supplement

EMI

photomultiplier tubes

EMI

Photomultiplier Tubes
Catalogue Supplement

INDEX

List of tube types (including variants)

Sections

Introductory Notes

This publication is a supplement to the EMI photomultiplier catalogue reference P001/fP70. It gives data and specifications on the new tube types which have been introduced since the printing of the main catalogue. Some of these tubes are still developmental and their specifications therefore are headed "Provisional Data". Equipment manufacturers are advised to consult EMI before designing such types into production instruments.

The new tubes incorporate many new design features which provide an even wider field of application for the EMI photomultiplier tube range. This is something which should interest all photomultiplier tube users irrespective of their own particular requirements.

Other EMI publications

The main photomultiplier catalogue P001/fP70 contains a section describing the fundamentals of photomultiplier tube operation and design parameters. Copies are available free on request.

Also available at no charge is a range of technical papers covering a wide variety of specialised subjects. A list is given on the next page.

Spectral Response Calibration Service

For several years a monochromator spectral calibration service has been available for photomultipliers, denoted by the suffix 'M' following the type number.

New equipment has now been developed which automatically measures the quantum efficiency in per cent and the radiant sensitivity in mA/W at wavelength intervals of 20nm so that the spectral response curve for a particular tube can be plotted in either unit.

The spectral measurements are made by comparing the response of the tube on test with that of a previously calibrated reference photodetector. The reference is calibrated by the same comparison method using a tube whose response has been measured by the National Physical Laboratory.

By integration of the spectral response curve, figures are also derived for the photocathode sensitivity in μA/lm, and the Corning Red, Corning Blue and Wratten 87 filter readings where appropriate. These are used by the test engineer to check the standard sensitivity results given on the tube test ticket.

For further information about this service, please contact EMI Electron Tube Division.

General notes on photomultiplier tube operating conditions

a) Take great care when clamping tubes, particularly those with quartz windows, as excess pressure may cause fracture and render the warranty void.

b) Tubes with plain glass bases should be used whenever minimum stray capacitance and electrical leakage are required. Matching Teflon sockets are supplied for this purpose.

c) Teflon sockets should not be used when the temperature is less than –40 °C. Individual connectors (Hyperboloidal contacts) are available for this purpose.

d) Any material in contact with the glass envelope must be maintained at cathode potential. Failure to do so may result in erratic operation and high dark current.

e) Magnetic shields should be used wherever possible (see page 64 of EMI Photomultiplier Catalogue).

f) Overall sensitivity is greatly affected by variations in overall voltage, particularly in the case of tubes with a large number of dynodes.

g) Tubes in the range 9810 to 9820 inclusive incorporate envelope screens which are connected to the photocathode terminal. In many applications the photocathode will be operated at high potential; therefore extreme care should be taken to prevent the possibility of endangering personnel in the vicinity.

For further information the address to contact is EMI Electronics Limited, Electron Tube & Microelectronics Division, 243 Blyth Road, Hayes, Middlesex, England.

Reprints of Published Technical Papers*
All reprints are supplied free of charge.

Title	Ref. No.
Neutron Detectors. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P001
Photomultiplier Tubes and Scintillation Counters. By J. Sharpe, B.Sc., C.Eng., F.I.E.E., and E. E. Thomson, Ph.D., M.Sc., D.I.C.	R/P002
Photoelectric Cells and Photomultipliers. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P006
Photomultipliers for Tritium Counting. Reprinted from "Tritium in the Physical and Biological Sciences". By J. Sharpe, B.Sc., C.Eng., F.I.E.E., and V. A, Stanley, M.Sc.	R/P007
Vacuum and Gas Photocells and Semiconductor Photocells. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P009
Fatigue and Saturation in Photomultipliers. By J. P. Keene, B.Sc.	R/P015
A Photomultiplier Circuit for Precision Spectrophotometry. By W. Budde	R/P019
Rapid Ozone Determination near an Accelerator. By G. W. Nederbragt, A. Van Der Horst, and J. Van Duijn	R/P020
Dark Current in Photomultiplier Tubes. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P021
Photomultiplier Applications to Nucleonic Measurement. By R. B. Owen, B.Sc., M.I.E.E.	R/P024
An Application of Photomultiplier Tubes in Temperature Measurement. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P025
Method for the automatic measurement of periodically changing spectral energy distributions of extremely weak light intensities. By J. Schanda, Hungary	R/P026
Archaeology—Thermoluminescent Dating of Ancient Ceramics. By M. J. Aitken, M. S. Tite and J. Reid	R/P027
Tests of Photomultipliers for Astronomical Pulse-Counting Applications. By J. P. Rodman and H. J. Smith	R/P028
Measurements of very low Spectral Intensities. By H. A. W. Tothill, Ph.D., A.C.G.I.	R/P029
Photocathodes used in Photomultiplier Tubes for Scintillation Counters—Characteristics and effect on performance. By V. A. Stanley, M.Sc.	R/P031
Some Statistical Properties of Pulses from Photomultipliers. By M. Gadsden	R/P032
EMI Scintillation Counters. By J. Sharpe, B.Sc., C.Eng., F.I.E.E.	R/P033
Notes on the Performance and Application of EMI windowless Particle Multipliers. By A. B. Smith, B.A., A.M.I.E.E.	R/P034
Electron Capture Decay of ^{40}K. By M. F. McCann, G. M. Lewis and K. M. Smith	R/P037
A synchronized direct reading spectrometer-spark system for time resolved spectra. The study of time-resolved spectra of copper spectra analysis lines used for the analysis of copper in aluminium alloys. By W. W. Schroeder and A. Strasheim	R/P039
Some Characteristics of a Venetian Blind Particle Multiplier used as a Detector in the Study of Ion-Molecule Reactions. By K. R. Ryan	R/P048
Homogeneous Chemiluminescent Measurement of Nitric Oxide with Ozone. Implications for continuous selective monitoring of gaseous air pollutants. By Arthur Fontijn, Alberto J. Sabadell, and Richard J. Ronco, AeroChem Research Laboratories, Inc., P.O. Box 12, Princeton, N.J. 08540—Reprinted from "Analytical Chemistry", Vol. 42, No. 6, May 1970	R/P050
On the use of a Photomultiplier as a Photon Counter. By J. F. James	R/P054
Photomultiplier tubes and their application. By G. C. Young	R/P055

