The amplifier should have negative feedback so that the stability of the signal is not impaired and distortion is not introduced.

If the circumstances are such that the signal-to-noise ratio cannot be kept within acceptable limits - usually where low incident light levels are combined with high frequencies, use of this type of tube should be abandoned in preference to a photo-multiplier tube, in which distortion due to capacitive shunting and noise sources other than shot noise are of lower relative importance.

Circuit examples

An example of a simple circuit which is useful for many purposes of static light measurement is shown in fig. 1.

Fig 1

The 50µA meter can be calibrated in millilumens or, if the whole of the cathode is illuminated, in lux. Assuming that the pointer of the meter will not move with frequencies above 20Hz, noise level calculations may be restricted to frequencies below this. With a photoemissive tube current of 5nA, the amplifier input voltage is 5V, the shot noise is 0.1mV, the resistance noise is 10µV and the equivalent noise voltage at the amplifier is 1µV.

The negative feedback in the system is about 1000 times, so the accuracy is solely determined by the accuracy of the 50µA meter, all other inaccuracies being small. Mains voltage variations between +10% and –15% have no effect on the measured result.

The circuit of fig.1 is calibrated as follows:

Adjust RV_2 so that the total cathode series resistance of the EC1000 is $\frac{A.R_1}{50\ 000}\ \Omega$, where R_1 is the value of the series resistor of the photoemissive tube and

     A is the sensitivity of the photoemissive tube (µA/lm) as marked on the tube.

Disconnect the EC1000 grid from the photoemissive tube and connect it to earth. Connect the mains input and adjust RV_1 so that the 50µA meter reads zero. The circuit is now set up and calibrated for 0.02mlm per µA deflection on the meter. For measurements of rapidly changing phenomena the series resistor (R_1) should be chosen for an acceptable signal-to-noise ratio and acceptable distortion, and the meter should be replaced by a resistor shunted by the input to an oscilloscope. Depending on the frequency, further adaptions of the circuit may be necessary, for example, further smoothing of the direct voltages and a d.c. heater supply for the EC1000.

For extremely rapid changes, when all the circuit time constants must be reduced as far as possible, the circuit of fig.2 may be used. With this circuit laser light flashes can be recorded with a rise time of the signal at the oscilloscope of 20ns.

Fig 2

GAS-FILLED PHOTOEMISSIVE TUBE

155UG

> ## QUICK REFERENCE DATA
>
> Gas-filled photoemissive tube with end-on incidence, sensitive to ultra-violet radiation and intended for use as an on-off device in flame failure circuits.
>
> Spectral response   0.20 to 0.29 μm
>
> Supply voltage (r.m.s.)   220   V

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - PHOTOEMISSIVE TUBES

OPERATING PRINCIPLE

When photons of sufficient energy strike the cathode of the tube, electrons may be released. Provided that the tube voltage is sufficiently high, these electrons may initiate a discharge. The probability that this will occur is dependent amongst other things on the value of the supply voltage and the intensity of the ultra-violet radiation.

The discharge will cease as soon as the instantaneous value of the tube voltage falls below the maintaining voltage.

CHARACTERISTICS

Spectral response (see page 7)   0.20 to 0.29 μm

Maintaining voltage   180 to 220   V

RATINGS

T_{amb} max. (operating)

    when used in the circuit of Fig.1   +70 ^{o}C
    when used in the circuits Fig.2 and Fig.3   +100 ^{o}C

T_{amb} min. (operating)   -25 ^{o}C

T_{amb} max. (storage)   +50 ^{o}C

T_{amb} min. (storage)   -50 ^{o}C

No electrical ratings are given for this tube. Designers are strongly advised to use the recommended circuits. Any departure may result in an unsafe operating mode which is likely to cause an internal short circuit in the tube before its rated useful life has expired.

It should be noted that most sources of visible light (e.g. the sun, fluorescent lamps, etc.) are also sources of ultra-violet radiation. Where the level of such radiation affects circuit operation adequate shielding or filtering should be provided.

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RECOMMENDED CIRCUITS.

1. **Direct relay circuit** $(T_{amb}$ max. $= 70^{o}C)$

FIG.1

R_1	$100\,\Omega \pm 10\%$		Relay:	
R_2	$220k\Omega \pm 10\%$		R	$12k\Omega \pm 10\%$
R_3	$270\Omega \pm 10\%$		I_{on}	$<3mA$
D	4 diodes 800V P.I.V.		I_{off}	0.5 to 1.5mA
	e.g. BYX10		P max.	$>1.2W$
C_1	12nF $\pm$ 15%			
C_2	25μF $\pm$ 15%			

NOTES

1. The filter R_1 C_1 reduces the effect of high voltage transients on the mains.

2. Incidental discharges of the tube will not activate the relay with the stated range of supply voltage.

SENSITIVITY

Under the worst probable conditions of supply voltage (190V), component variations and characteristic variation of the tube over 10 000 hours, the tube will activate the relay when the standard radiation source (Fig.4) is less than 50mm from the tube.

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2. **Indirect relay circuit 'A'** $(T_{amb} \text{ max.} = 100^{\circ}C)$

FIG.2

R_1	$100\Omega \pm 10\%$		C_1	$12nF \pm 15\%$
R_2	$100\Omega \pm 10\%$		C_2	$12nF \pm 15\%$
R_3	$120k\Omega \pm 10\%$		C_3	$2.2\mu F \pm 15\%$
R_4	$120k\Omega \pm 10\%$		D_1, D_2	diodes 800V P.I.V.
R_5	$470k\Omega \pm 10\%$			e.g. BYX10

NOTE

The filter R_1 C_1 reduces the effect of high voltage transients on the mains.

SENSITIVITY

The curve on page 8 shows the relationship between the output voltage (V_o) and the distance between the tube and the standard radiation source (Fig.4) under the worst probable conditions of supply voltage (198V) and component variations for the least sensitive new tube.

After the first 10 000 hours of operation the sensitivity will have decreased, but in all cases will be better than indicated by the appropriate curve on page 8, provided that the radiation source is doubled (two candles as in Fig.4).

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3. **Indirect relay circuit 'B'** (T_{amb} max. $= 100^{\circ}$C)

FIG.3

R_1	$100\Omega \pm 10\%$	C_1	$12nF \pm 15\%$
R_2	$100\Omega \pm 10\%$	C_2	$12nF \pm 15\%$
R_3	$330k\Omega \pm 10\%$	C_3	$2.2\mu F \pm 15\%$
R_4	$150k\Omega \pm 10\%$	D_1	diode 800V P.I.V. e.g. BYX10
R_5	$470k\Omega \pm 10\%$		

NOTE

The filter R_1 C_1 reduces the effect of high voltage transients on the mains.

SENSITIVITY

The curve on page 8 shows the relationship between the output voltage (V_o) and the distance between the tube and the standard radiation source (Fig.4) under the worst probable conditions of supply voltage (198V) and component variations for the least sensitive new tube.

After the first 10 000 hours of operation the sensitivity will have decreased, but in all cases will be better than indicated by the appropriate curve on page 8, provided that the radiation source is doubled (two candles as in Fig.4).

APPLICATION NOTES

To ensure that the intensity of radiation incident on the tube in its equipment will be sufficient throughout its service life (10 000 hours in the case of a new tube) the following procedure should be observed:

For the circuit of Fig.1

Place a standard radiation source (Fig. 4) 50mm from the tube and measure the average voltage across the relay.

In actual operation the same tube should be mounted at a distance from the flame such that the average voltage across the relay is at least equal to that obtained using the standard radiation source at 50mm distance. Care should be taken that the mains voltage is the same during both measurements. The flame used during this measurement should be the minimum flame which has to be detected. No further readjustment of the distance between tube and flame will be necessary when the tube is replaced.

For the circuits of Fig.2 and Fig.3

The output power from these circuits is too low to operate a relay directly. For effective discrimination, the voltage at the input of the amplifier must attain a certain threshold value when the ultra-violet radiation emitted by the flame reaches a certain critical intensity.

Therefore steps must be taken to ensure that the output voltage (V_o) from the recommended circuit will remain above this threshold value throughout the life of the tube. This may be done as follows:

Read from the dotted curve on the relevant graph on page 8 the distance d corresponding to the required minimum voltage V_o.

Place two standard radiation sources (Fig.4) at a distance d from the tube and measure the average output voltage with a high resistance d.c. voltmeter (this is the mean value around which the needle swings).

In actual operation the same tube should be mounted at a distance from the flame such that the average output voltage (V_o) is at least equal to that obtained using two standard radiation sources at a distance d.

Care should be taken that the mains voltage is the same during both measurements. The flame used during this measurement should be the minimum flame which has to be detected. No further readjustment of the distance between tube and flame will be necessary when the tube is replaced.

The above procedures do not, of course, include allowance for dirt deposited on the tube during life.

FIG. 4
Standard radiation source

DIMENSIONS AND CONNECTIONS

B9A/D
Base

Dimensions in mm

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Relative response (%) vs Wavelength (nm). Graph labelled 155UG, B8988.

RELATIVE SPECTRAL RESPONSE

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OUTPUT VOLTAGE AS A FUNCTION OF THE DISTANCE BETWEEN
RADIATION SOURCE AND THE LEAST SENSITIVE TUBE IN THE
CIRCUIT OF Fig.2

OUTPUT VOLTAGE AS A FUNCTION OF THE DISTANCE BETWEEN
RADIATION SOURCE AND THE LEAST SENSITIVE TUBE IN THE
CIRCUIT OF Fig.3

The curve is valid at 0 hours when the tube is irradiated by one 'standard radiation
source' and at 10 000 hours when irradiated by two 'standard radiation sources'.

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PHOTOMULTIPLIER TUBES

F

1. The overall supply voltage should be well stabilised, since the gain of a photomultiplier is critically dependent on the voltage. The percentage change in gain is approximately ten times the percentage change in supply voltage. Thus, to hold the gain stable to within 1% the power supply must be stabilised to within approximately 0.1%.

2. (a) High-stability carbon resistors should be used in the voltage divider chain.

(b) The current through the resistor chain should be high compared with the anode current if the fluctuations in the latter are not to affect the gain excessively. The relative change in gain is approximately proportional to the ratio of the anode current to the divider current. For example, to maintain the gain stable to within 1% when measuring continuous luminous flux, the current in the chain should be at least 100 times the anode current.

(c) When the tube is used for the detection of luminous pulses, as in scintillation counting, the fluctuations in gain can be restricted without the need for a high supply current by shunting each resistor in the divider chain with a capacitor, which supplies the additional current when required. Since the earlier cathodes carry a very much lower current than the later ones, it is sufficient in practice to bypass the last three or four stages only.

The capacitors should be chosen according to the following relationship:

$$C_n \simeq dC_{n-1}$$
$$C_{n-1} \simeq dC_{n-2} \text{ etc.}$$

where C_n = capacitor across resistor feeding last cathode

C_{n-1} = capacitor across resistor feeding last cathode but one

C_{n-2} = capacitor across resistor feeding last cathode but two

d = secondary emission factor of cathodes (typically 3.5)

If the time constant RC_n is made greater than 100t, where t is the time constant of the pulses, a peak anode current of 1mA will cause a change in gain of less than 1% if the current through the voltage divider chain is 1mA.

The voltage fluctuations occurring in this arrangement are small but of long duration, so that if the counting rate is high the fluctuations due to successive pulses may be partially superimposed, resulting in an error which is a function of the counting rate. In the example just given, the duration of each fluctuation would be approximately 600t, and if overlapping were not to occur, the counting rate could not exceed 1/600t p.p.s. For a pulse length of 10μs this corresponds to a rate of approximately 1700 p.p.s.

(d) Where a high current supply cannot be avoided, due to a high counting rate or the need to measure a continuous luminous flux, it is possible to employ a high current source of comparatively low voltage for the last three or four stages only, and a low current high voltage source for the remaining stages. If it is undesirable to maintain one power supply terminal at the sum of the two voltages with respect to earth, the common terminal may be earthed.

3. On no account should the tube be exposed to ambient light when the supply voltage is applied. A luminous flux of less than 10^{-5} lm is sufficient to cause the maximum permissible anode current to be exceeded. To obtain the maximum useful life from the photocathode the tube should be protected from light as far as possible even when not in use.

4. The dark current takes approximately 15 to 30 minutes after the application of the supply voltage to fall to a stable value. For this reason it is recommended that the equipment should be switched on half an hour before making any measurements requiring a high degree of accuracy.

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The dark current may be further reduced by applying to the photocathode a jet of dry air cooled by being passed, for example, through a spiral immersed in liquid nitrogen. It is very important to ensure that no condensation occurs on the base or socket of the tube if air-cooling is adopted.

5. It is advisable to fit a mu-metal screening can round the envelope of the tube if it is used in the vicinity of magnetic fields.

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'A' (S11) PHOTOCATHODE

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'C' (S1) PHOTOCATHODE

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'D' PHOTOCATHODE

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'DU' PHOTOCATHODE

SPECTRAL RESPONSE

RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'T' (S20) PHOTOCATHODE

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'TU' (EXTENDED S20) PHOTOCATHODE

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE 'U' (S13) PHOTOCATHODE

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RELATIVE SPECTRAL ENERGY DISTRIBUTION CURVE
FOR TYPE S4 PHOTOCATHODE

UNIVERSAL PHOTOSCINTILLATOR HOUSING ASSEMBLY

S5600
Series

TENTATIVE DATA

QUICK REFERENCE DATA

This assembly is essentially a probe-like mechanical system with provisions for mounting a photomultiplier tube, a voltage divider, a limiter and either a scintillator or a light guide.

Printed wiring boards carrying the limiter and voltage dividers are included, together with all necessary wiring. The photomultiplier tube and the scintillator or light guide must be ordered separately.

Maximum h.t. supply voltage for the photomultiplier tube (negative polarity)	2.5	kV
H. T. supply current	1.05 ± 10%	mA/kV
Limiter supply voltage (positive polarity)	24	V
Limiter supply current	35	mA

TYPE DESIGNATION

S5600/01   Complete assembly with mu-metal and soft-iron shields, fastening rings for light guide or scintillator, socket for photomultiplier tube, decoupling capacitors for photomultiplier tube, 2 printed circuit boards carrying the voltage divider, 1 printed circuit board carrying the limiter.
Without photomultiplier tube, scintillator or light guide. This assembly is intended for use with photomultiplier tube type 56AVP, 56DVP, 56DUVP, 56TUVP, 56TVP or 56UVP.

S5600/02   As S5600/01 but for use with photomultiplier tube type 56CVP.

S5600/03   As S5600/01 but for use with photomultiplier tube type 58AVP, 58DVP, 58UVP, XP1040 or XP1041.

M/5600/01   As S5600/01 but without the printed wiring boards carrying voltage divider and limiter.

M/5600/02   As S5600/02 but without the printed wiring boards carrying voltage divider and limiter.

M/5600/03   As S5600/03 but without the printed wiring boards carrying voltage divider and limiter.

M/5600/AR   As M/5600/01 but without anti-magnetic shields and without fastening rings for light guide or scintillator.

PHOTOMULTIPLIER TUBE

The photomultiplier tube must be ordered separately. For tube data see Handbook section 'Photomultiplier tubes'.

SCINTILLATOR

The plastic scintillator must be ordered separately. Details may be obtained from the Industrial Electronics Division.

LIGHT GUIDE

The light guide must be ordered separately. The maximum diameter is 40mm, and the required length must be stated when ordering.

ACCESSORIES

The following accessories can be ordered separately:

Fastening clip	PS A 100
Voltage divider for S5600/02 (2 circuits)	PS A 101
Two printed circuit boards without components, for mounting a voltage divider at choice	PS A 102
Voltage divider for S5600/01 and S5600/03 (2 circuits)	PS A 103
Limiter	PS A 104
Opaque cap	PS A 105
Fastening rings for light guide or scintillator	PS A 106
Soft iron shield	PS A 107
Foam plastic ring	PS A 108
Passive printed circuit board to replace limiter PS A 104 in case of direct connection to the anode	PS A 109
Mu-metal shield	TA 60/09

OPERATIONAL CONSIDERATIONS

The h.t. supply of the probe must have a negative polarity. The absolute maximum value of the h.t. is 2500V but, depending on the type of photo-multiplier tube used, it must not exceed the value giving a gain of 10^9. The h.t. supply current is 1.05mA/kV ± 10%.
The supply voltage of the limiter must have positive polarity. The voltage is 24V at a current of 35mA.

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CHARACTERISTICS OF THE LIMITER

Measuring set-up

Output signal peak amplitude = 1.6V across 100Ω

For a given output voltage the leading edge is max. $0.8V_S$

(V_S = tube interstage voltage)

Rise time from 0 to $0.75V_S$ = max. 2ns.

Maximum ambient temperature = $40^{\circ}C$.

CHARACTERISTICS OF S5600

equipped with photomultiplier tube 56AVP or 56DVP

Measuring set-up

Pulse rise time = max. 0.6ns.

Width at half height = max. 0.9ns.

Supply voltage for gain = 10^8: see photomultiplier tube data.

Output signal peak amplitude = max. $0.8V_S$

Rise time = 4ns.

UNIVERSAL PHOTOSCINTILLATOR HOUSING ASSEMBLY

S5600

Series

GENERAL CIRCUIT

S5600/01 with 56AVP

"Signal"

"Pulse calibration"

"Test"

TR2

TR1

R5 100Ω

D3

D2

D1

C5 10nF

C4 10nF

C3 100nF

R4 820Ω

24V Limiter supply voltage

+ −

C1 10nF

C2 10pF

R1 1kΩ

R2 100Ω

R3 820Ω

P1

a

d14 d13 d12 d11 d10 d9 d8 d7 d6 d5 d4 d3 d2 d1 acc g1 k

P11 P8 P12 P7 P13 P6 P14 P5 P15 P4 P16 P3 P17 P2 P19 P20

R36 R35 R34 R33 R32 R31 R22 R21 R20 R19 R18 R17 R16 R15

C36 8μF C35 C34 C33 C32 C31

8μF 2·2μF 1μF 470nF 220nF

C2 C2 C2 C2

d11 d12 d13 d14

R14 47MΩ 47MΩ

Rv

C1

R13 120kΩ 120kΩ

R12 120kΩ

R11 15kΩ

−HT

C2 C2 C2 C2 C2 C2 C2 C2 C2 C2 C2

C1 = 10nF — 1000V
C2 = 10nF — 500V

R15 = 68kΩ
R16 = 68kΩ
R17 = 35kΩ

R18,R19
R20,R21
R22,R31
R32,R33
R34,R35 R36

47kΩ

P1 to P20 (base connections 56AVP)
* P18 connected to P19 at the photomultiplier socket.

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VOLTAGE DIVIDER PS A 103

Printed circuit board 1

Circuit 1

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VOLTAGE DIVIDER PS A 103

Printed circuit board 2

Circuit 2

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LIMITER PS A 104

Printed circuit board

Circuit

Mullard

PHOTOMULTIPLIER TUBE XP1002

QUICK REFERENCE DATA

10 stage photomultiplier tube intended for use in laser applications working in the orange and green range and for photometry where a high sensitivity in the whole visible region is required.

Spectral response		Type T (S20)
Photocathode useful diameter	44	mm
Anode sensitivity (at $V_b = 1.8kV$)	400	A/lm

To be read in conjunction with
OPERATING NOTES - PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, sodium potassium caesium antimony	
Minimum useful diameter	44	mm
Spectral response		Type T (S20)
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	150	μA/lm
minimum	110	μA/lm
Average radiant sensitivity at		
420nm	70	mA/W
700nm	12	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	10	
Dynode material	silver magnesium oxygen caesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Overall sensitivity at $V_b = 1.8kV$		
average	400	A/lm
minimum	100	A/lm
**Dark current at $S = 60A/lm$		
average	15	nA
maximum	50	nA
Maximum anode pulse amplitude for linearity with input light pulse	30	mA

**Measured at 25°C

--- **Mullard** ---

CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	100	mA
Anode pulse rise time (at $V_b = 1.5$kV)	4.0	ns
Anode pulse width at half height (at $V_b = 1.5$kV)	12	ns
Transit time difference between the centre of the photocathode and the edge (at $V_b = 1.5$kV)	4.0	ns
Total transit time (at $V_b = 1.5$kV)	40	ns

Note - These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. 1

Fig.2

D430

CAPACITANCES

c_{a-d10}	3.0	pF
c_{a-all}	5.0	pF

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PHOTOMULTIPLIER TUBE XP1002

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max.	1.8	kV
I_a max. (continuous operation)	0.1	mA
V_{k-d1} max.	500	V
V_{k-d1} min.	180	V
V_{d1-d2} ········· $_{d9-d10}$ max.	300	V
V_{d1-d2} ········· $_{d9-d10}$ min.	80	V
*V_{a-d10} max.	300	V
*V_{a-d10} min.	80	V

*When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1001
Mu-metal shield	56128

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

Mullard

OUTLINE DRAWING OF XP1002

Incident ↓ radiation

Photocathode

⌀52.5 max.
⌀44 min.

3

d7 d8
d6 ⊙ ⊙ d9
d5 ⊙ 7 8 ⊙ d10
⊙ 6 9 ⊙
d5 ⊙ 5 10 ⊙ d10
d4 ⊙ 4 11 ⊙ a
⊙ 3 12 ⊙
d3 ⊙ 2 1 14 13 ⊙ IC
d2 ⊙ ⊙ ⊙ acc
d1 k
14-pin base
J.E.D.E.C. B14-38

148 max

123 ±5

33.5

All dimensions in mm

⌀58 max.

B6608

Mullard

PHOTOMULTIPLIER TUBE $\quad$ XP1002

ANODE SENSITIVITY AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE XP1010

QUICK REFERENCE DATA

10 stage low noise photomultiplier tube intended for use in X-ray and gamma-ray spectrometry

Spectral response		Type A (S11)
Photocathode useful diameter	32	mm
Anode sensitivity (at $V_b = 1.8kV$)	700	A/lm
Minimum plateau length (Mn, K_α line 5.9keV)	70	V
Maximum plateau slope	0.08	%/V
Background in middle of plateau	10	Hz

To be read in conjunction with
OPERATING NOTES - PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface		semi-transparent, caesium antimony
Minimum useful diameter	32	mm
Spectral response		Type A (S11)
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	80	$\mu A/lm$
minimum	70	$\mu A/lm$
Average radiant sensitivity at 420nm	65	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	10
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Overall sensitivity at $V_b = 1.8kV$

average	700	A/lm
minimum	400	A/lm
**Dark current at S=60A/lm		
average	10	nA
maximum	50	nA

**Measured at 25°C

Mullard

CHARACTERISTICS (contd.)

Maximum anode pulse amplitude for linearity with input light pulse	30	mA
*Minimum plateau length (Mn, K_α line 5.9keV)	70	V
*Maximum plateau slope	0.08	%/V
*Background in middle of plateau		
average	10	Hz
maximum	50	Hz
Total voltage in middle of plateau	1.1	kV
Energy resolution for Cu, K_α (8keV)	50	%

*Measured with a 32mm × 1mm NaI(Tl) crystal, at a counting rate of about 2.5kHz in the middle of the plateau, and with the discriminator bias set at 700mV. Pre-amplifier gain 250 (source $100\mu Ci^{55}Fe$).

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	100	mA
Anode pulse rise time (at $V_b = 1.5$kV)	4.0	ns
Anode pulse width at half height (at $V_b = 1.5$kV)	8.0	ns
Transit time difference between the centre of the photocathode and the edge (at $V_b = 1.5$kV)	3.0	ns
Total transit time (at $V_b = 1.5$kV)	36	ns

Note - These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. I

PHOTOMULTIPLIER TUBE XP1010

Fig.2

0430

CAPACITANCES

c_{a-d10}	3.0	pF
c_{a-all}	5.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

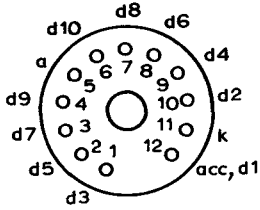|		
V_b max.	1.8	kV
I_a max. (continuous operation)	0.1	mA
V_{k-d1} max.	500	V
V_{k-d1} min.	120	V
$V_{d1-d2} \cdots \cdots \cdots _{d9-d10}$ max.	300	V
$V_{d1-d2} \cdots \cdots \cdots _{d9-d10}$ min.	80	V
*V_{a-d10} max.	300	V
*V_{a-d10} min.	80	V

*When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1002
Mu-metal shield	56127

Mullard

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

OUTLINE DRAWING OF XP1010

All dimensions in mm

Mullard

PHOTOMULTIPLIER TUBE XP1010

ANODE SENSITIVITY AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE XP1110

<div style="border:1px solid">

QUICK REFERENCE DATA

10 stage ruggedised photomultiplier tube intended for use in applications such as scintillation counting under limited dimensional conditions and optical measurements. It is particularly suitable for geophysical and astronomical missile experiments.

Spectral response	Type A (S11)	
Photocathode useful diameter	14	mm
Anode sensitivity (at 1.8kV)	250	A/lm

</div>

This data should be read in conjunction with
OPERATING NOTES – PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, caesium antimony	
Minimum useful diameter	14	mm
Spectral response	Type A (S11)	
Wavelength at maximum response	420 ± 30	nm
*Luminous sensitivity		
average	60	μA/lm
minimum	30	μA/lm
Average radiant sensitivity at 420nm	60	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	10
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG.1

Overall sensitivity at $V_b = 1.8$kV

average	250	A/lm
minimum	30	A/lm
**Dark current at S=30A/lm		
average	20	nA
maximum	100	nA
Maximum anode pulse amplitude for linearity with input light pulse	10	mA

**Measured at 25°C

Mullard

VOLTAGE DIVIDER AS IN FIG.2

Maximum anode pulse amplitude for linearity with input light pulse	30	mA
Anode pulse rise time (at $V_b = 1.8kV$)	3.0	ns
Anode pulse width at half height (at $V_b = 1.8kV$)	4.0	ns
Total transit time (at $V_b = 1.8kV$)	25	ns

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. 1

Fig. 2

D430

Mullard

CAPACITANCES

c_{a-d10}	1.9	pF
c_{a-all}	3.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	1.8	kV
I_a max. (continuous operation)	0.2	mA
V_{k-d1} max.	300	V
V_{k-d1} min.	120	V
V_{d1-d2} .... $_{d9-d10}$ max.	200	V
V_{d1-d2} .... $_{d9-d10}$ min.	80	V
**V_{a-d10} max.	200	V
**V_{a-d10} min.	80	V

*Or the voltage at which the tube when used in the circuit of Fig.1 has a gain of 10^7, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (Supplied as additional items)

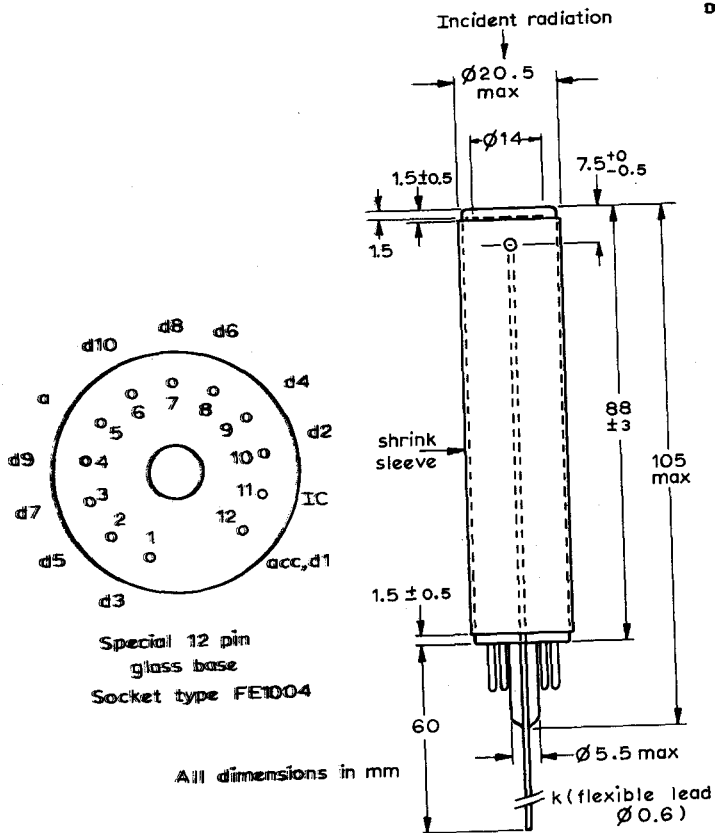|	
Socket	FE1004
Mu-metal shield	56134

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

Mullard

OUTLINE AND DIMENSIONS

Incident radiation

∅ 19 max

∅ 14 min

1.5

k

88 ±3.0

105 max

5.5 max

d10 d8 d6
a d4
d9 d2
d7 k
d5 acc,dl
d3

Special 12-pin glass base

Socket type FE1004

All dimensions in mm

D1946

10³
S (A/lm)
I_dark (nA)

XP1110

D474

Anode sensitivity (S)

I_dark

10²

10

1

1.0   1.2   1.4   1.6 V_b (k V)   1.8

ANODE SENSITIVITY AND DARK CURRENT
PLOTTED AGAINST TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE   XP1115

QUICK REFERENCE DATA

10 stage ruggedised photomultiplier tube intended for use in applications such as scintillation counting under limited dimensional conditions and optical measurements. It is particularly suitable for geophysical and astronomical missile experiments.

Spectral response		Type A (S11)
Photocathode useful diameter	14	mm
Anode sensitivity (at 1.8kV)	250	A/lm

This data should be read in conjunction with
OPERATING NOTES – PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, caesium antimony	
Minimum useful diameter	14	mm
Spectral response	Type A (S11)	
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	60	μA/lm
minimum	30	μA/lm
Average radiant sensitivity at 420nm	60	mA/W

*Measured using a tungsten lamp of colour temperature 2854K

MULTIPLIER SYSTEM

Number of stages	10	
Dynode material	silver magnesium oxygen caesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG.1

Overall sensitivity at $V_b = 1.8$kV		
average	250	A/lm
minimum	30	A/lm
**Dark current at $S = 30$A/lm		
average	20	nA
maximum	100	nA
Maximum anode pulse amplitude for linearity with input light pulse	10	mA

**Measured at 25°C

CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG.2

Maximum anode pulse amplitude for linearity with input light pulse	30	mA
Anode pulse rise time (at $V_b = 1.8kV$)	3	ns
Anode pulse width at half height (at $V_b = 1.8kV$)	4	ns
Total transit time (at $V_b = 1.8kV$)	22	ns

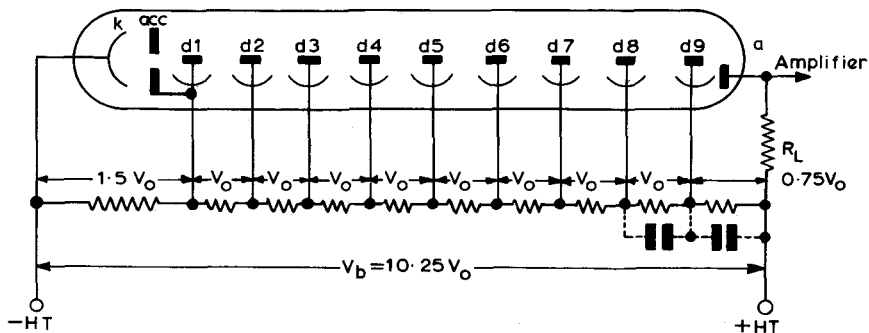Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.
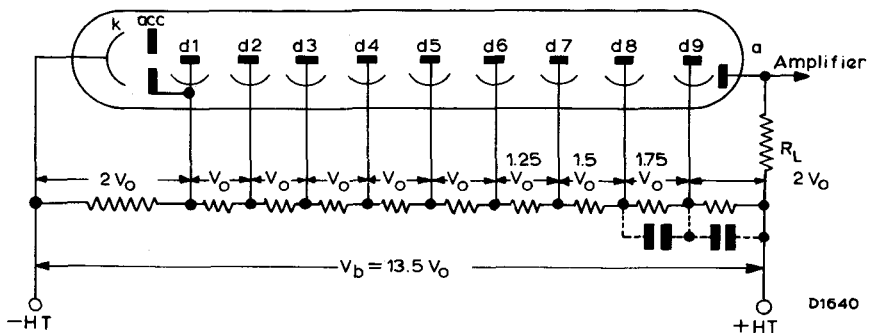

Fig.1

Fig.2

D430

Mullard

CAPACITANCES

c_{a-d10}	1.9	pF
c_{a-all}	3.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	1.8	kV
I_a max. (continous operation)	0.2	mA
V_{k-d1} max.	300	V
V_{k-d1} min.	120	V
$V_{d1-d2} \cdots\cdots\cdots d9-d10$ max.	200	V
$V_{d1-d2} \cdots\cdots\cdots d9-d10$ min.	80	V
**V_{a-d10} max.	200	V
**V_{a-d10} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig. 1, has a gain of about 10^7, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.
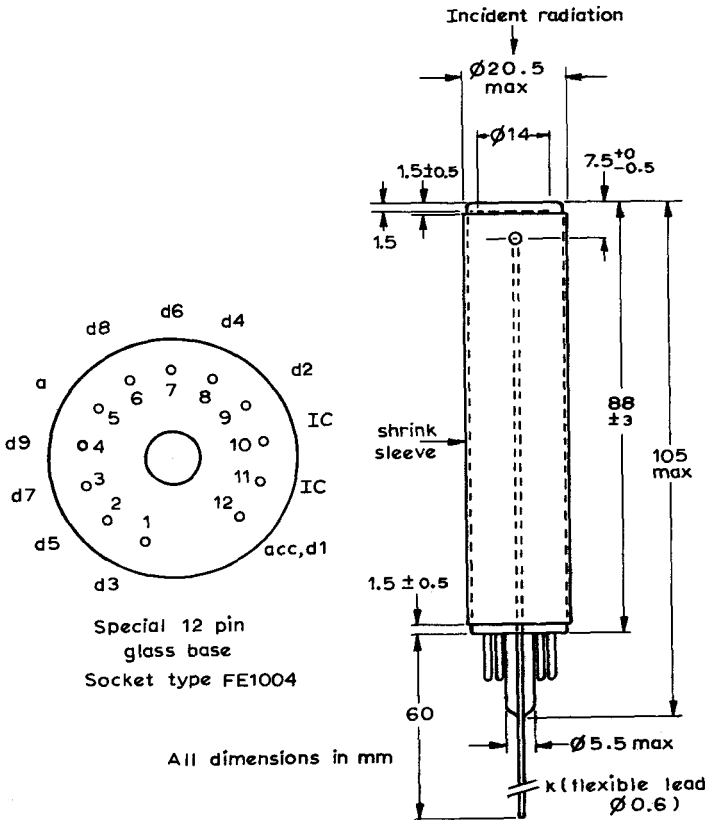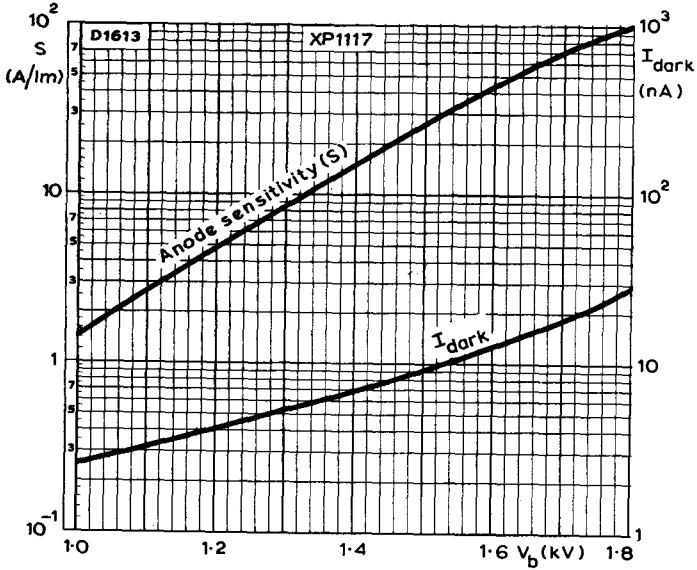
OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

7. The semi-flexible leads of the tube may be soldered into the circuit but heat must be conducted away from the glass seals. Excessive bending of the leads should be avoided.

D501

Base:
12 Semi-flexible leads

All dimensions in mm

Incident radiation

Ø14min.
Ø 20max.
1.5
k
88 ±3
105 max
170
welded
Ø5.5 max
12 Nickel tapes 0.1×1.0

ANODE SENSITIVITY AND DARK CURRENT
PLOTTED AGAINST TOTAL VOLTAGE

PHOTOMULTIPLIER TUBE   XP1116

QUICK REFERENCE DATA

10 stage photomultiplier tube intended for use in applications such as infrared telecommunication and ranging under limited dimensional conditions.

Spectral response		Type C (S1)
Photocathode useful diameter	14	mm
Anode sensitivity (at $V_b = 1.8kV$)	20	A/lm

This data should be read in conjunction with
OPERATING NOTES – PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, caesium on oxidised silver	
Minimum useful diameter	14	mm
Spectral response		Type C (S1)
Wavelength at maximum response	800 ±100	nm
*Luminous sensitivity		
average	20	$\mu A/lm$
minimum	15	$\mu A/lm$
Average radiant sensitivity at 800nm	2.0	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	10	
Dynode material	silver magnesium oxygen caesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Overall sensitivity at $V_b = 1.8kV$		
average	20	A/lm
minimum	10	A/lm
**Maximum dark current at S=20A/lm	10	μA
Maximum anode pulse amplitude for linearity with input light pulse	10	mA

**Measured at $25^O C$

CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG.2

Maximum anode pulse amplitude for linearity with input light pulse	30	mA
Anode pulse rise time (at $V_b = 1.8kV$)	3.0	ns
Anode pulse width at half height (at $V_b = 1.8kV$)	4.0	ns
Total transit time (at $V_b = 1.8kV$)	25	ns

Note - These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. 1

Fig. 2

D430

Mullard

PHOTOMULTIPLIER TUBE   XP1116

CAPACITANCES

c_{a-d10}	1.5	pF
c_{a-all}	2.5	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	1.8	kV
I_a max. (continuous operation)	30	μA
V_{k-d1} max.	300	V
V_{k-d1} min.	120	V
$V_{d1-d2}\cdots\cdots_{d9-d10}$ max.	200	V
$V_{d1-d2}\cdots\cdots_{d9-d10}$ min.	80	V
**V_{a-d10} max.	200	V
**V_{a-d10} min.	80	V

*Or the voltage at which the tube when used in the circuit of Fig. 1 has an anode sensitivity of 50A/lm, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES

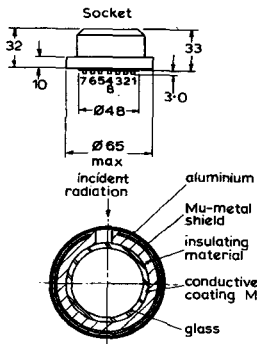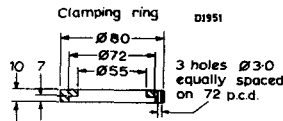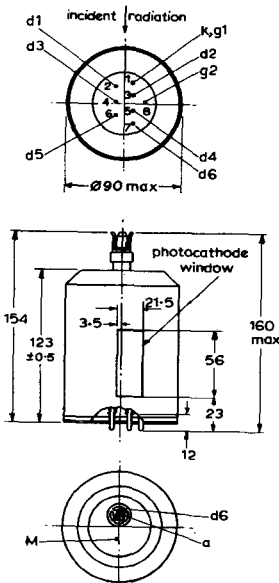|	
Socket	FE1004
Mu-metal shield	56134

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig. 1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig. 2.

Mullard

OUTLINE AND DIMENSIONS

Incident radiation

D1947

⌀20.5 max

⌀14

7.5$^{+0}_{-0.5}$

1.5±0.5

1.5

shrink sleeve

88 ±3

105 max

1.5 ± 0.5

60

⌀5.5 max

k (flexible lead ⌀0.6)

d10 d8 d6 d4 d2

a 6 7 8 9
5
10
d9 o4 11
d7 o3 12 IC
2
d5 1 acc, d1
d3

Special 12 pin glass base

Socket type FE1004

All dimensions in mm

Mullard

PHOTOMULTIPLIER TUBE   XP1117

QUICK REFERENCE DATA

9 stage photomultiplier tube intended for use in laser techniques working in the orange, yellow and green range under limited dimensional conditions. Its rugged construction makes it particularly suitable for industrial equipment.

Spectral response		Type T (S20)
Photocathode useful diameter	14	mm
Anode sensitivity (at $V_b = 1.8kV$)	100	A/lm

To be read in conjunction with
OPERATING NOTES - PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, sodium potassium caesium antimony	
Minimum useful diameter	14	mm
Spectral response	Type T (S20)	
Wavelength at maximum response	420 ±30	nm
*Average luminous sensitivity	100	μA/lm
Average radiant sensitivity at 420nm	60	mA/W

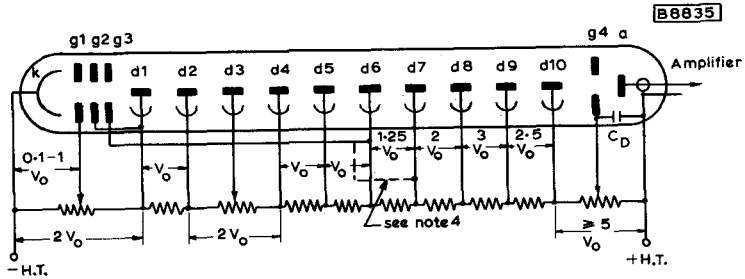*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	9
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Overall sensitivity at $V_b = 1.8kV$

average	100	A/lm
minimum	30	A/lm

**Dark current at S= 30A/lm

average	10	nA
maximum	100	nA

Maximum anode pulse amplitude for linearity with input light pulse   10   mA

**Measured at 25°C.

Mullard

CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for
linearity with input light pulse   30   mA

Anode pulse rise time (at $V_b = 1.8kV$)   3.0   ns

Anode pulse width at half height (at $V_b = 1.8kV$)   4.0   ns

Total transit time (at $V_b = 1.8kV$)   20   ns

Note – These time characteristics are for an infinitely short light pulse, fully illumi-
nating the photocathode.

Fig.1

Fig.2

CAPACITANCES

c_{a-d9} 1.5   pF

c_{a-all} 2.5   pF

Mullard

PHOTOMULTIPLIER TUBE   XP1117

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	1.8	kV
I_a max. (continuous operation)	0.2	mA
V_{k-d1} max.	300	V
V_{k-d1} min.	120	V
$V_{d1-d2}\cdots\cdots\cdots{}_{d8-d9}$ max.	200	V
$V_{d1-d2}\cdots\cdots\cdots{}_{d8-d9}$ min.	80	V
**V_{a-d9} max.	200	V
**V_{a-d9} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig. 1, has a gain of 3×10^6, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1004
Mu-metal shield	56134

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 0.5mA will be sufficient.

3. When pulses of high amplitude are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

Incident radiation

D442

$\phi 20.5$ max

$\phi 14$

1.5 ± 0.5

$7.5^{+0}_{-0.5}$

1.5

88 ± 3

shrink sleeve

105 max

1.5 ± 0.5

60

$\phi 5.5$ max

k (flexible lead $\phi 0.6$)

d8 d6 d4

a d2

d9 IC

d7 IC

d5 acc,d1

d3

6 7 8
5 9
4 10
3 11
2 12
1

Special 12 pin
glass base

Socket type FE1004

All dimensions in mm

Mullard

ANODE SENSITIVITY AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE XP1143

QUICK REFERENCE DATA

6 stage photomultiplier tube intended for measuring very short light pulses having a very high luminous flux.

Spectral response curve	Type S4	
Useful photocathode area	280	mm^2
Gain (at $V_b = 3.5kV$)	10^4	
Anode pulse rise time	<1.0	ns
Maximum anode pulse amplitude for linearity with input light pulse	5.0	A
Coaxial outlet impedance	50	Ω

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

PHOTOCATHODE

Surface	Opaque, caesium antimony	
Minimum useful area	280	mm^2
Spectral response curve	Type S4	
Wavelength at maximum response	400 ± 50	nm
*Luminous sensitivity		
average	40	$\mu A/lm$
minimum	25	$\mu A/lm$
Average radiant sensitivity (at 400nm)	40	mA/W

*Measured using a tungsten lamp of colour temperature 2854K

MULTIPLIER SYSTEM

Number of stages	6
Dynode material	silver magnesium oxygen caesium

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CHARACTERISTICS using recommended voltage divider

Supply voltage for gain $= 10^4$

average	3.5	kV
maximum	7.0	kV

Dark current at gain $= 10^4$

average	1.0	μA
maximum	6.0	μA

Maximum anode pulse amplitude for linearity
with input light pulse (linear within 5%)   5.0   A

Supply voltage for linearity (within 5%) up to 5A

average	6.5	kV
maximum	7.0	kV
Anode pulse rise time	<1.0	ns
Anode pulse width at half height	<2.0	ns
Total transit time	10	ns

Note – These time characteristics are for an infinitely short light pulse, fully illumi-
nating the photocathode.

$C_1 = 2.2nF, \ 7.5kV$

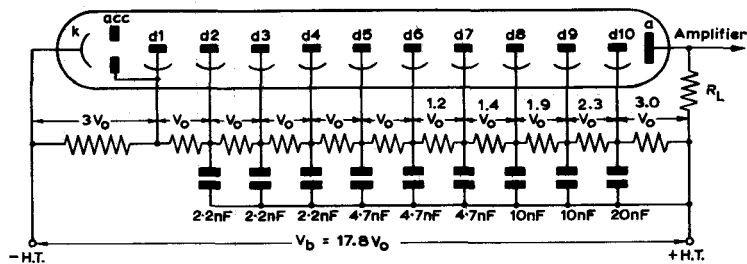$C_2 = 2.2nF, \ 7.0kV$

$C_3 = 2.2nF, \ 6.0kV$ Low inductance

$C_4 = 30nF, \ 4.0kV$ ceramic capacitors

$C_5 = 50nF, \ 3.0kV$

$R_L = 50\Omega$

CAPACITANCES

c_{a-d6} (without coaxial connector)	10	pF
c_{a-d6} (with coaxial connector)	12	pF
c_{a-all}	11	pF

Mullard

PHOTOMULTIPLIER TUBE — XP1143

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	7.5	kV
I_a max. (continuous)	0.2	mA
V_{k-d1} max.	1.0	kV
$V_{d1-d2}........d5-d6}$ max.	2.0	kV
**V_{a-d6} max.	2.75	kV

*Or the voltage at which the tube when used in the given voltage divider, has a gain of 5×10^4, whichever is the lower.

If the tube has been out of use for sometime it can be reconditioned by three hours running for each week it has been inoperative, the h.t. being increased from 2kV to the desired value in steps. The tube must be in complete darkness.

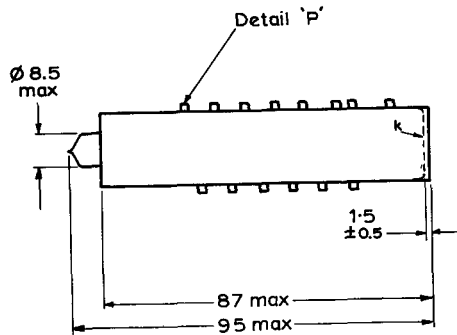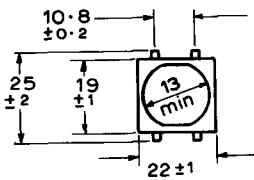**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.
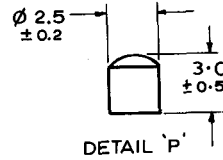
ACCESSORIES

Coaxial cable connector   General Radio type 874/C8A

Socket (see drawing below)   Supplied with the tube

All dimensions in mm

Mullard

GAIN AND DARK CURRENT PLOTTED AGAINST TOTAL VOLTAGE

PHOTOMULTIPLIER TUBE **XP1210**

QUICK REFERENCE DATA

10 stage photomultiplier tube intended for use in very fast light pulse detection, life time of excited states, fast coincidence measurements, Cerenkov measurements, etc.

Spectral response	Type A (S11)	
Photocathode useful diameter	42	mm
Gain (at $V_b = 4.0kV$)	10^7	
Maximum anode pulse rise time	1.0	ns
Coaxial outlet impedance	50	Ω

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

PHOTOCATHODE

Surface	semi-transparent, caesium antimony	
Minimum useful diameter	42	mm
Spectral response	Type A (S11)	
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	45	$\mu A/lm$
minimum	25	$\mu A/lm$
Average radiant sensitivity at 420nm	45	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	10
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS (see note 2)

Supply voltage for gain $=10^7$		
average	4.0	kV
maximum	5.0	kV
*Maximum dark current at gain $=10^7$	1.0	μA
Maximum anode pulse amplitude for linearity with input light pulse (linear within 5%)	75	mA
Maximum anode pulse rise time (at $V_b = 5.0$kV)	1.0	ns
Anode pulse width at half height (at $V_b = 5.0$kV)	1.5	ns
Maximum transit time difference between the centre of the photocathode and the edge (at $V_b = 5.0$kV)	0.2	ns
Total transit time (at $V_b = 5.0$kV)	20	ns

Note - These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

*Measured at 25°C

CAPACITANCES

c_{a-g4}	4.0	pF
c_{a-all}	6.0	pF
Decoupling capacitor between g4 and outside of coaxial connector (built-in)	400	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max.	5.0	kV
V_{k-d1} max.	900	V
V_{g2-g3} max.	1.75	kV
$V_{d1-d2} \cdots\cdots d9-d10$ max.	900	V
V_{a-g4} max.	1.5	kV

ACCESSORIES

Socket (see page 3)   56040

Coaxial cable connector   General Radio type 874/C8A

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OUTLINE DRAWING OF XP1210

Incident radiation   B8851

OUTLINE DRAWING OF 56040 SOCKET

All dimensions in mm

g3 connected to 8 or 14

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1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. Each tube is accompanied by a certificate showing the exact voltage divider to be used. This is designed to give optimum linearity, time characteristics and dark current at a gain of 10^7.

3. The disc-shaped dynode connections decrease the inductance of the connections and make good decoupling of the stages possible. This system results in a very rigid construction of the tube, and appreciably decreases ionic and light feedback.

4. The accelerator electrode g3 is connected to d6 or d7 inside the socket. The decoupling capacitor between g4 and the coaxial outlet is mounted inside the tube.

GAIN AND DARK CURRENT PLOTTED AGAINST TOTAL VOLTAGE

PHOTOMULTIPLIER TUBE   XP1220

TENTATIVE DATA

QUICK REFERENCE DATA

10 stage photomultiplier tube for use under severe shock and vibration conditions. Its very rugged construction makes it particularly suitable for geophysical and astronomical missile experiments.

Spectral response		Type A (S11)
Photocathode useful diameter	13	mm
Gain (at $V_b = 2.1kV$)	10^7	

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

PHOTOCATHODE

Surface		semi-transparent, caesium antimony
Minimum useful diameter	13	mm
Spectral response		Type A (S11)
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	70	$\mu A/lm$
minimum	35	$\mu A/lm$
Average radiant sensitivity at 420nm	50	mA/W

*Measured using a tungsten lamp of colour temperature 2854K

MULTIPLIER SYSTEM

Number of stages	10
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain = 10^7

average	2.1	kV
maximum	3.0	kV
**Maximum dark current at gain = 10^7	1.0	μA

**Measured at 25°C

Mullard

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VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	30	mA
Anode pulse rise time (at $V_b = 2.4kV$)	2.5	ns
Anode pulse width at half height (at $V_b = 2.4kV$)	4	ns
Total transit time (at $V_b = 2.4kV$)	19	ns

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

D1936

Fig.1

Fig.2

CAPACITANCES

c_{a-d10}	1.5	pF
c_{a-all}	3.7	pF

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PHOTOMULTIPLIER TUBE   XP1220

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	3.0	kV
I_a max. (continuous operation)	0.2	mA
V_{k-d1} max.	400	V
V_{k-d1} min.	120	V
$V_{d1-d2}........d9-d10}$ max.	300	V
$V_{d1-d2}........d9-d10}$ min.	80	V
**V_{a-d10} max.	300	V
**V_{a-d10} min.	80	V

*Or the voltage at which the tube when used in the circuit of Fig. 1, has a gain of 3×10^7, whichever is lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

OPERATING NOTE

To prevent damage to the glass envelope and heating of the electrodes the connections should not be soldered to the contacts. The use of conductive epoxy cement is recommended.

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DIMENSIONS AND CONNECTIONS

DETAIL 'P'

Detail 'P'

All dimensions in mm

PHOTOMULTIPLIER TUBE   XP1220

XP1220/P

The tube XP1220 is also available with a voltage divider, mounted in a cylindrical envelope, with type number XP1220/P.

DIMENSIONS AND CONNECTIONS

Anode (coaxial)-white

k-blue   d10-red

All dimensions in mm

34·5
33·5

2·2
1·8

k

14·2
13·8

105 max

400

D1938

Voltage divider

k   acc

d1   d2   d3   d4   d5   d6   d7   d8   d9   d10

a

O (white)

3·3 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ   2·2 MΩ

2·2MΩ

O (red)
O (blue)

D1939

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GAIN AND DARK CURRENT AS A FUNCTION OF
TOTAL VOLTAGE

PHOTOMULTIPLIER TUBE   XP2000

TENTATIVE DATA

QUICK REFERENCE DATA

10 stage venetian blind photomultiplier tube with a bialkali photocathode. The input optics design provides a uniform collection efficiency and, combined with the high sensitivity of the cathode, offers a typical pulse height resolution for ^{137}Cs of 7.5%. This tube is intended for use in nuclear applications requiring detection and measurement of radiation with scintillation counters.

Spectral response	Type D	
Photocathode useful diameter	44	mm
Gain (at $V_b = 1.5kV$)	2.5×10^5	
Quantum efficiency	28.4	%
Photocathode radiant sensitivity	100	mA/W
Pulse height resolution for ^{137}Cs	7.5	%

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

PHOTOCATHODE

Surface	semi-transparent, antimony potassium caesium	
Minimum useful diameter	44	mm
Spectral response	Type D	
Wavelength at maximum response	400 ± 30	nm
Radiant sensitivity (at 400nm) (see note 1)	100	mA/W
Quantum efficiency (at 400nm) (see note 2)	28.4	%
Window material	Type B-40	
Window shape	plano-plano	
Window thickness (approx.)	3	mm

MULTIPLIER SYSTEM

Dynode structure	venetian blind	
Number of stages	10	
Dynode material	silver magnesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Anode sensitivity (at V_b = 1.8kV)	60	A/lm
Gain (at V_b = 1.5kV)	2.5×10^5	
Anode dark current (at V_b = 1.5kV) (see notes 3 and 4)	5	nA
Anode pulse rise time (at V_b = 1.5kV) (see note 5)	7	ns
Anode pulse width at half height (at V_b = 1.5kV)	13	ns
Total transit time (at V_b = 1.5kV)	50	ns

VOLTAGE DIVIDER AS IN FIG. 2	typ.	max.	
Pulse height resolution for ^{137}Cs (at V_b = 1.5kV) (see note 6)	7.5	8.5	%
Gain deviation (at V_b = 1.5kV) for 24h at 1000 count/s (see notes 6 and 7)	2.0	3.0	%
Gain deviation for a count rate change of 10 000 count/s to 1000 count/s (at V_b = 1.5kV) (see notes 6 and 8)	1.0	3.0	%

Fig. 1   For general photometric applications

PHOTOMULTIPLIER TUBE XP2000

Fig. 2   For scintillation counting applications

$$C_a, C_1, C_2, C_3 = 10nF$$
$$C_4, C_5 \qquad = 5nF$$

The accelerator electrode potential should be adjusted to obtain maximum anode current.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max. (see note 9)	1.8	kV
I_a max. (continuous operation) (see note 10)	0.2	mA
$V_{k \text{ to } d1}$ max.	500	V
min.	100	V
$V_{d1 \text{ to } d2} \ldots \ldots d9 \text{ to } d10$ max.	300	V
$V_{a \text{ to } d10}$ max.	300	V
T_{amb} (operating) max.	+70	^{o}C
min.	-30	^{o}C

CAPACITANCES

$c_{a \text{ to } d10}$	max.	7.0	pF
$c_{a \text{ to all}}$	max.	8.5	pF

WEIGHT approx.	205	g

ACCESSORIES

Socket (14 pin JEDEC B14-38)	FE1001
Mu-metal shield	56128

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NOTES

1. The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 400 ± 5nm.

2. The quantum efficiency and radiant sensitivity have the following relationship:

$$\text{Quantum efficiency } \eta_Q = N_{kr} \times \frac{1.24}{\lambda} \times 100\%$$

where N_{kr} is the radiant sensitivity (mA/W), at a wavelength λ (nm).

3. During normal operation it is advisable to connect the photocathode to earth potential and the anode to positive high voltage. As it is sometimes necessary to have the photocathode at positive high voltage and the anode at earth potential, precautions should be taken to ensure a high-voltage insulation resistance between the photomultiplier and the mu-metal shield greater than $10^{15}\Omega$.

4. At an ambient temperature of 25°C.

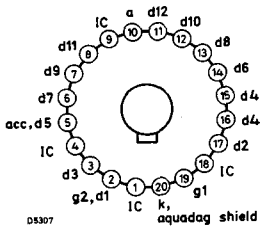5. The anode pulse rise time indicates the time required for the amplitude to rise from 10% to 90% of the peak amplitude. For this measurement the delta function light pulse illuminates the entire photocathode.

6. This measurement is made with a sodium iodine (thallium) scintillator SIS 44 × 50.

7. This measurement is made with a ^{137}Cs source placed in front of the photo-multiplier at such a distance to arrive at a count rate of 1000 count/s for the photopeak. The position of the photopeak is observed each hour for 24 hours. The mean gain deviation is calculated as follows:

$$D = \frac{\Sigma_{i=n}^{n} \left| \overline{P} - P_i \right|}{n} \times \frac{100}{\overline{P}} \%$$

where $P_i = i^{th}$ measurement of a series of n photopeaks measured at 1000 count/s and $\overline{P}$ = the average of the series.

8. This measurement is made with a ^{137}Cs source placed in front of the photo-multiplier at such a distance to arrive at a count rate of 10 000 count/s for the photopeak.
The position of the photopeak is observed.
The source is then removed to such a distance as to arrive at a count rate of 1000 count/s. The position of the photopeak is again observed.
The mean gain deviation is calculated as in note 7.

9. Or the voltage at which the tube shown in the circuit of the voltage divider in fig. 1 has a gain of 3×10^6, whichever is the lower.

10. The stability is dependent on the magnitude of the anode current. For applications requiring stability of operation, it is advisable to use an average anode current of 10μA or less.

11. It is strongly recommended that the tube is screened with a mu-metal shield against external magnetic fields.

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PHOTOMULTIPLIER TUBE   XP2000

Base: 14 pin (JEDEC B14-38)

Socket: FE1001

BASE CONNECTIONS AND OUTLINE DRAWING

GAIN AND DARK CURRENT AS A FUNCTION OF SUPPLY VOLTAGE

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VARIATION OF ANODE CURRENT AS A FUNCTION OF DYNODE D6 POTENTIAL

ANODE CURRENT AS A FUNCTION OF THE VOLTAGE BETWEEN
ANODE AND FINAL DYNODE

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VARIATION OF ANODE CURRENT DUE TO INFLUENCE OF
EXTERNAL MAGNETIC FIELD (see note 11)

$V_{k/d1} = 3V_o$

$V_o = 100V$

$---- V_{acc} = V_{d_1}$

$\underline{\qquad} V_{acc}$ adjusted for I_a max.

Mullard

PHOTOMULTIPLIER TUBE   XP2020

TENTATIVE DATA

QUICK REFERENCE DATA

12 stage photomultiplier tube with a bialkali type D photocathode. It is intended for applications requiring good time resolution and for measurement of low intensity light fluxes. The input optics design provides an excellent time resolution and a high collection efficiency. Combining high operation efficiency, low background and high gain, it provides good detection of single photons and is specially suitable for use with fast scintillators and for applications in coincidence measurements.

Spectral response	Type D	
Photocathode useful diameter	42	mm
Gain (at V_b = 3kV)	10^8	
Quantum efficiency (at 400nm)	25	%
Photocathode radiant sensitivity (at 437nm)	85	mA/W
Collection efficiency	88	%
Anode pulse rise time (at V_b = 2.5kV)	1.8	ns
Transit time fluctuation	0.3	ns
Background noise	900	count/s

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

PHOTOCATHODE

Surface (see note 1)	semi-transparent, potassium caesium antimony	
Minimum useful diameter	42	mm
Spectral response	Type D	
Wavelength at maximum response	400 ± 30	nm
Radiant sensitivity (at 437nm) (see note 2)	85	mA/W
Quantum efficiency (at 400nm) (see note 3)	25	%
Collection efficiency	88	%
Window material (see note 4)	borosilicate	
Window shape	plano-concave	
Radius of curvature	69	mm

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MULTIPLIER SYSTEM

Dynode structure   in line, electrostatically focused

Number of stages   12

Dynode material   silver magnesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Gain (at V_b = 2.5kV) 6×10^7

	typ.	max.	
Anode dark current (at gain = 10^8) (see note 5)	27	500	nA
Background noise (at gain = 10^7) (see note 6)	900	2500	count/s

VOLTAGE DIVIDER AS IN FIG. 2

Gain (at V_b = 2.5kV) 2×10^7

Linearity (max.) (within 5%) between anode pulse amplitude and input light pulse	250	mA
Peak current (max.)	0.5 to 1.0	A

VOLTAGE DIVIDER AS IN FIG. 3

Gain (at V_b = 2.5kV) 2×10^7

Anode pulse rise time (see note 7)		1.8	ns
Anode pulse width at half height		3.0	ns
Transit time difference between the centre of the photocathode and the edge	max.	0.5	ns
	typ.	0.25	ns
Transit time fluctuation (see note 7)		0.3	ns
Total transit time		30	ns

Fig. 1

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Fig. 2

$$C_1 = \frac{100Q}{V_o}, \; C_2 = \frac{100Q}{3V_o}, \; C_3 = \frac{100Q}{9V_o}, \; C_4 = \frac{100Q}{27V_o}, \; C_5 = \frac{100Q}{81V_o}$$

where Q is the charge carried to the anode during the anode current pulse

Fig. 3

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max. (see note 8)	3.0	kV
I_a max.	0.2	mA
$V_{k \text{ to } d1}$ max.	800	V
min.	210	V
$V_{k \text{ to } g1}$ max.	300	V
$V_{d1 \text{ to } d2} \ldots\ldots d11 \text{ to } d12}$ max.	400	V
$V_{a \text{ to } d12}$ (see note 9) max.	600	V
min.	80	V
T_{amb} (operating) max.	+70	^{o}C
min.	-30	^{o}C

CAPACITANCES

$c_{g1 \text{ to } k + g2 + acc + d1 + d5}$	30	pF
$c_{a \text{ to } d12}$ max.	7.0	pF
$c_{a \text{ to all}}$ max.	9.5	pF

WEIGHT approx.	240	g

ACCESSORIES

Socket (20 pin JEDEC B20-102)	FE1003
Mu-metal shield	56130 or 56131

NOTES

1. Since the XP2020 uses a type D photocathode, it is recommended not to expose the tube to high radiation intensities. It is advisable to limit the cathode peak current to 10mA at room temperature and to 0.1nA at $-100^{o}C$. The resistivity of the photocathode increases as the temperature decreases.

2. The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 400 ± 5nm.

3. The quantum efficiency and radiant sensitivity have the following relationship:

   Quantum efficiency $\eta_Q = N_{kr} \times \dfrac{1.24}{\lambda} \times 100\%$

   where N_{kr} is the radiant sensitivity (mA/W), at a wavelength λ(nm).

4. The window is made of special low activity glass to obtain a low background.

5. During normal operation it is advisable to connect the photocathode to earth potential and the anode to positive high voltage. It is therefore necessary to ensure that a high voltage insulation exists between the aquadag and the mu-metal shield of a resistance greater than $10^{15}\Omega$. Under these conditions the background and dark current may be higher than normal and somewhat unstable.

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NOTES (contd.)

Typical background spectrum from 1/10 to 10 equivalent photoelectrons at a gain of 3×10^7 with voltage divider shown in fig. 1 (see note 6)

6. The background noise is the summation between 1/10 equivalent photoelectron and infinity. The measurement is made at a detection threshold of 4.24×10^{-13} coloumb.

7. Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

8. Or the voltage at which the tube shown in the circuit of the voltage divider in fig. 1 has a gain of 5×10^8, whichever is the lower.

9. When calculating the anode voltage, the voltage across the load resistance must be taken into account.

10. The temperature range is limited by mainly mechanical stresses which may arise in the base. For temperatures below -30°C type XP2020/UB (XP2020 without a base) is recommended.

11. It is strongly recommended that the tube is screened with a mu-metal shield against external magnetic fields.
Under conditions of fully illuminated photocathode, the anode current will decrease by a factor of 2 when a magnetic field is applied:

   (a) Perpendicular to the dynodes, with a field intensity of 0.13mT.

   (b) Parallel to the dynodes, with a field intensity of 0.07mT.

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Base: 20 pin (JEDEC B20-102)
Socket: FE1003

BASE CONNECTIONS AND OUTLINE DRAWING

SPECTRAL RESPONSE CURVE TYPE D

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GAIN AND DARK CURRENT AS A FUNCTION OF SUPPLY VOLTAGE

PHOTOMULTIPLIER TUBE   XP2030

TENTATIVE DATA

QUICK REFERENCE DATA

10 stage venetian blind photomultiplier tube with a bialkali photocathode. The input optics design provides a uniform collection efficiency and, combined with the high sensitivity of the photocathode offers a typical pulse height resolution for ^{137}Cs of 7.5%. This tube is intended for use in nuclear applications requiring detection and measurement of radiation with scintillation counters.

Spectral response	Type D	
Photocathode useful diameter	69	mm
Gain (at $V_b = 1.5kV$)	2.5×10^5	
Quantum efficiency	32.6	%
Photocathode radiant sensitivity	115	mA/W
Pulse height resolution for ^{137}Cs	7.5	%

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

PHOTOCATHODE

Surface	semi-transparent antimony potassium caesium	
Minimum useful diameter	68	mm
Spectral response	Type D	
Wavelength at maximum response	400 ± 30	nm
Radiant sensitivity (at 400nm) (see note 1)	115	mA/W
Quantum efficiency (at 400nm) (see note 2)	32.6	%
Window material	Type B40	
Window shape	plano-plano	
Window thickness approx.	3.0	mm

MULTIPLIER SYSTEM

Dynode structure	venetian blind
Number of stages	10
Dynode material	silver magnesium

Mullard

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Anode sensitivity (at V_b = 1.8kV)		60	A/lm
Gain (at V_b = 1.5kV)		2.5×10^5	
Anode dark current (at V_b = 1.5kV) (see notes 3 and 4)		5.0	nA
Anode pulse rise time (at V_b = 1.5kV) (see note 5)		9.0	ns
Anode pulse width at half height (at V_b = 1.5kV)		16	ns
Total transit time (at V_b = 1.5kV)		57	ns

VOLTAGE DIVIDER AS IN FIG. 2

Pulse height resolution for ^{137}Cs (at V_b = 1.5kV) (see note 6)	max.	8.5	%
	typ.	7.5	%
Gain deviation (at V_b = 1.5kV) for 24h at 1000 count/s (see notes 6 and 7)	max.	3.0	%
	typ.	2.0	%
Gain deviation for a count change of 10 000 count/s to 1 000 count/s (see notes 6 and 8)	max.	3.0	%
	typ.	1.0	%

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max. (see note 9)		1.8	kV
I_a max. (see note 10)		0.2	mA
V_k to d1	max.	500	V
	min.	100	V
$V_{d1 \text{ to } d2 \dots d9 \text{ to } d10}$ max.		300	V
$V_{a \text{ to } d10}$ max.		300	V
T_{amb} (operating)	max.	+70	°C
	min.	-30	°C

PHOTOMULTIPLIER TUBE — XP2030

Fig. 1 For general photometric applications

Fig. 2 For scintillation counting applications

$$C_a, C_1, C_2, C_3 = 10\mu F$$
$$C_4, C_5 = 5\mu F$$

The accelerator potential should be adjusted to
obtain maximum anode current

CAPACITANCES

$c_{a \text{ to } d10}$ max.	7.0	pF
$c_{a \text{ to all}}$ max.	8.5	pF
WEIGHT approx.	245	g

ACCESSORIES

Socket (14 pin JEDEC B14-38)	FE1001
Mu-metal shield	56135

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NOTES

1. The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 400 ± 5nm.

2. The quantum efficiency and radiant sensitivity have the following relationship:

$$\text{Quantum efficiency } \eta_Q = N_{kr} \times \frac{1.24}{\lambda} \times 100\%$$

where N_{kr} is the radiant sensitivity (mA/W), at a wavelength λ(nm).

3. During normal operation it is advisable to connect the photocathode to earth potential and the anode to positive high voltage. It is therefore necessary to ensure that a high voltage insulation exists between the aquadag and the mu-metal shield of a resistance greater than $10^{15}\Omega$. Under these conditions the background and dark current may be higher than normal and somewhat unstable.

4. At an ambient temperature of 25°C.

5. The anode pulse rise time indicates the time required for the amplitude to rise from 10% to 90% of the peak amplitude. For this measurement the delta function light pulse illuminates the entire photocathode.

6. This measurement is made with a sodium iodine (thallium) scintillator SIS 44 × 50.

7. This measurement is made with a ^{137}Cs source placed in front of the photo-multiplier at such a distance to arrive at a count rate of 1000 count/s for the photopeak. The position of the photopeak is observed each hour for 24 hours. This mean gain deviation is calculated as follows:

$$D = \frac{\sum_{i=n}^{n} \left| \overline{P} - P_i \right|}{n} \times \frac{100}{\overline{P}} \%$$

where $P_i = i^{th}$ measurement of a series of n photopeaks measured at 1000 count/s and $\overline{P} = $ the average of the series.

8. This measurement is made with a ^{137}Cs source placed in front of the photo-multiplier at such a distance to arrive at a count rate of 10 000 count/s for the photopeak.
The position of the photopeak is observed.
The source is then removed to such a distance as to arrive at a count rate of 1000 count/s. The position of the photopeak is again observed.
The mean gain deviation is calculated as in note 7.

9. Or the voltage at which the tube shown in the circuit of the voltage divider in fig. 1 has a gain of 3×10^6, whichever is the lower.

10. The stability is dependent on the magnitude of the anode current. For applications requiring stability of operation, it is advisable to use an average anode current of 10μA or less.

11. It is strongly recommended that the tube is screened with a mu-metal shield against external magnetic fields.

Mullard

PHOTOMULTIPLIER TUBE   XP2030

Base: 14 pin (JEDEC B14-38)

Socket: FE1001

BASE CONNECTIONS AND OUTLINE DRAWING

GAIN AND DARK CURRENT AS A FUNCTION OF SUPPLY VOLTAGE

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ANODE CURRENT AS A FUNCTION OF THE VOLTAGE BETWEEN
ANODE AND FINAL DYNODE

VARIATION OF ANODE CURRENT AS A FUNCTION OF
DYNODE D6 POTENTIAL

VARIATION OF ANODE CURRENT DUE TO INFLUENCE OF
EXTERNAL MAGNETIC FIELD (see note 11)

$V_{k/d1} = 3V_o$

$V_o = 100V$

$----$ $V_{acc} = V_{o1}$

$\overline{}$ V_{acc} adjusted for I_a max.

Mullard

PHOTOMULTIPLIER TUBE   56AVP

QUICK REFERENCE DATA

14 stage photomultiplier tube for use in nuclear physics where a high degree of time definition or a high time resolution is required (fast coincidence, life of unstable particles, Cerenkov counters).

Spectral response		Type A (S11)
Photocathode useful diameter	42	mm
Gain (at $V_b = 2.2$kV)	10^8	
Anode pulse rise time	2.0	ns
Maximum anode pulse amplitude for linearity with input light pulse	300	mA

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

PHOTOCATHODE

Surface		semi-transparent, caesium antimony
Minimum useful diameter	42	mm
Spectral response		Type A (S11)
Wavelength at maximum response	420 ± 30	nm
*Luminous sensitivity		
average	65	μA/lm
minimum	45	μA/lm
Average radiant sensitivity at 420nm	55	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	14
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain = 10^8		
average	2.2	kV
maximum	2.5	kV
**Dark current at gain = 10^8		
average	0.5	μA
maximum	5.0	μA
Maximum anode pulse amplitude for linearity with input light pulse	100	mA

**Measured at 25°C

Mullard

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	300	mA
Anode pulse rise time (at $V_b = 2.5kV$)	2.0	ns
Anode pulse width at half height (at $V_b = 2.5kV$)	3.5	ns
Maximum transit time difference between the centre of the photocathode and 18mm from the centre (at $V_b = 2.5kV$)	0.8	ns
Total transit time (at $V_b = 2.5kV$)	43	ns
Maximum peak current	0.5 to 1.0	A

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. 1

Fig. 2

The voltage between the cathode and the focusing electrode (g1) should be adjusted around $0.15V_o$; the voltage between d1 and d2 should be adjusted around $0.8V_o$.

$C_1 = 100q/V_o$, $C_2 = 100q/3V_o$, $C_3 = 100q/9V_o$, $C_4 = 100q/27V_o$, etc., where

q = quantity of electricity transported by the anode

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CAPACITANCES

$c_{g1-(acc,d1)}$	25	pF
c_{a-d14}	7.0	pF
c_{a-all}	9.5	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	2.5	kV
I_a max. (continuous operation)	0.2	mA
V_{g1-k} max.	100	V
$V_{k-(acc,d1)}$ max.	800	kV
$V_{k-(acc,d1)}$ min.	250	kV
$V_{d1-d2}\cdots\cdots d13-d14$ max.	500	V
$V_{d1-d2}\cdots\cdots d13-d14$ min.	80	V
**V_{a-d14} max.	500	V
**V_{a-d14} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig. 1, has a gain of about 10^9, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1003
Mu-metal shield	56131

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 3mA will be sufficient.

3. The last stages of the tube must be decoupled by means of capacitors to avoid a serious voltage drop on the dynodes. A typical value for C_1 is 2nF.

4. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

5. In the case of high counting rates and large peak outputs, and to avoid a high tension supply of large power, it is possible to supply the first stages with a high tension of low output power and the last stages with an average voltage of high output.

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6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

7. If the cathode is connected to negative high tension, precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

8. The tube is capable of producing very high peak currents (up to 1A). The output time constant must be very small. Therefore, it is necessary, taking into account parasitic capacitances, to use a low load resistance. It is advisable to use a resistance matched coaxial cable. Under these conditions the tube easily delivers pulses of tens of volts, thus rendering an amplifier superfluous.

9. In a number of applications it is not necessary for the current to be proportional to the incident luminous flux; such short pulses are needed for time measurements only, and not for spectrography purposes. If, however, it is required at the same time to determine the energy of the incident radiation, it is possible to select a dynode at which the current is proportional to the incident flux. Starting from the anode, the current is divided at each stage by (d-1) where d is the secondary emission factor of the stage (approximately 3.5). It is therefore possible to locate a dynode, the current at which is lower than or equal to the saturation limit of the dynodes.

10. To avoid electric field distortion in the electron optical system the external conductive coating (M, pin no. 18) must be connected to a point whose potential is close to that of the cathode.

OUTLINE DRAWING OF 56AVP

Incident radiation

External
conductive
coating (M)

Ø52·5 max.

Ø42 min.

R=69 max.

170 ±5

192 max.

Ø51·8 max.

IC a d14 d12
d13 d10
d11 d8
d9 d6
d7 d4
d5 d2
d3 M
acc,d1 IC k g1

Special 20 pin base
Socket type FE1003

All dimensions in mm

B 8997

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GAIN AND DARK CURRENT
AS A FUNCTION OF TOTAL VOLTAGE

ANODE CURRENT PLOTTED AGAINST LUMINOUS FLUX
FOR VOLTAGE DIVIDER FIG. 2

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PHOTOMULTIPLIER TUBES

QUICK REFERENCE DATA

14 stage photomultiplier tubes for use in spectrometry and other applications where very low luminous fluxes are to be measured (single photon counting) and liquid scintillation counting of ^{14}C and ^{3}H. The tubes feature a high quantum efficiency and a very good collection efficiency. Very fast characteristics make these tubes particularly useful for fast coincidence measurements with low background noise.

56DUVP — The polished optical quartz window extends the response into the ultraviolet region and guarantees a very low background because of the absence of ^{40}K radiation.

56DVP — Suitable for detection of soft β-radiation.

56DVP/03 — Similar to 56DVP, but features a higher efficiency for single photons.

Spectral response	56DUVP	Type DU		
	56DVP, 56DVP/03	Type D		
Photocathode useful diameter			42	mm
Gain (at $V_b = 2.1kV$)			10^8	
Anode pulse rise time			2.0	ns
Quantum efficiency (at 400nm)			25	%
Efficiency for single photons (at $V_b = 2.1kV$)				
	56DUVP, 56DVP	15		%
	56DVP/03	≥ 20		%
Collection efficiency			80	%

Unless otherwise stated data is applicable to all types

This data should be read in conjunction with
OPERATING NOTES – PHOTOMULTIPLIER TUBES

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PHOTOCATHODE

Surface	semi-transparent, potassium caesium antimony	
Minimum useful diameter	42	mm
Spectral response	56DUVP	Type DU
	56DVP, 56DVP/03	Type D
Wavelength at maximum response	400 ±30	nm
*Minimum luminous sensitivity	45	μA/lm
Average radiant sensitivity at 437nm	75	mA/W
Average quantum efficiency at 400nm	25	%

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	14
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain $= 10^8$

average	2.1	kV
maximum	2.5	kV

**Dark current at gain $= 10^8$

average	0.2	μA
maximum	1.0	μA
Maximum anode pulse amplitude for linearity with input light pulse	100	mA

Minimum efficiency for single photons (see note 1)

56DUVP, 56DVP	15	%
56DVP/03	20	%
Average supply voltage for single photon efficiency of 15% (56DUVP, 56DVP) or 20% (56DVP/03) (see note 1)	2.1	kV

**Background noise at $V_b = 2.1$kV (see note 1)

average (56DUVP, 56DVP)	600	counts/s
maximum		
56DUVP, 56DVP	3000	counts/s
56DVP/03	1000	counts/s

**Measured at 25°C

CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	300	mA
Anode pulse rise time at $V_b = 2.5kV$	2.0	ns
Anode pulse width at half height at $V_b = 2.5kV$	3.5	ns
Maximum transit time difference between the centre of the photocathode and 18mm from the centre at $V_b = 2.5kV$	0.8	ns
Total transit time at $V_b = 2.5kV$	43	ns
Maximum peak current	0.5 to 1.0	A

Note – These time characteristics are for an infinitely short light pulse, fully illumi-
nating the photocathode.

RECOMMENDED CIRCUITS (see notes 4 to 10)

Fig. 1

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Fig. 2

The voltage between the cathode and the focusing electrode (g1) should be adjusted around $0.15V_o$; the voltage between d1 and d2 should be adjusted around $0.8V_o$.

$C_1 = 100q/V_o$, $C_2 = 100q/3V_o$, $C_3 = 100q/9V_o$, $C_4 = 100q/27V_o$, etc., where

q = quantity of electricity transported by the anode.

CAPACITANCES

$c_{g1-(acc, d1)}$	25	pF
c_{a-d14}	7.0	pF
c_{a-all}	9.5	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	2.5	kV
I_a max. (continuous operation)	0.2	mA
$V_{k-(acc, d1)}$ max.	800	V
$V_{k-(acc, d1)}$ min.	250	V
V_{g1-k} max.	100	V
$V_{d1-d2......d13-d14}$ max.	300	V
$V_{d1-d2......d13-d14}$ min.	80	V
**V_{a-d14} max.	500	V
**V_{a-d14} min.	80	V

*Or the voltage at which the tube when used in the circuit of Fig. 1, has a gain of about 5×10^8, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

PHOTOMULTIPLIER TUBES

ACCESSORIES (supplied as additional items)

Socket	FE1003
Mu-metal shields (see note 9)	56130
	56131

OPERATING NOTES

1. Measured under the following conditions:

    Threshold at the anode of the photomultiplier = 4.25×10^{-13}C
    Anode coupling capacitor = 10nF
    Anode load resistor = 100kΩ

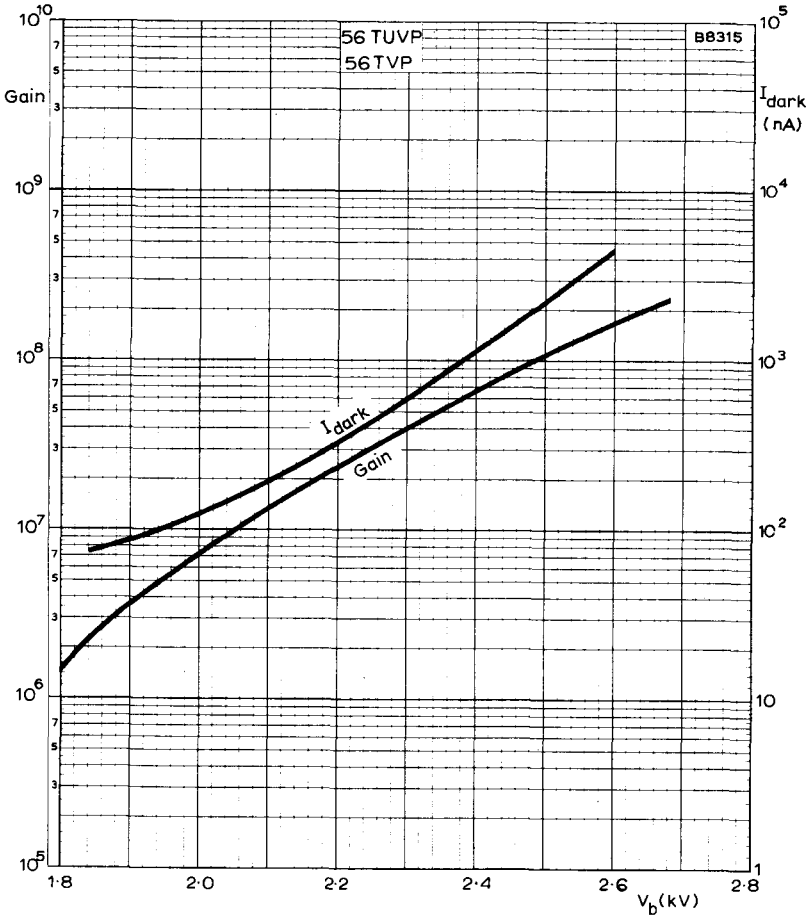2. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

3. The last stages of the tube must be decoupled by means of capacitors to avoid a serious voltage drop on the dynodes. A typical value for C_1 is 2nF.

4. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

5. In the case of high counting rates and large peak outputs, and to avoid a high tension supply of large power it is possible to supply the first stages with a high tension of low output power and the last stages with an average voltage of high output.

6. If the cathode is connected to negative high tension, precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

7. The tube is capable of producing very high peak currents (up to 1A). The output time constant must be very small. Therefore, it is necessary, taking into account parasitic capacitances, to use a low load resistance. It is advisable to use a resistance matched coaxial cable. Under these conditions the tube easily delivers pulses of tens of volts, thus rendering an amplifier superfluous.

8. Care should be taken to ensure that the anode voltage is adjusted to its optimum value. It should be noted that for equal supply voltages the gain of the tube is lower for voltage divider as in fig. 2 than for voltage divider as in fig. 1.

9. To avoid electric field distortion in the electron optical system, the external conductive coating (M, pin no. 18) must be connected to a point whose potential is close to that of the cathode. If the cathode is connected to negative h.t. precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

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Window material:-
56DUVP quartz
56DVP glass
56DVP/03 glass

External
conductive
coating (M)

Incident radiation

Ø 53·5 max.
Ø 42 min.
2
k
R= 69 max.
170 ±5
192 max.
Ø 51·8 max.

IC a d14 d12
d13   d10
d11   8 9 10 11 12 13 14 d8
d9   7   15 d6
d7   5 6   16 17 d4
d5   4 3 2 1 20 19 18 d2
d3   acc, d1 IC k g1 M

Special 20 pin base
Socket type FE1003

All dimensions in mm

ANODE CURRENT AS A FUNCTION OF LUMINOUS FLUX
FOR VOLTAGE DIVIDER AS IN FIG. 2

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GAIN AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

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PHOTOMULTIPLIER TUBES 56TUVP 56TVP

Unless otherwise stated, data is applicable to both types

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

PHOTOCATHODE

Surface		semi-transparent, sodium potassium caesium antimony	
Minimum useful diameter		42	mm
Spectral response	56TUVP	Type TU (extended S20)	
	56TVP	Type T (S20)	
Wavelength at maximum response		420 ±30	nm
*Luminous sensitivity			
average		115	μA/lm
minimum		90	μA/lm
Average radiant sensitivity at			
420nm		65	mA/W
700nm		12	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	14	
Dynode material	silver magnesium oxygen caesium	

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CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain = 10^8

average	2.5	kV
maximum	2.75	kV
*Maximum dark current at gain = 10^8	5.0	μA
Maximum anode pulse amplitude for linearity with input light pulse	100	mA

*Measured at 25°C

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	300	mA
Anode pulse rise time (at V_b = 2.5kV)	2.0	ns
Anode pulse width at half height (at V_b = 2.5kV)	3.5	ns
Maximum transit time difference between the centre of the photocathode and 18mm from the centre (at V_b = 2.5kV)	0.8	ns
Total transit time (at V_b = 2.5kV)	43	ns
Maximum peak current	0.5 to 1.0	A

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.
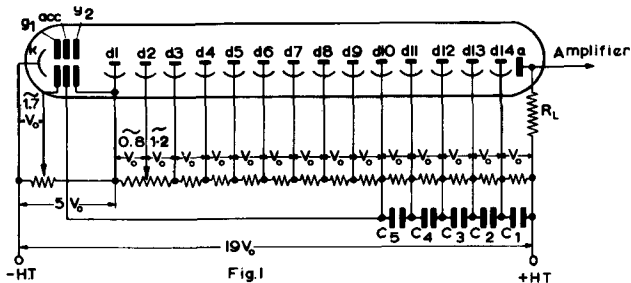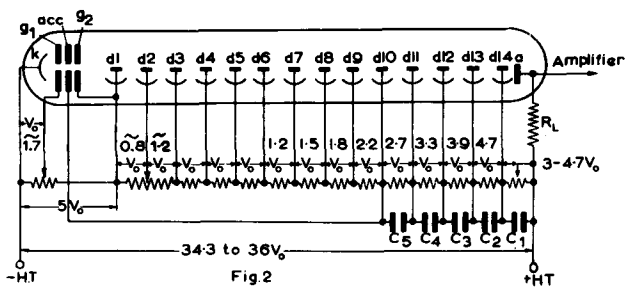

Fig. 1

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PHOTOMULTIPLIER TUBES

Fig. 2

The voltage between the cathode and the focusing electrode (g1) should be adjusted around $0.15V_o$; the voltage between d1 and d2 should be adjusted around $0.8V_o$.

$C_1 = 100q/V_o$, $C_2 = 100q/3V_o$, $C_3 = 100q/9V_o$, $C_4 = 100q/27V_o$, etc., where

q = quantity of electricity transported by the anode

CAPACITANCES

c_{g1-acc}	25	pF
c_{a-d14}	7.0	pF
c_{a-all}	9.5	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	2.75	kV
I_a max. (continuous operation)	0.2	mA
V_{k-d1} max.	800	V
V_{k-d1} min.	250	V
V_{k-g1} max.	100	V
$V_{d1-d2}\cdots\cdots\cdots d13-d14$ max.	500	V
$V_{d1-d2}\cdots\cdots\cdots d13-d14$ min.	80	V
**V_{a-d14} max.	500	V
**V_{a-d14} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig. 1, has a gain of about 10^9, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

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ACCESSORIES (supplied as additional items)

Socket   FE1003

Mu-metal shield   56131
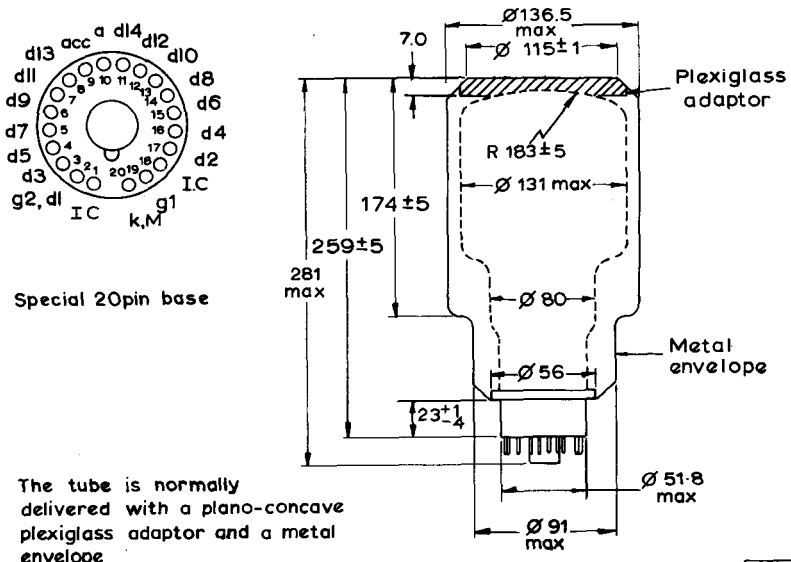
OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. The last stages of the tube must be decoupled by means of capacitors to avoid a serious voltage drop on the dynodes. A typical value for C_1 is 2nF.

3. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

4. In the case of high counting rates and large peak outputs, and to avoid a high tension supply of large power, it is possible to supply the first stages with a high tension of low output power and the last stages with an average voltage of high output.

5. To avoid electric field distortion in the electron optical system, the external conductive coating, M (pin no. 18), must be connected to a point whose potential is close to that of the cathode.

6. If the cathode is connected to negative high tension, precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

7. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig.2.

Incident radiation

B8335

56TUVP has
a quartz window

External
conductive
coating (M)

Ø52.5 max.