*Please quote titles and reference numbers when ordering.

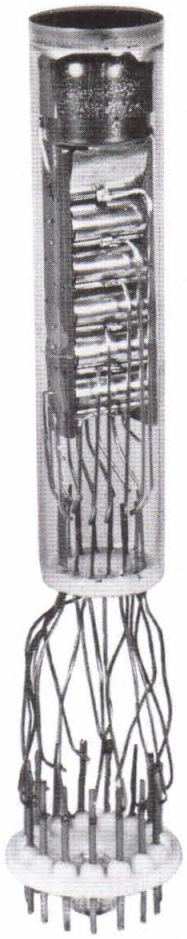
New 20mm (¾in) diameter tube with bialkali photocathode and 12 linear focused dynodes

Provisional Data

- Fast response—2 n.sec typical rise time
- Small size—20 mm diameter
- High gain—typically 10^6
- Low potassium borosilicate envelope

The D903 is a developmental tube of small physical size specially designed to give a very fast response time. Main applications include fast coincidence measurements in nuclear physics and general purpose use where compactness is important.

Flexible flying lead connections are standard on the D903 and a quartz window version is available to special order.



Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity measured with a Corning blue CS-5-58 filter (polished to half stock thickness) interposed; the overall voltage for 200A/lm and the relevant dark current (at 20°C). The quantum efficiency at 420nm can be estimated by multiplying the Corning blue reading by 2.5.
2. Test data is obtained with K to d1 held at 150 volts.
3. Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 2 μA.
5. In order to obtain a high value of peak output current, it is necessary to provide high voltages between the last dynode stages.

MECHANICAL CHARACTERISTICS

Envelope diameter	Maximum	19.2 mm (0.92in)
Cathode diameter	Minimum	13.0 mm (0.51in)
Cathode type	Bialkali (KCs)	
Window material	Low potassium borosilicate	
Dynodes	12 linear focused	
Base	15 wire flying leads	

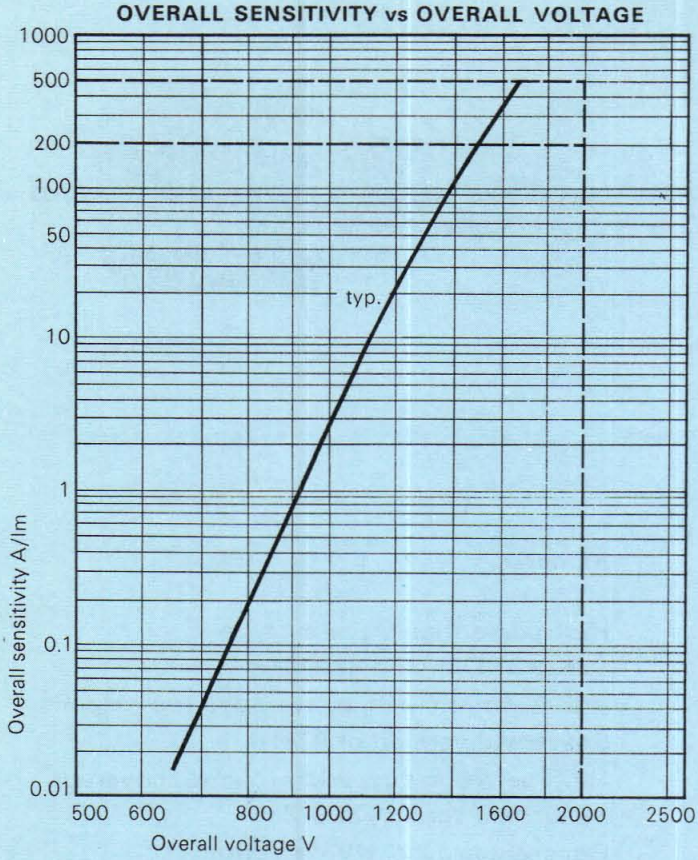
RATINGS

Overall sensitivity: rated		200A/lm
maximum		500A/lm
Voltage, cathode to d1: recommended		150V
maximum		300V
Voltage, anode to cathode: maximum		2000V
Anode current (mean): maximum		0.2mA
Anode dissipation: maximum		0.2W
Cathode current: maximum (using whole area)		0.1 μA
Anode pulse rise time: typical		1.8 n.sec.
Anode pulse f.w.h.m.: typical		2.5 n.sec.
Transit time: typical		20 n.sec.
Capacitance, anode to all dynodes: typical		4pF
Operating temperature: maximum		60 °C
minimum		—5 °C
Dark current shot noise	Lumens	8.0×10^{-13}
equivalent input*	Watts	7.3×10^{-16}