Ø42 min

2

IC   a   d14   d12
d13   d10
d11   d8
d9   d6
d7   d4
d5   d2
d3
acc,d1 IC k g1

k

R=69max

170 ±5

192 max

Special 20 pin base
Socket type FE1003

All dimensions in mm

Ø51.8 max

Mullard

PHOTOMULTIPLIER TUBES

56TUVP
56TVP

GAIN AND DARK CURRENT
AS A FUNCTION OF TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE 58AVP

QUICK REFERENCE DATA

14 stage photomultiplier tube intended for use in fast coincidence circuits and Cerenkov counters where a high degree of time definition is required. This tube is similar to type XP1040, except for the window construction.

Spectral response	Type A (S11)	
Photocathode useful diameter	110	mm
Gain (at 2.4kV)	10^8	

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

PHOTOCATHODE

Surface	semi-transparent, caesium antimony	
Minimum useful diameter	110	mm
Spectral response	Type A (S11)	
Wavelength at maximum response	420 ±30	nm
*Luminous sensitivity		
average	70	μA/lm
minimum	45	μA/lm
Average radiant sensitivity at 420nm	60	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

MULTIPLIER SYSTEM

Number of stages	14	
Dynode material	silver magnesium oxygen caesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain = 10^8		
average	2.4	kV
maximum	3.0	kV
**Dark current at gain = 10^8		
average	2.0	μA
maximum	12	μA
Maximum anode pulse amplitude for linearity with input light pulse	100	mA

**Measured at 25°C

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CHARACTERISTICS (contd.)

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	300	mA
Anode pulse rise time (at $V_b = 2.8kV$)	2.0	ns
Anode pulse width at half height (at $V_b = 2.8kV$)	3.0	ns
Transit time difference between the centre of the photocathode and 45mm from the centre (at $V_b = 2.8kV$)	1.0	ns
Transit time spread	1.0	ns
Total transit time (at $V_b = 2.8kV$)	46	ns
Maximum peak current	0.5 to 1.0	A

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig.1

Fig.2

D428

The voltage between the cathode and the focusing electrode (g1) should be adjusted around $1.7V_o$; the voltage between d1 and d2 should be adjusted around $0.8V_o$.

$C_1 = 100q/V_o$, $C_2 = 100q/3V_o$, $C_3 = 100q/9V_o$, $C_4 = 100q/27V_o$, etc., where

q = quantity of electricity transported by the anode

Mullard

PHOTOMULTIPLIER TUBE   58AVP

CAPACITANCES

c_{a-d14}	5.0	pF
c_{a-all}	7.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	3.0	kV
I_a max. (continuous operation)	0.2	mA
V_{k-g1} max.	300	V
V_{k-acc} max.	1.8	kV
V_{k-acc} min.	1.4	kV
$V_{k-d1, g2}$ max.	800	V
$V_{k-d1, g2}$ min.	250	V
$V_{d1-d2\cdots\cdots d13-d14}$ max.	500	V
$V_{d1-d2\cdots\cdots d13-d14}$ min.	80	V
**V_{a-d14} max.	500	V
**V_{a-d14} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig. 1, has a gain of about 10^9, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1003
Mu-metal shield	
tube with metal container	56133
tube without metal container	56129

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 3mA will be sufficient.

3. The last stages of the tube must be decoupled by means of capacitors to avoid a serious voltage drop on the dynodes. A typical value for C_1 is 2nF.

4. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

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OPERATING NOTES (contd.)

5. In the case of high counting rates and large peak outputs, and to avoid a high tension supply of large power it is possible to supply the first stages with a high tension of low output power and the last stages with an average voltage of high output.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current output with better time characteristics can be obtained when the tube is connected as in Fig. 2.

7. If the cathode is connected to negative high tension, precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

8. The tube is capable of producing very high peak currents (up to 1A). The output time constant must be very small. Therefore, it is necessary, taking into account parasitic capacitances, to use a low load resistance. It is advisable to use a resistance matched coaxial cable. Under these conditions the tube easily delivers pulses of tens of volts, thus rendering an amplifier superfluous.

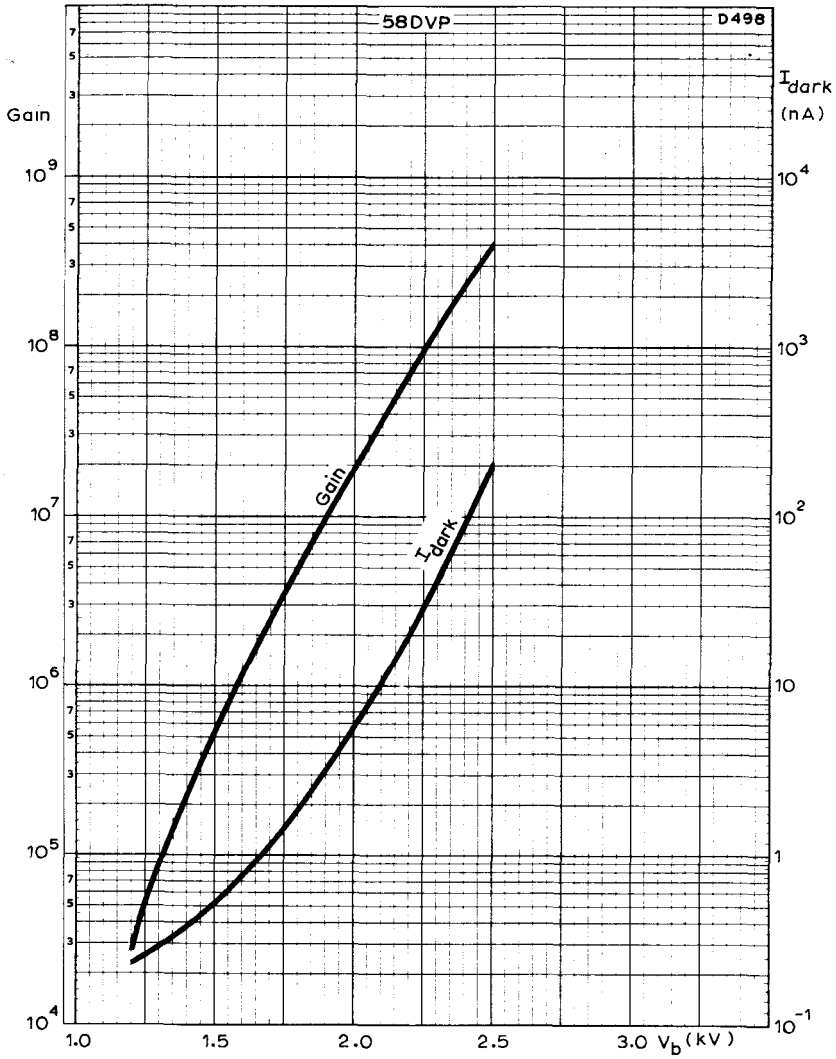9. In a number of applications it is not necessary for the current to be proportional to the incident luminous flux; such short pulses are needed for time measurements only, and not for spectrography purposes. If, however, it is required at the same time to determine the energy of the incident radiation, it is possible to select a dynode at which the current is proportional to the incident flux. Starting from the anode, the current is divided at each stage by (d-1) where d is the secondary emission factor of the stage (approximately 3.5). It is therefore possible to locate a dynode, the current at which is lower than or equal to the saturation limit of the dynodes.

OUTLINE DRAWING OF 58AVP

Special 20pin base

The tube is normally
delivered with a plano-concave
plexiglass adaptor and a metal
envelope

All dimensions in mm.

Plexiglass adaptor
Metal envelope

Mullard

PHOTOMULTIPLIER TUBE 58AVP

GAIN AND DARK CURRENT
AS A FUNCTION OF TOTAL VOLTAGE

Mullard

ANODE CURRENT AS A FUNCTION OF LUMINOUS FLUX

PHOTOMULTIPLIER TUBE   58DVP

QUICK REFERENCE DATA

14 stage photomultiplier tube intended for use in nuclear physics applications where very low luminous fluxes are to be measured and a high degree of time definition is required.

Spectral response		Type D
Photocathode useful diameter	110	mm
Quantum efficiency (at 400nm)	25	%

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

PHOTOCATHODE

Surface	semi-transparent, potassium caesium antimony	
Minimum useful diameter	110	mm
Spectral response		Type D
Wavelength at maximum response	400 ±30	nm
*Minimum luminous sensitivity	45	μA/lm
Average radiant sensitivity (at 437nm)	75	mA/W
Average quantum efficiency (at 400nm)	25	%

*Measured using a tungsten lamp of colour temperature 2854K

MULTIPLIER SYSTEM

Number of stages	14
Dynode material	silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Supply voltage for gain $= 10^8$

average	2.25	kV
maximum	3.0	kV
**Maximum dark current at gain $= 10^8$	2.0	μA
Maximum anode pulse amplitude for linearity with input light pulse	100	mA

**Measured at 25°C

VOLTAGE DIVIDER AS IN FIG.2

Maximum anode pulse amplitude for linearity with input light pulse	300	mA
Anode pulse rise time (at $V_b = 2.8$kV)	2.0	ns
Anode pulse width at half height (at $V_b = 2.8$kV)	3.0	ns
Transit time difference between the centre of the photocathode and 45mm from the centre (at $V_b = 2.8$kV)	1.0	ns
Total transit time (at $V_b = 2.8$kV)	46	ns
Maximum peak current	0.5 to 1.0	A

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig.1

Fig.2

D428

The voltage between the cathode and the focusing electrode (g1) should be adjusted around $1.7V_o$; the voltage between d1 and d2 should be adjusted around $0.8V_o$.

$C_1 = 100q/V_o$, $C_2 = 100q/3V_o$, $C_3 = 100q/9V_o$, $C_4 = 100q/27V_o$, etc., where

q = quantity of electricity transported by the anode.

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CAPACITANCES

c_{a-d14}	5.0	pF
c_{a-all}	7.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

*V_b max.	3.0	kV
I_a max. (continuous operation)	0.2	mA
V_{k-g1} max.	300	V
V_{k-acc} max.	1.8	kV
V_{k-acc} min.	1.4	kV
$V_{k-d1, g2}$ max.	800	V
$V_{k-d1, g2}$ min.	250	V
$V_{d1-d2} \cdots\cdots\cdots d13-d14$ max.	500	V
$V_{d1-d2} \cdots\cdots\cdots d13-d14$ min.	80	V
**V_{a-d14} max.	500	V
**V_{a-d14} min.	80	V

*Or the voltage at which the tube, when used in the circuit of Fig.1, has a gain of about 5×10^8, whichever is the lower.

**When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1003
Mu-metal shield (see note 4)	
tube with metal container	56133
tube without metal container	56129

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of about 3mA will be sufficient.

3. The last stages of the tube must be decoupled by means of capacitors to avoid a serious voltage drop on the dynodes. A typical value for C_1 is 2nF.

4. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

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5. In the case of high counting rates and large peak outputs, and to avoid a high tension supply of large power it is possible to supply the first stages with a high tension of low output power and the last stages with an average voltage of high output.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current output with better time characteristics can be obtained when the tube is connected as in Fig.2.

7. If the cathode is connected to negative high tension, precautions should be taken to ensure adequate high tension insulation between the external conductive coating and the mu-metal shield.

8. The tube is capable of producing very high peak currents (up to 1A). The output time constant must be very small. Therefore, it is necessary, taking into account parasitic capacitances, to use a low load resistance. It is advisable to use a resistance matched coaxial cable. Under these conditions the tube easily delivers pulses of tens of volts, thus rendering an amplifier superfluous.

9. In a number of applications it is not necessary for the current to be proportional to the incident luminous flux; such short pulses are needed for time measurements only, and not for spectrography purposes. If, however, it is required at the same time to determine the energy of the incident radiation, it is possible to select a dynode at which the current is proportional to the incident flux. Starting from the anode, the current is divided at each stage by (d-1) where d is the secondary emission factor of the stage (approximately 3.5). It is therefore possible to locate a dynode, the current at which is lower than or equal to the saturation limit of the dynodes.

10. Because of the resistivity of D type photocathodes, it is recommended not to expose the tube to too high intensities of radiation. It is advisable to limit the cathode peak current to a value of 10nA at room temperature and 0.1nA at $-100^{\circ}C$. The resistivity of the photocathode increases with decreasing temperature.

Special 20 pin base

top view

D1948

All dimensions in mm

Mullard

GAIN AND DARK CURRENT AS A FUNCTION OF
TOTAL VOLTAGE

Mullard

ANODE CURRENT AS A FUNCTION OF LUMINOUS FLUX
FOR VOLTAGE DIVIDER AS IN FIG.2

RADIANT SENSITIVITY PLOTTED AGAINST WAVELENGTH

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PHOTOMULTIPLIER TUBES 60DVP
60DVP/H

QUICK REFERENCE DATA

12 stage photomultiplier tubes intended for use in large solid or liquid scintil-lator detectors where a high time resolution is required.

The 60DVP/H is supplied with a plano-concave glass adaptor, optical coupling silicon grease and metal envelope. A plexiglass adaptor may be supplied on request.

Spectral response	Type D	
Photocathode useful diameter	200	mm
Gain (at V_b = 3kV)	10^8	
Anode pulse rise time	2.5	ns
Linearity (max.)	200	mA

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

PHOTOCATHODE

Surface	semi-transparent, curved, potassium caesium antimony	
Minimum useful diameter	200	mm
Spectral response (see note 1)	Type D	
Wavelength at maximum response	400 ±30	nm
Luminous sensitivity (see note 2)	65	μA/lm
Radiant sensitivity (at 400nm) (see note 3) typ.	75	mA/W
min.	60	mA/W
Window material	Type B-40	
Window shape	curved	
Radius of curvature	186	mm
Window thickness (approx.)	2.0	mm

MULTIPLIER SYSTEM

Dynode structure	in line, electrostatic focused
Number of stages	12
Dynode material	silver magnesium oxygen caesium

Mullard

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Anode dark current at a gain of 10^7

(see notes 4 and 5)	typ.	0.5	nA
	max.	10	nA
Supply voltage for a gain of 10^8	typ.	3.3	kV
	max.	3.7	kV
Background noise (see notes 4, 5 and 6)		1000	count/s

VOLTAGE DIVIDER AS IN FIG. 2

Linearity between anode pulse amplitude and input light pulse (max.)	200	mA
Anode pulse rise time (at V_b = 3kV)	2.5	ns
Anode pulse width at half height (at V_b = 3kV)	4.0	ns
Transit time difference between the centre of the photocathode and the edge (at V_b = 3kV)	2.0	ns
Transit time fluctuations (see note 7)	2.2	ns
Total transit time (at V_b = 3kV)	45	ns

Fig. 1

$$C_1 = \frac{100Q}{V_o}, \ C_2 = \frac{100Q}{3V_o}, \ C_3 = \frac{100Q}{9V_o}, \ C_4 = \frac{100Q}{27V_o}$$

where Q is the charge carried to the anode during
the anode current pulse

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Fig. 2

The grid voltage should be adjusted for the fastest response

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max. Fig. 1 (see note 8)		3.7	kV
Fig. 2		4.0	kV
I_a max. (continuous operation)		0.1	mA
$V_{k \text{ to } d1}$ max.		1000	V
min.		300	V
$V_{d1 \text{ to } d2} \ldots\ldots d10 \text{ to } d11}$ max.		400	V
min.		60	V
$V_{d11 \text{ to } d12}$ max.		600	V
$V_{a \text{ to } d12}$ (see note 9) max.		600	V
min.		80	V
T_{amb} (operating) (see note 10) max.		+70	°C
min.		-25	°C

CAPACITANCES

$c_{a \text{ to } d12}$ max.		7.0	pF
$c_{a \text{ to all}}$ max.		8.0	pF

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ACCESSORIES

Socket (20 pin JEDEC B20-102)   FE1003

Mu-metal shield   56132

The 60DVP/H is supplied with a plano-concave glass adaptor, optical coupling silicon grease and a metal envelope. The silicon grease should be applied to the adaptor photomultiplier interface before operation. A plexiglass adaptor may be supplied on request.

NOTES

1. Because of the resistivity of the type D photocathode, it is recommended that the tube is not exposed to excessive radiation. It is advisable to limit the peak cathode current to 10nA at room temperature and to 0.1nA at -100°C. The resistivity of the photocathode increases with decrease of temperature.

2. Measured with a tungsten ribbon lamp having a colour temperature of 2854K.

3. The radiant sensitivity is measured by placing a blue interference filter between the light source and the photocathode. The maximum spectral transmission of the interference filter is 400 ± 5nm.

4. During normal operation it is advisable to connect the photocathode to earth potential and the anode to positive high voltage. As it is sometimes necessary to have the photocathode at positive high potential and the anode at earth potential, precautions should be taken to ensure a high voltage insulation between the photomultiplier and the mu-metal shield greater than $10^{15}\Omega$. In this case, the background and dark currents may be higher than normal and somewhat unstable.

5. At an ambient temperature of 25°C.

6. The measurement is made at a detection threshold of 4.24×10^{-13} coulomb.

7. Transit time fluctuation is defined as the standard deviation of the transit time distribution of single electrons leaving the photocathode.

8. Or the voltage at which the tube has a gain of 5×10^8, whichever is the lower.

9. When calculating the anode voltage, the voltage across the load resistance should be taken into account.

10. The temperature range is limited by mainly mechanical stresses which may arise in the base. For temperatures below -30°C type 60DVP/UB (60DVP without base) is recommended.

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PHOTOMULTIPLIER TUBES

60DVP
60DVP/H

*A series resistor of 51Ω, $\frac{1}{2}$W is built into the base

BASE CONNECTIONS

OUTLINE DRAWING

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OUTLINE DRAWING (DIMENSIONED)

OUTLINE DRAWING OF 60DVP/H

Mullard

SPECTRAL RESPONSE CURVE

Mullard

PHOTOMULTIPLIER TUBES

QUICK REFERENCE DATA

150AVP 10 stage photomultiplier tube intended for use in scintillation counting, flying – spot scanner applications and various kinds of optical and industrial instruments.

150UVP 10 stage photomultiplier tube intended for use in optical spectrometry, ultra-violet photometry and other applications requiring a high sensitivity in the ultra-violet region.

Spectral response	150AVP	Type A (S11)	
	150UVP	Type U (S13)	
Photocathode useful diameter		32	mm
Anode sensitivity (at $V_b = 1.8kV$)		700	A/lm

Unless otherwise stated, data is applicable to both types

This data should be read in conjunction with
OPERATING NOTES – PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface		semi-transparent, caesium antimony	
Spectral response	150AVP	Type A (S11)	
	150UVP	Type U (S13)	
Wavelength at maximum response	150AVP	420 ±30	nm
	150UVP	400 ±30	nm
*Luminous sensitivity			
average		70	μA/lm
minimum		40	μA/lm
Average radiant sensitivity (at 400nm or 420nm)		60	mA/W

*Measured using a tungsten lamp of colour temperature 2854K

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MULTIPLIER SYSTEM

Number of stages
10

Dynode material
silver magnesium oxygen caesium

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG.1

Overall sensitivity (at $V_b = 1.8kV$)

average	700	A/lm
minimum	250	A/lm

*Dark current at $S = 60A/lm$

average	10	nA
maximum	50	nA

Maximum anode pulse amplitude for linearity with input light pulse — 30 mA

VOLTAGE DIVIDER AS IN FIG.2

Maximum anode pulse amplitude for linearity with input light pulse — 100 mA

Anode pulse rise time (at $V_b = 1.8kV$) — 3.5 ns

Anode pulse width at half height (at $V_b = 1.8kV$) — 6.5 ns

Transit time difference between the centre of the photocathode and the edge (at $V_b = 1.8kV$) — 3.0 ns

Total transit time (at $V_b = 1.8kV$) — 33 ns

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

*Measured at $25^{\circ}C$

Fig. 1

Mullard

Fig.2

D430

CAPACITANCES

c_{a-d10}	3.0	pF
c_{a-all}	5.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max.	1.8	kV
I_a max. (continuous operation)	0.1	mA
V_{k-d1} max.	500	V
V_{k-d1} min.	120	V
V_{d1-d2} .... $d9-d10$ max.	300	V
V_{d1-d2} .... $d9-d10$ min.	80	V
*V_{a-d10} max.	300	V
*V_{a-d10} min.	80	V

*When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.
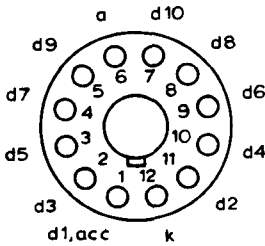
ACCESSORIES (supplied as additional items)

Socket	FE1002
Mu-metal shield	56127

Mullard

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of approximately 0.5mA will be sufficient.

3. When pulses with high amplitudes are taken from the anode, it is useful to decouple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current output with better time characteristics can be obtained when the tube is connected as in Fig.2.

Incident radiation

$\varnothing$39.5 max

$\varnothing$32 min

2

k

109 ±5

127 max.

22

$\varnothing$38 max

D491

a d10

d9 d8

d7 d6

d5 d4

d3 d2

d1,acc k

B12A base

All dimensions in mm

Mullard

PHOTOMULTIPLIER TUBES 150AVP 150UVP

ANODE SENSITIVITY AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

Mullard

PHOTOMULTIPLIER TUBE 150CVP

QUICK REFERENCE DATA

10 stage photomultiplier tube intended for use in applications such as infrared telecommunication and ranging, and in optical instruments operating in the far red and infrared region (astronomical measurements, spectroscopy, optical pyrometry, infrared radiation intensity control instruments).

Spectral response		Type C(S1)
Photocathode useful diameter	32	mm
Anode sensitivity (at 1.8kV)	100	A/lm

To be read in conjunction with
OPERATING NOTES - PHOTOMULTIPLIER TUBES

PHOTOCATHODE

Surface	semi-transparent, caesium on oxidised silver	
Minimum useful diameter	32	mm
Spectral response		Type C (S1)
Wavelength at maximum response	800 ±10	nm
*Luminous sensitivity		
average	25	μA/lm
minimum	15	μA/lm
**Infrared luminous sensitivity		
average	3.0	μA/lm
minimum	1.4	μA/lm
Average radiant sensitivity (at 800nm)	2.5	mA/W

*Measured using a tungsten lamp of colour temperature 2854K.

**The infrared lumen is the flux resulting from one lumen yielded by a tungsten lamp of colour temperature 2854K passing through an infrared filter Corning CS94 No. 2540, fusion 1613, thickness 2.61mm.

MULTIPLIER SYSTEM

Number of stages	10	
Dynode material	silver magnesium oxygen caesium	

CHARACTERISTICS

VOLTAGE DIVIDER AS IN FIG. 1

Overall sensitivity at $V_b = 1.8kV$

average	100	A/lm
minimum	20	A/lm
*Maximum dark current at S = 20A/lm	10	μA
Maximum anode pulse amplitude for linearity with input light pulse	5.0	mA

*Measured at $25^{\circ}C$

VOLTAGE DIVIDER AS IN FIG. 2

Maximum anode pulse amplitude for linearity with input light pulse	10	mA
Anode pulse rise time (at $V_b = 1.8kV$)	3.5	ns
Anode pulse width at half height (at $V_b = 1.8kV$)	6.5	ns
Transit time difference between the centre of the photocathode and the edge (at $V_b = 1.8kV$)	3.0	ns
Total transit time (at $V_b = 1.8kV$)	33	ns

Note – These time characteristics are for an infinitely short light pulse, fully illuminating the photocathode.

Fig. I

-H.T.   -H.T.

PHOTOMULTIPLIER TUBE 150CVP

Fig.2   D430

CAPACITANCES

c_{a-d10}	3.0	pF
c_{a-all}	5.0	pF

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_b max.	1.8	kV
I_a max. (continuous operation)	30	μA
V_{k-d1} max.	500	V
V_{k-d1} min.	120	V
V_{d1-d2}........$d9-d10$ max.	300	V
V_{d1-d2}........$d9-d10$ min.	80	V
*V_{a-d10} max.	300	V
*V_{a-d10} min.	80	V

*When calculating the anode voltage, the voltage drop across the load resistance should not be overlooked.

ACCESSORIES (supplied as additional items)

Socket	FE1002
Mu-metal shield	56127

Mullard

OPERATING NOTES

1. To achieve a stability of about 1% the ratio of the current through the voltage divider bridge to that through the heaviest loaded stage of the tube should be approximately 100.

2. For moderate intensities of radiation a bridge current of 0.5mA to 1.0mA will be sufficient.

3. When pulses with high amplitudes are taken from the anode, it is useful to de-couple the last stages as indicated in the circuit by means of capacitors of a few hundred pF, to avoid a voltage drop between these stages.

4. When the tube has been exposed to full daylight just before mounting, it will probably show an increased dark current, which will return to its normal value after several hours of operation.

5. It is advisable to screen the tube with a mu-metal cylinder against the influence of magnetic fields.

6. Different types of voltage dividers are possible. The voltage divider in Fig.1 has the higher gain, while a higher anode current with better time characteristics can be obtained when the tube is connected as in Fig. 2.

OUTLINE AND DIMENSIONS

Incident radiation
Ø 39·5 max
Ø 32 min
109±5
127 max
Ø 38 max

a   d10
d9   d8
d7   d6
d5   d4
d3   d2
d1,acc   k

B 12 A base

All dimensions in mm

D 1645

PHOTOMULTIPLIER TUBE 150CVP

ANODE SENSITIVITY AND DARK CURRENT PLOTTED AGAINST
TOTAL VOLTAGE

Mullard

CAMERA TUBES

G

A. PRINCIPLES OF OPERATION OF VIDICONS WITH MAGNETIC FOCUSING AND
MAGNETIC DEFLECTION

1. With integral mesh

M e c h a n i c a l   d e s i g n

The schematic arrangement of the vidicon with its accessories is shown in Fig.1.

The vidicon may be assumed to consist of three sections, namely, the electron gun,
the scanning section, and the target section.

Fig.1. Schematic electrode and coil arrangement

The electron gun contains a thermionic cathode, a grid g controlling the beam cur-
rent, and a limiter electrode a1 which accelerates the electrons and releases them
in a fine beam through its diaphragm.

The scanning section. The electron beam released by a1 enters the space enclosed
by the cylindrical electrode a2. By means of the combined action of the adjustable
electrical field of a2 (beam focus control) and a fixed axial magnetic field produced
by the focusing coil, the electrons are focused in one loop on to the target.

The far end of the a2 cylinder is closed with a fine metal mesh, a3, electrically
connected to a2, which produces a uniform, decelerating field in front of the target.
The focused beam is magnetically deflected by two pairs of deflection coils so that
it scans the target. Proper alignment of the beam with the axial magnetic field is
achieved either by an adjustable magnet, or, as shown in Fig.1, by two sets of
alignment coils producing an adjustable transverse magnetic field.

The target section is illustrated in Fig.2. It consists of:
- an optically flat glass faceplate,
- a transparent conductive film on the inner surface of the faceplate, connected electrically to the external target-electrode ring,
- a thin layer of photoconductive material deposited on the conductive film; in the dark this material has a high specific resistance, which decreases with increasing illumination.

The optical image to be televised is focused on the conductive film by means of a lens system.

Fig.2. Target section

O p e r a t i o n

The external target-electrode ring is connected via a load resistor to a positive voltage of the order of 30V (see Fig.3).

The target may be assumed to consist of a large number of target elements corresponding to the number of picture elements. Each target element consists of a small capacitor (C_e), connected on one side to the target electrode via the transparent conductive film and shunted by a light-dependent resistor (R_{ld}), see Fig.3.

When the target is scanned by the beam its surface will be "stabilised" at approximately the cathode potential (low-velocity stabilisation) and a potential difference will be established across the photoconductive layer, in other words, each elementary capacitor will be charged to nearly the same potential as applied to the electrode ring.

In the dark, the photoconductive material is a fairly good insulator, so that only a minute fraction of the charge of the elementary capacitors will leak away between successive scans. This charge will be restored by the beam; the resulting current to the target electrode is termed "dark current".

Fig.3

Mullard

When an optical image is focused on to the target, those target elements which are illuminated will become more conductive and will be partly discharged. As a consequence a pattern of positive charges corresponding to the optical image will be produced on the side of target facing the gun section.

While scanning this charge pattern the electron beam will deposit electrons on the positive elements until the latter are restored to their original cathode potential, causing a capacitive current to the target electrode and hence a voltage across the load resistor R_L. This voltage, negative going for the highlights, is the video signal and is fed to the pre-amplifier.

A vidicon is called "stabilised" when the magnitude of the beam current applied is just sufficient to restore the scanned surface to cathode potential, so that all elementary capacitors, including those at the highlights in the image, are recharged successively.

During the retrace periods the beam electrons should be prevented from landing on the target since otherwise the scan retraces will appear as dark lines in the picture obtained on the monitor. This may be achieved either by cutting off the beam with suitable negative blanking pulses on the control grid or by cutting off the target with adequate positive blanking pulses applied to the cathode.

2. With a separate mesh construction

The focus coils commonly used in vidicon cameras do not produce an ideal focus field distribution in the vicinity of the vidicon's photoconductive target.

The resulting "landing errors" of the scanning beam reduce the sensitivity and resolution at the periphery of the picture. The beam landing errors can be corrected by electron-optical means. A lens for this purpose may be formed by the cylindrical electrode (a2) and the mesh electrode (a3). In the vidicons with a separate mesh electrode a3 is electrically insulated from a2 and connected to a separate base pin.

The mesh electrode (a3) should be made positive with respect to the cylindrical electrode (a2); the optimum potential difference depends on:
a. the operating mode of the vidicon (choice of the focusing field and V_{a2});
b. the particular type of deflection coil unit used.
As a rule, to obtain the best resolution and most uniform whites the V_{a3} should be from 1.1 to 1.5 times higher than V_{a2}. Fig.4 shows a typical curve revealing the effect of the ratio V_{a3}/V_{a2} on the resolution measured on a vidicon type XQ1040 in a coil unit type AT1101. The fall-off in resolution at $V_{a3}/V_{a2} = 1$, corresponding to the situation with conventional vidicons, is caused by the defocusing effect of a space charge at the cathode side of the mesh electrode, produced by secondary electrons released from the mesh. This space charge can be prevented from building up by making a3 at least 15 volts positive relative to a2.
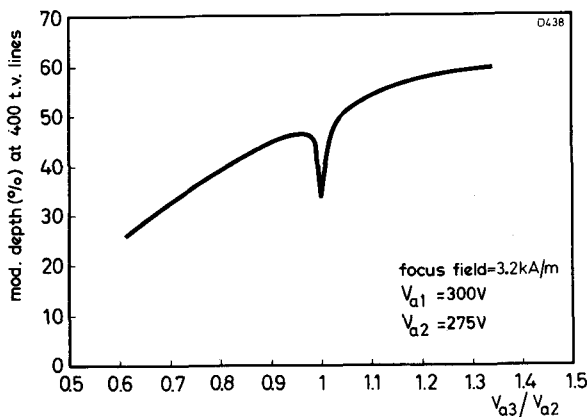
Fig.4. Effect of the V_{a3}/V_{a2} ratio on the resolution of a vidicon type XQ1040

Operation of a3 at a negative potential with respect to a2 must be avoided in any case, since this would cause permanent damage to the target, due to ion bombardment. A higher potential applied to a3 will slightly raise the required deflection currents but these will usually remain well within the ratings of the camera deflection circuits.

Caution If the camera wiring has been adapted* for the use of vidicons with separate mesh, insertion of an integral-mesh vidicon will result in normal performance of the tube and do no harm to the tube or the wiring of the camera. However, it should be borne in mind that the insertion of a separate-mesh vidicon in an unmodified camera may be detrimental to the vidicon, its target being damaged by ion bombardment; moreover, performance will be unsatisfactory.

*A leaflet is available on request giving suggestions for making cameras suitable for incorporating separate-mesh tubes.

B. EQUIPMENT DESIGN AND OPERATING CONSIDERATIONS

The target-electrode connection should be made by a spring contact which bears against the metal ring at the face end of the tube. The spring contact may be provided as part of the focusing coil design.

The target-electrode voltage should be limited to such a value that the peak dark current does not exceed $0.25\mu A$.

This is of particular importance for the design and adjustment of vidicon cameras with automatically controlled sensitivity (automatic control of the target-electrode voltage).

Operation of vidicons at excess dark current will result in damage to the photoconductive target and hence shorten the tube life.

The **deflection yoke** and the focus coil used must be so designed that the beam lands perpendicular to the target at all points of the scanned area, to ensure high uniformity of sensitivity and focus.

The **deflection circuits** must provide constant scanning speeds in order to obtain good black-level reproduction. The dark-current signal being proportional to the velocity of scanning, any change in this velocity will produce a black-level error.

The **polarity of the focusing coil** should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside and at the image end of the focusing coil.

The **alignment coil assembly** should be located on the tube so that its centre is at a distance of approx. 94mm from the face of the tube, and be positioned so that its axis coincides with the axis of the tube, the deflecting yoke and the focusing coil.

The **temperature of the faceplate** should never exceed $80^{O}C$, either during operation or storage. Operation at a faceplate temperature of 25 to $35^{O}C$ is recommended.

The temperature of the faceplate is determined by the heating effects of the incident illumination, the associated components and the environment and, to a minor extent, by the tube itself.

To reduce these heating effects and to permit operation in the preferred temperature range, under conditions of high light levels and high ambient temperatures respectively, the use of an infra-red filter between object and camera lens, or a flow of cooling air directed across the faceplate, is recommended.

Scanning amplitude

Full-size scanning of the 9.6mm × 12.8mm area of the photoconductive layer should always be applied.

Underscanning of the photoconductive layer, i.e. scanning of an area of less than 9.6mm × 12.8mm or failure of scanning for even a short duration should always be avoided, since this may cause permanent damage to the specified full-size area.

The **resolution of a vidicon** generally decreases with decreasing V_{a2} and V_{a3}. The voltage range will depend on the design of the focusing coil, which should be such as to provide a field strength within the range 2.9 to 3.5kA/m.

Definition, focus uniformity and picture quality also decrease with decreasing V_{a2} and V_{a3}. In general a2 and a3 should be operated above 250V.

A substantial increase in both limiting resolution and amplitude response may be obtained by increasing the operating voltage of a2 and a3 to 750V. With this mode of operation, the focusing field strength must be increased to approx. 5.6kA/m.

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Since beam-landing errors increase with increasing V_{a2} and V_{a3}, such operation will show a reduced signal output in the corners of the scanned area. When a vidicon with integral mesh is operated in this manner, the deflecting and focusing coils employed must be designed in such a way that beam-landing errors are minimised.

Compensation of residual beam-landing errors can be obtained by supplying modulating voltages of parabolic shape and of both horizontal and vertical scanning frequencies to the cathode and additionally, in order to prevent beam-modulation, to g, a1, a2, and a3.

A suitable amplitude for this mixed parabolic waveform is approximately 4V peak-to-peak. The polarity should be chosen such that the potential of the cathode is lowered as the beam approaches the edges of the scanned area. The use of this modulating waveform also improves the centre-to-edge focus of the vidicon.

Operation with V_{a2} and V_{a3} at 750V and a field strength of 5.6kA/m requires increased power for the deflecting and focusing coils, which will result in a higher tube temperature unless adequate provisions for cooling are made.

Compensation of beam-landing errors by means of mixed modulating voltages of parabolic shape is in general not needed for vidicons with separate mesh since the beam-landing errors may be sufficiently reduced by a proper choice of V_{a3}.

C. INSTRUCTIONS FOR USE FOR VIDICONS WITH MAGNETIC FOCUSING AND MAGNETIC DEFLECTION

1. In the case of a separate-mesh vidicon make certain that the camera is adapted for separate-mesh vidicons.
2. Clean the faceplate of the tube.
3. Insert the tube in the deflection unit so that the straight sides of the masked portions of the faceplate are essentially parallel to the line scan.
4. Press the socket firmly on to the base pins.
5. Cap lens and close iris.
6. Set: (a) grid-bias control at maximum negative bias (beam cut-off)
   (b) target-electrode voltage to approximately 25V
   (c) scanning amplitude to maximum scan.
7. Switch on camera equipment and monitor; allow a few minutes for heating up.
8. Adjust monitor to produce a faint, non-overscanned, raster.
9. Direct camera to the scene to be televised and uncap lens.
10. Turn grid-bias control slowly until a picture is produced on the monitor.
    If this picture appears washed out, increase beam current. If the picture is too faint, increase lens aperture.
11. Adjust beam focus (V_{a2} and V_{a3} for integral-mesh tubes, V_{a2} for separate-mesh tubes) and optical focus alternately for best possible focus.
12. Adjust scanning amplitudes:
    (a) by means of a mask of 9.6mm×12.8mm, which is in contact with and centred at the faceplate. Decrease horizontal and vertical deflecting currents until the periphery of this mask is just outside the raster on the monitor. This procedure may be facilitated by small adjustments of the centring controls;

(b) if no mask is available, direct the camera to a test chart having the correct
aspect ratio (4:3) and adjust the centring controls in such a way that the target
ring is just visible in the corners of the picture. Adjust distance from camera
to test chart and optical focus alternately, until the picture of the test chart com-
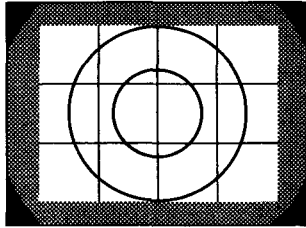pletely fills the scanned raster on the monitor.

Fig.5

13. Adjust alignment controls so that the centre of the picture does not move when beam
    focus (V_{a2} and V_{a3} for integral-mesh tubes, V_{a2} for separate-mesh tubes) is varied.
14. Cap lens and adjust target-electrode voltage to such a value that further increase
    would cause the background signal to become unacceptably high or non-uniform.
15. Uncap lens. Adjust beam focus control for optimum picture uniformity in respect
    of picture whites and resolution.
16. Adjust iris for a picture of sufficient contrast and adjust beam current to the mini-
    mum value which will give details in the picture highlights.
17. Check alignment, beam focus and optical focus.

Always:

- make sure the camera wiring is adapted for a separate-mesh tube before installation;
- make sure that the deflection circuits are operative before adjusting beam current;
- maintain the same scanned target area, hence avoid rotating the tube;
- use full size (9.6mm × 12.8mm) scanning of the target, hence avoid under-scanning;
- use sufficient beam current to stabilize the picture highlights;
- adjust V_{a3} of separate-mesh tubes to a value positive with respect to V_{a2};
- avoid peak dark currents in excess of 0.25μA;
- avoid directing the camera at the sun;
- keep lens capped when transporting the camera.

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D. VIDICON TUBES WITH OTHER ELECTRODE-GUN SYSTEMS

To facilitate the construction of compact, low power or light weight cameras vidicons with the following electron gun systems have been developed.

Type of electron gun	Focus	Deflection	Main features	Available type
hybrid gun	E	M	uniform high resolution no focus power required	–
reverse hybrid gun	M	E	uniform very high resolution no deflection power short tube	–
fully electrostatic gun	E	E	no deflection power no focus power	XQ1010

E = electrostatic, M = magnetic

E. PROPERTIES OF THE PHOTOCONDUCTIVE TARGETS AS USED IN THE VIDICONS OF THE XQ1010, XQ1030, XQ1040, XQ1050 SERIES

Spectral response

The spectral response of the targets used in the above tubes is shown in Fig.6.

dark current $I_{dark} = 20nA$
signal current $I_s = 20nA$

Fig.6

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Dark current

The range of dark currents determined at a faceplate temperature of $30 \pm 2^{\circ}C$ is shown in Fig.7.

Fig. 7

Transfer characteristics

The light transfer characteristics of a typical vidicon with three dark current settings as parameters are given in Fig.8.

Fig. 8

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SPURIOUS SIGNAL SPECIFICATION FOR PLUMBICON TUBES

SECTION A

Test conditions

The spurious signal tests on the Plumbicon tubes are carried out in the manufacturer's test channel under the following conditions:

1. Light source: 2854K colour temperature   (broadcast and industrial tubes)
   P20 light distribution   (tubes for medical X-ray equipment)

2. Filter inserted in the light path for chrominance tubes
   (see published data for required filter characteristics)

3. Test transparency, back-illuminated, projected on to the target by means of a high quality lens, producing an even illumination on the specified scanned area. The test transparency has an aspect ratio of 4:3 for the evaluation of broadcast and industrial quality tubes. The area of the chart is divided into three quality zones by two concentric circles as shown in Fig.1.

Fig.1

The test transparency is of a circular shape for the evaluation of tubes for medical X-ray equipment. The area of the chart is divided into three quality zones by two concentric circles as shown in Fig.2.

Fig.2

4. The video amplifier frequency response is essentially flat to 5MHz, with a sharp fall-off to 6MHz.

5. No gamma correction or aperture correction is applied in the video amplifier.

6. Light level. The light level on the Plumbicon target is adjusted to produce a peak highlight signal current in accordance with table I.

7. Beam current. The beam current should be adjusted for current stability according to the values quoted in table I.

8. Monitor. The obtained picture is observed on a monitor producing a non-blooming white.

*Registered trade mark for television camera tubes

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Table I – Highlight signal and beam current settings

			Tube diameter 30mm		Tube diameter 25mm	
			Scanned area $12.8 \times 17.1mm^2$		Scanned area $9.6 \times 12.8mm^2$	
			Highlight signal current (μA)	Beam current (μA)	Highlight signal current (μA)	Beam current (μA)
Broadcast quality tubes	Black and white		0.3	0.6	0.2	0.4
	Luminance	L	0.3	0.6	0.2	0.4
	Chrominance tubes	Red R	0.15	0.3	0.1	0.2
		Green G	0.3	0.6	0.2	0.4
		Blue B	0.15	0.3	0.1	0.2
Industrial quality tubes	Black and white		0.3	0.6	0.2	0.4
	Chrominance tubes	Red R	0.15	0.3	0.1	0.2
		Green G	0.3	0.6	0.2	0.4
		Blue B	0.15	0.3	0.1	0.2
X-ray medical tubes (for use in combination with an X-ray intensifier)	P20 light source		Scanned area 18mm circular		Scanned area 15mm circular	
			0.15	0.3	0.1	0.2

SECTION B

Definitions

Blemishes, can be regarded as either spots or smudges.

Spots and smudges are small areas of uneven modulation of any signal current between black level (dark current) and white level (peak signal current). For broadcast quality tubes and tubes for medical X-ray equipment a spot is defined as a blemish with a maximum linear dimension in any direction of 0.7% of the picture height, a smudge as a blemish with a maximum linear dimension in any direction exceeding 0.7% of the picture height.
For industrial quality tubes a spot is defined as a blemish with a maximum linear dimension in any direction of 1% of the picture height and a contrast in excess of 10% of 100% white level (highlight signal current as given in Section A, table I), as measured on a waveform oscilloscope (bandwidth 5.5MHz), black level being defined as 0%.

SECTION C

Number, size, location and contrast of blemishes

I. Broadcast quality tubes

Dimensions of blemishes in % of picture height	Permitted number of blemishes*					
	Black and white Luminance (L) tubes Red, Green (R, G)			Blue tubes (B)		
	Zone I	Zone II	Zone III	Zone I	Zone II	Zone III
> 0.7%	0	0	0	0	0	0
≤ 0.7% but > 0.45%	0	0	1	0	1**	3**
≤ 0.45% but > 0.2%	0	2†	2	1	2**	4**
≤ 0.2%	‡	‡	‡	‡	‡	‡

*The distance between any two spots shall be greater than 5% of the picture height.
**The sum of the number of spots in zones II and III shall not exceed 5.
† The sum of the diameters of these spots shall not exceed 0.7% of the picture height.
‡ Spots of this size are not counted unless the concentration causes a smudgy appearance. Such concentrations are evaluated as smudges, and, as contrast, the average contrast of the concentration is taken.
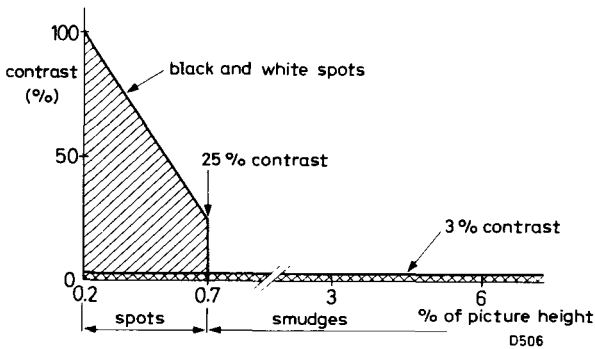The maximum contrasts allowed for blemishes are shown in Figs. 3 and 4.

Fig.3 (see notes 1 and 2)
Maximum contrasts allowed for spots and smudges for tubes
for monochrome, luminance and green channels

Notes

1. Spots and smudges with a maximum size of 3% of the picture height with contrasts less than 5% for the monochrome, green and luminance tubes or less than 8% for red and blue tubes are not counted.
2. Smudges with sizes over 3% of the picture height are allowed provided their contrasts remain within the cross-hatched areas.

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Fig.4 (see notes 1 and 2)
Maximum contrasts allowed for spots and smudges
for tubes for red and blue channels

1. Spots and smudges with a maximum size of 3% of the picture height with contrasts less than 5% for the monochrome, green and luminance tubes or less than 8% for red and blue tubes are not counted.

2. Smudges with sizes over 3% of the picture height are allowed provided their contrasts remain within the cross-hatched areas.

II. Industrial quality tubes

Dimensions of blemishes in % of picture height	Permitted number of blemishes*			
	Zone I	Zone II	Zone III	Total
>1%	0	0	0	0
≤1% but >0.7%	0	1	2	2
≤0.7% but >0.45%	1	2	4	4
≤0.45% but >0.2%	2	4	6	6
≤0.2%	‡	‡	‡	‡
Total permitted number of blemishes	2	4	6	6†

*The distance between any two spots shall be greater than 5% of the picture height in any direction.

‡ Spots of this size are not counted unless concentration causes a smudgy appearance. Such concentrations are evaluated as smudges, and as contrast, the average contrast of the concentration is taken.

Blemishes with contrasts ≤10% are not counted.

† For 30mm diameter tubes only.

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SPURIOUS SIGNAL SPECIFICATION FOR VIDICON TUBES

SECTION A Vidicons for telecine, other broadcast applications and critical industrial applications.

Test conditions

1. A back illuminated test transparency, with an aspect ratio of $4:3$, with three quality zones (see Fig.1) is projected on to the specified target area ($9.6 \times 12.8mm^2$), producing even illumination.

Fig.1

2. Light level adjusted to produce a total target current of $0.3\mu A$, target voltage adjusted for a dark current of approx. 20nA, temperature $30^{\circ} \pm 2^{\circ}C$, colour temperature of light source 2854K.
3. Tube aligned and focused in accordance with the published instructions for use.
4. Video-amplifier system having a bandwidth of 5.5MHz.
5. Monitor adjusted for a non-blooming white.
6. In the evaluation of blemishes the following definitions apply:
   a) a spot (black or white) is a blemish with a maximum linear dimension measured in any direction of 0.75% of the picture height (0.8% for industrial grade tubes, 1% for low cost tubes)
   b) a smudge (black or white) is a blemish with a maximum linear dimension measured in any direction exceeding 0.75% of picture height (0.8% for industrial grade tubes, 1% for low cost tubes)

Permitted number, size and location of blemishes*

Dimensions of blemishes in % of picture height	Permitted number of blemishes		
	Zone I	Zone II	Zone III
> 0.75%	0	0	0
≤0.75% but > 0.45%	0	0	1
≤0.45% but > 0.2%	0	2†	2
≤0.2%	‡	‡	‡

Notes
*Spots (black and white) and smudges (black and white) are not counted when their contrast expressed in % of picture white as measured on a waveform oscilloscope is less than 25% and 10% respectively.
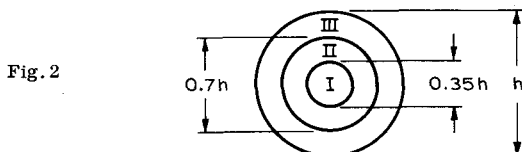†Sum of diameters of these spots shall not exceed 0.75%.
‡Spots of this size are allowed unless concentration causes a smudgy appearance. Such concentrations are evaluated as smudges, and, as contrast, the average contrast of the concentration is taken.

SECTION B   Vidicons for medical X-ray applications

Test conditions

1. A back illuminated test transparency with three quality zones (see Fig.2) is projected on to the specified target area (15mm dia circular) producing an even illumination.

Fig.2

2. Light level adjusted to produce a total target current of $0.2\mu A$, target voltage adjusted for a dark current of approx. 20nA, temperature $30^{o} \pm 2^{o}C$.

3. Tube aligned and focused in accordance with the published instructions for use.

4. Video-amplifier system having a bandwidth of 5.5MHz.

5. Monitor adjusted for a non-blooming white.

6. As Section A, test condition 6.

Permitted number, size and location of blemishes*

Dimensions of blemishes in % of picture height	Permitted number of blemishes		
	Zone I	Zone II	Zone III
> 0.75%	0	0	0
≤0.75% but > 0.45%	0	1	3
≤0.45% but > 0.2%	2	3	6
≤0.2%	‡	‡	‡

Notes

*Spots (black and white) and smudges (black and white) are not counted when their contrast expressed in % of picture white as measured on a waveform oscilloscope is less than 25% and 5% respectively.

‡Spots of this size are allowed unless concentration causes a smudgy appearance. Such concentrations are evaluated as smudges, and, as contrast, the average contrast of the concentration is taken.

Sum of numbers of spots in zones II and III shall not exceed 6.

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SECTION C   Vidicons for industrial applications

Test conditions

As Section A

Permitted number, size and location of blemishes*

Dimensions of blemishes in % of picture height	Permitted number of blemishes	
	Zone I + Zone II	Zone III
> 0.8%	0	0
≤ 0.8% but > 0.6%	0	1
≤ 0.6% but > 0.2%	2	3
< 0.2%	‡	‡

Notes

*Spots (black and white) and smudges (black and white) are not counted when their con-
trast expressed in % of picture white as measured on a waveform oscilloscope is less
than 50%.

‡Spots of this size are allowed unless concentration causes a smudgy appearance. Such
concentrations are evaluated as smudges, and, as contrast, the average contrast of
the concentration is taken.

SECTION D   Vidicons for low cost closed-circuit television cameras

Test conditions

As Section A

Permitted number, size and location of blemishes*

Dimensions of blemishes in % of picture height	Permitted number of blemishes	
	Zone I + Zone II	Zone III
> 1%	0	0
≤ 1% but > 0.6%	1	3
≤ 0.6% but > 0.2%	4	6
≤ 0.2%	‡	‡

Notes

*Spots (black and white) and smudges (black and white) are not counted when their con-
trast expressed in % of picture white as measured on a waveform oscilloscope is less
than 50%.

‡Spots of this size are allowed unless concentration causes a smudgy appearance. Such
concentrations are evaluated as smudges, and, as contrast, the average contrast of
the concentration is taken.

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TENTATIVE DATA

QUICK REFERENCE DATA

25.5mm diameter ruggedised vidicon camera tube with separate mesh, electro-static focusing and deflection. Intended for use in compact TV systems and other applications where vibration and shock conditions are experienced.

Resolution capability	≥ 600	TV lines

This data should be read in conjunction with
GENERAL OPERATIONAL RECOMMENDATIONS - VIDICON CAMERA TUBES

HEATER

Suitable for series or parallel operation, a.c. or d.c.

V_h	6.3 ±10%	V
I_h	300	mA

NOTE (applies to series operation only). The surge heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on. When used in a series heater chain, a current limiting device may be necessary in the circuit to ensure that this voltage is not exceeded.

FOCUSING

Electrostatic

DEFLECTION

Electrostatic

PHOTOCONDUCTIVE LAYER (see note 1)

Maximum diagonal of rectangle on
photoconductive layer (aspect ratio 3:4)   16   mm

For correct orientation of the image on the photoconductive layer, the horizontal
scan should be essentially parallel to the plane passing through the tube axis and
pin 2.

CAPACITANCE

Target electrode to all other electrodes   4.5   pF

x_1 to x_2 20   pF

y_1 to y_2 20   pF

The target electrode capacitance, which is effectively the output impedance, increases
when the tube is inserted in the coil assembly.

TYPICAL OPERATION

Operating conditions

V_{a4} (mesh)   425   V

V_{a3} (collector)   225   V

V_{a2} (focus)   100   V

V_{a1} (accelerator)   425   V

V_g adjusted for sufficient beam current to stabilise highlights.

V_x, V_y (deflection electrodes) (see note 2)   225   V

Maximum correction voltage for

   centring (see note 3)   20   V

   astigmatism (see note 4)   10   V

Peak-to-peak deflection voltage

   x-deflection (12.8mm scan per electrode) 55 ±10%   V

   y-deflection (9.6mm scan per electrode)   42 ±10%   V

Scanned area 9.6×12.8 mm

Faceplate temperature   30 ±2 ^oC

TYPICAL OPERATION (contd.)

Typical performance

Target electrode voltage for dark current of 20nA

range	20 to 55	V
typical	30	V

Decay (see note 5)

Residual signal current after dark pulse of 200ms	8	%

Resolution (see note 6)

Typical modulation depth measured for 400 TV lines, without aperture correction but corrected for losses introduced by the optical system.

centre of picture	>30	%
typical	40	%
corner of picture	>15	%
typical	25	%
Resolution capability (see note 7)	>600	TV lines
Grid voltage for picture cut-off with no blanking applied	-30 to -200	V
Average gamma of transfer characteristic for signal currents between 10nA and 300nA	0.7	
Geometry distortion	≤ 2.0	%
Signal current (see note 8)	150	nA
Wavelength at maximum response (approx.)	550	nm

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	100	V
V_{a4} max.	750	V
V_{a3} max.	750	V
V_{a2} max.	750	V
V_{a1} max.	750	V
$-V_g$ max.	200	V
$+V_g$ max.	0	V

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RATINGS (contd.)

V_{h-k} max.	50	V
Maximum voltage between any combination of deflection electrodes	200	V
Output current peak, max. (see note 9)	600	nA
Dark current peak, max.	250	nA
Cathode current max.	2.0	mA
Maximum faceplate illumination	5000	lux
Maximum faceplate temperature (operation and storage) (see note 10)	80	^oC

SHOCK AND VIBRATION

Shock

The tube will function satisfactorily after being subjected three times to a shock pulse of 30g for 11ms in each of six directions:- along the axis both directions and perpendicular to the axis along four mutually perpendicular directions.

Vibration

The tube will function satisfactorily when vibrated at a frequency of 25 to 500Hz with an acceleration of 20g in each of three mutually perpendicular directions one of which coincides with the axis of the tube. The rate of change of frequency is logarithmic and such that a complete cycle occupies approximately 10 minutes. The duration of the test is twelve complete cycles in each of the three directions.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	65	g

ACCESSORIES

Socket (provisional)	2422 505 00001

NOTES

1. Underscanning of the useful target area of 9.6 × 12.8mm or failure of scanning should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask.

2. Average d.c. voltage of the four deflection electrodes before correction for astigmatism.

3. Some centring of the scanned area of the target will be generally needed. The d.c. voltage difference between the electrodes x_1 and x_2 and the electrodes y_1 and y_2 needed for centring will not exceed the given value.

4. Astigmatism correction may be achieved by applying a voltage difference between the x-deflection and y-deflection pair of electrodes. The correction voltage will not exceed the given value.

5. Tube is exposed to an illumination of 8 lux at a colour temperature of 2854K with the target electrode voltage set for a dark current of 20nA.

6. Square wave response. Measured with a peak signal current of 200nA. Corners defined as 0.35 of diagonal from centre.

7. Measured with a video amplifier having an appropriate bandwidth.

8. With 8 lux, colour temperature 2854K on the faceplate.

9. Video amplifiers should be capable of handling signal currents of this magnitude without overloading the amplifier or distorting the picture.

10. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infrared filters should be used.

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D1159

Target electrode — 1.3±0.1

28.5 ±0.2

3±0.1

∅ 25.5±0.5

Vertical axis
g
a₂
IC
x₂
y₂
a₄
∅ 16.66
a₃
6 7 8 9
5
10
4
11
k
3
12
a₁
2
1
14
13
y₁
x₁
h
Short index pin
25 5/7° (14×)
Horizontal axis

159 ±3

Target electrode
y₁
x₁
a₄
x₂
y₂
a₂
a₃
g
a₁

k h h

3.18 max
short index pin
12.7 max
9.3 min
∅7.36 max
1.016 +0.050 −0.100

All dimensions in mm

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CAMERA TUBES
PLUMBICON*

XQ1020
XQ1020L   XQ1020G
XQ1020R   XQ1020B

QUICK REFERENCE DATA

30mm diameter Plumbicon separate mesh construction camera tubes with photoconductive layer and low velocity stabilisation. They are capable of use at high beam currents giving sensitive, high definition pick-up in monochrome and colour broadcast cameras.

XQ1020   – for use in monochrome television cameras

XQ1020L – provides the luminance component of a colour picture

XQ1020R – provides the red component of a colour picture

XQ1020G – provides the green component of a colour picture

XQ1020B – provides the blue component of a colour picture

Dark current	< 3	nA
Resolution capability	> 600	TV lines
Transfer characteristic	linear	

GENERAL OPERATIONAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE are given on pages 6 to 8.

HEATER

Suitable for parallel operation only

V_h 6.3 ± 5%   V

I_h 300   mA

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Image dimensions on photoconductive layer
3:4 aspect ratio (see note 1)   12.8 × 17.1   mm

For correct orientation of the image on the photoconductive layer, the horizontal scan should be essentially parallel to the plane passing through the tube axis and the index pin.

CAPACITANCE

Target electrode to all other electrodes   3 to 6   pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

*Registered trade mark for television camera tubes

Mullard

TYPICAL OPERATION

Operating conditions

V_k	0	V
V_{target}	45	V
V_{a3}	675	V
V_{a2}	600	V
V_{a1}	300	V
V_g adjusted to give the required beam current		
Scanned area	12.8×17.1	mm
Faceplate illumination	See note 2	
Faceplate temperature	20 to 45	^{o}C

	XQ1020, XQ1020L, G	XQ1020R, B	
Highlight signal current	300	150	nA

Typical performance

Dark current	< 3	nA

Resolution

Typical modulation depth measured at centre of picture for 400 TV lines, without aperture correction but corrected for losses introduced by the optical system:-

XQ1020, XQ1020L	40	%
XQ1020R	35	%
XQ1020G	40	%
XQ1020B	50	%
Resolution capability	> 600	TV lines
Signal-to-noise ratio	See note 3	
Gamma of transfer characteristic (see note 4)	0.95 ± 0.05	
Wavelength at maximum response (approx.)	500	nm

Lag (see note 5)

	XQ1020, XQ1020L, R, G	XQ1020B	
Max. residual signal after dark pulse of 60ms	5	6	%
Max. residual signal after dark pulse of 200ms	2	3	%

Sensitivity (see note 6)

XQ1020, XQ1020L	> 275	μA/lm
XQ1020R	> 60	μA/lm
XQ1020G	> 125	μA/lm
XQ1020B	> 32	μA/lm

CAMERA TUBES
PLUMBICON

XQ1020
XQ1020L XQ1020G
XQ1020R XQ1020B

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	50	V
V_{a3} max.	1100	V
V_{a2} max.	800	V
V_{a3-a2} max.	350	V
V_{a1} max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
I_k max.	6.0	mA
$V_{h-k(pk)}$ max.		
Cathode positive	50	V
Cathode negative	50	V
Maximum faceplate illumination (see note 7)	500	lux
Faceplate temperature (operation and storage)		
Maximum	50	^{o}C
Minimum	-30	^{o}C
Minimum warm-up time of heater to be observed before drawing cathode current	1.0	min

EQUIPMENT DESIGN RECOMMENDATIONS

V_{target} (see note 8)	25 to 45	V
V_{a3}	650 to 700	V
V_{a2}	550 to 600	V
V_g	0 to -100	V
Minimum peak-to-peak blanking voltage		
when applied to the grid	70	V
when applied to the cathode	25	V

The current drawn by the tube from the first anode supply will not exceed 2.0mA.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	100	g

ACCESSORIES (see separate data sheets)

Socket	56021
Coil assembly	
for XQ1020	AT1132
for XQ1020L, R, G, B	AT1113/01

Mullard

NOTES

1. Underscanning of the useful target area of 12.8×17.1mm, or failure of scanning, should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask to reduce the effects of internal reflections in the faceplate.

2. Adjusted to give the required peak signal current. For a typical XQ1020 or XQ1020L the required illumination will be approximately 4 lux. The signal currents stated for the XQ1020R,G,B will be obtained with an incident illumination of approximately 10 lux (2854K colour temperature), this figure being based on the use of the following filters:

   for XQ1020R Schott OG2 thickness 3mm
       XQ1020G Schott VG9 thickness 1mm
       XQ1020B Schott BG12 thickness 1mm
   Transmission curves for these filters are given on page 10.

   For a monochrome camera, the faceplate illumination is related to the scene illumination by the formula

   $$B_{ph} = B_{sc} \frac{R.T}{4F^2(m+1)^2}$$

   where B_{sc} = scene illumination
       B_{ph} = faceplate illumination
       R = scene reflectivity (average or that of the object under consideration, whichever is relevant)
       T = lens transmission factor
       F = lens aperture
       m = linear magnification from scene to target

   A similar formula may be derived for the illumination on the photoconductive layers of the R, G and B tubes, in which the effects of the various components in the complete optical system are taken into account.

3. The noise contribution of the Plumbicon tube is negligible compared with that of the head amplifier. A well designed head amplifier having a bandwidth of 5MHz will give an r.m.s. noise current of about 1.5nA, and at a peak signal current of 150nA this will result in a visual equivalent signal-to-noise ratio of 43dB.

4. Gamma is to a certain extent dependent on the wavelength of the incident illumination. The use of gamma-correcting circuits is recommended.

5. Measured with a 100% signal current of 100nA and with a light source of colour temperature 2854K. The appropriate filter is inserted in the light path when measuring colour tubes.

6. As measured under the following conditions:

   Tubes are exposed to an illumination of 4.54 lux at a colour temperature of 2854K. The appropriate filter is inserted in the light path. The current obtained is a measure of the colour sensitivity, and is expressed in micro-amperes per lumen of white light before the filter.

   Filters used:
   for XQ1020R Schott OG2 thickness 3mm
       XQ1020G Schott VG9 thickness 1mm
       XQ1020B Schott BG12 thickness 3mm
   Transmission curves for these filters are given on page 10.

Mullard

7. For short intervals. During storage the tube face should be covered with the plastic hood provided. When the camera is idle the lens should be capped.

8. The target electrode voltage should be adjusted to 45V. If the scene to be televised contains excessive highlights, the target electrode voltage may be reduced to a minimum of 25V; this, however, will result in some reduction in performance, particularly in respect of sensitivity.

OUTLINE DRAWING OF XQ1020 SERIES

All dimensions in mm   * Total glass thickness = 7.2 ± 0.2

The maximum distance between the axis of anti-reflection glass disc and geometrical centre of the target electrode ring, measured in the plane of faceplate is 0.2mm. The base will fit a gauge as shown above. The holes in the gauge may deviate 0.01mm max. from their true geometric positions. The thickness of the gauge is 7mm. The ends of the pins are tapered or rounded but not brought to a sharp point.

Mullard

GENERAL OPERATIONAL RECOMMENDATIONS

Transport, handling and storage

During transport, handling or storage, the tube should be placed so that the faceplate is not below the level of the base.

Base pins

The pins of this tube are of tungsten. Accordingly, care must be taken when the tube and socket are mated, in order to avoid breaking the pins or damaging the glass-to-metal seals.

Target electrode

The connection to the target electrode is made at the face end of the tube by a spring contact which is part of the coil assembly.

Photoconductive layer

In some instances the properties of the photoconductive layer may slightly deteriorate during long idle periods, such as encountered between the manufacturer's last test and the first time of operation by the user. It is therefore recommended to operate the tube at approximately monthly intervals from receipt. To restore the photoconductive layer, the tube should be operated for a few hours with normal voltage settings and a signal current of 150nA, and should be adjusted to overscan an evenly illuminated target.

Light transfer

Because the light transfer characteristic has a gamma of approximately unity, it may be desirable for broadcast applications to incorporate a gamma-correcting circuit in the video system, with a gamma adjustable from 0.4 to 1.0. In addition, provision should be made for limiting the video signal above 100% of peak white level, in order to prevent overloading of the video amplifier system when the tube is exposed to scenes containing small peaked highlights as caused by reflections from shiny objects.

Signal-to-noise ratio

Since the tube does not generate noise to any noticeable extent, the signal-to-noise ratio will be determined mainly by the noise factor of the video amplifier system.

Under normal studio lighting conditions the high sensitivity of the tube produces a high signal-to-noise ratio provided that the output of the tube is fed into a well designed input stage of the video amplifier system. In such a system horizontal and vertical aperture correction may be incorporated to ensure sufficient gain in resolving power without significantly impairing the signal-to-noise ratio.

OPERATING INSTRUCTIONS

1. Clean the faceplate of the tube and insert in the coil assembly in such a way that the plane defined by the tube axis and the index pin is essentially parallel to the direction of the horizontal scan.

2. Carefully mate the socket with the base pins.

3. Cap the lens and close the iris.

Mullard

OPERATING INSTRUCTIONS (contd.)

4. Adjust the operating conditions as follows:

   (a) Grid bias control to maximum negative bias (beam cut-off)

   (b) Target electrode voltage to 45V

   (c) Scanning amplitudes to maximum (overscanning)

5. Switch on camera and picture monitor equipment. Allow a few minutes for warm-ing up.

6. Adjust the monitor to produce a faint, non-overscanned raster.

7. Direct the camera towards the scene to be televised and uncap the lens.

8. Slowly adjust the grid bias control until a picture is produced on the monitor. If the picture is too faint, increase the lens aperture.

9. Adjust V_{a2} and V_{a3} control (beam focus) and optical focus alternately for optimum focus.

10. Align the beam of the Plumbicon tube by one of the following methods:

   (a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when V_{a2} and V_{a3} (beam focus) is varied. This is catered for automatically in some cameras.

   (b) Reduce the target electrode voltage to a very low value. Adjust the align-ment fields until the most uniform picture is obtained, as observed on the monitor or an oscilloscope.

11. Adjust the scanning amplitudes as follows:

   (a) By means of a 12.8×17.1mm mask which is in contact with and centred on the faceplate. Decrease the horizontal and vertical scanning amplitudes until the periphery of the mask is just outside the raster on the monitor. This may be facilitated by small adjustments of the centring controls.

   (b) If no mask is available, direct the camera towards a test chart having an aspect ratio of 4:3 and adjust the centring controls in such a way that the target ring is just visible in the corners of the picture. Adjust the distance from camera to test chart, and re-focus until the image of the test chart is positioned on the faceplate as indicated on the adjoining figure.

Decrease both scanning amplitudes until the image of the test chart com-pletely fills the scanned raster on the monitor.

Mullard

OPERATING INSTRUCTIONS (contd.)

12. Adjust the iris for a picture of sufficient contrast and adjust the beam current to a value at which all highlights are stabilised.

13. Check alignment, beam focus and optical focus.

14. **Procedure for standby operation**

From operation to standby –

(a) Cap lens

(b) Set V_g for beam cut-off

(c) Reduce heater voltage to 4V or less

From standby to normal operation –

(a) Restore heater voltage to 6.3V

(b) Wait 1 minute

(c) Increase beam current to normal value

(d) Uncap lens

ALWAYS

Use full size (12.8 × 17.1mm) scanning of the target and avoid underscanning.

Adjust sufficient beam current to stabilise the picture highlights.

Ensure that the deflection circuits are operative before turning on the beam current.

Operate a3 at a voltage equal to or more positive than a2.

Avoid pointing the camera directly into the sun.

Keep the lens capped when transporting the camera.

Mullard

TYPICAL SPECTRAL RESPONSE CURVES

Mullard

TRANSMISSION CURVES FOR SCHOTT FILTERS

QUICK REFERENCE DATA

These tubes are identical to the XQ1020 series, except for the quality of the photoconductive layer and are intended for industrial and educational cameras.

XQ1021 – for use in monochrome television cameras

XQ1021R – provides the red component of a colour picture

XQ1021G – provides the green component of a colour picture

XQ1021B – provides the blue component of a colour picture

Dark current	< 3	nA
Resolution capability	> 600	TV lines
Transfer characteristic	linear	

Data identical to that of XQ1020 series

*Registered trade mark for television camera tubes.

QUICK REFERENCE DATA

30mm diameter Plumbicon camera tube with photoconductive layer, low velocity stabilisation, and separate mesh construction giving sensitive, high definition pick-up. This tube is exclusively intended for use with X-ray image intensifiers in medical equipment.

Dark current	< 3	nA
Transfer characteristic	linear	

GENERAL OPERATIONAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE are given on pages 6 to 8

HEATER

Suitable for parallel operation only

V_h	6.3 ±5%	V
I_h	300	mA

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Diameter of the circular area on photoconductive layer (see note 1) — 18 mm

CAPACITANCE

Target electrode to all other electrodes — 3 to 6 pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

*Registered trade mark for television camera tubes

TYPICAL OPERATION

Operating conditions

V_k	0	V
V_{target}	15 to 45	V
V_{a3}	675	V
V_{a2}	600	V
V_{a1}	300	V
V_g adjusted to give the required beam current		
Scanned area	18 × 18	mm
Faceplate illumination (see note 3) approx.	2	lux
Faceplate temperature	25 to 40	^{o}C
Highlight target electrode current	100 to 500	nA
Average signal output	60	nA

Typical performance

Dark current	< 3	nA
Resolution (see note 4)		

Typical modulation depth measured at centre of picture for 625 lines, without aperture correction but corrected for losses introduced by the optical system.

	< 30	%
Signal-to-noise ratio	See note 5	
Gamma of transfer characteristic (see note 6)	0.95 ±0.05	
Wavelength at maximum response (approx.)	500	nm
Lag (see note 7)		
Residual signal after dark pulse of 60ms		
Maximum	10	%
Typical	5	%
Residual signal after dark pulse of 200ms		
Maximum	4	%
Typical	2	%
Sensitivity (see note 8)		
Minimum	200	μA/lm
Typical	275	μA/lm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	50	V
V_{a3} max.	1100	V
V_{a2} max.	800	V
V_{a3-a2} max.	350	V
V_{a1} max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
I_k max.	6.0	mA
$v_{h-k(pk)}$ max.		
Cathode positive	50	V
Cathode negative	50	V
Maximum faceplate illumination (see note 9)	100	lux
Faceplate temperature (operation and storage)		
Maximum	50	^{o}C
Minimum	-30	^{o}C
Maximum first anode dissipation	1.0	W
Minimum warm-up time of heater to be observed before drawing cathode current	1.0	min

EQUIPMENT DESIGN RECOMMENDATIONS

V_{target} (see note 2)	15 to 45	V
V_{a3}	650 to 700	V
V_{a2}	550 to 600	V
V_g	0 to -100	V
Minimum peak-to-peak blanking voltage		
when applied to the grid	70	V
when applied to the cathode	25	V

The current drawn by the tube from the first anode supply will not exceed 1.0mA.

MOUNTING POSITION	Any

WEIGHT

Tube alone (approx.)	100	g

ACCESSORIES (see separate data sheets)

Socket	56021
Coil assembly	AT1122, AT1132

NOTES

1. Underscanning of the useful target area of 18mm diameter, or failure of scanning, should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask to reduce the effects of internal reflections in the faceplate.

2. The target electrode voltage should be adjusted to the value indicated on the test sheet as delivered with each individual tube.

3. For a monochrome camera, the faceplate illumination is related to the scene illumination by the formula

$$B_{ph} = B_{sc} \frac{R.T}{4F^2(m+1)^2}$$

where B_{sc} = scene illumination

B_{ph} = faceplate illumination

R = scene reflectivity (average or that of the object under consideration, whichever is relevant)

T = lens transmission factor

F = lens aperture

m = linear magnification from scene to target

4. With a signal current of 100nA and a beam current of 500nA. Horizontal amplitude response can be raised by the application of aperture correction. Such compensation, however, does not affect the vertical resolution, nor does it influence the limiting resolution.

5. The noise contribution of the Plumbicon tube is negligible compared with that of the head amplifier. A well designed head amplifier having a bandwidth of 5MHz will give an r.m.s. noise current of about 1.5nA, and at a peak signal current of 150nA this will result in a visual equivalent signal-to-noise ratio of 43dB.

6. The near unity gamma ensures good contrast when televising low contrast X-ray image intensifier pictures as encountered in radiology. Further contrast improvement may be obtained by the use of gamma-correcting circuits.

7. Measured with a 100% signal current of 100nA which has been flowing through the layer for a minimum of 5 seconds, and with a light source having P20 distribution. The beam should be adjusted for correct stabilisation.

8. Measured with a fluorescent light source having P20 distribution.

9. For short intervals. During storage the tube face should be covered with the plastic hood provided. When the camera is idle the lens should be capped.

Mullard

XQ1022

OUTLINE DRAWING AND DIMENSIONS

D660

18 P.C.D

h

a2   k

a3   g

45°

Index pin IC

7 holes
$\varnothing$ 1.750
± 0.005

18 P.C.D

1 hole
$\varnothing$ 9.00
± 0.01

45°

1 hole
$\varnothing$ 3.000±0.005

Gauge for base pins
(See note below)

Target electrode

a3

a2

a1

g

k h h

All dimensions in mm

$\varnothing$ 30.6 max

1.2 nom

3.2 ±0.1

$\varnothing$ 30.15 ± 0.3

214 max

190 ± 2

$\varnothing$ 34.5 ± 0.3

7.0 min

21±0.5

20 max

11 max

7 pins
$\varnothing$ 1.52±0.03

1 pin
$\varnothing$ 2.5±0.2

$\varnothing$ 8.7 max

The base will fit a gauge as shown above. The holes in the gauge may deviate 0.01mm max. from their true geometric positions. The thickness of the gauge is 7mm. The ends of the pins are tapered or rounded but not brought to a sharp point.

Mullard

GENERAL OPERATIONAL RECOMMENDATIONS

Transport, handling and storage

During transport, handling or storage, the tube should be placed so that the face-plate is not below the level of the base.

Base pins

The pins of this tube are of tungsten. Accordingly, care must be taken when the tube and socket are mated, in order to avoid breaking the pins or damaging the glass-to-metal seals.

Target electrode

The connection to the target electrode is made at the face end of the tube by a spring contact which is part of the coil assembly.

Photoconductive layer

In some instances the properties of the photoconductive layer may slightly deteriorate during long idle periods, such as encountered between the manufacturer's last test and the first time of operation by the user. It is therefore recommended to operate the tube at approximately monthly intervals from receipt. To restore the photoconductive layer, the tube should be operated for a few hours with normal voltage settings and a signal current of 150nA, and should be adjusted to overscan an evenly illuminated target.

Signal-to-noise ratio

Since the tube does not generate noise to any noticeable extent, the signal-to-noise ratio will be determined mainly by the noise factor of the video amplifier system.

Under normal operation the high sensitivity of the tube produces a high signal-to-noise ratio provided that the output of the tube is fed into a well designed input stage of the video amplifier system. In such a system horizontal and vertical aperture correction may be incorporated to ensure sufficient gain in resolving power without significantly impairing the signal-to-noise ratio.

OPERATING INSTRUCTIONS

1. Clean the faceplate of the tube and insert in the coil assembly.

2. Carefully mate the socket with the base pins.

3. Place mask in front of and in close contact with faceplate.

4. Adjust the operating conditions as follows:

   (a) Grid bias control to maximum negative bias (beam cut-off).

   (b) Target electrode voltage to zero volts.

   (c) Scanning amplitudes to maximum (overscanning).

Mullard

OPERATING INSTRUCTIONS (contd.)

5. Switch on camera and picture monitor equipment. Allow a few minutes for warming up.

6. Adjust the monitor to produce a faint, non-overscanned raster.

7. Remove camera head from image intensifier unit.

8. Direct camera to lightbox or place suitable lightbox on objective holder. Switch on light and adjust illumination level to correspond to approximately 3 lux for the whites of the testchart on the faceplate.

9. Adjust target electrode voltage to the value indicated on the tube's test sheet.

10. Slowly adjust the grid bias control until a picture is produced on the monitor. If the picture is too faint, increase the lens aperture.

11. Adjust $V_{a2,a3}$ control (beam focus) and optical focus alternately for optimum focus.

12. Align the beam of the Plumbicon by one of the following methods:

    (a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when $V_{a2,a3}$ (beam focus) is varied. This is catered for automatically in some cameras.

    (b) Reduce the target electrode voltage to a very low value. Adjust the alignment fields until the most uniform picture is obtained, as observed on the monitor or an oscilloscope.

13. Decrease scanning amplitudes until a perfectly circular picture is produced on the monitor, with its diameter equal to the height of the monitor raster. This procedure may be facilitated by a small adjustment of the vertical centring control. Adjust the horizontal centring control until the circular picture is properly centred in the centre of the monitor raster.

14. Remove lightbox and attach camera head to image intensifier unit.

15. Place suitable image intensifier testchart in front of image intensifier. Switch on image intensifier and X-ray source.

16. Adjust optical focus and beam focus for maximum picture detail.

Mullard

OPERATING INSTRUCTIONS (contd.)

ALWAYS

Use full size scanning of the target and avoid underscanning.

Adjust sufficient beam current to stabilise the picture highlights.

Ensure that the deflection circuits are operative before turning on the beam current.

Avoid pointing the camera directly into the sun.

Keep the lens capped when transporting the camera.

Mullard

CAMERA TUBES
PLUMBICON*

XQ1023
XQ1023L
XQ1023R

TENTATIVE DATA

QUICK REFERENCE DATA

30mm diameter Plumbicon sensitive pick-up tubes with photoconductive layer, extended red response and high resolution. The tubes are provided with separate mesh for good uniformity of signal and resolution, good highlight handling and low velocity target stabilisation. An anti-halation glass disc is fitted.

XQ1023 – for use in monochrome television cameras
XQ1023L – provides the luminance component of a colour picture
XQ1023R – provides the red component of a colour picture

Dark current	< 3	nA
Resolution capability	> 700	TV lines
Transfer characteristic	linear	

GENERAL OPERATIONAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE are given on pages 6 to 8.

HEATER

Suitable for parallel operation only

V_h	6.3 ±5%	V
I_h	300	mA

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Image dimensions on photoconductive layer
3:4 aspect ratio (see note 1) — 12.8×17.1 mm

For correct orientation of the image on the photoconductive layer, the horizontal scan should be essentially parallel to the plane passing through the tube axis and the index pin.

CAPACITANCE

Target electrode to all other electrodes — 3 to 6 pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

*Registered trade mark for television camera tubes

Mullard

TYPICAL OPERATION

Operating conditions

V_k	0	V
V_{target}	45	V
V_{a3}	675	V
V_{a2}	600	V
V_{a1}	300	V
V_g adjusted to give the required beam current		
Scanned area	12.8×17.1	mm
Faceplate illumination	See note 2	
Faceplate temperature	20 to 45	$^{\circ}$C
Highlight signal current	300	nA
Beam current	600	nA

Typical performance

Dark current	< 3	nA

Resolution

Typical modulation depth measured at centre of picture for 400 TV lines, without aperture correction but corrected for losses introduced by the optical system:-

Highlight signal current	300	nA
Beam current	600	nA
Picture centre	55	%
Picture corners	40	%
Resolution capability	> 700	TV lines
Signal-to-noise ratio	See note 3	
Gamma of transfer characteristic (see note 4)	0.95 ± 0.05	
Wavelength at maximum response (approx.)	500	nm

Lag (see note 5)	XQ1023	XQ1023L	XQ1023R		
Signal current	300	40	150	40	nA
Beam current		600		300	nA
Typical residual signal after dark current of 60ms	3	14	5	13	%
Typical residual signal after dark pulse of 200ms	1.5	5	2	5	%

Sensitivity

XQ1023, XQ1023L (see note 6)	450	μA/lm
XQ1023R (see note 7)	160	μA/lm

Mullard

CAMERA TUBES
PLUMBICON

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	50	V
V_{a3} max.	1100	V
V_{a2} max.	800	V
V_{a3-a2} max.	350	V
V_{a1} max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
I_k max.	6	mA
$v_{h-k(pk)}$ max.		
Cathode positive	50	V
Cathode negative	50	V
Maximum faceplate illumination (see note 8)	500	lux
Faceplate temperature (operation and storage)		
Maximum	50	°C
Minimum	-30	°C
Minimum warm-up time of heater to be observed before drawing cathode current	1.0	min

EQUIPMENT DESIGN RECOMMENDATIONS

V_{target} (see note 9)	25 to 45	V
V_{a3}	650 to 700	V
V_{a2}	550 to 600	V
V_g	0 to -100	V
Minimum peak-to-peak blanking voltage		
when applied to the grid	70	V
when applied to the cathode	25	V

The current drawn by the tube from the first anode supply will not exceed 1.0mA.

MOUNTING POSITION	Any

WEIGHT

Tube alone (approx.)	100	g

ACCESSORIES (see separate data sheets)

Socket	56021
Coil assembly	
for XQ1023	AT1132, AT1132/01
for XQ1023L, R	AT1113/01

Mullard

NOTES

1. Underscanning of the useful target area of 12.8×17.1 mm, or failure of scanning, should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask to reduce the effects of internal reflections in the faceplate.

2. Adjusted to give the required peak signal current. For a typical XQ1023 or XQ1023L the required illumination will be approximately 3 lux. The signal currents stated for the XQ1023R will be obtained with an incident illumination of approximately 10 lux (2854K colour temperature), this figure being based on the use of the Schott OG2 3mm thick filter.

   Transmission curves for the filter are given on page 10.

   For a monochrome camera, the faceplate illumination is related to the scene illumination by the formula

$$B_{ph} = B_{sc} \frac{R \cdot T}{4 F^2 (m+1)^2}$$

   where B_{sc} = scene illumination

   B_{ph} = faceplate illumination

   R = scene reflectivity (average or that of the object under consideration, whichever is relevant)

   T = lens transmission factor

   F = lens aperture

   m = linear magnification from scene to target

   A similar formula may be derived for the illumination on the photoconductive layers of the XQ1023L, XQ1023R tubes, in which the effects of the various components in the complete optical system are taken into account.

3. The noise contribution of the Plumbicon tube is negligible compared with that of the head amplifier. A well designed head amplifier having a bandwidth of 5MHz will give an r.m.s. noise current of about 1.5nA, and at a peak signal current of 150nA this will result in a visual equivalent signal-to-noise ratio of 43dB.

4. Gamma is to a certain extent dependent on the wavelength of the incident illumination. The use of gamma-correcting circuits is recommended.

5. Measured with a signal current which has been flowing through the target for at least 30 seconds and the beam current sufficient to just stabilise the signal current. The figures in columns 2 and 4 are for the performance of the tubes under low-key conditions when overbeamed.

6. All measurements are made with an infra-red absorbing filter, Balzers, Calflex B1/K1 interposed between light source and target. Measured with 4.54 lux on the specified target area, when the infra-red absorbing filter is removed. The transmission curve for this filter is given on page 9.

7. Measured as in (6) but with Schott OG2 3mm thick filter interposed between light source and target.

   Transmission curve for the filter is given on page 10.

Mullard

8. For short intervals. During storage the tube face should be covered with the plastic hood provided. When the camera is idle the lens should be capped.

9. The target electrode voltage should be adjusted to 45V. If the scene to be televised contains excessive highlights, the target electrode voltage may be reduced to a minimum of 25V; this, however, will result in some reduction in performance, particularly in respect of sensitivity.

OUTLINE DRAWING OF XQ1023 SERIES

All dimensions in mm * Total glass thickness = 7.2±0.2

The maximum distance between the axis of anti-reflection glass disc and geometrical centre of the target electrode ring, measured in the plane of faceplate is 0.2mm. The base will fit a gauge as shown above. The holes in the gauge may deviate 0.01mm max. from their true geometric positions. The thickness of the gauge is 7mm. The ends of the pins are tapered or rounded but not brought to a sharp point.

Mullard

GENERAL OPERATIONAL RECOMMENDATIONS

Transport, handling and storage

During transport, handling or storage, the tube should be placed so that the face-plate is not below the level of the base.

Base pins

The pins of this tube are of tungsten. Accordingly, care must be taken when the tube and socket are mated, in order to avoid breaking the pins or damaging the glass-to-metal seals.

Target electrode

The connection to the target electrode is made at the face end of the tube by a spring contact which is part of the coil assembly.

Photoconductive layer

In some instances the properties of the photoconductive layer may slightly deteriorate during long idle periods, such as encountered between the manufacturer's last test and the first time of operation by the user. It is therefore recommended to operate the tube at approximately monthly intervals from receipt. To restore the photoconductive layer, the tube should be operated for a few hours with normal voltage settings and a signal current of 150nA, and should be adjusted to overscan an evenly illuminated target.

Light transfer

Because the light transfer characteristic has a gamma of approximately unity, it may be desirable for broadcast applications to incorporate a gamma-correcting circuit in the video system, with a gamma adjustable from 0.4 to 1.0. In addition, provision should be made for limiting the video signal above 100% of peak white level, in order to prevent overloading of the video amplifier system when the tube is exposed to scenes containing small peaked highlights as caused by reflections from shiny objects.

Signal-to-noise ratio

Since the tube does not generate noise to any noticeable extent, the signal-to-noise ratio will be determined mainly by the noise factor of the video amplifier system.

Under normal studio lighting conditions the high sensitivity of the tube produces a high signal-to-noise ratio provided that the output of the tube is fed into a well designed input stage of the video amplifier system. In such a system horizontal and vertical aperture correction may be incorporated to ensure sufficient gain in resolving power without significantly impairing the signal-to-noise ratio.

OPERATING INSTRUCTIONS

1. Clean the faceplate of the tube and insert in the coil assembly in such a way that the plane defined by the tube axis and the index pin is essentially parallel to the direction of the horizontal scan.

2. Carefully mate the socket with the base pins.

3. Cap the lens and close the iris.

OPERATING INSTRUCTIONS (contd.)

4. Adjust the operating conditions as follows:

   (a) Grid bias control to maximum negative bias (beam cut-off).

   (b) Target electrode voltage to 45V.

   (c) Scanning amplitudes to maximum (overscanning).

5. Switch on camera and picture monitor equipment. Allow a few minutes for warming up.

6. Adjust the monitor to produce a faint, non-overscanned raster.

7. Direct the camera towards the scene to be televised and uncap the lens.

8. Slowly adjust the grid bias control until a picture is produced on the monitor. If the picture is too faint, increase the lens aperture.

9. Adjust V_{a2} and V_{a3} control (beam focus) and optical focus alternately for optimum focus.

10. Align the beams of the Plumbicon by one of the following methods:

    (a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when V_{a2} and V_{a3} (beam focus) is varied. This is catered for automatically in some cameras.

    (b) Reduce the target electrode voltage to a very low value. Adjust the alignment fields until the most uniform picture is obtained, as observed on the monitor or an oscilloscope.

11. Adjust the scanning amplitudes as follows:

    (a) By means of a 12.8×17.1mm mask which is in contact with and centred on the faceplate. Decrease the horizontal and vertical scanning amplitudes until the periphery of the mask is just outside the raster on the monitor. This may be facilitated by small adjustments of the centring controls.

    (b) If no mask is available, direct the camera towards a test chart having an aspect ratio of 4:3 and adjust the centring controls in such a way that the target ring is just visible in the corners of the picture. Adjust the distance from camera to test chart, and re-focus until the image of the test chart is positioned on the faceplate as indicated on the adjoining figure.

    Decrease both scanning amplitudes until the image of the test chart completely fills the scanned raster on the monitor.

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OPERATING INSTRUCTIONS (contd.)

12. Adjust the iris for a picture of sufficient contrast and adjust the beam current to a value at which all highlights are stabilised.

13. Check alignment, beam focus and optical focus.

14. Procedure for standby operation

From operation to standby –

(a) Cap lens

(b) Set V_g for beam cut–off

(c) Reduce heater voltage to 4V or less

From standby to normal operation –

(a) Restore heater voltage to 6.3V

(b) Wait 1 minute

(c) Increase beam current to normal value

(d) Uncap lens

ALWAYS –

Use full size (12.8 × 17.1mm) scanning of the target and avoid underscanning.

Adjust sufficient beam current to stabilise the picture highlights.

Ensure that the deflection circuits are operative before turning on the beam current.

Operate a3 at a voltage equal to or more positive than a2.

Avoid pointing the camera directly into the sun.

Keep the lens capped when transporting the camera.

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Spectral sensitivity characteristic measured at a constant signal output
of 50nA from 12.8 × 17mm (except at low sensitivity values)

Typical transmission curve of heat-reflecting interference filter,
Type CALFLEX-B1/K1

Mullard

TRANSMISSION CURVES FOR SCHOTT FILTERS

Mullard

CAMERA TUBES
PLUMBICON*

QUICK REFERENCE DATA

These tubes are identical to XQ1023 series except for the quality of photo-conductive layer and are intended for industrial and educational cameras.

XQ1024 – for use in monochrome television cameras

XQ1024R – provides the red component of a colour picture

Dark current	< 3	nA
Resolution capability	> 700	TV lines
Transfer characteristic	linear	

Data identical to that of XQ1023 series

*Registered trade mark for television camera tubes.

Mullard

CAMERA TUBES
PLUMBICON*

XQ1025
XQ1025L
XQ1025R

QUICK REFERENCE DATA

30mm diameter Plumbicon sensitive pick-up tubes with photoconductive layer, extended red response and high resolution. The tubes are provided with separate mesh for good uniformity of signal and resolution, good highlight handling and low velocity stabilisation. The tubes are identical to XQ1023 series tubes but incorporate an infrared reflection filter on the anti-halation glass disc.

XQ1025   – provides monochrome pictures with true rendering of colour tones

XQ1025L – provides the luminance component of a colour picture

XQ1025R – provides the red component of a colour picture

Data identical to that of XQ1023 series tubes except for spectral response curves on page 2.

*Registered trade mark for television camera tubes.

Mullard

NOTES

1. The infrared reflecting filter eliminates the need for additional filters in the colour splitting system when XQ1025L and XQ1025R are used in colour cameras originally designed for XQ1020 series tubes. If applicable, an infrared absorbing filter for wavelengths in excess of 900nm should be incorporated in the optical system of the camera.

2. The filters for individual tubes have been selected so that the spreads in the spectral response in the longer wavelength region of XQ1023 series tubes are greatly reduced, thereby producing minimum differences in colour rendering between colour cameras of identical manufacture.

3. The filter consists of a hard coating on the anti-halation glass disc. Care must be taken to avoid scratches during handling and cleaning.

4. The data of XQ1023 series referring to B1/K1 filter does not apply.

TYPICAL SPECTRAL RESPONSE CURVES

Mullard

QUICK REFERENCE DATA

These tubes are identical to XQ1025 series tubes, except for the quality of photoconductive layer and are intended for industrial and educational cameras.