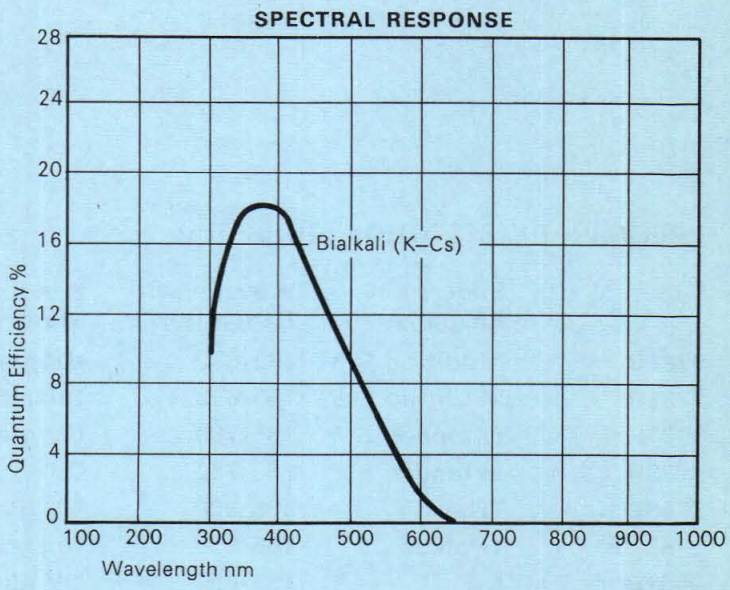
*Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

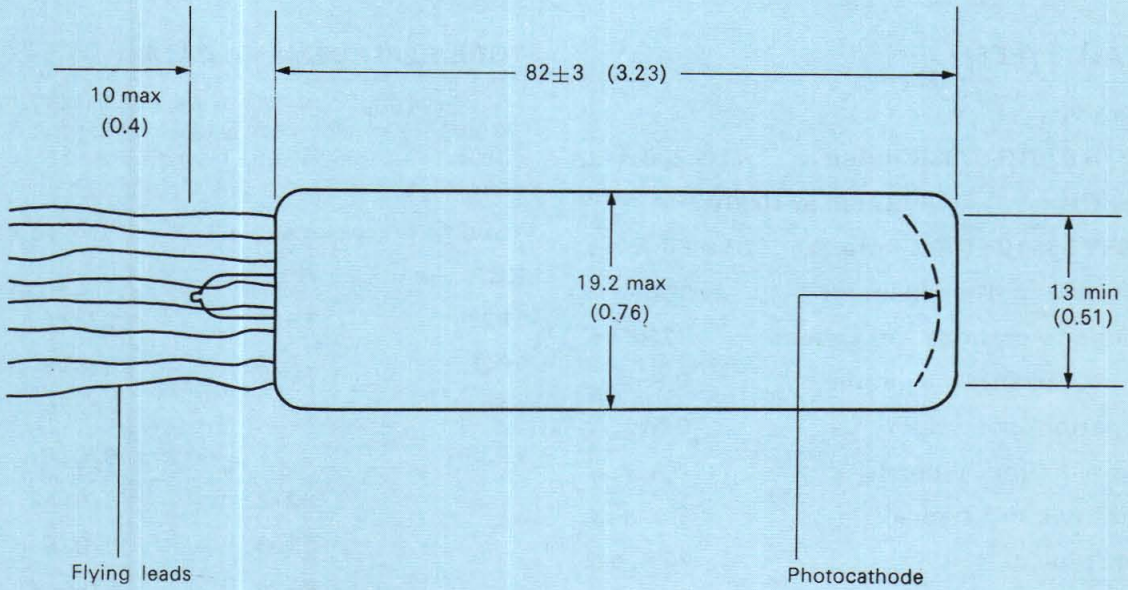
Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					200A/lm				500A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
D903B	—	50	—	7.0	1500	—	20	—	1650	—	50

OVERALL SENSITIVITY vs OVERALL VOLTAGE



SPECTRAL RESPONSE





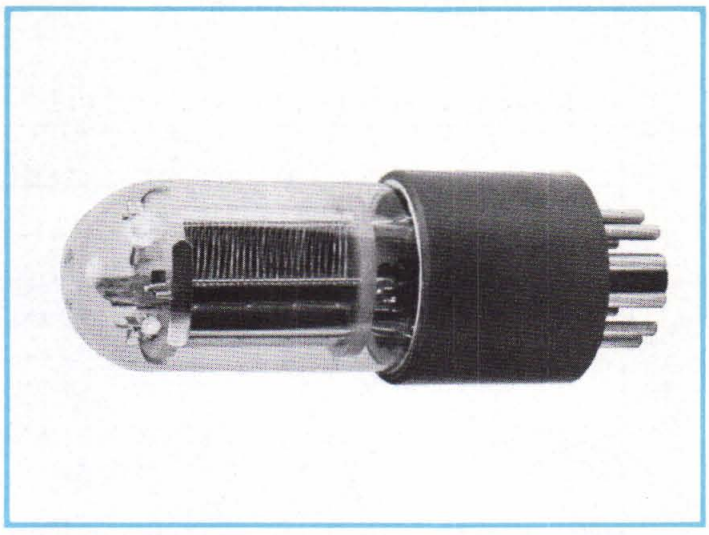
All dimensions in millimetres (inches in parenthesis).