XQ1026   -- for use in monochrome television cameras

XQ1026R - provides the red component of a colour picture

Data identical to that of XQ1025 series

*Registered trade mark for television camera tubes.

Mullard

```
                        QUICK REFERENCE DATA

    25.5mm (1 inch) diameter vidicon television camera tube with integral mesh,
    low heater consumption, magnetic focusing, and magnetic deflection. Intended
    for use in low-cost industrial cameras, home cameras and for amateur use.

    Decay – residual signal after 50ms              25            %

    Resolution capability                          > 500       TV lines
```

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h $6.3 \pm 10\%$ V

I_h $110 \pm 10\%$ mA

When the tube is used in a series chain, the heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on.

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Maximum diagonal of quality rectangle
on photoconductive layer (aspect ratio 3:4)   16   mm

The direction of the horizontal scan should be essentially parallel to the plane defined by the short index pin and the longitudinal tube axis.

CAPACITANCE

Target electrode to all other electrodes   4.6   pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

Mullard

TYPICAL OPERATION

Operating conditions

$V_{a2,a3}$ (see note 1)	250 to 300	V
V_{a1}	300	V
V_g	adjusted for sufficient beam current to stabilise highlights	

Minimum peak-to-peak blanking voltage		
when applied to the grid	75	V
when applied to the cathode	20	V

Field strength at centre of focus coil (see note 2)	3.2	A/mm
Field strength of adjustable alignment coils or magnets	0 to 320	A/m
Scanned area	9.6×12.8	mm
Faceplate temperature	30 to 35	^{o}C

Typical performance

	Min.	Typ.	Max.	
Target electrode voltage for a dark current of 20nA	10	–	100	V
Output current at 20nA dark current (see note 3)	150	–	–	nA
Decay: residual signal current after dark pulse of 50ms (see notes 4,5,6)	–	25	35	%
Amplitude response at picture centre for 400 TV lines (see note 7)	25	40	–	%
Resolution capability at centre of picture	500	–	–	TV lines
Grid voltage for picture cut-off with no blanking applied	–45	–60	–110	V
Average gamma of transfer characteristic for signal currents between 20nA and 200nA	–	0.65	–	
Wavelength at maximum response (approx.)	–	550	–	nm

Spurious signals – shading

Tubes are rejected for smudge, lines, streaks, mottled background, grainy background, or uneven background having contrast ratios greater than 1.5:1.

Spurious signals – spots and blemishes
(see notes 5 and 8)

Mullard

CAMERA TUBE
VIDICON

XQ1032
(7262A)

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	100	V
$V_{a2,a3}$ max.	750	V
V_{a1} max.	750	V
$-V_g$ max.	300	V
$+V_g$ max.	0	V
I_k max.	2	mA
v_{h-k}(pk) max.		
Cathode positive	125	V
Cathode negative	10	V
Maximum peak output current (see note 9)	0.55	μA
Maximum peak dark current	250	nA
Maximum faceplate illumination	10 000	lux
Maximum faceplate temperature during storage and operation (see note 10)	70	^{o}C

Scanning of a 9.6mm × 12.8mm area of the photoconductive layer should always be applied. The use of a mask of these dimensions is recommended. Scanning of an area less than this may cause permanent damage to the specified full-size area.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	50	g

ACCESSORIES

Socket	Cinch No.54A18088 or equivalent
Coil assembly	AT1102 or equivalent

NOTES

1. Beam focus is obtained by the combined effect of the focus electrode (a2), the voltage of which should be adjustable over the indicated range, and a focus coil having an average field strength of 3.2A/mm.

2. The polarity of the focus coil should be such that a north-seeking pole, located outside but adjacent to the image end of the focus coil, will be attracted to the image end of the focus coil.

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NOTES (contd.)

3. With 10 lux (colour temperature = 2854K) on the faceplate.

4. With a dark current of 20nA and a signal current of 200nA.

5. The deflection circuit must provide sufficiently linear scanning for good black-level reproduction. Since the output current is proportional to the velocity of scanning, any change in this velocity will produce non-uniformity.

6. Signal current is defined as the component of the output current after the dark current has been subtracted.

7. Square wave response. Measured with a video amplifier system having an appropriate bandwidth.

8. Conditions:

Dark current 20nA and output current of 220nA.

The camera is focused on a uniformly illuminated two-zone test pattern. Zone 1 at the centre has a diameter equal to the raster height. Zone 2 occupies the remainder of the scanned area.

The scanning amplitudes of a rectangular monitor are adjusted to obtain a raster with an aspect ratio of 3:4. The monitor set-up and contrast control are adjusted for a faint raster when the lens of the camera is capped, and for a non-blooming bright raster when uncapped.

Under the above conditions the number and size of the spots visible in the monitor picture will not exceed the limits stated below. Both black and white spots are counted unless the amplitude is less than 50% of the peak white signal.

Spot size in % of raster height	Maximum number of spots	
	Zone 1	Zone 2
>0.9	none	none
0.9 to 0.6	2	2
0.6 to 0.3	2	3
<0.3	*	*

*Spots of this size are not counted unless their concentration is so high as to cause a smudgy appearance.

9. Video amplifiers should be capable of handling target-electrode currents of this magnitude without overloading the amplifier or distorting the picture.

10. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infrared filters should be used.

CAMERA TUBE
VIDICON

XQ1032
(7262A)

OUTLINE DRAWING OF XQ1032

All dimensions in mm

D2500

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CAMERA TUBES
PLUMBICON*

XQ1070   XQ1070/01
XQ1070L   XQ1070/01L
XQ1070R   XQ1070/01R
XQ1070G   XQ1070/01G
XQ1070B   XQ1070/01B

QUICK REFERENCE DATA

25.4mm (1 in) diameter Plumbicon camera tubes with photoconductive layer and separate mesh construction for broadcast, educational and high quality industrial applications. The basic types XQ1070, L, R, G, B are provided with an anti-halation glass disc, while the types XQ1070/01, L, R, G, B are with-out. These tubes are mechanically interchangeable with 1 inch vidicons with separate mesh and have the same pin connections.

XQ1070   - for use in monochrome television cameras
XQ1070L - provides the luminance component of a colour picture
XQ1070R - provides the red component of a colour picture
XQ1070G - provides the green component of a colour picture
XQ1070B - provides the blue component of a colour picture

Dark current	<3	nA
Resolution capability	>750	TV lines
Transfer characteristic	linear	

GENERAL OPERATIONAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE are given on pages 8 to 10.

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h	6.3 ± 5%	V
I_h	95	mA

When the tube is used in a series chain, the heater voltage must not exceed 9.5V r.m.s. when the supply is switched on. To avoid registration errors in colour cameras, stabilisation of the heater voltage is recommended.

FOCUSING   Magnetic

DEFLECTION   Magnetic

PHOTOCONDUCTIVE LAYER

Image dimensions on photoconductive layer
3:4 aspect ratio (see note 1)   9.6 × 12.8   mm

For correct orientation of the image on the photoconductive layer, the horizontal scan should be essentially parallel to the plane passing through the tube axis and the short index pin.

CAPACITANCE

Target electrode to all other electrodes   3 to 5   pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

*Registered trade mark for television camera tubes

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TYPICAL OPERATION

Operating conditions

Scanned area		9.6×12.8	mm
Faceplate temperature		20 to 45	^{o}C
Voltage mode	low	high	V
V_k	0	0	V
V_{target}	45	45	V
V_{a3} (see note 2)	600	960	V
V_{a2} (see note 2)	375	600	V
V_{a1}	300	300	V

V_g (see notes 3 and 4)
Faceplate illumination (see notes 4 and 5) $\Biggr\}$ Adjusted to give the values of I_s and I_b shown below.

Letter suffix: -	none, L, G	R, B	
Highlight signal current (I_s)	200	100	nA
Beam current (I_b)	400	200	nA

Typical performance

Dark current	<3	nA

Resolution (see note 6)

Typical modulation depth measured at centre of picture for 400 TV lines, without aperture correction, in the high voltage mode. The typical figure obtained in the low voltage mode will be 2 to 3% lower.

XQ1070 and /01, XQ1070L and /01L	40	%
XQ1070R, XQ1070/01R	35	%
XQ1070G, XQ1070/01G	40	%
XQ1070B, XQ1070/01B	45	%
Resolution capability	>750	TV lines
Gamma of transfer characteristic (see note 7)	0.95 ± 0.05	

Wavelength (approx.) (see page 11)
at maximum response   490   nm

Sensitivity (see note 8)

	Minimum	Typical	
XQ1070 and /01, XQ1070L and /01L	325	400	µA/1m
XQ1070R, XQ1070/01R	70	80	µA/1m
XQ1070G, XQ1070/01G	130	165	µA/1m
XQ1070B, XQ1070/01B	35	37	µA/1m

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Lag (typical values)

Light source - colour temperature 2854K

Filter - appropriate filter used for types ending R, G or B (See note 8)

Low key conditions	Build-up lag (see note 9)				Decay lag (see note 10)				
Time interval	60	200	60	200	60	200	60	200	ms
I_s	20	20	40	40	20	20	40	40	nA
I_b	200	200	400	400	200	200	400	400	nA
Suffix R, B	90	98			11	4			%
Suffix none, L, G			95	99			7	2.5	%

High key conditions

	Build-up lag				Decay lag				
Time interval	60	200	60	200	60	200	60	200	ms
I_s	100	100	200	200	100	100	200	200	nA
I_b	200	200	400	400	200	200	400	400	nA
Suffix R	97	100			2.5	1			%
Suffix B	97	100			3.5	2			%
Suffix none, L, G			98	100			1.5	0.6	%

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max. (see note 11)	50	V
V_{a3} max.	1100	V
V_{a2} max.	800	V
V_{a3-a2} max.	450	V
V_{a1} max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
I_k max.	3.0	mA
$V_{h-k(pk)}$ max.		
Cathode positive	125	V
Cathode negative	50	V

RATINGS (ABSOLUTE MAXIMUM SYSTEM) (contd.)

Z_{h-k} min. at v_{h-k} pk >10V (k -ve)	2.0	kΩ
Maximum faceplate illumination (see note 12)	500	lux
†Maximum faceplate temperature (operation and storage)	50	^oC
Minimum faceplate temperature (operation and storage)	-30	^oC
Minimum warm-up time of heater to be observed before drawing cathode current	1.0	min

†During long term storage the ambient temperature should not exceed 30^oC

EQUIPMENT DESIGN RECOMMENDATIONS

	low	high	
V_{target} (see note 13)	25 to 45	25 to 45	V
V_{a3}	570 to 630	920 to 1000	V
V_{a2}	350 to 400	570 to 630	V
V_g	0 to -100	0 to -100	V
Minimum peak-to-peak blanking voltage			
when applied to the grid		70	V
when applied to the cathode		25	V

The current drawn by the tube from the first anode supply will not exceed 1mA.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	60	g

ACCESSORIES (see separate data sheets)

Socket	Cinch no. 54A18088 or equivalent
Coil assemblies - monochrome cameras	AT1102/01, AT1103 or equivalent
- colour cameras	AT1116 or equivalent
(see note 14)	

NOTES

1. Underscanning of the useful target area of 9.6×12.8mm, or failure of scanning, should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask to reduce the effects of internal reflections in the faceplate.

2. V_{a2} and V_{a3} are adjusted for optimum beam focus. The optimum voltage V_{a3-a2} to obtain minimum beam landing errors (should be ≤2) depends on the type of coil assembly used. For the types specified a ratio of 1.5:1 to 1.6:1 is recommended.

NOTES (contd.)

3. V_g is adjusted to give the specified beam current (I_b) as required by the tube type. I_b is defined as the maximum amount of signal current (I_s) that can be obtained at a given setting of V_g.

4. In the performance figures, e.g. for resolution and lag, the signal current and beam current conditions are given, e.g. as $I_s = 20nA$, $I_b = 200nA$. This means a signal current of 20nA and a beam setting which just allows a signal current of 200nA.

    N.B. The signal currents are measured with an integrating instrument connected in the signal electrode lead and a uniform illumination on the scanned area. The peak signal currents as measured on a wave-form oscilloscope will be a factor α larger.

    $(\alpha = \dfrac{100}{100-\beta}$, β = total blanking time in %. For the CCIR system $\alpha = 1.33)$

5. Face plate illumination is adjusted to give the specified highlight signal current as required by the tube type. For a typical XQ1070 or XQ1070/01 the required illumination will be approximately 5 lux. The signal currents stated for the XQ1070R, G, B and XQ1070/01R, G, B will be obtained with an illumination of approximately 12.5 lux (2854K colour temperature), and with the appropriate filter inserted in the light path.

    For XQ1070R and /01R Schott OG570 thickness 3mm
    XQ1070G and /01G Schott VG9 thickness 1mm
    XQ1070B and /01B Schott BG12 thickness 3mm
    Transmission curves for these filters are given on page 11.

    For a monochrome camera, the faceplate illumination is related to the scene illumination by the formula

    $$B_{ph} = B_{sc} \frac{R.T}{4F^2(m+1)^2}$$

    where B_{sc} = scene illumination

    B_{ph} = faceplate illumination

    R = scene reflectivity (average or that of the object under consideration, whichever is relevant)

    T = lens transmission factor

    F = lens aperture

    m = linear magnification from scene to target

    A similar formula may be derived for the illumination on the photoconductive layers of the R, G and B tubes, in which the effects of the various components in the complete optical system are taken into account.

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NOTES (contd.)

6. The horizontal amplitude response can be raised by the application of suitable correction circuits which affect neither the vertical resolution nor the limiting resolution.

7. Gamma is to a certain extent dependent on the wavelength of the incident illumination. The use of gamma-correcting circuits is recommended.

8. As measured under the following conditions:

Tubes are exposed to an illumination of 4.0 lux at a colour temperature of 2854K. The appropriate filter is inserted in the light path. The current obtained is a measure of the colour sensitivity, and is expressed in micro-amperes per lumen of white light before the filter.

Filters used as listed in note 5.

9. After 10s of complete darkness. The figures given represent typical percentages of the ultimate signal current obtained 60ms or 200ms respectively after the illumination has been applied.

10. After a minimum of 5s of illumination on the target the figures given represent typical residual signals in percentages of the original signal current 60ms or 200ms respectively after the illumination has been removed.

11. Automatic sensitivity control cannot be obtained in Plumbicon tubes by regulating the target electrode voltage. Adequate control can be achieved by iris control and neutral density filters.
When a Plumbicon tube is used in cameras originally designed for vidicon tubes, the automatic sensitivity control circuits should be made inoperative and the target electrode voltage set to 45V.

12. For short intervals. During storage the tube face should be covered with the plastic hood provided. When the camera is idle the lens should be capped.

13. The target electrode voltage should be adjusted to 45V. If the scene to be televised contains excessive highlights, the target electrode voltage may be reduced to a minimum of 25V; this, however, will result in some reduction in performance, particularly in respect of sensitivity.

14. Approximate values of focus, line and field currents for a scanned area of 9.6 × 12.8mm.

	Focus current†† (mA)		Line current (peak mA)		Field current (peak mA)	
At V_{a3} (V)	600	960	600	960	600	960
At V_{a2} (V)	375	600	375	600	375	600
Unit AT1102/01	18	23	200	250	27	34
Unit AT1103	20	26	200	250	29	38
Unit AT1116	83	105	260	330	38	48

††Adjusted for correct electrical focus. The direction of the focus current is such that a north-seeking pole is attracted towards the image end of the focus coil.

Maximum line and field alignment coil currents are 21mA for AT1103 and 15mA for AT1116 corresponding to a flux density of approximately 400μT (4Gs).

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OUTLINE DRAWING OF XQ1070 SERIES

Short index pin

Target electrode

a2
g
a3
a1

k h h

Inner diameter of guard ring $^{21.2}_{20.8}$

Faceplate refractive index 1.49
anti-halation disc refractive index 1.52

All dimensions in mm

$\phi^{20.4}_{20.1}$

5.1
4.9

$\phi^{28.6}_{28.2}$

3.1
2.9

1.4
1.2

Anti-halation glass disc not on types with /01 suffix

162
154

ϕ^{26}_{25}

0.4 max

Resin

$\phi 26.6$ max

9.3 min

12.8 max

3.0 max

5.0 max

$\phi 1.27 ^{+0.05}_{-0.10}$

$\phi 6.8$ max

D5829

GENERAL OPERATIONAL RECOMMENDATIONS

Transport, handling and storage

During transport, handling or storage, the tube should be placed so that the face-plate is not below the level of the base.

Base pins

The pins of this tube are of Kovar. Accordingly, care must be taken when the tube and socket are matched, in order to avoid damaging the pins or the glass-to-metal seals.

Target electrode

The connection to the target electrode is made at the face end of the tube by a spring contact which is part of the coil assembly.

Photoconductive layer

In some instances the properties of the photoconductive layer may slightly deter-iorate during long idle periods, such as encountered between the manufacturer's last test and the first time of operation by the user. It is therefore recommended to operate the tube at approximately monthly intervals from receipt. To restore the photoconductive layer, the tube should be operated for a few hours with nor-mal voltage settings and a signal current of 150nA, and should be adjusted to overscan an evenly illuminated target.

Light transfer

Because the light transfer characteristic has a gamma of approximately unity, it may be desirable for broadcast applications to incorporate a gamma-correcting circuit in the video system, with a gamma adjustable from 0.4 to 1.0. In addi-tion, provision should be made for limiting the video signal above 100% of peak white level, in order to prevent overloading of the video amplifier system when the tube is exposed to scenes containing small peaked highlights as caused by reflections from shiny objects.

Signal-to-noise ratio

Since the tube does not generate noise to any noticeable extent, the signal-to-noise ratio will be determined mainly by the noise factor of the video amplifier system.

Under normal studio lighting conditions the high sensitivity of the tube produces a high signal-to-noise ratio provided that the output of the tube is fed into a well designed input stage of the video amplifier system. In such a system horizontal and vertical aperture correction may be incorporated to ensure sufficient gain in resolving power without significantly impairing the signal-to-noise ratio.

OPERATING INSTRUCTIONS

1. Clean the faceplate of the tube and insert in the coil assembly in such a way that the plane defined by the tube axis and the mark on the base is essentially para-llel to the direction of the vertical scan.

2. Carefully mate the socket with the base pins.

3. Cap the lens and close the iris.

OPERATING INSTRUCTIONS (contd.)

4. Adjust the operating conditions as follows:

   (a) Grid bias control to maximum negative bias (beam cut-off)

   (b) Target electrode voltage to 45V.

   (c) Scanning amplitudes to maximum (overscanning)

5. Switch on camera and picture monitor equipment. Allow a few minutes for warm-ing up.

6. Adjust the monitor to produce a faint, non-overscanned raster.

7. Direct the camera towards the scene to be televised and uncap the lens.

8. Slowly adjust the grid bias control until a picture is produced on the monitor. If the picture is too faint, increase the lens aperture.

9. Adjust V_{a2} control (beam focus) and optical focus alternately for optimum focus.

10. Align the beams of the Plumbicon by one of the following methods:

   (a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when V_{a2} (beam focus) is varied. This is cat-ered for automatically in some cameras.

   (b) Reduce the target electrode voltage to a very low value. Adjust the align-ment fields until the most uniform picture is obtained, as observed on the monitor or an oscilloscope.

11. Adjust the scanning amplitudes as follows:

   (a) By means of a 9.6 × 12.8mm mask which is in contact with and centred on the faceplate. Decrease the horizontal and vertical scanning amplitudes until the periphery of the mask is just outside the raster on the monitor. This may be facilitated by small adjustments of the centring controls.

   (b) If no mask is available, direct the camera towards a test chart having an aspect ratio of 4:3 and adjust the centring controls in such a way that the target ring is just visible in the corners of the picture. Adjust the distance from camera to test chart, and re-focus until the image of the test chart is positioned on the face-plate as indicated on the adjoining figure.

Decrease both scanning amplitudes until the image of the test chart com-pletely fills the scanned raster on the monitor.

12. Adjust the iris for a picture of sufficient contrast and adjust the beam current to a value at which all highlights are stabilised.

13. Check alignment, beam focus and optical focus.

14. Procedure for standby operation

From operation to standby -

(a) Cap lens

(b) Set V_g for beam cut-off

(c) Switch off heater

From standby to normal operation -

(a) Restore heater voltage to 6.3V

(b) Wait 1 minute

(c) Increase beam current to normal value

(d) Uncap lens

ALWAYS -

Use full size (9.6 × 12.8mm) scanning of the target and avoid underscanning.

Adjust sufficient beam current to stabilise the picture highlights.

Ensure that the deflection circuits are operative before turning on the beam current.

Operate a3 at a voltage equal to or more positive than a2.

Avoid pointing the camera directly into the sun.

Keep the lens capped when transporting the camera.

Mullard

TRANSMISSION CURVES FOR SCHOTT FILTERS

TYPICAL SPECTRAL RESPONSE CURVE

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CAMERA TUBES
PLUMBICON*

XQ1071   **XQ1071/01**
XQ1071R   **XQ1071/01R**
XQ1071G   **XQ1071/01G**
XQ1071B   **XQ1071/01B**

QUICK REFERENCE DATA

25.4mm (1 in) diameter Plumbicon camera tubes with photoconductive layer and separate mesh construction for industrial, educational and medical appli- cations. The basic types XQ1071, R, G, B are provided with an anti-halation glass disc, while the types XQ1071/01 R, G, B are without. These tubes are mechanically interchangeable with 1 inch vidicons with separate mesh and have the same pin connections.

XQ1071   - for use in monochrome television cameras
XQ1071R - provides the red component of a colour picture
XQ1071G - provides the green component of a colour picture
XQ1071B - provides the blue component of a colour picture

Dark current	<3	nA
Resolution capability	>750	TV lines
Transfer characteristic	linear	

Data identical to that of XQ1070 and XQ1070/01 series.

*Registered trade mark for television camera tubes

Mullard

CAMERA TUBES
PLUMBICON*

XQ1080 XQ1080R
XQ1080L XQ1080G
XQ1080B

QUICK REFERENCE DATA

25.4mm (1 in) diameter Plumbicon camera tubes with high resolution photo-conductive layer and separate mesh construction for broadcast, educational and high quality industrial applications in which high contrast ratios may occur. Features of these tubes include anti-comet-tail (A.C.T.) electron gun for highlight handling, extremely low lag, lightpipe for adjustable bias lighting to minimise lag under low-key conditions, anti-halation glass disc and a low output capacitance for improved signal to noise ratio.

The precision construction of the electrode system, the ceramic centring ring and the rear loading coil unit combine to form a system giving precise optical and electrical alignment.

XQ1080   - for use in monochrome television cameras
XQ1080L   - provides the luminance component of a colour picture
XQ1080R   - provides the red component of a colour picture
XQ1080G   - provides the green component of a colour picture
XQ1080B   - provides the blue component of a colour picture

Dark current (without bias lighting)	≤ 3	nA
Resolution capability	>750	TV lines
Transfer characteristic	linear	

GENERAL OPERATIONAL RECOMMENDATIONS AND INSTRUCTIONS FOR USE are given on pages 10 to 12.

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h	6.3 ± 5%	V
I_h	95	mA

When the tube is used in a series chain, the heater voltage must not exceed 9.5V r.m.s. when the supply is switched on. To avoid registration errors in colour cameras, stabilisation of the heater voltage is recommended.

FOCUSING   Magnetic

DEFLECTION   Magnetic

PHOTOCONDUCTIVE LAYER

Image dimensions on photoconductive layer
3:4 aspect ratio (see note 1)   9.6×12.8   mm

For correct orientation of the image on the photoconductive layer, the horizontal scan should be essentially parallel to the plane passing through the tube axis and the marker line on the protecting sleeve at the base (see note 2).
Optical alignment (see note 3).

CAPACITANCE

Target electrode to all other electrodes   2 to 3   pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

*Registered trade mark for television camera tubes

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TYPICAL OPERATION

Operating conditions with anti-comet-tail action (see notes 4, 5 and 6)

All voltages are specified with respect to cathode during read-out mode.

Scanned area		9.6×12.8	mm
Mode (see note 7)	read-out	A.C.T.	
V_k (see note 8)	0	0 to 15	V
V_{target} (see note 9)	45	45	V
V_{a5} (see notes 10 and 11)	750	750	V
V_{a4} (see note 10)	475	475	V
V_{a2} (see note 8)	250	0 to 30	V
$V_{a1, a3}$	300	300	V
V_g see notes: -	12	8	
Grid blanking peak voltage (see note 13)	50	50	V

Faceplate illumination (see note 14)

Typical beam current, signal current and pulse settings (see note 8): -

	XQ1080 XQ1080L	XQ1080R	XQ1080G	XQ1080B	
Peak signal current	200	100	200	100	nA
Peak beam current	400	200	400	200	nA
Peak A.C.T. level	280	140	280	140	nA
Cathode pulse	10	5	10	5	V
Grid pulse	40	30	40	30	V
A_2 pulse	220 to 250	220 to 250	220 to 250	220 to 250	V

Bias lighting via lightpipe (see notes 15 and 16)

Temperature of faceplate	20 to 45	°C

Deflection, focus and alignment coil assembly   AT1115

Deflection, focus and alignment currents at V_{a5} 750V, V_{a4} 475V: -

Focus current (see note 17)	32	mA
Line current (peak to peak)	290	mA
Field current (peak to peak)	35	mA

Maximum line and field alignment current ± 15mA, corresponding to a flux density of approximately 4×10^{-4}T (4Gs).

Typical performance

Dark current (without bias lighting)	≤ 3	nA

Sensitivity at colour temp. 2854K (see note 18)

	Minimum	Typical	
XQ1080	325	400	μA/lm
XQ1080L	325	400	μA/lm
XQ1080R	70	80	μA/lm
XQ1080G	130	165	μA/lm
XQ1080B	35	37	μA/lm

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Typical performance (contd)

Gamma of transfer characteristic (see note 19)
Transfer characteristics (see graph on page 14)
Highlight handling (see note 8)   min. 5 lens stops
Spectral response: -   max. response at   approx. 500   nm
          cut-off at   approx. 650   nm

Resolution

Modulation depth, i.e. uncompensated amplitude response at 400 TV lines at the centre of the picture. The figures represent the typical horizontal amplitude response as measured with a lens aperture of f5.6. (see notes 12, 20 and 21).

	XQ1080 XQ1080L	XQ1080R	XQ1080G	XQ1080B	
Peak highlight signal current	200	100	200	100	nA
Peak beam current	400	200	400	200	nA
Typical modulation depth	40	35	40	45	%

Modulation transfer characteristics (see graph on page 14)
Limiting resolution ≥ 750 TV lines

Lag (typical values)

Light source - colour temperature 2854K
Filter - appropriate filter used for types ending R, G or B
Bias lighting - see notes 15 and 16

Low key conditions	Extra dark current (nA)	Build-up lag (see note 22)		Decay lag (see note 23)			
Time interval		60	200	60	200	60	200	60	200	ms
I_s		20	20	40	40	20	20	40	40	nA
I_b		200	200	400	400	200	200	400	400	nA
XQ1080	0		98	100			5	2	%
XQ1080L	2.5		100	100			2.5	1	%
XQ1080G	5		100	100			1.5	0.5	%
XQ1080R XQ1080B	0	>95	100		8	3			%
	2.5	100	100		3.5	2			%
	5	100	100		1.5	1			%

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High key conditions	Extra dark current (nA)	Build-up lag (see note 22)				Decay lag (see note 23)				
Time interval		60	200	60	200	60	200	60	200	ms
I_s		100	100	200	200	100	100	200	200	nA
I_b		200	200	400	400	200	200	400	400	nA
XQ1080 XQ1080L XQ1080G	0 to 5			98	100			1.5	0.6	%
XQ1080R	0 to 5	>97	100			2.5	1			%
XQ1080B	0 to 5	>97	100			3.5	2			%

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	50	V
V_{a5} max.	1100	V
V_{a4} max.	800	V
V_{a5-a4} difference max.	350	V
V_{a2} max.	350	V
$V_{a1, a3}$ max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
Grid A.C.T. pulse max. (see notes 5 and 8)	45	V
$v_{h-k(pk)}$ max.		
Cathode positive	125	V
Cathode negative	50	V
Z_{h-k} min. at v_{h-k} pk > 10V (k -ve)	2	kΩ
Maximum faceplate illumination (see note 24)	500	lux
Maximum faceplate temperature (operation and storage)	50	°C
Minimum faceplate temperature (operation and storage)	-30	°C

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx)	70	g

ACCESSORIES

Socket (see note 15)   Cinch 133-98-11-015 modified for bias lighting

Coil assembly set   AT1115

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NOTES

1. Underscanning of the useful target area of 9.6×12.8mm, or failure of scanning, should be avoided, since this may cause damage to the photoconductive layer. The boundaries outside this area should preferably be covered by a mask to reduce the effects of internal reflections in the faceplate.

2. The position of this marker line corresponds with the position of the small area contact on the ceramic centring ring. The spring contact in the coil unit, AT1115, is located accordingly. Total possible rotation of the tube while maintaining contact, is approx. 30°.

3. The outer diameter of the ceramic centring ring is concentric with the inner diameter of the mesh ring (anode 5). In the AT1115 coil unit the tube is centred with this ring as a reference, this ensures proper optical alignment of the tube in the optical system of a colour camera.

4. When the tube is to be used without anti-comet-tail action, anode 2 should be connected to anodes 1 and 3, and no A.C.T. pulses should be applied to the cathode and grid. The performance of the tube will then be as described herein with the exception of the highlight handling.

5. Pulse timing and amplitudes for A.C.T. action (CCIR system)

   (blanking on grid - see notes 7 and 13)

   For proper operation of the A.C.T. electrode gun three pulses are required, being:

   a. - A positive-going pulse on the cathode with an adjustable amplitude of 0 to 15V. This pulse can be chosen to coincide with the full line-blanking period.

   b. - A positive-going pulse on the grid with an adjustable amplitude of 25 to 40V. The duration of this pulse should be chosen such that it just includes the fly back period ($\approx 5\mu s$) of the line deflection (e.g. $\approx 6\mu s$).

   c. - A negative-going pulse on anode 2 with an amplitude of approx. 250V, adjusted to result in a V_{a2} voltage during the A.C.T. mode of 0 to 30V. Duration of this pulse should be equal to that of the grid pulse.

The timing diagram is as follows:

A = Line blanking period: = 12μs, V_k pulse
B = A.C.T. period: = 5μs, grid and anode 2 pulses
C = Line flyback period: = 5μs
D = Clamping time: 2 to 3μs

05898

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NOTES (contd.)

6. The D.C. voltage supply and/or pulse supply to these electrodes should have a sufficiently low impedance to prevent distortion caused by the peak currents drawn during the A.C.T. mode.

These peak currents may amount to:

cathode	2mA
grid	0mA
anodes 1 and 3	1mA
anode 2	150μA
anode 4	300μA
anode 5	300μA

The cathode impedance should preferably be chosen $\leq$ 300Ω.

Video pre-amplifier. In the presence of highlights, peak signal currents of the order of 15-45μA may be offered to the pre-amplifier during flyback. Special measures have to be taken in the pre-amplifier to prevent temporary overloading.

7. a. - Read-out mode: defined as the operating conditions during the active line scan (full line period - line blanking interval).
For the CCIR system this will amount to 64μs - 12μs = 52μs.

b. - A.C.T. mode: defined as the operating conditions during that part of the line blanking interval during which the A.C.T. electrode gun is fully operative. The A.C.T. interval is equal to or slightly overlaps the line flyback time.

8. Pulse amplitude settings

Cathode pulse V_k : adjusted to obtain an A.C.T. limiting level at 1.3 to 1.5 times peak signal white current.

Anode 2 pulse : adjusted for maximum and most uniform A.C.T. action over the total scanned area.

Grid pulse : adjusted for proper handling of a highlight with a diameter of 10% of picture height and with a brightness corresponding to 32 times peak signal white.

N.B. Extension of the A.C.T. range can be obtained by increasing the grid pulse; this may, however, introduce dark current.

9. Plumbicon tubes do not permit automatic sensitivity control by means of regulation of the target electrode voltage. Adequate control is therefore to be achieved by other means (iris control and neutral density filters).
If the tube is applied in cameras originally designed for vidicon tubes, the automatic sensitivity control circuitry should be made inoperative and the target electrode voltage set to 45V.

10. The optimum voltage ratio V_{a5}/V_{a4} to obtain minimum beam landing errors (preferably $\leq$ 1V) depends on the type of coil unit used. For type AT1115 a ratio of 1.5:1 to 1.6:1 is recommended.

11. Operation with A.C.T. at V_{a5} > 750V is not recommended since this may introduce dark current.

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NOTES (contd.)

12. Adjusted with the A.C.T. made inoperative, e.g. by setting the cathode pulse to 15V. The grid voltage is adjusted to produce a beam current just sufficient to allow a peak signal current of twice the typical value, I_{sp}, as observed and mea - sured on a waveform oscilloscope. This amount of beam current is termed I_{bp}.

N.B. The signal current, I_s, and beam current, I_b, conditions quoted with the performance figures for e.g., lag, relate to measurements with an inte-grating instrument connected in the target electrode lead and a uniform illumination on the scanned area.

The corresponding peak currents, I_{sp} and I_{bp}, as measured on a waveform oscilloscope will be a factor α larger ($\alpha = 100/100 -\beta$), β being the total blanking time in %; for CCIR system α amounts to 1.33.

13. Blanking can also be applied to the cathode:

a. - without A.C.T. action (see note 4), required cathode pulse approx. 25V.

b. - with A.C.T. action: timing, polarity and amplitudes of the A.C.T. pulses will have to be adapted.

14. In the case of a monochrome camera the illumination on the photoconductive layer, B_{ph}, is related to scene illumination, B_{sc}, by the formula:

$$B_{ph} = B_{sc} \frac{R.T.}{4F^2 (m + 1)^2}$$

in which R represents the average scene reflectivity or the object reflectivity, whichever is relevant, T the lens transmission factor, F the lens aperture, and m the linear magnification from scene to target.

A similar formula may be derived for the illumination level in the photoconduct-ive layers of the R, G and B tubes in which the effects of the various components of the complete optical system have been taken into account.

15. The special socket incorporates a small incandescent light bulb (6V, 1W), which projects its light on to the pumping stem via a blue-green transmitting filter. The light is conducted via a fine glass rod (lightpipe) to cause a bias illumination on the target. The desired amount of bias light can be obtained by adjusting the current through the filament of the small bulb.

16. For monochrome operation a bias lighting, corresponding to 2 to 3nA extra dark current, is usually adequate for excellent speed of response.

In a colour camera the speeds of response of the tubes can be balanced by adjust - ing the amount of bias lighting per tube.

17. Focus current adjusted for correct electrical focus. The direction of the focus current shall be such that a north seeking pole is attracted towards the image end of the focus coil, with this pole located outside of and at the image end of the focus coil.

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NOTES (contd.)

18. Measuring conditions:

Illumination 4 lux (luminous flux = 0.5 mlm) at black body temperature of 2854K, the appropriate filter inserted in the light path.

Filters used:

XQ1080R	Schott	OG570	thickness	3 mm
XQ1080G	Schott	VG9	thickness	1 mm
XQ1080B	Schott	BG12	thickness	3 mm

For transmission curves see page 13.

19. Gamma-stretching circuitry is recommended.

20. Typical faceplate illumination level for the XQ1080 to produce 200nA signal current will be approx. 4 lux. The signal current stated for the colour tubes R, G, B will be obtained with an incident white light level (c.t. = 2854K) on the filter of approx. 10 lux. These figures are based on the filters described in note 18). For filter BG12, however, a thickness of 1mm is chosen.

21. The horizontal amplitude response can be raised by the application of suitable correction circuits, which affects neither the vertical resolution nor the limiting resolution.

22. After 10 seconds of complete darkness. The figures given represent typical percentages of the ultimate signal current obtained 60ms or 200ms respectively after the illumination has been applied.

23. After a minimum of 5s of illumination on the target. The figures given represent typical residual signals in % of the original signal current 60ms or 200ms respectively after the illumination has been removed.

24. For short intervals. During storage the tube face should be covered with the plastic hood provided; when the camera is idle the lens should be capped.

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OUTLINE DRAWING OF XQ1080 SERIES

Faceplate thickness 1.2 mm

Faceplate refractive index 1.49

Anti-halation disc refractive index 1.52

All dimensions in mm   D5887

Mullard

GENERAL OPERATIONAL RECOMMENDATIONS

Transport, handling and storage

During transport, handling or storage, the tube should be placed so that the face-plate is not below the level of the base.

Base pins

The pins of this tube are of Kovar. Accordingly, care must be taken when the tube and socket are matched, in order to avoid damaging the pins or the glass-to-metal seals.

Target electrode

The connection to the target electrode is made at the face end of the tube by a spring contact which is part of the coil assembly.

Photoconductive layer

In some instances the properties of the photoconductive layer may slightly deteriorate during long idle periods, such as encountered between the manufacturer's last test and the first time of operation by the user. It is therefore recommended to operate the tube at approximately monthly intervals from receipt. To restore the photoconductive layer, the tube should be operated for a few hours with normal voltage settings and a signal current of 150nA, and should be adjusted to overscan an evenly illuminated target.

Light transfer

Because the light transfer characteristic has a gamma of approximately unity, it may be desirable for broadcast applications to incorporate a gamma-correcting circuit in the video system, with a gamma adjustable from 0.4 to 1.0. In addition, provision should be made for limiting the video signal above 100% of peak white level, in order to prevent overloading of the video amplifier system when the tube is exposed to scenes containing small peaked highlights as caused by reflections from shiny objects.

Signal-to-noise ratio

Since the tube does not generate noise to any noticeable extent, the signal-to-noise ratio will be determined mainly by the noise factor of the video amplifier system.

Under normal studio lighting conditions the high sensitivity of the tube produces a high signal-to-noise ratio provided that the output of the tube is fed into a well designed input stage of the video amplifier system. In such a system horizontal and vertical aperture correction may be incorporated to ensure sufficient gain in resolving power without significantly impairing the signal-to-noise ratio.

OPERATING INSTRUCTIONS

1. Clean the faceplate of the tube and insert in the coil assembly in such a way that the plane defined by the tube axis and the mark on the base is essentially parallel to the direction of the vertical scan.

2. Carefully mate the socket with the base pins.

3. Cap the lens and close the iris.

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OPERATING INSTRUCTIONS (contd.)

4. Adjust the operating conditions as follows:

   (a) Grid bias control to maximum negative bias (beam cut-off)

   (b) Target electrode voltage to 45V.

   (c) Scanning amplitudes to maximum (overscanning)

5. Switch on camera and picture monitor equipment. Allow a few minutes for warming up.

6. Adjust the monitor to produce a faint, non-overscanned raster.

7. Direct the camera towards the scene to be televised and uncap the lens.

8. Slowly adjust the grid bias control until a picture is produced on the monitor. If the picture is too faint, increase the lens aperture.

9. Adjust V_{a2} control (beam focus) and optical focus alternately for optimum focus.

10. Align the beams of the Plumbicon tube by one of the following methods:

    (a) Adjust the alignment fields in such a way that the centre of the picture on the monitor does not move when V_{a2} (beam focus) is varied. This is catered for automatically in some cameras.

    (b) Reduce the target electrode voltage to a very low value. Adjust the alignment fields until the most uniform picture is obtained, as observed on the monitor or an oscilloscope.

11. Adjust the scanning amplitudes as follows:

    (a) By means of a 9.6 × 12.8mm mask which is in contact with and centred on the faceplate. Decrease the horizontal and vertical scanning amplitudes until the periphery of the mask is just outside the raster on the monitor. This may be facilitated by small adjustments of the centring controls.

    (b) If no mask is available, direct the camera towards a test chart having an aspect ratio of 4:3 and adjust the centring controls in such a way that the target ring is just visible in the corners of the picture. Adjust the distance from camera to test chart, and re-focus until the image of the test chart is positioned on the faceplate as indicated on the adjoining figure.

    Decrease both scanning amplitudes until the image of the test chart completely fills the scanned raster on the monitor.

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OPERATING INSTRUCTIONS (contd.)

12. Adjust the iris for a picture of sufficient contrast and adjust the beam current to a value at which all highlights are stabilised.

13. Check alignment, beam focus and optical focus.

14. Procedure for standby operation

From operation to standby -

(a) Cap lens

(b) Set V_g for beam cut-off

(c) Switch off heater

From standby to normal operation -

(a) Restore heater voltage to 6.3V

(b) Wait 1 minute

(c) Increase beam current to normal value

(d) Uncap lens

ALWAYS -

Use full size (9.6 × 12.8mm) scanning of the target and avoid underscanning.

Adjust sufficient beam current to stabilise the picture highlights.

Ensure that the deflection circuits are operative before turning on the beam current.

Operate a5 at a voltage equal to or more positive than a4.

Avoid pointing the camera directly into the sun.

Keep the lens capped when transporting the camera.

Mullard

TRANSMISSION CURVES FOR SHOTT FILTERS

D5888

Modulatioռ depth(%)

V_{a5} = 750V
V_{a4} = 475V
$V_{a1,a3}$ = 300V
I_s = 200nA
I_b = 400nA

blue
green
white
red

f(MHz)

SQUARE WAVE MODULATION TRANSFER CHARACTERISTICS

Mullard

CAMERA TUBES
PLUMBICON*

XQ1081 XQ1081G
XQ1081R XQ1081B

QUICK REFERENCE DATA

25.4mm (1 in) diameter Plumbicon camera tubes with high resolution photo-conductive layer and separate mesh construction for industrial and educational monochrome and colour cameras in which high contrast ratios may occur. Features of these tubes include anti-comet-tail (A.C.T.) electron gun for highlight handling, extremely low lag, lightpipe for adjustable bias lighting to minimise lag under low-key conditions, anti-halation glass disc and a low output capacitance for improved signal to noise ratio.

The precision construction of the electrode system, the ceramic centring ring and the rear loading coil unit combine to form a system giving precise optical and electrical alignment.

XQ1081   - for use in monochrome television cameras
XQ1081R   - provides the red component of a colour picture
XQ1081G   - provides the green component of a colour picture
XQ1081B   - provides the blue component of a colour picture

Dark current	≤3	nA
Resolution capability	>750	TV lines
Transfer characteristic	linear	

Data identical to that of XQ1080 Series

*Registered trade mark for television camera tubes

CAMERA TUBES
PLUMBICON*

XQ1090   XQ1100
XQ1091   XQ1101
Series

QUICK REFERENCE DATA

25.4mm (1 in) diameter Plumbicon camera tubes with high resolution photo-conductive layer and separate mesh construction. Features of these tubes include anti-comet-tail (A.C.T.) electron gun for highlight handling, extremely low lag and a lightpipe for adjustable bias lighting to minimise lag under low-key conditions.

All tubes of these four series are front loading.

XQ1090 and XQ1100 series are for use in monochrome and colour cameras in broadcast applications.

XQ1091 and XQ1101 series are for use in monochrome and colour cameras in industrial applications.

XQ1090 and XQ1091 series have an anti-halation glass disc

XQ1100 and XQ1101 series are without an anti-halation glass disc

The usual suffix coding applies: -

No suffix	- for use in monochrome television cameras
Suffix L	- provides the luminance component of a colour picture
Suffix R	- provides the red component of a colour picture
Suffix G	- provides the green component of a colour picture
Suffix B	- provides the blue component of a colour picture

Dark current	≤ 3	nA
Resolution capability	> 750	TV lines
Transfer characteristic	linear	

All electrical and mechanical data of these tubes are identical to those of the XQ1080 or XQ1081 series with the following exceptions: -

CAPACITANCE

Target electrode to all other electrodes   3 to 5   pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

ACCESSORIES

Coil assembly   AT1103, AT1116 or equivalent

*Registered trade mark for television camera tubes

Mullard

Short index pin

Target
electrode

a5
a2
g
a1, a3
a4

k h h

Inner diameter of guard ring $\frac{21.2}{20.8}$

Faceplate refractive index 1.49
anti-halation disc refractive index 1.52

All dimensions in mm

$\emptyset\frac{20.4}{20.1}$

5.1
4.9

$\emptyset\frac{28.6}{28.2}$

3.1
2.9

1.4
1.2

Anti-halation
glass disc not
on types with
/01 suffix

162
154

$\emptyset\frac{26}{25}$

0.4
max

Resin

$\emptyset26.6$
max

9.3
min

12.8
max

3.0
max

5.0
max

$\emptyset1.27 ^{+0.05}_{-0.10}$

$\emptyset6.8$
max

D5900

Mullard

CAMERA TUBE VIDICON
20PE11

TENTATIVE DATA

QUICK REFERENCE DATA

17.7mm diameter vidicon television camera tube with integral mesh, low heater consumption, magnetic focusing, and magnetic deflection. Intended for use in low-cost industrial cameras, home cameras and for amateur use.

Decay – residual signal after 50ms	20	%
Resolution capability	>400	TV lines

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h	6.3 ±10%	V
I_h	95 ±10%	mA

When the tube is used in a series chain, the heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on.

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Maximum diagonal of quality rectangle on photoconductive layer (aspect ratio 3:4)	11	mm

The direction of the horizontal scan should be essentially parallel to the plane defined by the short index pin and the longitudinal tube axis, unless rotation of the tube is found necessary to minimise the number of blemishes in the picture.

CAPACITANCE

Target electrode to all other electrodes	2.0	pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

Mullard

TYPICAL OPERATION

Operating conditions

$V_{a2,a3}$ (see note 1)	250 to 300	V
V_{a1}	300	V
V_g	adjusted for sufficient beam current to stabilise highlights	

Minimum peak-to-peak blanking voltage

when applied to the grid	75	V
when applied to the cathode	20	V

Field strength at centre of focus coil (see note 2)	4.0	A/mm
Field strength of adjustable alignment coils or magnets	0 to 320	A/m
Scanned area	6.6×8.8	mm
Faceplate temperature	30 to 35	^oC

Typical performance

	Min.	Typ.	Max.	
Target electrode voltage for a dark current of 20nA	10	–	80	V
Output current at 20nA dark current (see note 3)	60	120	–	nA
Decay: residual signal current after dark pulse of 50ms (see notes 4, 5, 6)	–	20	30	%
Resolution capability at centre of picture	400	–	–	TV lines
Grid voltage for picture cut-off with no blanking applied	-20	-60	-80	V
Average gamma of transfer characteristic for signal currents between 20nA and 200nA	–	0.65	–	
Wavelength at maximum response (approx.)	–	550	–	nm

Spurious signals – shading

> Tubes are rejected for smudge, lines, streaks, mottled background, grainy background, or uneven background having contrast ratios greater than 1.5:1.

Spurious signals – spots and blemishes
(see notes 5, 7)

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	80	V
$V_{a2,a3}$ max.	750	V
V_{a1} max.	350	V
$-V_g$ max.	350	V
$+V_g$ max.	0	V
v_{h-k} (pk) max.		
cathode positive	125	V
cathode negative	10	V
Maximum peak output current (see note 8)	0.5	μA
Maximum peak dark current	150	nA
Maximum faceplate illumination	10 000	lux
Maximum faceplate temperature during storage and operation (see note 9)	70	^{o}C

Scanning of a 6.6mm × 8.8mm area of the photoconductive layer should always be applied. The use of a mask of these dimensions is recommended. Scanning of an area less than this may cause permanent damage to the specified full-size area.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	18	g

ACCESSORIES

Socket	Special miniature 7 pin (J.E.D.E.C. E7-1)
Coil assembly	M10AT or equivalent

NOTES

1. Beam focus is obtained by the combined effect of the focus electrode (a2), the voltage of which should be adjustable over the indicated range, and a focus coil having an average field strength of 4A/mm.

2. The polarity of the focus coil should be such that a north-seeking pole, located outside but adjacent to the image end of the focus coil, will be attracted to the image end of the focus coil.

Mullard

NOTES (contd.)

3. With 10 lux (colour temperature = 2854K) on the faceplate.

4. With a dark current of 20nA and an initial signal current of 200nA.

5. The deflection circuit must provide sufficiently linear scanning for good black-level reproduction. Since the output current is proportional to the velocity of scanning, any change in this velocity will produce non-uniformity.

6. Signal current is defined as the component of the output current after the dark current has been subtracted.

7. Conditions:

Dark current 20nA and output current of 220nA.

The camera is focused on a uniformly illuminated two-zone test pattern. Zone 1 at the centre has a diameter equal to the raster height. Zone 2 occupies the remainder of the scanned area.

The scanning amplitudes of a rectangular monitor are adjusted to obtain a raster with an aspect ratio of 3:4. The monitor set-up and contrast control are adjusted for a faint raster when the lens of the camera is capped, and for a non-blooming bright raster when uncapped.

Under the above conditions the number and size of the spots visible in the monitor picture will not exceed the limits stated below. Both black and white spots are counted unless the amplitude is less than 50% of the peak white signal.

| Spot size | Maximum number of spots | |
in % of raster height	Zone 1	Zone 2
> 0.8	none	1
0.8 to 0.6	2	2
0.6 to 0.3	2	3
< 0.3	*	*

*Spots of this size are not counted unless their concentration is so high as to cause a smudgy appearance.

8. Video amplifiers should be capable of handling target-electrode currents of this magnitude without overloading the amplifier or distorting the picture.

9. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infrared filters should be used.

OUTLINE DRAWING OF 20PE11

Target electrode

1.0

2.3

Ø 19.6 ± 0.2

Ø 17.7 ± 0.3

h

h   g

IC   3 4 5   a1
      2   6
      1 7

k   a2, a3

108 max   92 ±3

Pin dimensions as in B7G base
The centre of the socket must
allow entry of the pump stem

Target electrode

a2, a3

g   a1

13 max

k h   h

All dimensions in mm

Ø 8.5 max (stem flange)

Ø 5.5 max

D2503

QUICK REFERENCE DATA

17.7mm diameter vidicon television camera tube with separate mesh, low heater consumption, magnetic focusing and magnetic deflection. Intended for use in low-cost industrial cameras, home cameras and for amateur use.

Resolution capability	>550	TV lines

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h	6.3 ±10%	V
I_h	95 ±10%	mA

When the tube is used in a series chain, the heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on.

FOCUSING

Magnetic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Maximum diagonal of quality rectangle on photoconductive layer (aspect ratio 3:4)	11	mm

The direction of the horizontal scan should be essentially parallel to the plane defined by the short index pin and the longitudinal tube axis, unless rotation of the tube is found necessary to minimise the number of blemishes in the picture.

CAPACITANCE

Target electrode to all other electrodes	2.0	pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

Mullard

TYPICAL OPERATION

Operating conditions

V_{a3}		400	V
V_{a2} (see note 1)		250 to 300	V
V_{a1}		300	V
V_g		adjusted for sufficient beam current to stabilise highlights	

Minimum peak-to-peak blanking voltage

when applied to the grid	75	V
when applied to the cathode	20	V

Field strength at centre of focus coil (see note 2)   4.0   A/mm

Field strength of adjustable alignment coils or magnets   0 to 320   A/m

Scanned area 6.6×8.8 mm

Faceplate temperature   30 to 35 $^{\circ}C$

Typical performance

	Min.	Typ.	Max.	
Target electrode voltage for a dark current of 20nA	10	–	80	V
Output current at 20nA dark current (see note 3)	100	–	–	nA
Decay : residual signal current after dark pulse of 50ms (see notes 4, 5, 6)	–	20	30	%
Resolution capability at centre of picture	550	–	–	TV lines
Grid voltage for picture cut-off with no blanking applied	-35	-60	-80	V
Average gamma of transfer characteristic for signal currents between 20nA and 200nA	–	0.65	–	
Wavelength at maximum response (approx.)	–	550	–	nm

Spurious signals – shading

Tubes are rejected for smudge, lines, streaks, mottled background, grainy background, or uneven background having contrast ratios greater than 1.5:1.

Spurious signals – spots and blemishes (see notes 5, 7)

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	80	V
V_{a3} max.	750	V
V_{a2} max.	750	V
V_{a1} max.	350	V
$-V_g$ max.	125	V
$+V_g$ max.	0	V
v_{h-k}(pk) max.		
cathode positive	125	V
cathode negative	10	V
Maximum peak output current (see note 8)	0.5	μA
Maximum peak dark current	150	nA
Maximum faceplate illumination	10 000	lux
Maximum faceplate temperature during storage and operation (see note 9)	70	^{o}C

Scanning of a 6.6mm × 8.8mm area of the photoconductive layer should always be applied. The use of a mask of these dimensions is recommended. Scanning of an area less than this may cause permanent damage to the specified full–size area.

MOUNTING POSITION

Any

WEIGHT

Tube alone (approx.)	20	g

ACCESSORIES

Socket	Special miniature 7 pin (J.E.D.E.C. E7–1)
Coil assembly	M10AT or equivalent

NOTES

1. Beam focus is obtained by the combined effect of the focus electrode (a2), the voltage of which should be adjustable over the indicated range, and a focus coil having an average field strength of 4A/mm.

2. The polarity of the focus coil should be such that a north–seeking pole, located outside but adjacent to the image end of the focus coil, will be attracted to the image end of the focus coil.

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NOTES (contd.)

3. With 10 lux (colour temperature = 2854K) on the faceplate.

4. With a dark current of 20nA and an initial signal current of 200nA.

5. The deflection circuit must provide sufficiently linear scanning for good black-level reproduction. Since the output current is proportional to the velocity of scanning, any change in this velocity will produce non-uniformity.

6. Signal current is defined as the component of the output current after the dark current has been subtracted.

7. Conditions:

Dark current 20nA and output current of 220nA.

The camera is focused on a uniformly illuminated two-zone test pattern. Zone 1 at the centre has a diameter equal to the raster height. Zone 2 occupies the remainder of the scanned area.

The scanning amplitudes of a rectangular monitor are adjusted to obtain a raster with an aspect ratio of 3:4. The monitor set-up and contrast control are adjusted for a faint raster when the lens of the camera is capped, and for a non-blooming bright raster when uncapped.

Under the above conditions the number and size of the spots visible in the monitor picture will not exceed the limits stated below. Both black and white spots are counted unless the amplitude is less than 50% of the peak white signal.

Spot size in % of raster height	Maximum number of spots	
	Zone 1	Zone 2
>0.8	none	1
0.8 to 0.6	2	2
0.6 to 0.3	2	3
<0.3	*	*

*Spots of this size are not counted unless their concentration is so high as to caus ɔ a smudgy appearance.

8. Video amplifiers should be capable of handling target-electrode currents of this magnitude without overloading the amplifier or distorting the picture.

9. Under difficult environmental conditions a flow of cooling air directed at the face-plate is recommended. When televising flames and furnaces appropriate infrared filters should be used.

Mullard

CAMERA TUBE VIDICON **20PE13**

OUTLINE DRAWING OF 20PE13

Target electrode

$\varnothing$ 19.6 ± 0.2

1.0

2.3

$\varnothing$ 17.7 ± 0.3

h
h g
a3 ○3 ○4 5○ a1
○2 6○
○1 7○
k a2

108 max

92 ± 3

Pin dimensions as in B7G base
The centre of the socket must
allow entry of the pump stem

Target electrode

a2
g

a3
a1

13 max

k h h

$\varnothing$ 8.5 max (stem flange)

$\varnothing$ 5.5 max

All dimensions in mm

D2504

Mullard

TENTATIVE DATA

17.7mm diameter vidicon television camera tube with separate mesh, low heater consumption, electrostatic focusing and magnetic deflection. Intended for use in low-cost industrial cameras, home cameras and for amateur use, where small size and low power consumption are important parameters.

Resolution capability	550	tv lines

HEATER

Suitable for parallel or series operation, a.c. or d.c.

V_h	6.3 ±10%	V
I_h	95 ±10%	mA

When the tube is used in a series chain, the heater voltage must not exceed $9.5V_{r.m.s.}$ when the supply is switched on.

FOCUSING

Electrostatic

DEFLECTION

Magnetic

PHOTOCONDUCTIVE LAYER

Maximum diagonal of quality rectangle

on photoconductive layer (aspect ratio 3:4)	11	mm

The direction of the horizontal scan should be essentially parallel to the plane defined by the short index pin and the longitudinal tube axis, unless rotation of the tube is found necessary to minimise the number of blemishes in the picture.

CAPACITANCE

Target electrode to all other electrodes	2.0	pF

This capacitance, which is effectively the output impedance, increases when the tube is inserted in the coil assembly.

Operating conditions

V_{a4}	500	V
V_{a3} (beam focusing electrode)	45 to 65	V
$V_{a1,a2}$	300	V
Maximum peak to peak blanking voltage		
when applied to grid	75	V
when applied to cathode	20	V
Field strength of adjustable alignment coil	0 to 320	A/m
Faceplate illumination (highlight)	10	lx

Performance

V_g (for picture cut-off) with no blanking applied	-35 to -80	V
Average gamma of transfer characteristic for signal currents between 10 and 100nA	0.65	
Target voltage	10 to 45	V
Dark current	20	nA
Signal current (see note 1)		
typical	200	nA
minimum	100	nA
Limiting resolution at picture centre	550	tv lines

Spurious signals - shading

Tubes are rejected for smudge, lines, streaks, mottled background, grainy background, or uneven background having contrast ratios greater than 1.5:1.

Spurious signals - spots and blemishes
(see notes 2,4)

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{target} max.	80	V
V_{a4} max.	600	V
V_{a3} max.	350	V
$V_{a1,a2}$ max.	350	V
$-V_g$ max.	200	V
$+V_g$ max.	0	V
v_{h-k} (pk) max.		
cathode positive	125	V
cathode negative	10	V
Maximum peak dark current	150	nA
Maximum peak output current	500	nA
Maximum faceplate illumination	10 000	lx
Maximum faceplate temperature during storage and operation	70	^{o}C

Scanning of a 6.6mm × 8.8mm area of the photoconductive layer should always be applied. The use of a mask of these dimensions is recommended. Scanning of an area less than this may cause permanent damage to the specified full size area.

MOUNTING POSITION

   Any

WEIGHT

Tube only (approx.)	23	g

ACCESSORIES

Socket	Special miniature 7 pin (J.E.D.E.C. E7-1)
Deflection yoke	KV19B

NOTES

1. With 10 lux (colour temperature = 2854K) on the faceplate.

2. The deflection circuit must provide sufficiently linear scanning for good black level reproduction. Since the output current is proportional to the velocity of scanning, any change in this velocity will produce non-uniformity.

3. Signal current is defined as the component of the output current after the dark current has been subtracted.

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NOTES (contd.)

4. The camera is focused on a uniformly illuminated two zone test pattern. Zone 1 at the centre has a diameter equal to the raster height. Zone 2 occupies the remainder of the scanned area.

The scanning amplitudes of a rectangular monitor are adjusted to obtain a raster with an aspect ratio of 3:4. The monitor set-up and contrast controls are adjusted for a faint raster when the lens of the camera is capped and for a non-blooming bright raster when uncapped.

Under the above conditions the number and size of the spots visible in the monitor picture will not exceed the limits stated below. Both black and white spots are counted unless the amplitude is less than 50% of the peak white signal.

Spot size in % of raster height	Maximum number of spots	
	Zone 1	Zone 2
>0.8	none	1
0.8 to 0.6	2	2
0.6 to 0.3	2	3
<0.3	*	*

*Spots of this size are not counted unless their concentration is so high as to cause a smudgy appearance.

5. Video amplifiers should be capable of handling target-electrode currents of this magnitude without overloading the amplifier or distorting the picture.

6. Under difficult environmental conditions a flow of cooling air directed at the faceplate is recommended. When televising flames and furnaces appropriate infrared filters should be used.

Mullard

OUTLINE DRAWING OF 20PE14

Target electrode

1.0   2.3

∅ 19.6
± 0.2

∅ 17.7
± 0.3

h
h   g
  ○ ○ ○
  3 4 5
a4 ○2 6○ a1,a2
  ○1 7○
k   a3

108   92
max   ±3

Pin dimensions as in B7G base
The centre of the socket must
allow entry of the pump stem

Target
electrode
a3   a4
g   a1,a2

13
max

k h h

∅ 8.5 max
(stem flange)

∅ 5.5 max

All dimensions in mm   D4752

Mullard

IMAGE INTENSIFIER AND IMAGE CONVERTER TUBES

H ≡

IMAGE INTENSIFIER AND IMAGE CONVERTER TUBES

GENERAL EXPLANATORY NOTES

1. DESCRIPTION

Image intensifier and converter tubes are electron-optical devices in which the image of a scene or object is focused on a photocathode and is then intensified electronically. The intensified image is visible on a luminescent screen.

The image of the scene is focused by an optical lens on to a semi-transparent photocathode. The light distribution in the optical image is converted into a similar photocurrent distribution. The photocurrent is made up of emitted electrons and these are accelerated towards the luminescent screen by an electrode system having a high positive potential relative to the photocathode. An electron lens produces a focused image on the screen.

2. DEFINITIONS

An IMAGE INTENSIFIER TUBE is a device which intensifies visible images.

An IMAGE CONVERTER TUBE is a similar device which is primarily sensitive to invisible radiation.

3. CONSTRUCTION

An image tube consists basically of a photocathode, a focusing system and a luminescent screen.

3.1 The photocathode

The properties of the photocathode are defined by the spectral response and the sensitivity. The sensitivity may be given in two ways: radiant sensitivity (mA/W) and luminous sensitivity (μA/lm).

For **night vision applications**, using a near infrared searchlight, one may use an image converter with an S1-type photocathode.

For **high speed photography** of visible scenes, one should preferably use a tube with a photocathode of S11 or S20 spectral response on a conducting substrate (to prevent a substantial voltage drop across the cathode surface during the light pulse).

Passive night vision systems require photocathodes of the highest possible response to visible light, preferably combined with an appreciable response in the near infrared region of the spectrum, for example, the Mullard S20 photocathode with enhanced red response.

3.2 Focusing

Focusing systems can be divided into two types: electrostatic and magnetic.

The majority of modern tubes are based on the electrostatic focusing properties of concentric spheres.

Magnetic focusing systems are not suited to portable apparatus due to their weight.

Mullard

3. CONSTRUCTION (contd.)

3.3 The luminescent screen

Image tubes can be provided with screens of different spectral response and resolution, depending on the type of application. Screens for direct viewing are usually of the P20 type, which closely matches the luminous efficiency of the human eye. If the screen has to be photographed a blue-violet screen (for example, type P11) may be more suitable. Optical coupling of a screen to a photocathode and integration of background noise are two examples which may require the use of special phosphors.

4. CHARACTERISTICS

4.1 Noise

With the supply voltage applied and no input illumination incident on the photo-cathode, the tube screen will have a finite background brightness, which may be caused by one or more of the following effects:

Thermionic emission of the photocathode. This is particularly apparent in the S1 photocathode, and is highly dependent on the cathode temperature (Richardson's law).

Field emission

Electron scintillations

Ion scintillations

Long term phosphorescence of the screen. This may have been caused by previous operation of the tube or by previous exposure of the screen to high levels of illumination of a spectral distribution which can excite phosphorescence. It is, therefore, recommended that image tubes are stored in darkness.

Noise is expressed in terms of Background Equivalent Illumination (B.E.I.)* which is the input illumination required to give an increase in screen luminance equivalent to the background luminance.

*More correctly: Background equivalent input illumination.

4.2 Gain

The gain of image tubes may be expressed in two ways: conversion coefficient and luminance gain.

Conversion coefficient is defined as the quotient of the luminous intensity in a direction normal to the screen (cd) and the luminous flux incident on the photo-cathode (lm) and is expressed in cd/lm.

In the case of infrared tubes the incident luminous flux is infrared filtered, and the conversion coefficient is expressed in cd/lm irf (infrared filtered).

4. CHARACTERISTICS (contd.)

4.2 Gain (contd.)

Luminance gain is defined as

$$\frac{\pi L_o}{E_i}$$

where L_o = luminance (cd/m^2) in a direction normal to the screen, measured with an eye-corrected photometer having an acceptance angle less than 2 degrees

and E_i = illumination (lux) incident on a specified area of the photocathode, produced by a tungsten lamp at a colour temperature of 2850K.

Luminance gain is expressed as a number.

4.3 Resolution

The resolution figures in the data refer to the photocathode and apply to a bar pattern (black bars on a white background with a mark/space ratio 1:1 and contrast approaching 100%). The resolution pattern is imaged on the photocathode using a high quality projection system, and the screen is observed using a microscope of ×50 magnification.

5. ALTITUDE

Image tubes which are not encapsulated should not be used at pressures below 7×10^4 N/m^2 (525 torr), equivalent to a height of 3km above sea level.

6. MOUNTING

Most image tubes are provided with bearing surfaces which should be used for mounting and for electrical contacts. The tube should never bear on the cathode or screen windows, and bearing on the cylindrical metal parts should be avoided. The maximum axial force on the bearing surface of any tube must not exceed 100N (10kg force), unless otherwise stated. Soldered connections should never be made to the metal parts of the tube.

IMAGE INTENSIFIER TUBE   XX1050

QUICK REFERENCE DATA

Self-focusing electrostatic diode image intensifier tube with fibre-optic windows.

Minimum luminance gain	85	
Photocathode	S20 with enhanced red response	
Screen phosphor	P20	
Useful cathode and screen diameters	25	mm
Anode voltage	15	kV
Overall dimensions (approx.)	Ø50 x 60	mm
Weight (approx.)	145	g

This data should be read in conjunction with GENERAL EXPLANATORY NOTES -
IMAGE INTENSIFIER AND IMAGE CONVERTER TUBES

PHOTOCATHODE

Surface	S20 with enhanced red response	
Wavelength at maximum response	500	nm
Minimum useful diameter	25	mm
External surface of cathode window	Flat to within 2μm over entire diameter	

SCREEN

Surface	Metal-backed P20	
Fluorescent colour	Yellow-green	
Persistence	Medium short	

The screen luminance falls to 36% (e^{-1}) of the initial peak value 200μs after the excitation is removed.

Minimum useful diameter	25	mm
External surface of screen window	Flat to within 2μm over entire diameter	

FOCUSING

Self-focusing electrostatic with image inversion.

CHARACTERISTICS (Measured at $V_a = 15kV$, $T_{amb} = -50$ to $+30^{\circ}C$)

Minimum luminance gain (see note 1)	85	
Minimum photocathode sensitivity (measured using a tungsten lamp of colour temperature 2850K)	175	$\mu A/lm$
Minimum radiant sensitivity at $\lambda = 800nm$	10.0	mA/W
at $\lambda = 850nm$	3.0	mA/W
Centre magnification, M_c (see note 2)	0.935 ± 0.010	
Distortion (see note 3)	7.00 ± 1.65	%
Minimum centre resolution (see note 4)	60	line pairs/mm
Minimum edge resolution (see note 5)	50	line pairs/mm
Maximum background equivalent illumination (see note 6)	0.2	μlux

Axial eccentricity

A point at the centre of the photocathode will form an image within a concentric circle of 1.5mm diameter on the screen.

OPERATING CONDITIONS

V_a (see note 7)	15	kV

Either the anode or the cathode should be connected to the instrument housing, depending upon the application. It is recommended that the cathode be connected thus to obtain the lowest possible background.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_a max.	16	kV
V_a min. (useful continuous operation)	10	kV
Maximum continuous photocathode illumination (see note 8)	2.0	lux
T_{amb} max.	+50	$^{\circ}C$

MOUNTING POSITION	Any	
WEIGHT (approx.)	145	g

IMAGE INTENSIFIER TUBE   XX1050

NOTES

1. Luminance gain is defined as $\dfrac{\pi . L_o}{E_i}$

where L_o = luminance (cd/m^2) in a direction normal to the screen, measured with an eye-corrected photometer having an acceptance angle of less than 2 degrees.
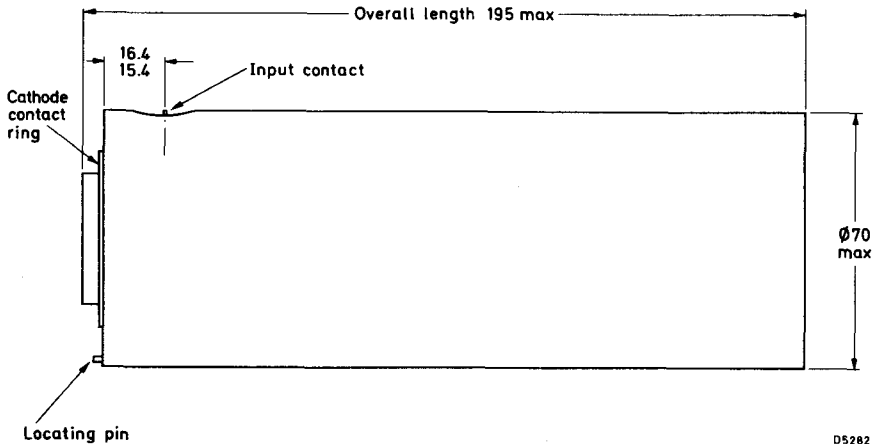
and E_i = illumination (lux) incident on a 19mm diameter concentric area of the cathode, produced by a tungsten lamp at a colour temperature of 2850K.

2. This is the magnification of a 2mm diameter concentric circle on the photocathode, as measured on the screen.

3. Percentage distortion = $(\dfrac{M_d}{M_c} - 1) \times 100$, where M_d is the magnification of a 20mm diameter concentric circle on the photocathode, as measured on the screen and M_c is the centre magnification at a distance of 1mm from the centre of the photocathode.

4. Measured at the centre of the photocathode.

5. Measured at the photocathode at a distance of 7mm from the centre.

6. This is the value of input illumination required to give an increase in screen luminance equivalent to the background luminance.

7. Permanent damage may result from a temporary reversal of polarity.

8. This figure assumes uniform illumination of the photocathode. Permanent damage may result if the tube is exposed to radiant power so great as to cause excessive heating of the photocathode.

Mullard

All dimensions in mm

Contacts to cathode and screen should preferably be made to the respective bearing surfaces. Contact rings should be kept well clear of the fibre-optic windows. Maximum contact force must not exceed 1kg.

Mullard

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE CURVES

Mullard

IMAGE INTENSIFIER ASSEMBLY   XX1060

QUICK REFERENCE DATA

High gain self-focusing image intensifier assembly for night vision systems.
It requires an a.c. input.

Minimum luminance gain	35 000	asb/lx
Photocathode	S25	
Screen phosphor	P20	
Useful cathode and screen diameters	25	mm
Supply voltage (pk-pk)	2.7	kV
Overall dimensions (approx.)	$\phi 70 \times 195$	mm
Weight (max.)	880	g

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - IMAGE INTENSIFIER AND IMAGE
CONVERTER TUBES

PHOTOCATHODE

Surface	S25	
Wavelength at maximum response (see page 6)	550	nm
Useful diameter	25	mm
External surface of fibre optic cathode window	Flat to within 2µm (nom.) over entire surface	

SCREEN

Surface	Metal backed P20
Fluorescent colour (see page 7)	Yellow-green
Overall persistence	Medium

The screen luminance falls to 36% (e^{-1}) of the initial peak value 5ms after the excitation is removed.

Useful diameter	25	mm
External surface of fibre optic screen window	Flat to within 2µm over entire surface	

FOCUSING

Electrostatic self-focusing with image inversion

Mullard

CHARACTERISTICS (Measured at V_{supply} (pk-pk) = 2.7kV ± 5%,

f_{supply} = 1500 ± 100Hz,

T_{amb} = 23 ± 4°C)

Minimum luminance gain (see note 1)	35 000	asb/lx
Typical photocathode sensitivity		
(measured using a tungsten lamp of colour temperature 2850K)	230	μA/lm
Typical radiant sensitivity at λ = 800nm	15	mA/W
λ = 850nm	5.0	mA/W
Centre magnification, M_c (see note 2)	0.91 ± 0.09	
Maximum distortion (see note 3)	22	%
Minimum centre resolution (see note 4)	30	line pairs/mm
Minimum edge resolution (see note 5)	28	line pairs/mm
Minimum modulation transfer factors at cathode centre (see note 6)		
at 2.5 cycles/mm	98	%
at 7.5 cycles/mm	75	%
at 16 cycles/mm	45	%
Maximum background equivalent illumination (see note 7)	0.2	μlx

Axial eccentricity

A point at the centre of the photocathode will form an image within a concentric circle of 1.25mm diameter on the screen.

Maximum screen luminance ratio (see note 8)	5:1	

TYPICAL OPERATING CONDITIONS (see note 9)

V_{supply}(pk-pk)	2.7	kV
f_{supply}	1.5	kHz
Cathode illumination	100	μlx

The supply voltage must be applied between the a.c. input pin and the cathode contact surface. The photocathode must be connected to the metal cylindrical housing having a minimum internal diameter of 73mm and a minimum length of 185mm.

Mullard

IMAGE INTENSIFIER ASSEMBLY   XX1060

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{supply} (pk-pk) max.	2850	V
f_{supply} max.	2000	Hz
f_{supply} min.	1200	Hz
Maximum photocathode illuminance (see note 10)	10	mlx
T_{amb} max. (for 2 hours max.)	68	^{o}C
T_{amb} max. (for long term storage)	35	^{o}C
T_{amb} max. (for continuous operation)	35	^{o}C

MOUNTING POSITION

Any. The tube must be contained in a cylindrical housing and radially positioned by the locating pin. The axial position is determined by the bearing surface. The force on the bearing surface must not exceed 100 newtons (10kg force).

WEIGHT (max.)	880	g

NOTES

1. Luminance gain is defined as: $\dfrac{\pi L_o}{E_i}$ apostilb/lux,

   where L_o = luminance (cd/m^2) in a direction normal to the screen, measured over a 14mm diameter concentric area with an eye corrected photo-meter having an acceptance angle of less than 2 degrees.
   and E_i = illuminance (nominally 200 μlx) incident on a 19mm diameter con-centric area of the cathode, produced by a tungsten lamp at a colour temperature 2850K.

2. The magnification of a 2mm diameter concentric circle on the photocathode, as measured on the screen.

3. Percentage distortion = $(\dfrac{M_d}{M_c} - 1) \times 100$, where M_d is the magnification of a 20mm diameter concentric circle on the photocathode, as measured on the screen and M_c is the centre magnification at a distance of 1mm from the centre of the photocathode.

4. Measured at the centre of the photocathode.

5. Measured at the photocathode at a distance of 7mm from the centre.

Mullard

6. These values are obtained using the standard method adopted in MIL specifications whereby the m.t.f. values are normalised at approximately 1.5 cycles/mm. When the m.t.f. is measured with the values normalised at zero spatial frequency, the following results are obtained:

at 2.5 cycles/mm	88	%
at 7.5 cycles/mm	70	%
at 16 cycles/mm	38	%

7. The value of input illuminance required to give an increase in screen luminance equivalent to the background luminance.

8. The screen luminance ratio is defined as the ratio of the maximum and minimum screen luminance over a 20mm diameter concentric area on the screen, for uniform cathode illuminance.

9. Warning. After switching off, the a.c. input pin may still be at a d.c. potential of a few kV. It is advisable to discharge this pin against the cathode contact ring, (not against the bearing surface).

10. Intermittent flashes producing much higher cathode illuminances are allowed, but the tube must not be used in full daylight. The voltage multiplier has an integral series resistor which causes the tube to cut off at illuminance levels higher than 10mlx.

SIMPLE OUTLINE DRAWING OF XX1060

Mullard

DETAILED OUTLINE DRAWING OF XX1060

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE

Mullard

TYPICAL SPECTRAL EMITTANCE FOR A P20 TYPE PHOSPHOR

Mullard

IMAGE INTENSIFIER ASSEMBLY XX1060/01

QUICK REFERENCE DATA

High gain self-focusing image intensifier assembly for night vision systems. It will operate with automatic brightness control (a.b.c.) when used with an oscillator having a controlled regulation characteristic.

Minimum luminance gain	35 000	asb/1x
Photocathode	S25	
Screen phosphor	P20	
Useful cathode and screen diameters	25	mm
Supply voltage (pk-pk) (see note 1)	2.7	kV
Overall dimensions (approx.)	⌀70 x 195	mm
Weight (max.)	880	g

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES - IMAGE INTENSIFIER AND IMAGE
CONVERTER TUBES

PHOTOCATHODE

Surface	S25	
Wavelength at maximum response (see page 6)	550	nm
Useful diameter	25	mm
External surface of fibre optic cathode window	Flat to within 2μm (nom.) over entire surface	

SCREEN

Surface	Metal backed P20
Fluorescent colour (see page 6)	Yellow-green
Overall persistence	Medium

The screen luminance falls to 36% (e^{-1}) of the initial peak value 5ms after the excitation is removed.

Useful diameter	25	mm
External surface of fibre optic screen window	Flat to within 2μm over entire surface	

FOCUSING

Electrostatic self-focusing with image inversion

CHARACTERISTICS (Measured at V_{supply} (pk-pk) = 2.7kV ± 5%.
$\qquad f_{supply}$ = 1500 ± 100Hz,
$\qquad T_{amb}$ = 23 ± 4°C)

Minimum luminance gain (see note 2)	35 000	asb/lx
Typical photocathode sensitivity		
(measured using a tungsten lamp of colour temperature 2850K)	230	μA/1m
Typical radiant sensitivity at λ = 800nm	15	mA/W
λ = 850nm	5.0	mA/W
Centre magnification, M_c (see note 3)	0.91 ± 0.09	
Maximum distortion (see note 4)	22	%
Minimum centre resolution (see note 5)	30	line pairs/mm
Minimum edge resolution (see note 6)	28	line pairs/mm
Minimum modulation transfer factors at cathode centre (see note 7)		
at 2.5 cycles/mm	98	%
at 7.5 cycles/mm	75	%
at 16 cycles/mm	45	%
Maximum background equivalent illumination (see note 8)	0.2	μlx

Axial eccentricity

A point at the centre of the photocathode will form an image within a concentric circle of 1.25mm diameter on the screen.

Maximum screen luminance ratio (see note 9)	5:1	
Input capacitance (measured with no input illumination)	10 to 20	pF

TYPICAL OPERATING CONDITIONS (see note 10)

V_{supply}(pk-pk) (see note 1)	2.7	kV
f_{supply}	1.5	kHz
Cathode illumination	100	μlx

The supply voltage must be applied between the a.c. input pin and the cathode contact surface. The photocathode must be connected to the metal cylindrical housing having a minimum internal diameter of 73mm and a minimum length of 185mm.

IMAGE INTENSIFIER ASSEMBLY   XX1060/01

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{supply} (pk-pk) max. (see note 1)	instantaneous	2900	V
	continuous	2850	V
f_{supply} max.		2500	Hz
f_{supply} min.		1000	Hz
Maximum photocathode illuminance (see note 11)		10	lx
T_{amb} max. (for 2 hours max.)		68	^{o}C
T_{amb} max. (for long term storage)		35	^{o}C
T_{amb} max. (for continuous operation)		35	^{o}C

MOUNTING POSITION

Any. The tube must be contained in a cylindrical housing and radially positioned by the locating pin. The axial position is determined by the bearing surface. The force *on the bearing surface must not exceed 100 newtons (10kg force).*

WEIGHT (max.)   880   g

NOTES

1. The intensifier must be used only with an oscillator having a regulation characteristic as follows:

Load condition	Output voltage (pk-pk)
50pF	2600 ± 200
50pF in parallel with 25MΩ	1900 ± 400

2. Luminance gain is defined as: $\dfrac{\pi L_o}{E_i}$ apostilb/lux,

   where L_o = luminance (cd/m^2) in a direction normal to the screen, measured over a 14mm diameter concentric area with an eye corrected photometer having an acceptance angle of less than 2 degrees.

   and E_i = illuminance (nominally 200 μlx) incident on a 19mm diameter concentric area of the cathode, produced by a tungsten lamp at a colour temperature 2850K.

3. The magnification of a 2mm diameter concentric circle on the photocathode, as measured on the screen.

4. Percentage distortion = $\left(\dfrac{M_d}{M_c} -1\right) \times 100$, where M_d is the magnification of a 20mm diameter concentric circle on the photocathode, as measured on the screen and M_c is the centre magnification at a distance of 1mm from the centre of the photocathode.

5. Measured at the centre of the photocathode.

6. Measured at the photocathode at a distance of 7mm from the centre.

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NOTES (contd.)

7. These values are obtained using the standard method adopted in MIL specifica-
tions whereby the m.t.f. values are normalised at approximately 1.5 cycles/mm.
When the m.t.f. is measured with the values normalised at zero spatial fre-
quency, the following results are obtained:

at 2.5 cycles/mm	88	%
at 7.5 cycles/mm	70	%
at 16 cycles/mm	38	%

8. The value of input illuminance required to give an increase in screen luminance
equivalent to the background luminance.

9. The screen luminance ratio is defined as the ratio of the maximum and minimum
screen luminance over a 20mm diameter concentric area on the screen, for
uniform cathode illumination.

10. Warning. After switching off, the a.c. input pin may still be at a d.c. potential
of a few kV. It is advisable to discharge this pin against the cathode contact ring,
(not against the bearing surface).

11. Intermittent flashes producing much higher cathode illuminances are allowed,
but the tube must not be used in full daylight.

SIMPLE OUTLINE DRAWING OF XX1060/01

Mullard

DETAILED OUTLINE DRAWING OF XX1060/01

D4951

TYPICAL SPECTRAL EMITTANCE FOR A P20 TYPE PHOSPHOR

D4953

P20 type phosphor

Electron excitation 12kV

Relative spectral emittance (%)

Wavelength (nm)

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE

D4952

Absolute radiant sensitivity (mA/W)

Wavelength (nm)

Mullard

IMAGE INTENSIFIER ASSEMBLY   XX1063

QUICK REFERENCE DATA

High gain, fast response, self-focusing image intensifier assembly with integral power supply and automatic brightness control (a.b.c.) for night vision systems.

Minimum luminance gain	35 000	asb/lx
Photocathode	S25	
Screen phosphor	P20	
Useful cathode and screen diameters	25	mm
Response time (max.)	1.0	s
Supply voltage (d.c.)	6.75	V
Overall dimensions (approx.)	⌀70 × 195	mm
Weight (approx.)	900	g

This data should be read in conjunction with
GENERAL EXPLANATORY NOTES – IMAGE INTENSIFIER AND IMAGE CONVERTER TUBES

PHOTOCATHODE

Surface   S25

Wavelength at maximum response (see page 7)   550   nm

Useful diameter   25   mm

External surface of fibre optic cathode window   Flat to within 2μm (nom.) over entire surface

SCREEN

Surface   Metal backed P20

Fluorescent colour (see page 7)   Yellow-green

Overall persistence   Medium

The screen luminance falls to 36% (e^{-1}) of the initial peak value 5ms after the excitation is removed.

Useful diameter   25   mm

External surface of fibre optic screen window   *Flat to within 2μm* over entire surface

FOCUSING

Electrostatic self-focusing with image inversion

Mullard

CHARACTERISTICS (Measured at V_{supply} (d.c.) = 6.75V ± 1%

I_{supply} = 25mA at input illuminance < 0.5 lx

T_{amb} = 23 ± 4°C)

Minimum luminance gain (see note 1)	35 000	asb/lx
Typical photocathode sensitivity		
(measured using a tungsten lamp of colour temperature 2850K)	230	μA/lm
Typical radiant sensitivity at λ = 800nm	15	mA/W
λ = 850nm	5.0	mA/W
Centre magnification, M_c (see note 2)	0.91 ± 0.09	
Maximum distortion (see note 3)	22	%
Minimum centre resolution (see note 4)	30 line pairs/mm	
Minimum edge resolution (see note 5)	28 line pairs/mm	
Minimum modulation transfer factors at cathode centre (see note 6)		
at 2.5 cycles/mm	98	%
at 7.5 cycles/mm	75	%
at 16 cycles/mm	45	%
Maximum background equivalent illuminance (see note 7)	0.2	μlx

Axial eccentricity

A point at the centre of the photocathode will form an image within a concentric circle of 1.25mm diameter on the screen.

Minimum screen luminance for cathode illuminance of 10 lx	10	cd/m^2
Maximum screen luminance ratio (see note 8)	5:1	
Maximum screen luminance	500	cd/m^2
Maximum response time (see note 9)	1.0	s

TYPICAL OPERATING CONDITIONS

V_{supply} (d.c.)	6.75	V
Cathode illumination	100	μlx

The supply voltage must be applied between the input socket (+ve) and the cathode contact surface. The photocathode must be connected to the metal cylindrical housing having a minimum internal diameter of 73mm and a minimum length of 185mm.

Mullard

IMAGE INTENSIFIER ASSEMBLY　　　XX1063

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_{supply} (d.c.) max.	6.75	V
Maximum photocathode illuminance (see note 10)	100	lx
T_{amb} max. (for 2 hours max.)	68	^{o}C
T_{amb} max. (for long term storage)	35	^{o}C
T_{amb} max. (for continuous operation)	35	^{o}C

MOUNTING POSITION

Any. The tube must be contained in a cylindrical housing and radially positioned by the locating pin. The axial position is determined by the bearing surface. The force on the bearing surface must not exceed 100 newtons (10kg force).

WEIGHT (approx.)　　　　　　　　　　　　　　　　900　　　　g

NOTES

1. Luminance gain is defined as: $\dfrac{\pi L_o}{E_i}$ apostilb/lux,

   where L_o = luminance (cd/m^2) in a direction normal to the screen, measured over a 14mm diameter concentric area with an eye corrected photometer having an acceptance angle of less than 2 degrees.

   and E_i = illuminance (nominally 200 μlx) incident on a 19mm diameter concentric area of the cathode, produced by a tungsten lamp at a colour temperature 2850K.

2. The magnification of a 2mm diameter concentric circle on the photocathode, as measured on the screen.

3. Percentage distortion = $(\dfrac{M_d}{M_c}$ -1) $\times$ 100, where M_d is the magnification of a 20mm diameter concentric circle on the photocathode, as measured on the screen and M_c is the centre magnification at a distance of 1mm from the centre of the photocathode.

4. Measured at the centre of the photocathode.

5. Measured at the photocathode at a distance of 7mm from the centre.

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NOTES (contd.)

6. These values are obtained using the standard method adopted in MIL speci-
fications whereby the m.t.f. values are normalised at approximately 1.5 cycles
/mm. When the m.t.f. is measured with the values normalised at zero spatial
frequency, the following results are obtained:

at 2.5 cycles/mm	88	%
at 7.5 cycles/mm	70	%
at 16 cycles/mm	38	%

7. The value of input illuminance required to give an increase in screen luminance
equivalent to the background luminance.

8. The screen luminance ratio is defined as the ratio of the maximum and minimum
screen luminance over a 20mm diameter concentric area on the screen, for
uniform cathode illuminance.

9. With an input illuminance of $E_i = 5 \times 10^{-3}$ lx.
E_i is increased in less than 1ms to a value of 10lx; the screen will flash
instantaneously and then black out for a brief period. Thereafter the screen
luminance will increase to a steady value. The response time is defined as the
interval between the instant of the increase of E_i and the instant at which the
screen luminance reaches a value of 3.4 cd/m^2 following blackout, (see fig.1)
below:

Fig. 1

10. This applies for short periods only. Prolonged exposure to bright lights will
shorten the life of the tube.

DETAILED OUTLINE DRAWING OF XX1063

SIMPLE OUTLINE DRAWING OF XX1063

Overall length 195 max

16.4
15.4

D.C. input socket

Cathode
contact
ring

Locating pin

⌀70
max

D5403

TYPICAL A.B.C. TRANSFER CHARACTERISTIC

Output
luminance
L_o
cd/m^2

D5479

Input illuminance E_i lx

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TYPICAL SPECTRAL EMITTANCE FOR A P20 PHOSPHOR

P20 type phosphor

Electron excitation 12kV

Relative spectral emittance (%)

Wavelength (nm)

TYPICAL PHOTOCATHODE SPECTRAL RESPONSE

Absolute radiant sensitivity (mA/W)

Wavelength (nm)

Mullard

IMAGE CONVERTER TUBE 6929

QUICK REFERENCE DATA

Diode image converter tube intended for use in the infrared region of the spectrum.

Photocathode	type C(S1)	
Screen phosphor	P20	
Useful cathode diameter	19	mm
Useful screen diameter	14.5	mm
Anode voltage	12	kV
Overall dimensions (approx.)	⌀35 × 60	mm
Weight (approx.)	42	g

To be read in conjunction with
GENERAL EXPLANATORY NOTES - IMAGE INTENSIFIER AND IMAGE
CONVERTER TUBES

PHOTOCATHODE

Surface	C(S1), caesium on oxidised silver	
Wavelength at maximum response	800 ±100	nm
Minimum useful diameter	19	mm
External radius of curvature of window	31	mm

SCREEN

Surface	metal backed P20	
Fluorescent colour	yellow-green	
Overall persistence	medium short	

The screen luminance falls to 36% (e^{-1}) of the initial peak value $200\mu s$ after the excitation is removed.

Minimum useful diameter	14.5	mm

FOCUSING

Self-focusing electrostatic with image inversion

CHARACTERISTICS (measured with V_a = 12kV at T_{amb} = 20°C)

Minimum conversion coefficient (see note 1)	0.4	cd/lm irf
Centre magnification M_c (see note 2)	0.74 ±0.025	
Distortion (see note 3)	5.5 to 10	%
Minimum centre resolution (see note 4)	50	line pairs/mm
Minimum edge resolution (see note 5)	12	line pairs/mm
Maximum background equivalent illumination (see note 6)	12×10^{-3}	lux irf
Maximum dark current	0.02	μA
Maximum axial eccentricity (see note 7)	1.0	mm

TYPICAL OPERATING CONDITIONS

V_a	12	kV
I_a	0.02	μA

Either the anode or the cathode should be earthed depending upon the application.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

V_a (pk) max.	13	kV
V_a max. (continuous operation)	12.5	kV
V_a min. (continuous operation)	9.0	kV
I_a max. (continuous operation)	0.1	μA
*Photocathode illumination		
continuous	10	lux irf
**intermittent	100	lux irf
T_{amb}		
maximum	+50	°C
minimum	−50	°C

*Assuming uniform irradiation of the photocathode.

**A duty factor of 0.3 with a maximum averaging time of 15min applies.

MOUNTING POSITION		Any
WEIGHT (approx.)	42	g

NOTES

1. This parameter is measured with the radiation from a tungsten lamp operating at a colour temperature 2854K. The radiation is filtered by means of a CS94 filter (Corning type 2540, Melt No. 1613, 2.61mm thick), before falling on the photo-cathode. The conversion coefficient is defined as the ratio of the luminous intensity of the screen in candela and the luminous flux in lumens which would be incident on the photocathode if the infrared filter were removed. This is indicated by "irf" (infrared filtered).