PIN CONNECTIONS (viewed from below starting left of short pin or key)

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**socket**
D903B	—	d1	d3	d5	d7	d9	d11	A	d12	d10	d8	d6	d4	d2	K	**flying leads**

Side Window Tubes

- Nominal tube diameter: 30 mm ($1\frac{1}{8}$ in)
- 9 compact focused dynodes with CsSb secondary emitting surfaces
- Tubes overcapped with base type B11A (B11–88)
  Uncapped versions are available as follows:
  9661B available uncapped as 9660B
  9665B ,, ,, ,, 9662B
  9664B ,, ,, ,, 9663B
  9670B ,, ,, ,, 9669B



PRELIMINARY SELECTION GUIDE

Type	Spectral Response	Wavelength Range (nm)	Window Material	Remarks
9781B	Modified S-5	185-650	UV glass	High performance parent type
9783B	Modified S-5	165-650	Quartz	Spectrosil version of 9781B
9781R	Extended S-5	185-750	UV glass	9781B variant with guaranteed red response
9783R	Extended S-5	165-750	Quartz	Spectrosil version of 9781R
9785B	Trialkali	185-830	UV glass	High performance, wide spectral coverage
9785QB	Trialkali	165-830	Quartz	Spectrosil version of 9785B
9661B	S-5	185-650	UV glass	General purpose, UV detection
9665B	S-5	165-650	Quartz	Quartz version of 9661B
9664B	S-10	185-800	UV glass	I.R. response (see also 9785B)
9670B	S-10	165-800	Quartz	Spectrosil version of 9664B (see also 9785QB)

RATINGS (ALL TYPES)

Overall sensitivity:		
9781B 9783B 9781R 9783R	Rated at	50 & 200 A/lm
9785B 9785QB	Rated at	1000V
9661B 9665B 9664B 9670B	Rated at	20 & 50 A/lm
Voltage, cathode to d1: maximum		150V
Voltage, anode to cathode: maximum		1250V
Anode current (mean): maximum		0.5mA
Anode dissipation: maximum		0.5W
Anode pulse rise time: typical		2 n. sec.
Anode pulse f.w.h.m.: typical		4 n. sec.
Transit time: typical		20 n. sec.
Capacitance, anode to all dynodes: typical		6pF
Operating temperature: maximum		60 °C
minimum		—180 °C

TUBE REPLACEMENT DATA

The following EMI types are direct plug-in replacements, although it may be necessary to adjust the overall voltage to obtain the same operating conditions. If this is the case, it is normally a reduction in overall voltage that is required.

Tube to be replaced		EMI replacement type
RCA	HTV	
1P21	1P21	9781A*
1P28	1P28	9781B, 9661B
1P22		9661B
1P28A		9781R
	R212	9781B
	R106	9783B
	R136	9785QB
	R213	9785B
	R446	9785B
	R456	9785QB

* 'A' denotes selected tube. When ordering please specify "equivalent to 1P21".

CHARACTERISTICS

	Cathode Sensitivity μA/lm		Overall Sensitivity 50A/lm				Overall Sensitivity 200A/lm			
			V Overall		Dark Current nA		V Overall		Dark Current nA	
	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.
9781B 9783B	40	60	670	800	1	10	800	—	4	—
9781R* 9783R*	40	60	670	800	1	10	800	—	4	—
			20A/lm				50A/lm			
9661B 9665B	20	40	750	1000	2	20	850	—	5	—
9664B* 9670B*	20	35	750	1000	2	20	850	—	5	—

* For red sensitivity specification see adjacent table.

	Cathode Sensitivity μA/lm		Overall Red to Blue Sensitivity Ratio†	Overall Voltage 1000V			
				Overall Sens. A/lm		Dark Current nA	
	Min.	Typ.	Min.	Min.	Typ.	Typ.	Max.
9785B 9785QB	20	50	10%	40	250	5	50

† See adjacent table for method of measurement.