2. Measured at 3.2mm diameter concentric circle on the cathode.

3. Percentage distortion = $(\frac{M_d}{M_c} - 1) \times 100$ where M_d is the magnification at a distance 7.6mm from the centre of the photocathode, M_c is the magnification at the centre of the photocathode.

4. Measured at the photocathode within a circle of 3.2mm diameter.

5. Measured at the photocathode at a distance of 4.75mm from the centre.

6. This is the value of equivalent input illumination (irf) required to give an increase of luminance on the screen equal to the background luminance.

7. This is defined as the deviation of the cathode centre image from centre of the screen.

8. Permanent damage to the tube may result if it is exposed to radiant energy so great as to cause excessive heating of the photocathode.

9. Support for the tube may be provided by a simple clamp arrangement on either terminal. Only light pressure should be applied to avoid damage to the glass metal seals.

10. Connections to the terminals of the tube must not be soldered but should be made by either spring clips or simple clamps.

11. The tube is sensitive to stray magnetic fields which may impair the tube's resolution. In certain applications a mu-metal shield may be required.

Mullard

B7843

Ø 34.92 / 33.66

Ø 30.86 / 30.60

Bearing surface

5.08
3.56

Cathode window

External radius of photocathode
window = 31

Depth to cathode
pole = 3.18
1.66

Photocathode
terminal

Ø 33.4 max.

3 processing terminals 120°
apart connected to
cathode and covered
with Araldite resin.

Seal-off does not extend
beyond this line.

Ø 33.4 max.

Screen terminal

19.58
18.06

51.68
49.92

59.30
56.78

10.41
9.15

Depth to outside of
screen = 5.08
3.56

Screen window

Bearing
surface

5.08
3.56

Ø 30.86 / 30.60

Ø 34.92 / 33.66

All dimensions in mm

Mullard

PHOTOCATHODE RELATIVE SPECTRAL EMISSIVITY CURVE

RELATIVE SPECTRAL RESPONSE OF PHOSPHOR

Mullard

CHANNEL ELECTRON MULTIPLIERS

J

CHANNEL ELECTRON MULTIPLIERS

GENERAL EXPLANATORY NOTES

1. DESCRIPTION

A channel electron multiplier is a small curved glass tube, the inside wall of which is coated with a resistive material. When a potential is applied between the ends of the tube the resistive surface forms a continuous dynode, analogous to the separate dynodes of a conventional photomultiplier together with its associated resistive chain.

An electron entering the negative potential end of the multiplier generates secondary electrons on collision with the wall of the tube. These are accelerated along the tube until they strike the wall again where they generate further secondary electrons. This avalanching process continues along the length of the tube producing a large pulse of electrons at the positive end of the tube.

The channel electron multiplier must operate in a vacuum. For space research, the environmental vacuum is sufficient but in the laboratory the multiplier must be used in a vacuum chamber.

2. DEFINITIONS

2.1 Gain

The output pulse corresponding to one input electron will show a statistical spread. Due to saturation effects in the multiplier this spread is approximately Gaussian and the gain is defined as its median value.

For a gain of 1.0×10^8 a single input electron will produce an output of 16 picocoulombs.

The gain is constant up to a count rate of 1000 pulses per second. Above this the gain falls by approximately 3dB per octave. The count rate capability of the system may be increased by lowering the measuring threshold.

2.2 Background

The background pulse count rate is the number of pulses detected per second above the specified threshold and operating voltage when the input end of the multiplier is closed. There is no appreciable variation of background count rate when either the applied voltage or ambient temperature is changed.

2.3 Starting voltage

The starting voltage is the operating voltage at which 90% of the output pulses from single electron inputs exceed the specified threshold.

2.4 Resolution

The resolution of the multiplier is calculated from the pulse height distribution by taking the full width half maximum (F. W. H. M.) spread divided by its median value. This is expressed as a percentage.

2.5 Effective input aperture

The effective input aperture is defined as the boundary within which the count above the equivalent threshold remains greater than 50% of its maximum value.

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3. MODE OF OPERATION

The multiplier is most commonly used with pulse counting circuits to detect individual particles or quanta. For this application closed end multipliers are recommended. A typical circuit is shown in Figure 1. The output pulse is capacitively coupled into a suitable charge sensitive pulse amplifier and discrimator. Under certain circumstances the multiplier may be used as a current amplifier. In this case an open-ended multiplier is necessary, the output being collected at a separate electrode as shown in Figure 2.

Fig. 1   Fig. 2

The collector electrode is biased positively to ensure collection of all output electrons. For satisfactory linearity the multiplier should be operated with a gain of less than 10^5 and the output current should not exceed 1% of the standing current.

4. OPERATIONAL NOTES

4.1 Mounting

It is recommended that, in general, the leads are not used for mounting the device as sustained vibration may result in fracture of the electrical connections. This applies particularly to bakable versions.

4.2 **Vacuum environment**

Normal vacuum precautions should be observed. In particular gross contamination with hydrocarbon vapours will cause rapid loss of gain and should be avoided. If necessary the device may be cleaned in iso-propyl alcohol and air dried at a temperature not exceeding 70°C.

The device is stable in air and may be vacuum cycled repeatedly without damage.

4.3 **Baking conditions**

The specified baking conditions apply when the device is under vacuum. The temperature must not exceed the specified maximum operating and storage temperature unless the pressure is less than $50mN/m^2$ (3.7×10^{-4} torr). No voltage should be applied to the device during bake-out.

4.4 **Thermal stability**

Due to the negative temperature coefficient of resistance of the devices thermal runaway is possible. Operation below the maximum voltage and temperature limits specified will ensure that this does not occur.

4.5 **Choice of operating voltage**

Use of an operating voltage approximately 500 volts greater than the starting voltage will ensure that all output pulses exceed the threshold and are recorded. If, as a result of prolonged use the median gain of the multiplier falls, the operating voltage may be increased in order to restore the gain to its original value.

Mullard

CHANNEL ELECTRON MULTIPLIERS

B310AL B310AL/01
B310BL B310BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass planar spiral tube.

The B310AL has an open–ended output.
The B310BL has a closed output.
The B310AL/01 and B310BL/01 are bakable versions.

Typical gain (at 3.0kV)	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0	$\times 10^9$ Ω
Gain (see note 1)	1.0	1.3	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	1.1	1.25	–	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	4.0	kV
Temperature (operating and storage) max.	70	^{o}C
Bake temperatures max. (see note 2)		
B310AL, B310BL	120	^{o}C
B310AL/01, B310BL/01	400	^{o}C
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT   1.0   g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400°C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

Ø0.25 nickel wire (length 50) with conducting cement contact

Max. overall electrode Ø3.0

All dimensions in mm

D2186

CHANNEL ELECTRON MULTIPLIERS

B312AL   B312AL/01
B312BL   B312BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass planar spiral tube with a rectangular-section input cone 2.0×8.0mm.

The B312AL has an open-ended output.
The B312BL has a closed output.
The B312AL/01 and B312BL/01 are bakable versions.

Typical gain (at 3.0kV)	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain (see note 1)	1.0	1.3	–	$\times 10^8$
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.2	0.5	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input aperture	1.7×7.5	2.0×8.0	–	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	4.0	kV
Temperature (operating and storage) max.	70	$^{\text{o}}$C
Bake temperatures max. (see note 2)		
B312AL, B312BL	120	$^{\text{o}}$C
B312AL/01 and B312BL/01	400	$^{\text{o}}$C
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT   1.0   g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400$^{\text{o}}$C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

$\emptyset$0.25 nickel wire (length 50) with conducting cement contact

All dimensions in mm

D2167

CHANNEL ELECTRON MULTIPLIERS

B318AL B318AL/01
B318BL B318BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass planar spiral tube with a 5.0mm diameter input cone.

The B318AL has an open-ended output.

The B318BL has a closed output.

The B318AL/01 and B318BL/01 are bakable versions.

Typical gain (at 3.0kV)	1.3×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain (see note 1)	1.0	1.3	$- \times 10^8$	
Background above an equivalent threshold of 2.0×10^7 electrons	$-$	0.25	0.5	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	$-$	50	70	%
Effective cone diameter	4.0	5.0	$-$	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	4.0	kV
Temperature (operating and storage) max.	70	^oC
Bake temperatures max. (see note 2)		
B318AL, B318BL	120	^oC
B318AL/01, B318BL/01	400	^oC
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT	1.3	g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400°C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

∅0.25 nickel wire (length 50) with conducting cement contact

6.6 / 5.0

1.0 max.

3.0 / 2.0

15.5 / 13.5

25.5 / 24.5

18 / 15

Max. overall electrode

∅3.0

2.2 / 1.7 O.D.

1.4 / 1.1 I.D.

0.5 max.

1.0max.

All dimensions in m m

D2188

CHANNEL ELECTRON MULTIPLIERS

B330AL B330AL/01
B330BL B330BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass C-shaped tube.

The B330AL has an open-ended output.

The B330BL has a closed output.

The B330AL/01 and B330BL/01 are bakable versions.

Typical gain (at 3.0kV)	1.5×10^8	
Typical resistance	3.9×10^9	Ω
Maximum operating voltage	4.0	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 3.0kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0 $\times 10^9$	Ω
Gain (see note 1)	1.0	1.5	– $\times 10^8$	
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	2.0	2.5	2.6	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	1.1	1.25	–	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	4.0	kV
Temperature (operating and storage) max.	70	$^{\circ}$C
Bake temperatures max. (see note 2)		
B330AL, B330BL	120	$^{\circ}$C
B330AL/01, B330BL/01	400	$^{\circ}$C
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT   1.3   g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400°C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

Max. overall electrode ∅ 3.0

∅ 0.25 nickel wire (length 50) with conducting cement contact

3.5
1.5

90° ± 2°

2.2 / 1.7 O.D.
1.4 / 1.1 I.D.

44 / 40

All dimensions in mm

02189

CHANNEL ELECTRON MULTIPLIERS

B410AL   B410AL/01
B410BL   B410BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass planar spiral tube.

The B410AL has an open-ended output.
The B410BL has a closed output.
The B410AL/01 and B410BL/01 are bakable versions.

Typical gain (at 2.5kV)	1.5×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	3.5	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain (see note 1)	1.0	1.5	$- \times 10^8$	
Background above an equivalent threshold of 2.0×10^7 electrons	-	0.1	0.2	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	-	50	70	%
Effective input diameter	2.0	2.2	-	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	3.5	kV
Temperature (operating and storage) max.	70	^{o}C
Bake temperatures max. (see note 2)		
B410AL, B410BL	120	^{o}C
B410AL/01, B410BL/01	400	^{o}C
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT   3.0   g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400°C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

∅ 0.25 nickel wire (length 50) with conducting cement contact

Max. overall electrode
∅ 4.5

3.5
1.5

29
26

27.5
24.5

30.5
29.5

3.65
3.35 O.D.
2.3
2.1 I.D.

0.5 max.

1.0 max.

All dimensions in mm

02190

Mullard

CHANNEL ELECTRON MULTIPLIERS

B419AL B419AL/01
B419BL B419BL/01

QUICK REFERENCE DATA

Channel electron multipliers in the form of a glass planar spiral tube with a 10mm diameter input cone.

The B419AL has an open-ended output.

The B419BL has a closed output.

The B419AL/01 and B419BL/01 are bakable versions.

Typical gain (at 2.5kV)	1.7×10^8	
Typical resistance	3.0×10^9	Ω
Maximum operating voltage	3.5	kV

Unless otherwise stated, data is applicable to all types

This data should be read in conjunction with

GENERAL EXPLANATORY NOTES - CHANNEL ELECTRON MULTIPLIERS

CHARACTERISTICS (measured at 2.5kV and 1000 pulse/s where applicable)

	Min.	Typ.	Max.	
Resistance	2.0	3.0	5.0×10^9	Ω
Gain (see note 1)	1.0	1.7	$- \times 10^8$	
Background above an equivalent threshold of 2.0×10^7 electrons	–	0.25	0.5	pulse/s
Starting voltage with an equivalent threshold of 2.0×10^7 electrons	1.7	2.0	2.2	kV
Resolution (F.W.H.M.) at a modal gain of 1.0×10^8	–	50	70	%
Effective input diameter	9.0	10.0	–	mm

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	3.5	kV
Temperature (operating and storage) max.	70	^oC
Bake temperatures max. (see note 2)		
B419AL, B419BL	120	^oC
B419AL/01, B419BL/01	400	^oC
Ambient pressure with high voltage applied max.	50	mN/m^2
	3.7×10^{-4}	torr

WEIGHT	4.0	g

MOUNTING POSITION

Any. In environments where vibration may be encountered the device should not be supported by the leads alone.

NOTES

1. The gain of a typical multiplier will increase by a factor of 2 for an increase of operating voltage of 500V.

2. Baking will cause a permanent slight loss in gain and it is advisable to keep the baking time to a minimum, for example, baking for 16 hours at 400°C will reduce gain by approximately a factor of 2.

OUTLINE DRAWING

CHANNEL ELECTRON MULTIPLIER PLATE

G40-50

TENTATIVE DATA

An array of channel electron multipliers fused into the shape of a disc. The multipliers are electrically connected in parallel by means of nickel-chromium electrodes evaporated on to the faces of the disc.

SPECIFICATION

Diameter of disc	$53.0 \begin{smallmatrix}+0\\-0.2\end{smallmatrix}$	mm
Minimum useful diameter	51.8	mm
Thickness of disc	1.6 ± 0.1	mm
Channel diameter	40	μm
Channel pitch	50	μm
Open area (approx.)	60	%
Electrode material	nickel-chromium	
Electrical resistance between electrodes (approx.)	10^7	Ω
Current gain at 1.0kV (min.)	1000	

For linear relationship between input and output the output current must not exceed 0.1 of the standing current.

The plates are cut such that the channel electron multipliers form an angle of 13° to the perpendicular axis of the plate.

APPLICATIONS

These devices must operate in a vacuum, and may be used to detect electrons, ions, soft X-rays and ultra-violet photons falling on the input face of the disc, by producing electron pulses from the output face of the corresponding channel.

For space experiments the environmental vacuum is adequate for their operation.

In laboratory use they must be incorporated in a vacuum chamber, where they will have important applications in field ion microscopy, electron microscopy and allied areas of work.

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Operating voltage max.	2.0	kV
Temperature (operating and storage) max. (see note)	70	^{o}C
Bake temperature max.	300	^{o}C
Ambient pressure with high voltage applied max.	13.3	mN/m^2
	1.0×10^{-4}	torr
Diameter of plate clamping rings max.	52.4	mm

Note – The plate should be stored in a dry or vacuum environment.

Mullard

GEIGER-MÜLLER TUBES

K

GEIGER - MÜLLER TUBES

GENERAL EXPLANATORY NOTES

1. DESCRIPTION

Mullard halogen quenched Geiger-Müller tubes are manufactured to the highest standards for the reliable detection and measurement of alpha and beta particles and X and gamma radiation. When used within the specified limits they have a long life, with a minimum shelf life of two years and a minimum count life of 5×10^{10} counts.

A Geiger-Müller tube is a gasfilled device consisting basically of an electrode at a positive potential (anode) surrounded by a metal cylinder at a negative potential (cathode). For greater robustness in Mullard tubes the cathode is used, where possible, as the major part of the enclosing envelope. The filling normally consists of a mixture of rare gases and a quenching gas which terminates each discharge following the ionisation of the main gases by the incident radiation. In all Mullard tubes the quenching gas is a halogen giving them important advantages over tubes in which the quenching gas is an organic vapour. During the quenching process the halogen molecules dissociate temporarily whereas organic agents are decomposed permanently, resulting in a shorter life due to decrease of plateau length.

Choice of tube for a particular application may be determined by considering the following factors: -

(a) Type of radiation to be measured (α, β, γ, X).

(b) Intensity of radiation to be measured.

(c) Temperature range of operation.

(d) Physical dimensions restrictions.

(e) Accuracy required.

2. PLATEAU CHARACTERISTICS

The characteristic curve for a Geiger-Müller tube is the "plateau" (Fig. 1.) which is obtained by plotting the counting rate in a fixed radiation field against increasing applied voltage. The point at which counts are first recorded is known as the "starting voltage (Vs)" and the counting rate then increases rapidly until the "threshold voltage (Vt)" of the plateau is reached. During a further increase of the voltage by a 100 volts or more the count rate remains essentially uniform and the end of the plateau is marked by a considerable increase in the count rate. In practice the "plateau length" is rarely flat and the deviation, "plateau slope", is calculated as the percentage change in count rate for a given change, usually 100 volts, in applied voltage. Slope is also frequently specified as %/V.

Unlike the organic vapours there is no decomposition of the halogen as a result of the discharge, and the plateau characteristics are maintained throughout the long life of the Geiger-Müller tube. Decrease of the anode resistance shortens the dead time and also the plateau length. A decrease of the resistance below the indicated value causes the tube to oscillate. It also follows that the tube must be kept clean and dry. The published specifications are from measurements taken in Circuits A, B or C (Fig. 2.) as shown on the data sheets for each tube type.

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Fig. 1

Fig. 2

3. CIRCUIT REQUIREMENTS

Operation of a halogen quenched tube at too high a charge per pulse is the only known cause of deterioration of its characteristics and this may occur quite rapidly or extend over a period of weeks or even months. Only a small percentage of tubes is usually affected and the problem is completely resolved by mounting the anode resistor on the Geiger-Müller tube and keeping the total capacitance, which the tube can see, at a low level.

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4. DEAD TIME

The dead time (Fig. 3.) of a Geiger-Müller tube is defined as the interval after the initiation of a voltage pulse during which (assuming no interference by an external circuit) a subsequent ionizing event does not produce a discharge. Dead time varies with the applied voltage and the published figures are typical for the mid-point of the plateau with the stated anode resistor.

Fig. 3

5. RECOVERY TIME

Recovery time has variously been defined as the minimum time interval after the initiation of a voltage pulse before the next voltage pulse of normal size or the next voltage pulse which has a specific percentage of normal size. In practice this percentage is fixed by the input voltage sensitivity of the counting equipment. Recovery time is rarely included in tube specifications but as a rough guide may be taken as approximately twice the dead time.

6. TEMPERATURE RANGE

Halogen quenched tubes have a much wider temperature range than organic quenched types. Mullard Geiger-Müller tubes can be used between -50°C and 75°C with a temperature coefficient of starting voltage of only 0.02V/°C. Gamma sensitive tubes to operate at 145°C can be made to special order.

7. BACKGROUND

The "background" of a counter is the counting rate in the absence of the radiation which the counter is meant to measure. The most important sources of background are: -

(a) The gamma radiation from the environment and from cosmic radiation.

(b) The mesons from cosmic radiation.

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7. BACKGROUND (Contd.)

    (c) The beta particles from contaminations and impurities of the materials from which the detector itself is made.

    (d) The spontaneous discharges or pulses in the detector and the counting circuit which do not originate from radiation.

From published experimental data the gamma contribution accounts for 60 to 75% of the background and 23 to 35% is due to the cosmic mesons. For the majority of Geiger-Müller tube applications the background can be reduced to an acceptable level by shielding the tube with lead or steel. By this most of the gamma contribution is eliminated.

For the measurement of low activity beta sources, end window Geiger-Müller tubes, which have a high efficiency for electrons and a low efficiency for gammas, have been developed (ref. MX152 and MX166). They are manufactured from selected materials to give a low inherent background and due to their good long term elect- rical stability and their large output pulses the associated circuit can be very simple.

To eliminate cosmic mesons it has been customary to surround the beta tube with a ring of cosmic ray tubes in anticoincidence. By using a compact guard tube type MX155 instead of the ring of large tubes, a considerable economy in the bulk, and therefore the cost, of the external shield can be achieved.

8. ENERGY DEPENDENCE

The sensitivity of Geiger-Müller tubes to gamma radiation is influenced consider- ably by the energy of the radiation and the typical response of four tube types is shown in Fig. 4. Their curves can be broadly explained as follows: -

At energies above about 300 to 400keV, the action of the tube is due to the emission of electrons from the cathode and the higher the atomic number of the cathode material the greater will be the electron emission. Radiation with an energy of less than 300 to 400keV is absorbed by the filling gas, the absorption increasing as the energy decreases. This gives rise to the characteristic peak in sensitivity which occurs at about 60keV when the sensitivity decreases rapidly through cut-off by the thickness or density of the cathode wall.

By the use of an external filter a near linear sensitivity can be obtained. The effect of typical filters on sensitivity is given in Fig. 5. Designs for these filters are illustrated in Fig. 6.

Fig. 4

Fig. 5

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Typical filter designs for energy correction

MX146

MX151

MX163

MX164

Perspex   Tin   Lead

All dimensions in mm

D5805

Fig. 6

Mullard

GEIGER MÜLLER TUBE MX118

QUICK REFERENCE DATA

Halogen quenched X-ray sensitive tube

Recommended working voltage   1250   V

Efficiency is over 50% for wavelengths between 0.12 and 0.25nm (1.2 to 2.5Å)

OUTLINE DRAWING

All dimensions in mm

D523

WINDOW

Thickness	3.5 to 4	mg/cm^2
Effective diameter	20	mm
Material	mica	

CATHODE

Wall thickness	1.2	mm
Sensitive length	110	mm
Material	Chrome iron (27% chrome)	

FILLING   Argon and halogen

CAPACITANCE

Anode to cathode	2.7	pF

ELECTRICAL CONNECTIONS

Cathode	Body
Anode	Cap

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OPERATING CHARACTERISTICS ($T_{amb} = 20^{\circ}C$)

measured in circuit of Fig.1

Max. starting voltage	1040	V
Max. threshold voltage	1100	V
Min. plateau length	200	V
Max. plateau slope	0.08	%/V
Recommended working voltage	1250	V
Max. background at 1250V shielded with 50mm lead and 3mm aluminium	50	counts/min
Dead time at 1250V	150	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	1350	V
Max. ambient temperature	+75	$^{\circ}C$
Min. ambient temperature	-55	$^{\circ}C$

SENSITIVITY

Quantum efficiency is more than 50% to $K\alpha$ radiation of Cu, Ni, Co, Fe and Cr.

TEST INPUT CIRCUIT

Fig. 1

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GEIGER MÜLLER TUBE MX118

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

TEMPERATURE DEPENDENCE OF VARIOUS VOLTAGES

Mullard

GEIGER MÜLLER TUBE   MX119

QUICK REFERENCE DATA

Halogen quenched high current gamma tube

Recommended working voltage	600	V
Gamma sensitivity at 10mR/h (^{60}Co source)	5700	counts/min

OUTLINE DRAWING


```
|←——— 95 ———→|←——— 80 max ———→|
```

Anode
plain braided
copper wire

Cathode
tinned braided
copper wire

∅ 10 max

All dimensions in mm   D52?

CATHODE

Thickness	400	mg/cm^2
Sensitive length	40	mm
Material	Chrome iron (20% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.2	pF

ELECTRICAL CONNECTIONS

Cathode	Tinned copper flying lead
Anode	Untinned copper flying lead

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig.1

Max. starting voltage	370	V
Max. threshold voltage	450	V
Min. plateau length	225	V
Max. plateau slope	0.15	%/V
Recommended working voltage	600	V
Max. background at 600V shielded with 50mm lead and 3mm aluminium	20	counts/min
Max. dead time at 600V	35	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	$M\Omega$
Max. anode voltage	725	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	~40	^{o}C

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER MÜLLER TUBE   MX119

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

CURRENT AS A FUNCTION OF DOSE RATE

Mullard

TEMPERATURE DEPENDENCE OF STARTING VOLTAGE

Mullard

GEIGER MÜLLER TUBE MX120/01

QUICK REFERENCE DATA

Halogen quenched all−metal gamma tube

Recommended working voltage	420	V
Gamma sensitivity at 1.0mR/h (Radium source)	6800	counts/min

OUTLINE DRAWING

Cathode
tinned braided
copper wire

P.V.C sheath over length of 164±1

Metal cap

Anode
plain braided
copper wire

sensitive length

ø 23
±0.25

19±1

9±1

100±5

168±2

All dimensions in mm

D533

CATHODE

Thickness	525	mg/cm^2
Sensitive length	140	mm
Material	Chrome iron (27% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	4.5	pF

ELECTRICAL CONNECTIONS

Cathode	Tinned copper flying lead
Anode	Untinned copper flying lead

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OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig.1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	370	V
Min. plateau length	100	V
Max. plateau slope	0.15	%/V
Recommended working voltage	420	V
Max. background at 420V, unshielded	90	counts/min
Dead time at 420V	200	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	$M\Omega$
Max. anode voltage	470	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	-55	^{o}C

(The starting voltage is independent of temperature within this range)

SENSITIVITY

Sensitivity at 1.0mR/h (Radium source)	6800	counts/min

TEST INPUT CIRCUIT

Fig. 1

GEIGER MÜLLER TUBE   MX120/01

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

Dead time (μs) plotted against Vb (V), D536

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

Mullard

GEIGER MÜLLER TUBE   MX123

QUICK REFERENCE DATA

Halogen quenched end window beta tube

Recommended working voltage	600	V
Window thickness	1.5 to 2.5	mg/cm^2

Beta particles arriving at the window with an energy exceeding 26 to 35kV will be counted.

OUTLINE DRAWING

All dimensions in mm

4.8 ±0.25
metal
Ø 34.9 ±0.25
Ø 24.1±1 window
R1±0.5
Ø 2.8 ±0.2
Ø 25.9 ±0.2
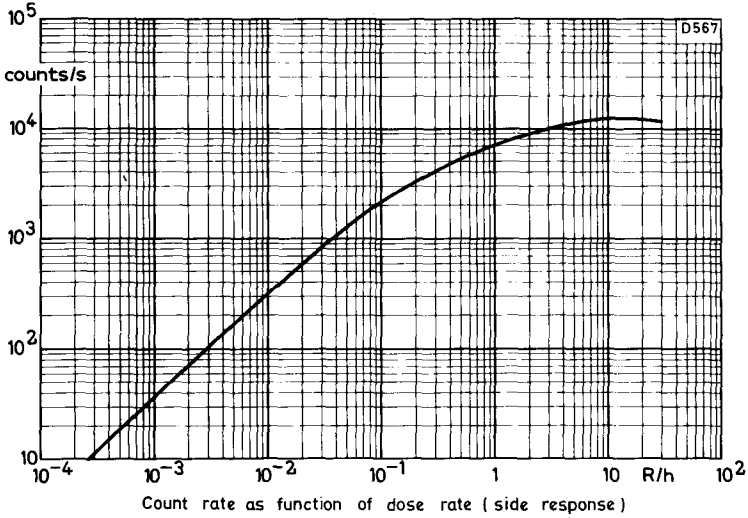Ø 25.35 ±0.25
5.1±0.25
1.2±0.25
46±0.3
67±1
D537

WINDOW

Thickness	1.5 to 2.5	mg/cm^2
Effective diameter	24.1	mm
Material	mica	

CATHODE

Thickness	0.9	mm
Sensitive length	26	mm
Material	Chrome iron (27% chrome)	

FILLING   Neon, argon and halogen

Mullard

CAPACITANCE

    Anode to cathode   5.0   pF

ELECTRICAL CONNECTIONS

    Cathode   Wall

    Anode   Turret

OPERATING CHARACTERISTICS ($T_{amb} = 20\,^{\circ}C$)

    measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)	500	V
Max. threshold voltage	550	V
Min. plateau length	150	V
Max. plateau slope	0.15	%/V
Recommended working voltage	600	V
Max. background at 600V shielded with 50mm lead and 3mm aluminium	25	counts/min
Dead time at 600V	60	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	700	V
Max. ambient temperature	+75	$^{\circ}C$
Min. ambient temperature	-55	$^{\circ}C$

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER MÜLLER TUBE   MX123

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

TEMPERATURE DEPENDENCE OF STARTING VOLTAGE

Mullard

GEIGER MÜLLER TUBE MX124/01

QUICK REFERENCE DATA

Halogen quenched liquid sample Geiger Müller tube

Recommended working voltage	450	V
Sample volume	9 to 10	ml

OUTLINE DRAWING

Ø 25 max over 142 min length

Type 1
white polythene
hollow stopper

All dimensions in mm

D542

CATHODE

Spiral diameter (mean)	12.5	mm
Sensitive length	60	mm
Material		Chrome iron

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.5	pF

ELECTRICAL CONNECTIONS

Cathode	Offset wire
Anode	Central wire
For use with mercury pools	

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig.1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	400	V
Min. plateau length	100	V
Max. plateau slope	0.15	%/V
Recommended working voltage	450	V
Max. background at 450V shielded with 50mm lead and 3mm aluminium	50	counts/min
Dead time at 450V	100	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	500	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	–55	^{o}C

LIQUID CAPACITY

To top of inner tube	9 to 10	ml

TEST INPUT CIRCUIT

Fig.1

Mullard

GEIGER MÜLLER TUBE   MX124/01

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

TEMPERATURE DEPENDENCE OF STARTING VOLTAGE

Mullard

GEIGER-MÜLLER TUBE   MX142

QUICK REFERENCE DATA

Halogen quenched liquid sample Geiger-Müller tube

Recommended working voltage	420	V
Sample volume	4.6 to 7.0	ml

OUTLINE DRAWING

Ø26 ±0.5

Ø23

9.5 ±0.5

28.5

102

Anode

A

C

Cathode

B2A base

Wall thickness (mean) 15mg/cm²

All dimensions in mm

D5598

CATHODE

Spiral diameter (mean)	12	mm
Sensitive length	25	mm
Material		Chrome iron

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.0	pF

ELECTRICAL CONNECTIONS

B2A base

Mullard

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	370	V
Min. plateau length	100	V
Max. plateau slope	0.25	%/V
Recommended working voltage	420	V
Max. background at 420V shielded with 50mm lead and 3mm aluminium	20	counts/min
Dead time at 420V	110	µs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	500	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	-55	^{o}C

LIQUID CAPACITY

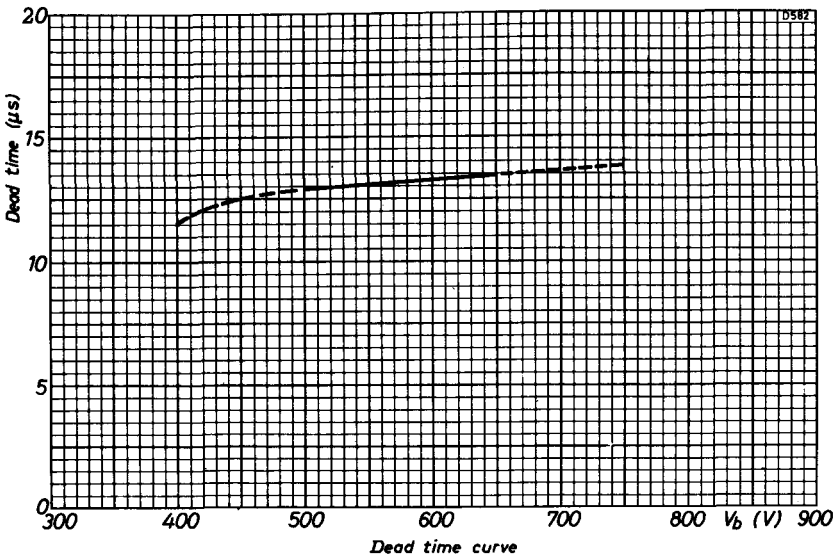|		
To top of inner tube	4.6 to 7.0	ml

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER MÜLLER TUBE　　　　MX145

QUICK REFERENCE DATA

Halogen quenched all-metal gamma tube

Recommended working voltage	420	V
Gamma sensitivity at 1.0mR/h (Radium source)	13 000	counts/min

OUTLINE DRAWING

All dimensions in mm　　　　D552

CATHODE

Thickness	525	mg/cm^2
Sensitive length	240	mm
Material	Chrome iron (27% chrome)	

FILLING　　　　Neon, argon and halogen

CAPACITANCE

Anode to cathode	10	pF

ELECTRICAL CONNECTIONS

Cathode	Tinned copper flying lead
Anode	Untinned copper flying lead

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	370	V
Min. plateau length	100	V
Max. plateau slope	0.15	%/V
Recommended working voltage	420	V
Max. background at 420V, unshielded	160	counts/min
Dead time at 420V	200	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	470	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	−55	^{o}C

(The starting voltage is independent of temperature over this range)

SENSITIVITY

Sensitivity at 1.0mR/h (Radium source)	13 000	counts/min

TEST INPUT CIRCUIT

Fig. 1

GEIGER MÜLLER TUBE   MX145

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

Mullard

GEIGER MÜLLER TUBE MX146

Recommended working voltage	500	V
Sensitivity range (^{60}Co gamma radiation)	10^{-4} to 1	R/h

OUTLINE DRAWING

All dimensions in mm

CATHODE

Thickness	250	mg/cm^2
Sensitive length	40	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.0	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25\,^{o}C$)

measured in circuit of Fig. 1

Max. starting voltage	325	V
Starting voltage temperature coefficient	0.5	V/degC
Max. threshold voltage	400	V
Min. plateau length	200	V
Max. plateau slope	0.03	%/V
Recommended working voltage	500	V
Max. background at 500V unshielded	45	counts/min
Max. dead time at 500V	90	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	4.7	MΩ
Max. anode voltage	600	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	–50	^{o}C

TEST INPUT CIRCUIT

R1 = 10MΩ

R2 = 220kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig. 1

GEIGER MÜLLER TUBE — MX146

Count rate as function of dose rate

Current as function of dose rate

Mullard

Dead time curve

Plateau curve

Mullard

GEIGER MÜLLER TUBE   MX147

<table>
<tr><td colspan="3">**QUICK REFERENCE DATA**</td></tr>
<tr><td colspan="3">Halogen quenched end window beta and gamma tube</td></tr>
<tr><td>Recommended working voltage</td><td>500</td><td>V</td></tr>
<tr><td>Window thickness</td><td>2 to 3</td><td>mg/cm^2</td></tr>
<tr><td>Window diameter</td><td>9</td><td>mm</td></tr>
</table>

OUTLINE DRAWING

All dimensions in mm

WINDOW

Thickness	2 to 3	mg/cm^2
Effective diameter	9	mm
Material	mica	

CATHODE

Thickness	250	mg/cm^2
Sensitive length	39	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.0	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^{o}C$)

measured in circuit of **Fig.**1

Max. starting voltage	325	V
Starting voltage temperature coefficient	0.5	V/degC
Max. threshold voltage	400	V
Min. plateau length	200	V
Max. plateau slope	0.03	%/V
Recommended working voltage	500	V
Max. background at 500V shielded with 50mm lead and 3mm aluminium	10	counts/min
Max. dead time at 500V	90	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	4.7	MΩ
Max. anode voltage	600	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	−50	^{o}C

TEST INPUT CIRCUIT

R1 = 10MΩ

R2 = 220kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig.1

GEIGER MÜLLER TUBE   MX147

Count rate as function of dose rate (side response)

Current as function of dose rate

Mullard

Plateau curve

Dead time curve

GEIGER MÜLLER TUBE   MX148

QUICK REFERENCE DATA

Halogen quenched end window alpha, beta and gamma tube

Recommended working voltage	575	V
Window thickness	1.5 to 2	mg/cm^2
Window diameter	19.8	mm

OUTLINE DRAWING

All dimensions in mm

WINDOW   D566

Thickness	1.5 to 2	mg/cm^2
Effective diameter	19.8	mm
Material	mica	

CATHODE

Thickness	1.2	mm
Sensitive length	37	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.5	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

Mullard

OPERATING CHARACTERISTICS ($T_{amb} = 25^{o}C$)

measured in circuit of Fig. 1

Max. starting voltage	350	V
Max. threshold voltage	450	V
Min. plateau length	250	V
Max. plateau slope	0.02	%/V
Recommended working voltage	575	V
Max. background at 575V shielded with 50mm lead and 3mm aluminium	15	counts/min
Max. dead time at 575V	175	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	$M\Omega$
Max. anode voltage	700	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	-50	^{o}C

TEST INPUT CIRCUIT

$R = 10m\Omega$

Fig. 1

Mullard

Count rate as function of dose rate (side response)

Plateau curve

Dead time curve

Starting voltage as function of ambient temperature

Mullard

GEIGER MÜLLER TUBE   **MX149**

QUICK REFERENCE DATA

Halogen quenched end window beta and gamma tube

Recommended working voltage	575	V
Window thickness	2.5 to 3.5	mg/cm^2
Window diameter	27.8	mm

OUTLINE DRAWING

All dimensions in millimetres

WINDOW

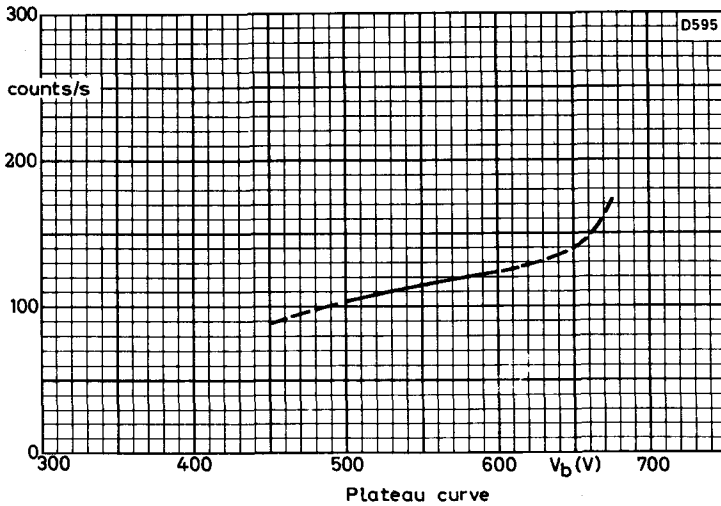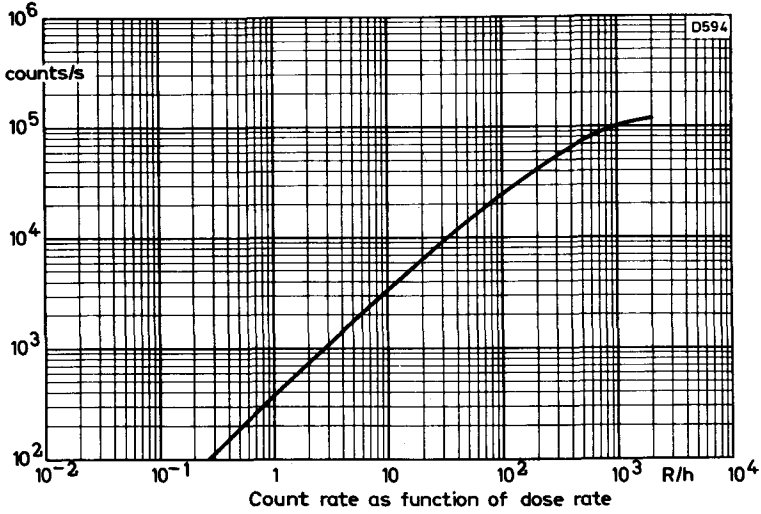|		
Thickness	2.5 to 3.5	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1.3	mm
Sensitive length	37	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	3.5	pF

Mullard

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^oC$)

measured in circuit of Fig.1

Max. starting voltage	375	V
Max. threshold voltage	450	V
Min. plateau length	250	V
Max. plateau slope	0.035	%/V
Recommended working voltage	575	V
Max. background at 575V shielded with 50mm lead and 3mm aluminium	25	counts/min
Max. dead time at 575V	190	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	MΩ
Max. anode voltage	700	V
Max. ambient temperature	+75	^oC
Min. ambient temperature	−50	^oC

TEST INPUT CIRCUIT

R1 = 10MΩ

R2 = 220kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig.1

GEIGER MÜLLER TUBE   MX149

Count rate as function of dose rate (side response)

Plateau curve

Mullard

Dead time curve

Starting voltage as function of ambient temperature

Mullard

GEIGER MÜLLER TUBE   MX151

QUICK REFERENCE DATA

Halogen quenched high current gamma and high energy beta (>0.5MeV) tube

Recommended working voltage	575	V
Gamma dose rate range (^{60}Co source)	10^{-3} to 3.10^{2}	R/h

OUTLINE DRAWING

All dimensions in millimetres

CATHODE

Thickness	80 to 100	mg/cm^2
Sensitive length	16	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	1.0	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^{o}C$)

measured in circuit of Fig.1

Max. starting voltage	380	V
Max. threshold voltage	500	V
Min. plateau length	150	V
Max. plateau slope	0.15	%/V
Recommended working voltage	575	V
Max. background at 575V shielded with 50mm lead and 3mm aluminium	2	counts/min
Max. dead time at 575V	15	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	$M\Omega$
Max. anode voltage	650	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	−40	^{o}C

TEST INPUT CIRCUIT

R1 = 2.2MΩ

R2 = 56kΩ

C1 = 1pF

R1 C1 = R2 C2
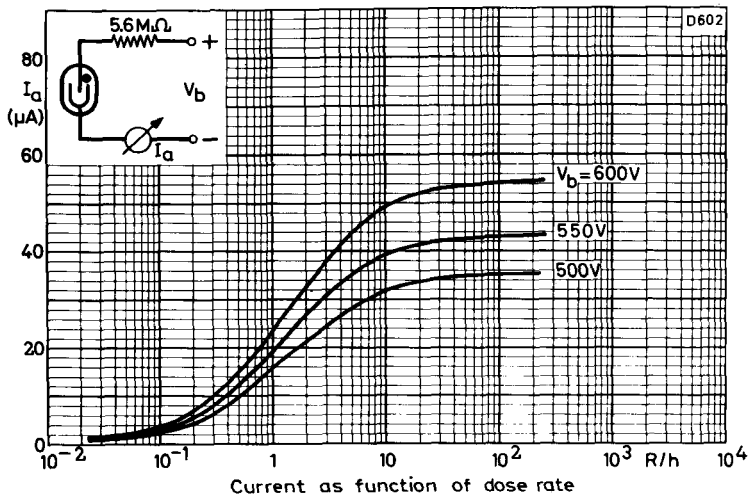

Fig.1

GEIGER MÜLLER TUBE $\qquad$ **MX151**

Count rate as function of dose rate

Current as function of dose rate

Mullard

Current as function of dose rate

Energy response curve (side response)

Mullard

GEIGER MÜLLER TUBE   MX151

D581

counts/s

Count rate approx 1000 counts/s

1500

1000

500

0
300   400   500   600   700 V_b (V)   800

Plateau curve

D582

20

Dead time (μs)

15

10

5

0
300   400   500   600   700   800 V_b (V)   900

Dead time curve

Mullard

Starting voltage as function of ambient temperature

Mullard

GEIGER MÜLLER TUBE   MX152

OUTLINE DRAWING

All dimensions in mm

WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	19.8	mm
Material	mica	

CATHODE

Thickness	1.2	mm
Sensitive length	13	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	1.0	pF

Mullard

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25\,^{\circ}C$)

measured in circuit of Fig.1

Max. starting voltage	350	V
Max. threshold voltage	500	V
Min. plateau length	200	V
Max. plateau slope	0.09	%/V
Recommended working voltage	600	V
Max. background at 600V shielded with 100mm iron outside 30mm lead	5	counts/min
Max. background at 600V shielded as above in anticoincidence circuit with guard tube MX155	1.2	counts/min
Max. dead time at 600V	65	µs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	MΩ
Max. anode voltage	700	V
Max. ambient temperature	+50	$^{\circ}C$
Min. ambient temperature	–50	$^{\circ}C$

TEST INPUT CIRCUIT

R1 = 4.7MΩ

R2 = 100kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig.1

NOTE

The tube should be kept dry and well cleaned to safeguard against leakage.

GEIGER MÜLLER TUBE   MX152

Count rate as function of dose rate (side response)

Plateau curve

Mullard

Dead time curve

Starting voltage as function of ambient temperature

GEIGER MÜLLER TUBE

MX155

QUICK REFERENCE DATA

Halogen quenched cosmic ray guard tube for low background measurements in combination with a beta tube, for example types MX152 or MX166, in an anticoincidence circuit. It can also be used in combination with a gas–flow counter.

Recommended working voltage	900	V
Hollow anode diameter	40	mm

OUTLINE DRAWING

76±1
max 15
max 15
53−57
min30
4 x 0.127
max 75
a
k
39−41
min 30
max 80
D589
4 x 0.127

All dimensions in millimetres

CATHODE AND ANODE

Thickness	1	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	8.0	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Strap

Mullard

OPERATING CHARACTERISTICS ($T_{amb} = 25^{o}C$)

measured in circuit of Fig.1

Max. starting voltage	650	V
Max. threshold voltage	800	V
Min. plateau length at 50 counts/s	400	V
Max. plateau slope at 50 counts/s	0.03	%/V
Recommended working voltage	900	V
Max. background at 900V shielded with 100m iron outside 30mm lead	70	counts/min
Max. dead time at 50 counts/s	1.0	ms

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	10	MΩ
Max. anode voltage	1.2	kV
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	–50	^{o}C

TEST INPUT CIRCUIT

R = 10MΩ

RECOMMENDED CIRCUIT

For use as guard tube in anticoincidence circuits in combination with MX152 or MX166.

R1 = 10MΩ

R2 = 10MΩ

Fig.1

Fig.2

Mullard

GEIGER MÜLLER TUBE   MX155

Count rate as function of dose rate

Plateau curve

Mullard

Starting voltage as function of temperature

GEIGER MÜLLER TUBE   MX163

QUICK REFERENCE DATA

Halogen quenched high current gamma and high energy beta (>0.5MeV) tube

Recommended working voltage	550	V
Gamma dose rate range (^{60}Co source)	10^{-2} to 2.10^3	R/h

OUTLINE DRAWING

All dimensions in millimetres

CATHODE

Thickness	80 to 100	mg/cm^2
Sensitive length	8	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, helium and halogen

CAPACITANCE

Anode to cathode	0.7	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^\circ C$)

measured in circuit of Fig. 1

Max. starting voltage	400	V
Max. threshold voltage	500	V
Min. plateau length	100	V
Max. plateau slope	0.3	%/V
Recommended working voltage	550	V
Max. background at 550V shielded with 50mm lead and 3mm aluminium	1	count/min
Max. dead time at 550V	11	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	$M\Omega$
Max. anode voltage	600	V
Max. ambient temperature	+75	$^\circ C$
Min. ambient temperature	−40	$^\circ C$

TEST INPUT CIRCUIT

R1 = 2.2MΩ

R2 = 47kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig. 1

GEIGER MÜLLER TUBE   MX163

Count rate as function of dose rate

Plateau curve

Mullard

Current as function of dose rate

Current as function of dose rate

Mullard

GEIGER MÜLLER TUBE   MX164

QUICK REFERENCE DATA

Halogen quenched high current gamma and beta (>0.25MeV) tube

Recommended working voltage	575	V
Cathode wall thickness	32 to 40	mg/cm^2
Gamma dose rate range (^{60}Co source)	10^{-3} to 10^2	R/h

OUTLINE DRAWING

All dimensions in millimetres

CATHODE

Thickness	32 to 40	mg/cm^2
Sensitive length	28	mm
Material	Chrome iron (28% chrome)	

FILLING   Neon, argon and halogen

CAPACITANCE

Anode to cathode	1.1	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25°C$)

measured in circuit of Fig.1

Max. starting voltage	380	V
Max. threshold voltage	500	V
Min. plateau length	150	V
Max. plateau slope	0.08	%/V
Recommended working voltage	575	V
Max. background at 575V shielded with 50mm lead and 3mm aluminium	12	counts/min
Max. dead time at 575V	45	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.2	$M\Omega$
Max. anode voltage	650	V
Max. ambient temperature	+75	°C
Min. ambient temperature	–50	°C

TEST INPUT CIRCUIT

R1 = 4.7MΩ

R2 = 100kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig.1

GEIGER MÜLLER TUBE   MX164

D599

Count rate as function of dose rate

D600

Plateau curve

Mullard

Current as function of dose rate

Current as function of dose rate

Mullard

Dead time curve

Starting voltage as function of ambient temperature

GEIGER MÜLLER TUBE   MX166

QUICK REFERENCE DATA

Halogen quenched end window alpha and beta tube for low level measurements
in combination with guard tube type MX155.

Recommended working voltage	600	V
Window thickness	1.5 to 2	mg/cm^2
Window diameter	27.8	mm

OUTLINE DRAWING

All dimensions in mm

D605

WINDOW

Thickness	1.5 to 2	mg/cm^2
Effective diameter	27.8	mm
Material	mica	

CATHODE

Thickness	1.3	mm
Sensitive length	18	mm
Material	Chrome iron (28% chrome)	

FILLING

Neon, argon and halogen

CAPACITANCE

Anode to cathode	1.4	pF

Mullard

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^{o}C$)

measured in circuit of Fig.1

Max. starting voltage	375	V
Max. threshold voltage	500	V
Min. plateau length	250	V
Max. plateau slope	0.07	%/V
Recommended working voltage	600	V
Max. background at 600V shielded with 100mm iron outside 30mm lead	9	counts/min
Max. background at 600V shielded as above in anticoincidence circuit with guard tube MX155	2	counts/min
Max. dead time at 600V	60	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	4.7	MΩ
Max. anode voltage	750	V
Max. ambient temperature	+50	^{o}C
Min. ambient temperature	−50	^{o}C

TEST INPUT CIRCUIT

R1 = 10MΩ

R2 = 220kΩ

C1 = 1 pF

R1 C1 = R2 C2

Fig.1

Mullard

GEIGER MÜLLER TUBE   MX166

D606

Count rate as function of dose rate (side response)

D607

Plateau curve

Mullard

Dead time curve

Starting voltage as function of ambient temperature

Mullard

GEIGER MÜLLER TUBE — MX167/01

OUTLINE DRAWING

All dimensions in mm

WINDOW

Thickness	3.5 to 4	mg/cm^2
Effective diameter	51	mm
Material	mica	

CATHODE

Thickness	1.25	mm
Sensitive length	25	mm
Material	Chrome iron (28% chrome)	

FILLING

Neon, argon and halogen

CAPACITANCE

Anode to cathode	5.0	pF

ELECTRICAL CONNECTIONS

Cathode	Strap
Anode	Clip

OPERATING CHARACTERISTICS ($T_{amb} = 25^{O}C$)

measured in circuit of Fig.1

Max. starting voltage	400	V
Max. threshold voltage	700	V
Min. plateau length	400	V
Max. plateau slope	0.04	%/V
Recommended working voltage	900	V
Max. background at 900V shielded with 50mm lead and 3mm aluminium	45	counts/min
Max. dead time at 900V	45	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	3.9	MΩ
Max. anode voltage	1100	V
Max. ambient temperature	+75	^{O}C
Max. ambient temperature for continuous operation	+50	^{O}C
Min. ambient temperature	−50	^{O}C

TEST INPUT CIRCUIT

R = 4.7MΩ

Fig.1

GEIGER MÜLLER TUBE   MX167/01

Count rate as function of dose rate

D612

Current as function of dose rate

D613

Current as function of dose rate

GEIGER MÜLLER TUBE MX167/01

Plateau curve

Dead time curve

Starting voltage as function of ambient temperature

GEIGER - MÜLLER TUBES

MX168
MX168/01
MX168/02

QUICK REFERENCE DATA

Halogen quenched mica end window beta and gamma tubes

Recommended working voltage	420	V
Window thickness - MX168 and MX168/02	2.5 to 3	mg/cm^2
- MX168/01	1.5 to 2.5	mg/cm^2
Window diameter	17	mm

OUTLINE DRAWING - MX168 and MX168/01

(Outline drawing for MX168/02 on page 4)

80 max
75±1
28.5±1
9.5±0.5
Ø26 ±0.5
Ø23
Ø24
Anode
A
C
Cathode
B2A base
P.V.C sheath over this length
9±1
All dimensions in mm
D639

WINDOW

Thickness - MX168 and MX168/02	2.5 to 3	mg/cm^2
- MX168/01	1.5 to 2.5	mg/cm^2
Effective diameter without protective cover (Protective cover reduces effective window area by 40%)	17	mm
Material	mica	

CATHODE

Thickness	2.6	mm
Sensitive length	38	mm
Material	Chrome iron (20 to 30% chrome)	

FILLING Neon, argon and halogen

Mullard

CAPACITANCE

Anode to cathode   3.5   pF

ELECTRICAL CONNECTIONS

MX168 and MX168/01   B2A base

MX168/02   Flying leads

OPERATING CHARACTERISTICS (T_{amb} = 20°C)

measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)   350   V

Max. threshold voltage   370   V

Min. plateau length   100   V

Max. plateau slope   0.15   %/V

Recommended working voltage   420   V

Max. background at 420V shielded with
50mm lead and 3mm aluminium   30   counts/min

Dead time at 420V   100 μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor   2.7   MΩ

Max. anode voltage   470   V
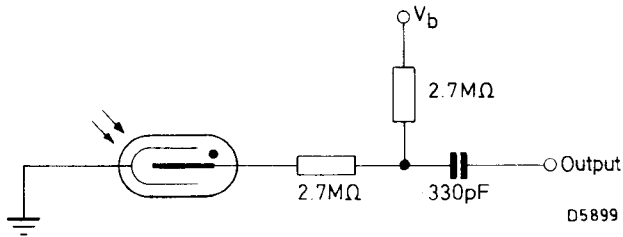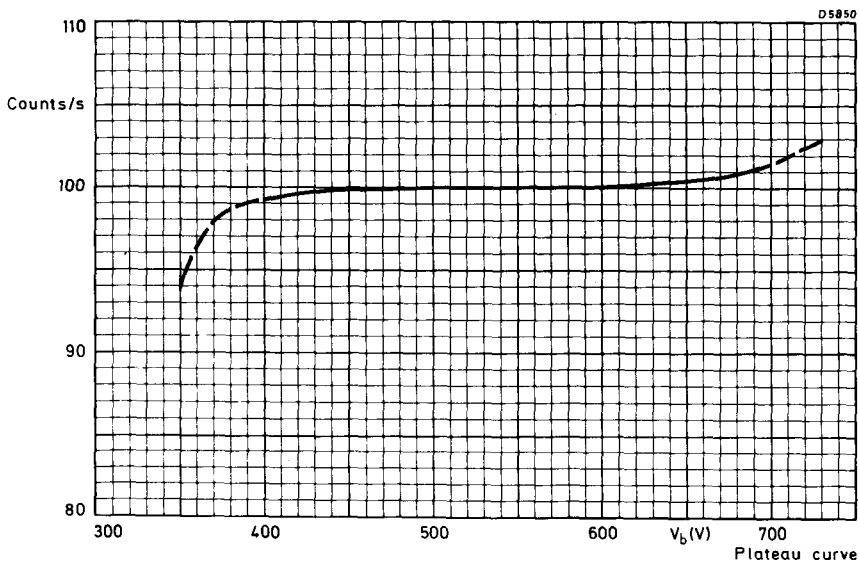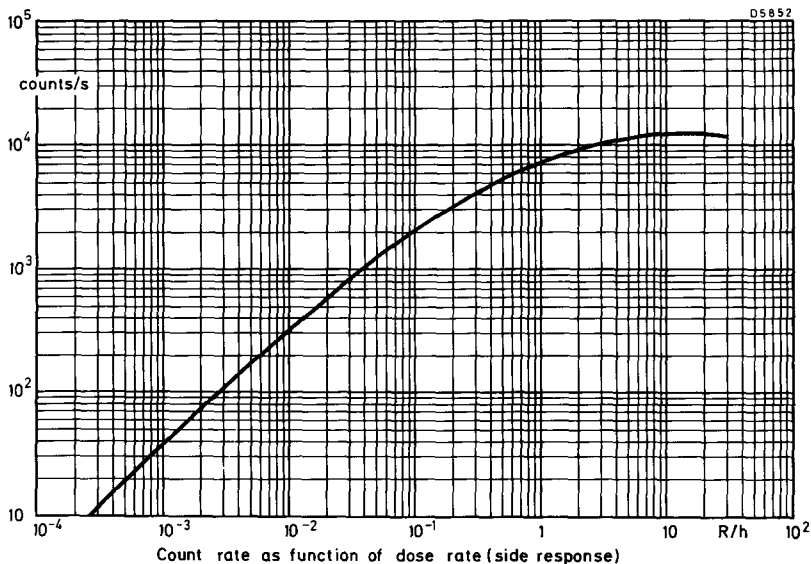
Max. ambient temperature   +75   °C

Min. ambient temperature   -55   °C

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER - MÜLLER TUBES

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

OUTLINE DRAWING - MX168/02

Mullard

GEIGER MÜLLER TUBE   MX180

QUICK REFERENCE DATA

Halogen quenched all-metal gamma tube

Recommended working voltage	425	V
Gamma sensitivity at 1.0mR/h (Radium source)	2200	counts/min

OUTLINE DRAWING

All dimensions in mm   D643

CATHODE

Thickness	1600	mg/cm^2
Sensitive length	46	mm
Material	Chrome iron (20 to 30% chrome)	

FILLING

Neon, argon and halogen

CAPACITANCE

Anode to cathode	4	pF

ELECTRICAL CONNECTIONS

B2A base

Mullard

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	375	V
Min. plateau length	100	V
Max. plateau slope	0.15	%/V
Recommended working voltage	425	V
Max. background at 425V, unshielded	60	counts/min
Dead time at 425V	100	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	$M\Omega$
Max. anode voltage	475	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	–55	^{o}C

SENSITIVITY

Sensitivity at 1.0mR/h (Radium source)	2200	counts/min

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER MÜLLER TUBE   MX180

PLATEAU CURVE

PULSE AMPLITUDE PLOTTED AGAINST WORKING VOLTAGE

Mullard

DEAD TIME PLOTTED AGAINST WORKING VOLTAGE

Mullard

GEIGER-MÜLLER TUBE $\qquad$ MX188

QUICK REFERENCE DATA

Halogen quenched high current gamma tube

Recommended working voltage	400	V
Gamma sensitivity at 5mR/h (^{226}Ra source)	20	counts/s

OUTLINE DRAWING

White - anode

Black - cathode

Flexible leads

All dimension in mm

The tube passes through a tubular gauge, 75mm long, 12mm dia., and will not enter a gauge 10.5mm dia.

D1698

CATHODE

Thickness	400	mg/cm^2
Sensitive length	40	mm
Material	Chrome iron (20% chrome)	

FILLING

Neon, argon and halogen

CAPACITANCE

Anode to cathode	2.0	pF

ELECTRICAL CONNECTIONS

Cathode	Black flexible lead
Anode	White flexible lead

Mullard

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

measured in circuit of Fig.1

Max. starting voltage	330	V
Max. threshold voltage	370	V
Min. plateau length	100	V
Max. plateau slope	0.2	%/V
Recommended working voltage	400	V
Max. background at 400V shielded with 50mm lead and 3mm aluminium	10	counts/min
Max. dead time at 400V	20	µs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	470	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	−40	^{o}C

TEST INPUT CIRCUIT

Fig. 1

Mullard

GEIGER-MÜLLER TUBE   MX190

OUTLINE DRAWING   All dimensions in mm

WINDOW

Thickness	1.5 to 2.0	mg/cm^2
Effective diameter	17	mm
Material	mica	

CATHODE

Thickness	1.0	mm
Sensitive length	37	mm
Material	Chrome iron (27% chrome)	

FILLING   Neon, argon and halogen

Mullard

CAPACITANCE

    Anode to cathode   2.0   pF

ELECTRICAL CONNECTIONS

    Flying leads

OPERATING CHARACTERISTICS ($T_{amb} = 20^{o}C$)

    measured in circuit of Fig. 1

Max. starting voltage (input sensitivity 0.25V)	350	V
Max. threshold voltage	400	V
Min. plateau length	300	V
Max. plateau slope	0.02	%/V
Recommended working voltage	550	V
Max. background at 550V shielded with 50mm lead and 3mm aluminium	15	counts/min
Dead time at 550V	150	μs

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Min. anode resistor	2.7	MΩ
Max. anode voltage	700	V
Max. ambient temperature	+75	^{o}C
Min. ambient temperature	-50	^{o}C

TEST INPUT CIRCUIT

V_b

2.7MΩ

2.7MΩ   330pF   Output

D5899

Fig. 1

Mullard

GEIGER-MÜLLER TUBE   MX190

Count rate as function of dose rate (side response)

Plateau curve

Mullard

D5853

Dead time curve

D5854

Starting voltage as function of ambient temperature

Mullard

VACUUM PRODUCTS

L

EVAPORATION ION PUMP

EIP-12

Low cost evaporation ion pump and gauge head consisting of a Bayard-Alpert gauge with an additional zirconium getter filament. The getter is evaporated from the getter filament to form an even film on the bulb and a pin is provided to enable an electrical connection to be made to this film. The ionisation action of the gauge is used to enhance the pumping speed.

The Bayard-Alpert gauge can be used independently for pressure measurements, or to automatically determine the exact system pressure at which the getter should be activated. The W1 glass can be sealed direct to Pyrex.

CHARACTERISTICS AND OPERATING CONDITIONS

Pressure range			
measurement		10^{-3} to 10^{-10}	torr
pumping		10^{-3} to 10^{-11}	torr
Pumping speed (for nitrogen)			
at 10mA emission current	av.	0.4	l/s
Sensitivity (for nitrogen)	approx.	12	per torr
Gauge emission current range			
measurement		1μA to 10	mA
outgassing	max.	75	mA
Insulation resistance before pumping			
collector to other electrodes	min.	10^{14}	Ω
grid to other electrodes	min.	10^{12}	Ω
Getter filament current			
for firing (a.c. or d.c.) at 8V		8	A
a.c. or d.c. at 10V	max.	10	A

Note – The gauge filament must not be operated above a pressure of 10^{-3} torr.

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Grid wattage for outgassing	nom.	30	W
for short periods	max.	40	W
Bulb temperature during operation	max.	100	^{o}C
Bake-out temperature before pumping	max.	450	^{o}C

TYPICAL OPERATING CONDITIONS

Measurement and Pumping   Outgassing   D1978

Potentials are given with respect to earth

OUTLINE DRAWING OF EIP-12

All dimensions in mm

TYPICAL FILAMENT CHARACTERISTIC OF GAUGE

IONISATION GAUGE HEADS

IOG-12
IOG-12W/UKG2
IOG-13T

Ultra-high vacuum Bayard-Alpert gauge heads having identical electrode structure.

IOG-12W/UKG2 is a wide bore version of IOG-12 for greater conductance. IOG-12 and IOG-12W/UKG2 are suitable for direct sealing to G28 and Kodial glass systems. The gauge heads have an electrically conductive layer on the inside of the glass envelope. By applying a fixed potential to the layer, excess primary electrons are attracted directly to the walls rather than oscillating around the collector, thereby leading to very stable measurements of low pressures.

IOG-13T has a fernico skirt with a prepared edge for argon arc welding to stainless steel, or into suitable vacuum flanges, thereby giving a demountable, NUDE insertion gauge.

The gauge heads feature a low thermal inertia and a low filament power consumption.

CHARACTERISTICS AND OPERATING CONDITIONS

Pressure range		10^{-3} to 10^{-10}	torr
Sensitivity (for nitrogen)	approx.	12	per torr
X-ray limit		10^{-10}	torr
Filament voltage			
measurement		0 to 5	V
outgassing		0 to 8	V
Collector voltage (with respect to filament)			
measurement		−25 to −80	V
outgassing		connected to grid	
Grid voltage (with respect to filament)			
measurement		+112 to +145	V
outgassing		+550	V
Emission current range			
measurement		1μA to 10mA	
outgassing			
IOG-12, IOG-12W/UKG2		50	mA
IOG-13T		30	mA
Insulation resistance			
Collector to other electrodes	min.	10^{14}	Ω
Grid to other electrodes	min.	10^{12}	Ω

Note – The screen on IOG-12 and IOG-12W/UKG2 should be at collector potential.

Mullard

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Grid power for outgassing

IOG-12, IOG-12W/UKG2	max.	30	W
IOG-13T	max.	20	W
Bulb or skirt temperature during operation	max.	100	^{o}C
Bake-out temperature	max.	450	^{o}C

OPERATING POSITION   Any

OUTLINE DRAWING OF IOG-12

D1970

All dimensions in mm

OUTLINE DRAWING OF IOG–12W/UKG2

Filament

Grid

Collector

$\varnothing^{39}_{37}$

D1971

12
8

22
18

Filament
support

Grid

Filament

View of pins

14 11
10 7

$\varnothing^{55.5}_{53.5}$

150
140

$\varnothing^{1.35}_{1.15}$

8
4

14
10

43
37

$\varnothing^9_5$

All pins

$\varnothing^{1.35}_{1.15}$

$\varnothing^9_7$

12
6

All dimensions in mm

OUTLINE DRAWING OF IOG–13T

0.6
0.4

26
24

28
25

8
4

14
10

97.5
87.5

43
37

10
6

$\varnothing^9_5$

All pins $\varnothing^{1.35}_{1.15}$

$\varnothing^9_7$

D1979

22
18

12
8

Collector

Grid

Grid

11
7

14
10

Filament

Filament
support

$\varnothing^{51.0}_{50.6}$

All dimensions in mm

Mullard

FILAMENT CHARACTERISTICS

IONISATION GAUGE HEAD

IOG-18N

Low X-ray level ultra-high vacuum Bayard-Alpert gauge head with a fernico skirt for easy welding to stainless steel.

The gauge head features closed end cap grid and ultra-thin wire collector.

CHARACTERISTICS AND OPERATING CONDITIONS

Pressure range	10^{-3} to 4×10^{-11}	torr
Sensitivity (for nitrogen)	approx. 12	per torr
Filament voltage		
measurement	0 to 5	V
outgassing	0 to 8	V
Collector voltage (with respect to filament)		
measurement	-65	V
outgassing	connected to grid	
Grid voltage (with respect to filament)		
measurement	+110	V
outgassing	+550	V
Screen voltage (with respect to filament)		
measurement	-55	V
outgassing	not connected	
Emission current range	$1\mu A$ to 30mA	
Insulation resistance		
collector to other electrodes	min. 10^{14}	Ω
grid to other electrodes	min. 10^{12}	Ω

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Grid input power	max.	20	W
Base temperature during operation	max.	100	^{o}C
Bake-out temperature	max.	450	^{o}C

MECHANICAL DATA

Material	
filament	tungsten
skirt	fernico

MOUNTING POSITION   Any

Mullard

All dimensions in mm

FILAMENT CHARACTERISTICS

IONISATION GAUGE HEAD

IOG-71

Ruggedised triode ionisation gauge head suitable for use where pressure readings lower than 10^{-7} torr are not required. The gauge head can be connected to a vacuum system either by direct fusion to glass or by means of a clamping ring and an elastomer 'O' ring.

CHARACTERISTICS AND OPERATING CONDITIONS

Pressure range	10^{-3} to 5×10^{-8}	torr
Sensitivity (for dry air)	20	per torr
Filament voltage	adjust to give required grid current	
Collector voltage	-20	V
Grid voltage	+125	V
Grid current		
above 10^{-4} torr	5.0	mA
below 10^{-4} torr	10	mA
Outgassing	filament current of 7A for 30s (at lowest pressure) Apply 7.5V (8A approx.) across grid for 1 minute min.	

Note – It is recommended that a d.c. amplifier should be used to measure the collector current, since this may be as low as 10^{-8}A in the lower pressure regions.

RATINGS (ABSOLUTE MAXIMUM SYSTEM)

Filament operating pressure	max.	5×10^{-3} torr
Filament voltage	max.	10 V
Bake-out temperature	max.	450 °C

OUTLINE DRAWING OF IOG - 71

All dimensions in mm

Mullard

FILAMENT CHARACTERISTICS

ACCESSORIES

M

COIL ASSEMBLY

AT1102/01

APPLICATION

Deflection assembly, consisting of deflection and focus coils and alignment ring magnets, for a 1 inch Vidicon*). It is identical to the AT1102, however it can be used for universal applications.

MECHANICAL DATA

Dimensions in mm

front view

---

*) Front loading

E

ELECTRICAL DATA (typical values)

line deflection coils

frame
deflection coils

focus coil

coils	measuring points	earth points	inductance (mH)	resistance (Ω)
$S_1 + S_2$	2 - 4	2	0.75	2.5
$S_3 + S_4$	3 - 5	5	23	80
S_5	6 - 7	-	-	4200

Required currents for normal operation (V_{g4} = 300 V)

Line deflection current   : 170 mA p-p
Frame deflection current : 24 mA p-p
Focus current   : 17 mA

Mullard

Geometric distortion

Distortions inside the circle: about 1 % of picture height
Distortions outside the circle: about 2 % of picture height

Alignment range: ± ≥10 % of picture height

Mullard

COIL ASSEMBLY

AT1103

APPLICATION

Coil assembly consisting of deflection, focus and alignment coils for a 1 inch Plumbicon* tube, front loading.
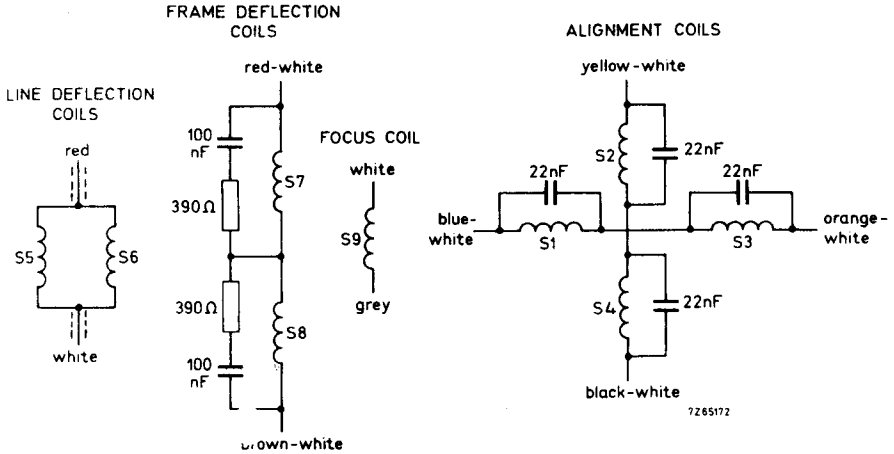
MECHANICAL DATA

Dimensions in mm

front view

ELECTRICAL DATA   (typical values)

coils		inductance (mH)	resistance at 25 °C (Ω)
line deflection coils	$S_1 \parallel S_2$	$0.95 \pm 3\%$	$2.6 \pm 10\%$
frame deflection coils	$S_3 + S_4$	$27 \quad \pm 3\%$	$77 \quad \pm 10\%$
alignment coils (horizontal)	$S_5 + S_7$		$670 \quad \pm 10\%$
alignment coils (vertical)	$S_6 + S_8$		$670 \quad \pm 10\%$
focus coil	S_9		$2500 \quad \pm 10\%$

Required currents for normal operation $(V_{g3} = 600 \text{ V}; V_{g4} = 840 \text{ V})$

Line deflection current	250	mA p-p
Frame deflection current	38	mA p-p
Focus current at 60 gauss	26	mA
Alignment current at 2 gauss	10.5 mA	

Mullard
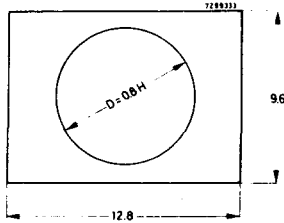
Geometric distortion

Distortions inside the circle   max. 0.5 % of picture height

Distortions outside the circle   max. 1 % of picture height

COIL ASSEMBLY

AT1113/01

```
                    QUICK REFERENCE DATA

Deflection assembly, consisting of deflection, focus and alignment coils, for
use with Plumbicon* camera tubes in colour cameras.

                                   V_{a2} = 300V    V_{a2} = 600V
Line deflection current (p-p)          160              225      mA

Frame deflection current (p-p)          25               35      mA
```

OPERATING CONDITIONS

	$V_{a2} = 300V$	$V_{a2} = 600V$	
Plumbicon tube voltage			
Line deflection current (p-p)	160	225	mA
Frame deflection current (p-p)	25	35	mA
Focus current (L_9 and L_{10} in series)	75	100	mA
Maximum alignment currents	±5	±5	mA

LINEARITY

Linearity inside the circle	≤0.5% of picture height
Linearity outside the circle	≤1.0% of picture height

D620

12

16

Scanned area of tube
Dimensions in mm

*Registered trade mark for television camera tubes.

Mullard

ELECTRICAL CHARACTERISTICS

D621

line deflection coils
1

frame deflection coils

alignment coils

focus coils

N.T.C. thermistors = $1300\Omega \pm 20\%$ at 25°C

R = $560\Omega \pm 5\%$

1 = black
2 = transparent (screened)
3 = brown
4 = yellow (screened)
5 = red
6 = orange
7 = yellow
8 = 9 = blue
10 = white
11 = –
12 = –
13 = grey

B7600

Terminating panel

Coils	Measuring points	Inductance (mH)	Resistance at 25°C (Ω)
$L_1 + L_2$	2–4	$0.995 \pm 3.5\%$	$2.6 \pm 10\%$
$L_3 + L_4$	3–5	$22.1 \pm 3.5\%$	$63.8 \pm 10\%$
$L_5 + L_7$	6–8		$2143 \pm 10\%$
$L_6 + L_8$	7–9		$2143 \pm 10\%$
$L_9 + L_{10}$	10–13		$148 \pm 10\%$
Internal shield	1		

Temperature dependence of alignment coils $L_5 + L_7$ and $L_6 + L_8$ from 25 to 60°C $< 1\%$.

Mullard

OUTLINE AND DIMENSIONS OF AT1113/01

D622

All dimensions in mm.

Mullard

The AT1113/03 consists of three Plumbicon* tube coil assemblies AT1113/01, which have been selected in order to match their electrical tolerances.

Registration

The coil assemblies are supplied in matched sets of three units wherein the misreg - istration in any set is not greater than 0.1% of picture height inside the circle and 0.25% outside the circle.

All dimensions in mm   D4753

For further data see Plumbicon tube deflection unit AT1113/01.

*Registered trade mark for television camera tubes.

Mullard

COIL ASSEMBLY SET

AT1115

APPLICATION

The AT1115 is a triplet of coil assemblies each consisting of deflection, focus and alignment coils for the 1 inch Plumbicon* tube XQ1080, rear loading.

MECHANICAL DATA

Dimensions in mm

---

*Registered trade mark for television camera tubes

E

ELECTRICAL DATA   (typical values)

FRAME DEFLECTION COILS

ALIGNMENT COILS

LINE DEFLECTION COILS

red-white

yellow-white

FOCUS COIL

red

100 nF

S7

390 Ω

white

S2 — 22nF

22nF   22nF

S5   S6

390 Ω

S9

blue-white

S1   S3

orange-white

white

100 nF

S8

grey

S4 — 22nF

brown-white

black-white

7Z65172

coils	inductance (mH)	resistance (Ω)
line deflection coils	0.78	2.4 ± 10 %
frame deflection coils	26	64 ± 10 %
alignment coils (horz. and vert.)		550 ± 10 %
focus coil		1760 ± 10 %

Required currents for normal operation (V_{g3} = 475 V; V_{g4} = 750 V)

An alignment current of 2 mA will cause a shift of 1 % of picture height, measured with a Plumbicon XQ1080.

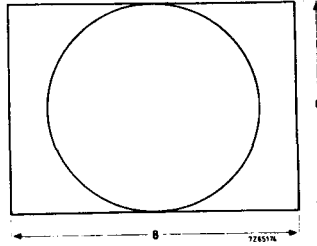|	
Line deflection current	295 mA p-p
Frame deflection current	36 mA p-p
Focus current	32 mA
Alignment current	7.5 mA

Mullard

<u>Geometric distortion</u>

Distortions inside the circle   max. 0.5 % of picture height

Distortions outside the circle   max. 1 % of picture height

<u>Registration</u>

The deflection units are supplied in matched sets of three units wherein the misregistration in any set is not greater than 0.05 % of picture height inside the circle and 0.1 % outside the circle.

Mullard

COIL ASSEMBLY

APPLICATION

Coil assembly consisting of deflection, focus and alignment coils for a 1 inch Plumbicon* tube, front loading

MECHANICAL DATA

Dimensions in mm

front view

*Registered trade mark for television camera tubes

E

Mullard

ELECTRICAL DATA

Maximum operating temperature   75 °C

coils		inductance (mH)	resistance (Ω)
line deflection coils	S7 // S8	$0.78 \pm 10\ \%$	$2.4 \pm 10\ \%$
frame deflection coils	S5 + S6	$28 \quad \pm 10\ \%$	$62 \quad \pm 10\ \%$
alignment coils (horizontal)	S1 + S3		$550 \quad \pm 10\ \%$
alignment coils (vertical)	S2 + S4		$550 \quad \pm 10\ \%$
focus coil *)	S9		$149 \quad \pm 10\ \%$

Required currents for normal operation $(V_{g3} = 600\ V; V_{g4} = 950\ V)$

Line deflection current	330	mA p-p
Frame deflection current	48	mA p-p
Focus current at 58 gauss	105	mA
Alignment current at 2 gauss	7.5 mA	

---

*) Polarity of focus coil: grey terminal positive. The polarity of the focus coil should be such that a north-seeking pole is attracted to the image end of the coil, with this pole located outside of and at the image end of the coil.

Mullard

COIL ASSEMBLY

Geometric distortion

Inside the circle	max. 0.5 % of picture height
Outside the circle	max. 1 % of picture height

MOUNTING

To get line scanning in horizontal position the unit has to be positioned with the signal contact 120 ° clockwise with respect to north (front view).

To avoid geometric distortion the mu -metal screening may not become deformed.

To guarantee the specification the lacquered screws may not be removed.

Mullard

COIL ASSEMBLY　　　　　　　　　　　　　AT1117

APPLICATION

Coil assembly consisting of deflection and alignment coils for a 5/8 inch Plumbicon*tube, rear loading.

MECHANICAL DATA

Dimensions in mm

*Registered trade mark for television camera tubes

E

ELECTRICAL DATA

ALIGNMENT COILS

LINE DEFLECTION COILS

FRAME DEFLECTION COILS

coils		inductance (mH)	resistance at 25 $^{\circ}$C (Ω)
line deflection coils	S2 // S4	$0.785 \pm 10\%$	$10 \pm 10\%$
frame deflection coils	S1 + S3	$13.2 \pm 10\%$	$115 \pm 10\%$
alignment coils (horizontal)	S6 + S8		$520 \pm 10\%$
alignment coils (vertical)	S5 + S7		$520 \pm 10\%$

<u>Required currents for normal operation</u> ($V_{g2-4} = 300$ V; $V_{g5} = 600$ V)

Line deflection current   140   mA p-p

Frame deflection current   25   mA p-p

Alignment current at 2 gauss   7.5 mA

COIL ASSEMBLY

AT1117

Geometric distortion

Distortions inside the circle   max. 0.5 % of picture height

Distortions outside the circle   max. 1 % of picture height

COIL ASSEMBLY

AT1119

The Plumbicon* tube coil assembly AT1119 is one unit of the three units which together form the selected coil assembly set AT1115.

For data see data sheets of Plumbicon tube coil assembly set AT1115.

*Registered trade mark for television camera tubes.

COIL ASSEMBLIES

QUICK REFERENCE DATA

Deflection assembly, consisting of deflection, focus and alignment coils, for use with Plumbicon* camera tubes in monochrome cameras.

	$V_{a2} = 300V$	$V_{a2} = 600V$	
Line deflection current (p-p)	160	235	mA
Frame deflection current (p-p)	25	35	mA

OPERATING CONDITIONS

Plumbicon tube voltage	$V_{a2} = 300V$	$V_{a2} = 600V$	
Line deflection current (p-p)	160	235	mA
Frame deflection current (p-p)	25	35	mA
Focus current (L_9 and L_{10} in series)	17	25	mA
Maximum alignment currents	± 5	± 5	mA

LINEARITY

	AT1122	AT1132
Linearity inside the circle	≤1%	≤0.5% of picture height
Linearity outside the circle	≤2%	≤1.0% of picture height

D620

Scanned area of tube
Dimensions in mm

*Registered trade mark for television camera tubes

Mullard

ELECTRICAL CHARACTERISTICS

N.T.C. thermistor = $1300\Omega \pm 20\%$ at $25^{\circ}C$

R = $560\Omega \pm 5\%$

B7602

Terminating panel

Coils	Measuring points	Inductance (mH)	Resistance (Ω)
$L_1 + L_2$	2–4	0.99	2.6
$L_3 + L_4$	3–5	22.1	63.8
$L_5 + L_7$	6–8		2390
$L_6 + L_8$	7–9		2390
L_9	12–13		1100
L_{10}	10–11		1650
Internal shield	1		

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COIL ASSEMBLIES

OUTLINE AND DIMENSIONS

All dimensions in mm.　B7598

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COIL ASSEMBLY

AT1132/01

APPLICATION

Coil assembly consisting of deflection, focus and alignment coils for a Plumbicon* tube.

MECHANICAL DATA

Dimensions in mm

*Registered trade mark for television camera tubes

E

ELECTRICAL DATA (typical values)

S_1 - S_2 = line deflection coils	R_1, R_3 = 1300 $\Omega \pm$ 20% at 25 °C (NTC)
S_3 - S_4 = frame deflection coils	R_2, R_4, R_7 = 560 Ω
S_5 - S_8 = alignment coils	R_5 = 33 Ω
S_9 - S_{10} = focus coils	R_6 = 32 $\Omega \pm$ 20% at 25 °C (NTC)
C_1 = 10 nF	R_8, R_9, R_{10}, R_{11} = 22 kΩ

coils	measuring points	inductance (mH)	resistance (Ω)
$S_1 + S_2$	2 - 4	0.995	2.6
$S_3 + S_4$	3 - 5	22.1	63.8
$S_5 + S_7$	6 - 8		2143 [1]
$S_6 + S_8$	7 - 9		2143 [1]
$S_9 + S_{10}$	10 - 13		2750
Internal shield	1		

1) Resistance drift between 25 and 60 °C is 0.75%

<u>Required currents for normal operation</u> (V_{g3} = 600 V)

line deflection current	:	225 mA p-p
frame deflection current	:	35 mA p-p
focus current ($S_9 + S_{10}$ in series):		25 mA
maximum alignment currents	:	±5 mA

<u>Geometric distortion</u>

Distortions inside the circle : max. 0.5 % of picture height

Distortions outside the circle: max. 1 % of picture height

All dimensions in mm

All dimensions in mm

All dimensions in mm

TUBE SOCKET

FE1004

D2202

All dimensions in mm

COIL ASSEMBLY   KV12

TENTATIVE DATA

QUICK REFERENCE DATA

Coil assembly consisting of deflection and focus coils and alignment ring magnets for 17.7mm diameter vidicon tubes, for example 20PE11 and 20PE13.

DEFLECTION COILS

Inductance (measured at 1kHz)	see page 2
Resistance	see page 2

Polarity

If a positive voltage is applied to the red lead (horizontal coil) and to the green lead (vertical coil), the north poles are on the right and at the bottom when looking at the front of the coil.

Deflection distortions:

Lustre distortion:

Barrel, keystone and pincushion distortions are within 2%.

Rectangularity is $90° ±2°$

FOCUS COIL

Resistance		see page 2
Flux density (at 120mA)	5 ±10%	mT
	50 ±10%	gauss

Polarity

If a positive voltage is applied to the brown lead, the south pole is at the front of the coil.

CENTRING MAGNETS

Flux density max.	0.5 ±0.1	mT
	5 ±1	gauss
Flux density min.	0.05	mT
	0.5	gauss
Magnet rotation torque	0.005 to 0.15	Nm
(with one ring fixed)	50 to 1500	gf cm

INSULATION RESISTANCE

At d.c., between coil and coil, coil and earth (min.)	50	MΩ

OPERATING TEMPERATURE   -10 to +60   °C

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LEADS

Colour coding as shown

Length from rear surface of focus flange	190 ±10	mm
Ends of leads stripped for length	5	mm

COIL ASSEMBLY

KV19B

QUICK REFERENCE DATA

Coil assembly consisting of deflection coils and alignment rings for 17.7mm diameter vidicon tubes, for example 20PE14.

DEFLECTION COILS

Inductance (measured at 1kHz)   see page 2

Resistance   see page 2

Polarity

If a positive voltage is applied to the red lead (horizontal coil) and to the green lead (vertical coil), the monitor scan will be normal.

Deflection distortions

Barrel and coil shape·distortions do not exceed 2%.

Rectangularity is $90^{o} \pm 2^{o}$

ALIGNMENT RINGS

Central flux density	max.	5 ±0.1	mT
		50 ±1	gauss
	min.	0.1	mT
		1	gauss
Magnet rotation torque		0.005 to 0.15	Nm
(with one ring fixed)		50 to 1500	gf cm

INSULATION RESISTANCE

At 100V d.c. between each coil
and earth circuit (min.)   50 $M\Omega$

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(a) Connections - deflection coils

Red

Horizontal coil

Blue

Green

Vertical coil

Yellow

Black

Electrical specification

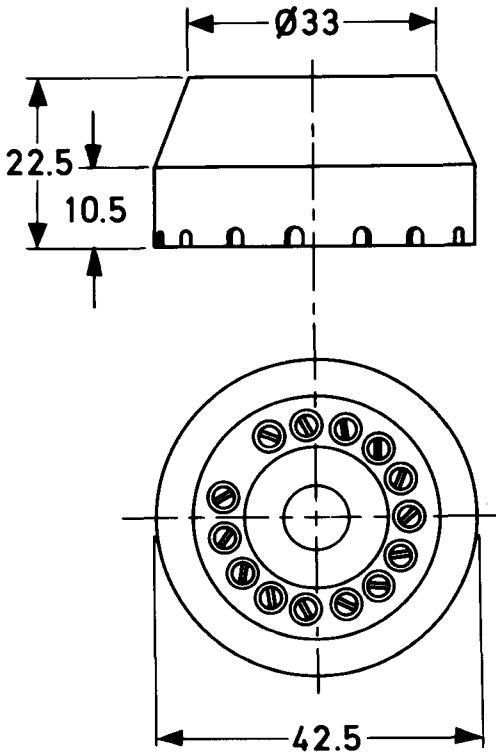|	Inductance	D.C. resistance
Horizontal coils	0.9 ±10%mH	4.6 ±10% Ω
Vertical coils	23 ±10% mH	146 ±10% Ω

All dimensions in mm

D4912

TUBE SOCKET

40467

Socket intended for 14-pin all glass bases

Material: Synthetic resin insulating material
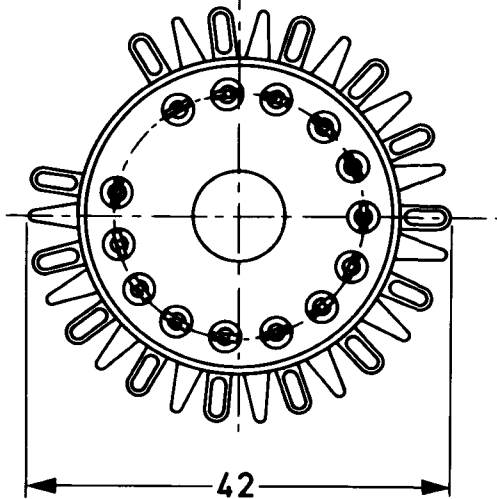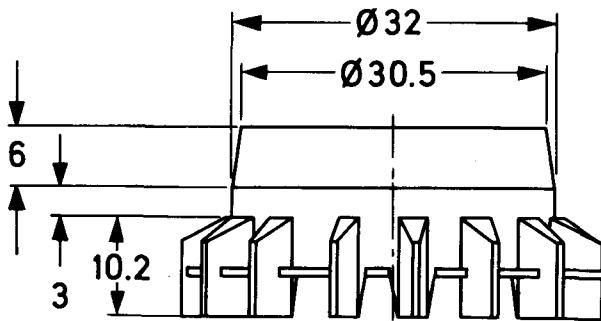14 silver plated fork-shaped contacts

All dimensions in millimetres

Ø33

22.5
10.5

42.5

D2180

Mullard

TUBE SOCKET

55566

Socket intended for 14-pin bases

Material: Synthetic resin insulating material
14 gold plated fork-shaped contacts

All dimensions in millimetres

D 2181

Mullard

TUBE SOCKET

56021

Socket intended for Plumbicon* camera tubes

13

2

6

1.5

31

26

35

D507

2

All dimensions in mm

*Registered trade mark for television camera tubes

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INDEX TO BOOK 2, PART 2

ELECTRO-OPTICAL DEVICES, RADIATION DETECTORS

Type No.	Section	Type No.	Section
MX190	K	XQ1021B; G; R	G
MY13-38	B	XQ1022	G
ORP10	D	XQ1023	G
ORP12	C	XQ1023L; R	G
ORP13	D	XQ1024	G
ORP52	C	XQ1024R	G
ORP60	C	XQ1025	G
ORP61	C	XQ1025L; R	G
ORP62	C	XQ1026	G
ORP69	C	XQ1026R	G
Q13-110BA	B	XQ1032 (7262A)	G
Q13-110GU	B	XQ1070	G
RPY18	C	XQ1070B; G; L; R	G
RPY20	C	XQ1070/01	G
RPY33	C	XQ1070/01B: G; L; R	G
RPY58A	C	XQ1071	G
RPY71	C	XQ1071B; G; R	G
RPY75	D	XQ1071/01	G
RPY75A	D	XQ1071/01B; G; R	G
RPY76	D	XQ1080	G
RPY76A	D	XQ1080B; G; L; R	G
RPY77	D	XQ1081	G
RPY78	D	XQ1081B; G; R	G
S5600 series	F	XQ1090	G
XP1002	F	XQ1090B; G; L; R	G
XP1010	F	XQ1091	G
XP1110	F	XQ1091B; G; L; R	G
XP1115	F	XQ1100	G
XP1116	F	XQ1100B; G; L; R	G
XP1117	F	XQ1101	G
XP1143	F	XQ1101B; G; L; R	G
XP1210	F	XX1050	H
XP1220	F	XX1060	H
XP2000	F	XX1060/01	H
XP2020	F	XX1063	H
XP2030	F	20PE11	G
XQ1010	G	20PE13	G
XQ1020	G	20PE14	G
XQ1020B; G; L; R	G	56AVP	F
XQ1021	G	56DUVP	F

Type No.	Section
56DVP	F
56TUVP	F
56TVP	F
58AVP	F
58DVP	F
60DVP	F
60DVP/H	F
61SV	D
62SV	D
90AG	E
90AV	E
90CG	E
90CV	E
92AG	E
92AV	E
150AV	E
150AVP	F
150CV	E
150CVP	F
155UG	E
6929	H
7262A see XQ1032	
40467	M
55566	M
56021	M

ELECTRO-OPTICAL DEVICES, RADIATION DETECTORS

CONTENTS