RED SENSITIVITY

9785B, 9785QB

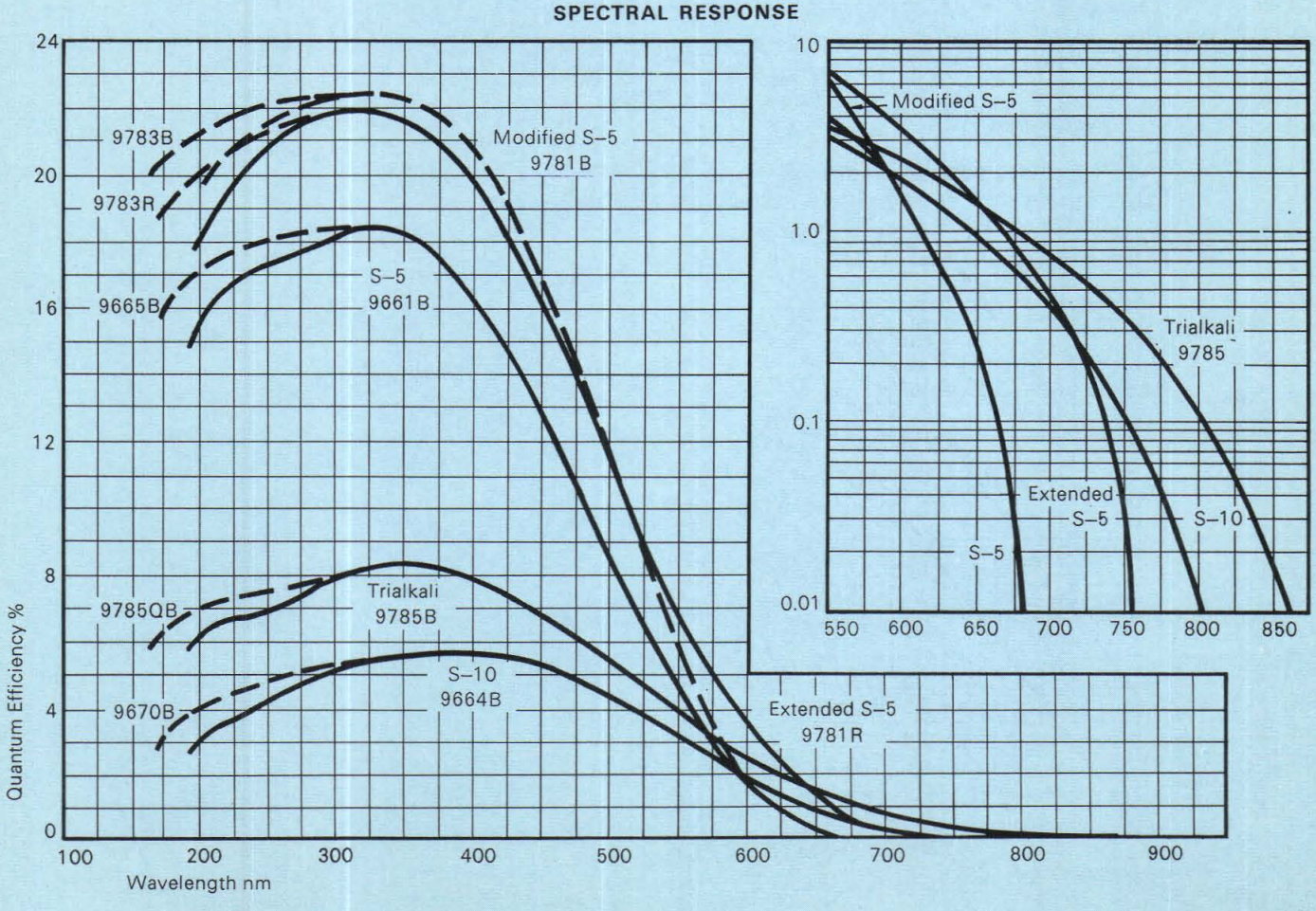
The red/blue sensitivity ratio is determined by operating the tube at 50A/lm and adjusting the white light intensity to give an anode current of 1mA. A Kodak Wratten 87 filter, which passes all radiation of wavelength longer than 750 nm, is placed between the photocathode and the light source and the resultant anode current measured. The ratio of this reading to a similar reading taken with a Corning blue filter CS–5–58 (polished to half stock thickness) is calculated.

9781R, 9783R, 9664B, 9670B

In order to specify the red sensitivity of these types, the tube is operated at 50A/lm and the light intensity adjusted to give an anode current of 1mA. A Kodak Wratten 88A filter, which passes all radiation of wavelength longer than 730nm, is placed between the photocathode and the light source and the resultant anode current in μA taken as an indication of the red response of the tube.

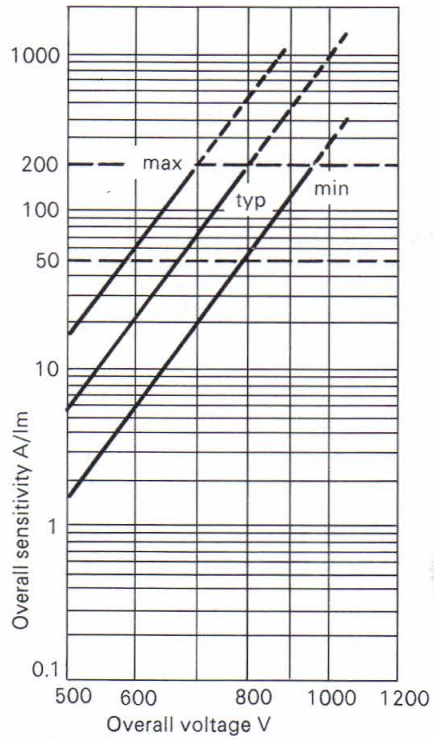
	Red Sensitivity with Wratten 88A filter	
	Min.	Typ.
9781B	—	0.1
9781R 9783R	0.5	2.0
9664B 9670B	2.0	5.0

SPECTRAL RESPONSE

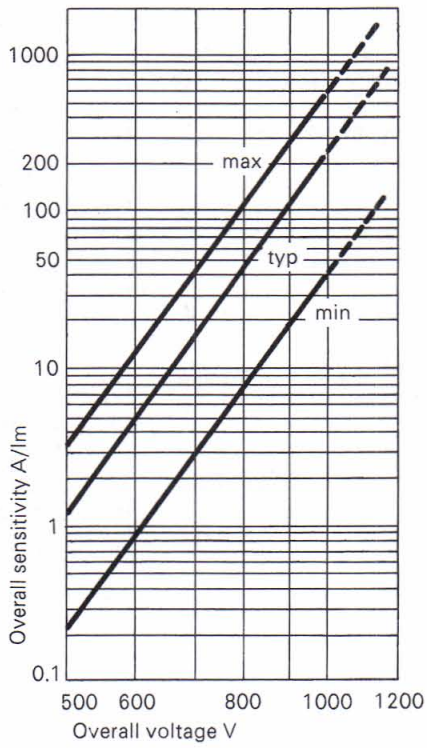


OVERALL SENSITIVITY vs OVERALL VOLTAGE

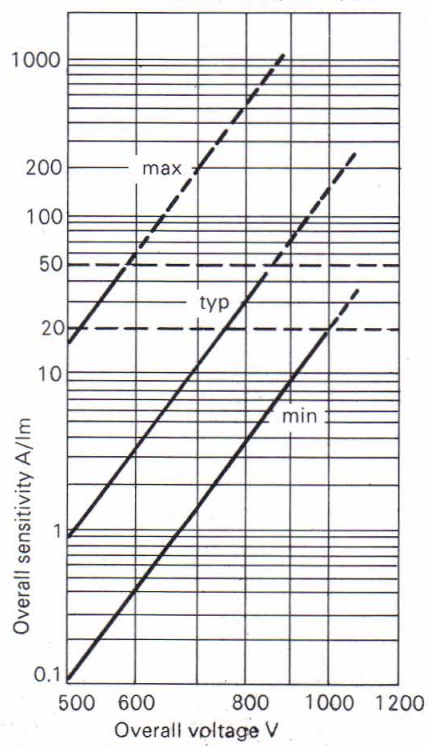
9781/9783



9785



9661/9665/9664/9670



Notes

1 *Test Ticket Information*

a) Each tube is individually calibrated and the test ticket provided with the tube specifies the cathode sensitivity in μA/lm, the overall voltages for 50 A/lm and 200 A/lm (9781, 9783) or 20 A/lm and 50 A/lm (9661, 9665, 9664, 9670) and the dark currents at these overall sensitivities. A Wratten 88A filter reading is also given for types 9781R, 9783R, 9664B and 9670B (see page 6). For the 9785, the cathode sensitivity is specified in μA/lm. The overall sensitivity in A/lm and dark current are given at an overall voltage of 1000V. A red/blue sensitivity ratio is also quoted (see page 6).

b) Test data is obtained with cathode—d1 voltage held at 100V and a linear dynode chain. The light source is a tungsten filament lamp operated at a colour temperature of 2857°K. The overall sensitivity is given for illumination of the effective cathode area, which is less than the geometrical area. For the cathode sensitivity measurement, 100V are applied between cathode and d1 with all other electrodes connected to d1.

2 *Selection*

It is possible to select tubes for one or more parameters to meet individual customer's requirements. In this case, the suffix 'A' is used in place of the 'B' or in addition to the 'R' e.g. 9785A, 9781RA.

3 *Stability*

a) The magnitude of the anode current determines the operating stability of these tubes and for highest stability in d.c. conditions, the mean anode current should not exceed 1μA. However, mean anode currents up to 10μA will not seriously affect the stability of operation.

b) For all tubes, the overall multiplication is extremely sensitive to variations in the applied voltage and the output of the power supply must therefore be very stable and have minimal ripple.

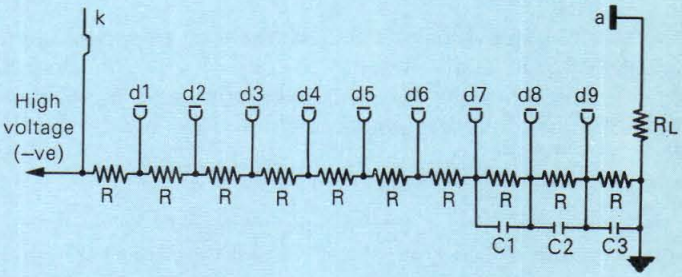
c) Any material in contact with the glass envelope must be held at cathode potential. Failure to do so may result in erratic operation and high dark current. (Great care should be taken in clamping tubes, particularly those with quartz windows as excess pressure may fracture the glass and invalidate the guarantee).

4 *Temperature Considerations*

The dark current of all photomultiplier tubes is a very critical function of temperature and operation of tubes above normal ambient temperature (22°C) will result in a higher dark current than that specified on the test ticket. Tubes may be selected for very low dark current but for very stringent applications the use of a cooled photomultiplier housing is recommended.

5 *Dynode Chain Design*

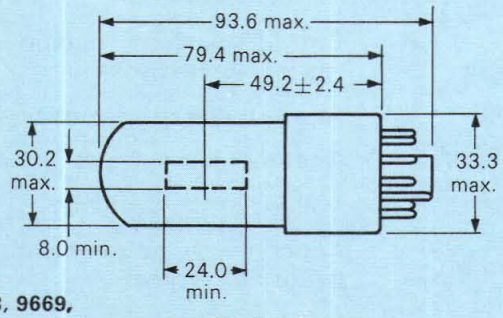
A typical dynode chain is shown below. The dynode resistance value should be sufficient to prevent the dynode potential varying with signal current and a dynode chain current of 10 times the mean anode current is generally suitable. The dynode resistor value, R, is normally chosen to be between 10KΩ and 100KΩ. The use of a zener diode between k–d1 is not critical and a resistor may be used.
For pulsed applications, when the ratio of peak anode current to mean anode current is high, the last dynode should be decoupled to ground with an 0.1 μF capacitor and the next two dynodes decoupled with 0.01 μF capacitors.
Further details of dynode chain design and power supply requirements are given in the EMI Photomultiplier Catalogue, reference P001/fP70, available on request.



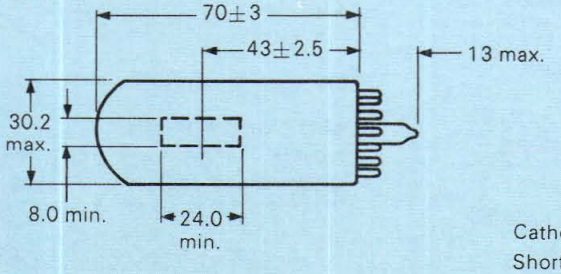
6 *Base Configurations*

All types are supplied overcapped with a small-shell submagnel 11-pin base type B11A (B11-88). A matching PTFE B11A socket is available from EMI and should be installed so that the keyway in the socket faces the incident radiation.
The uncapped tubes, types 9660B, 9662B, 9663B and 9669B are supplied complete with matching PTFE socket type B14B.

Tube Types 9781, 9783, 9661, 9665, 9664, 9670, 9785



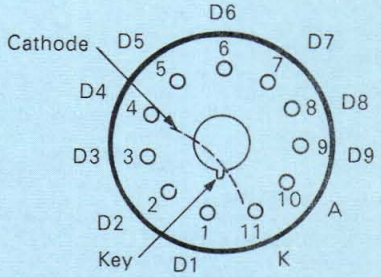
Tube Types 9660, 9662, 9663, 9669,

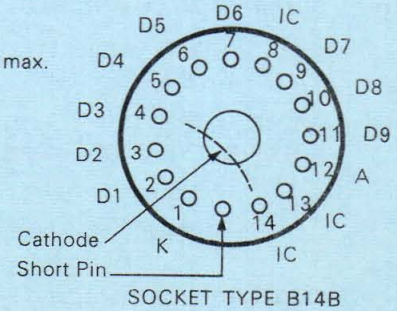


All dimensions are in millimetres

Pin Connections
(Viewed from below)

SOCKET TYPE B11A





SOCKET TYPE B14B

New 30mm(1⅛in) diameter tubes with bialkali or S20 photocathodes and 11 dynodes

Provisional Data

- Wide spectral coverage —210 to 850 nm (170–850 nm quartz version)
- High gain—typically 10^6 at 1000V
- Physically interchangeable with S10 tubes EMI 9592, 9529 and SII, EMI 9524, 9526 and 9601
- Small size—30 mm diameter envelope with 23 mm photocathode

The 9824 (previously D110) is intended to supersede the 9524S in applications requiring a tube of small physical size having a combination of low background and good "blue" response. Such applications include low energy nuclear radiation monitoring, geological studies and low light level photometry.

The D125 is a developmental tube primarily designed as an alternative to existing S10 types where higher red sensitivity is required without circuit changes. Applications include wide range spectrophotometry, photometry, laser detection, colorimetry, film scanning and automated process control.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity with filters interposed (detailed below); the overall voltage for 200A/lm and the relevant dark current (at 20°C).
   A Corning glass filter (CS-5-58 ground to half stock thickness) is used to give a measure of the 'blue' sensitivity; a Corning glass filter (CS-2-62), which passes all radiation longer than 600nm, to indicate 'red' sensitivity, and a Wratten 87 filter, which passes all radiation longer than approximately 800nm, to indicate sensitivity in the near infra-red region.
2. Test data is obtained with K to d1 held at 150V and the 'standard' dynode chain.*
3. Generally, tubes should be operated at, or near their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 2μA.

*For recommended dynode chains, refer to groups H, I, J on page 14 of the EMI Photomultiplier Tube Catalogue ref. P001/fP70 (available on request).

Mechanical Characteristics

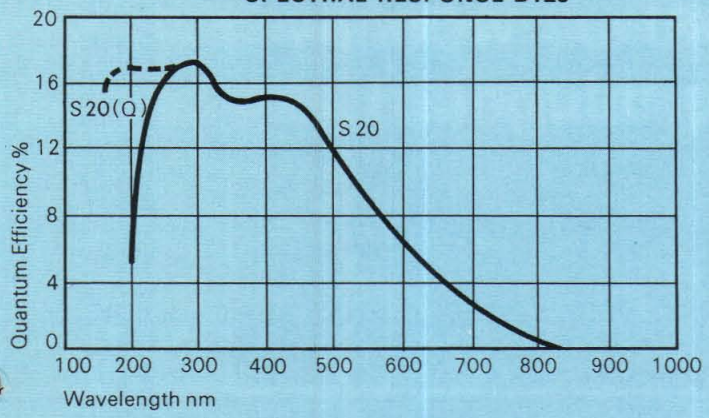
Envelope diameter:	**Maximum 29.00 mm (1.14 in)**
Cathode diameter:	**Nominal 23.00 mm (0.91 in)**
Cathode type:	**9824 Bialkali (KCs) D125 Trialkali (S20)**
Window material:	**9824B, D125, Corning 9741 9824QB, D125QB quartz (spectrosil)**
Dynodes:	**11 box and grid with Cs Sb surfaces**
Base:	**B14B low loss pressed glass (socket supplied)**

RATINGS		**9824**	**D125**
Overall sensitivity: rated		**200A/lm**	**200A/lm**
maximum		**2000A/lm**	**2000A/lm**
Voltage, cathode to d1:			
recommended		**150V**	**150V**
maximum		**300V**	**300V**
Voltage, anode to cathode: maximum		**2000V**	**2000V**
Anode current (mean): maximum		**0.1mA**	**0.1mA**
Anode dissipation: maximum		**0.1W**	**0.1W**
Cathode current: maximum (using whole area)		**0.05μA**	**1μA**
Anode pulse rise time: typical		**12 n. sec.**	**12 n. sec.**
Anode pulse f.w.h.m.: typical		**50 n. sec.**	**50 n. sec.**
Transit time: typical		**70 n. sec.**	**70 n. sec.**
Capacitance, anode to all dynodes: typical		**6 pF**	**6 pF**
Operating temperature: maximum		**60°C**	**60°C**
minimum		**—5°C**	**—180°C**
Dark current shot noise equivalent input*	**Lumens**	**8.0×10^{-14}**	**4.5×10^{-13}**
	Watts	**6.5×10^{-17}**	**8.4×10^{-16}**

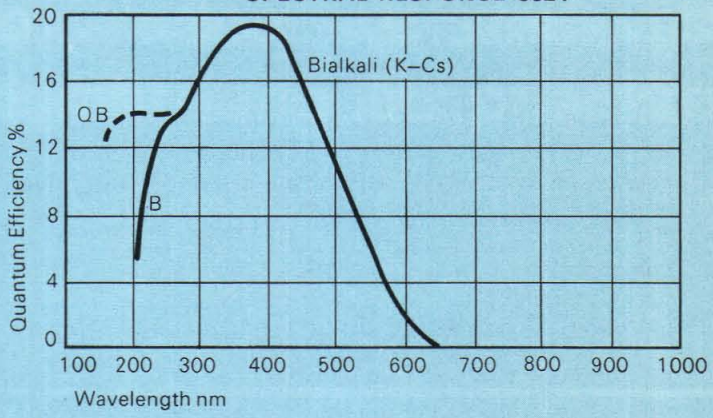
* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					200A/lm				2000A/lm		
	uA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9824B 9824QB	—	50	5.0	7.5	1150	—	0.2	2.0	1550	—	2.0
D125B D125QB	80	120	—	—	1050	—	5.0	25	1450	—	50

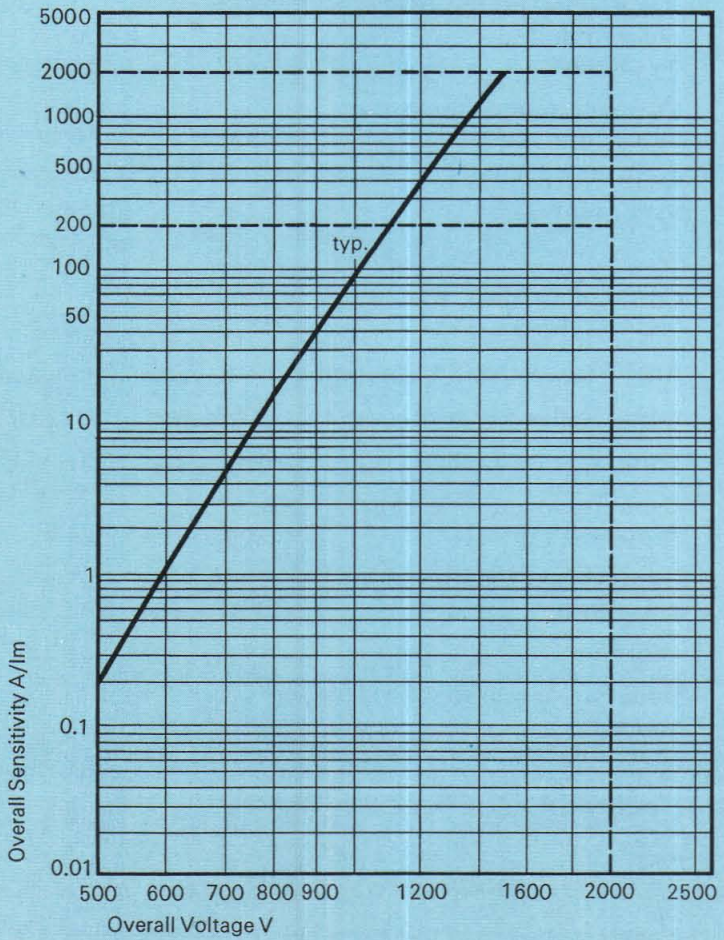
SPECTRAL RESPONSE D125

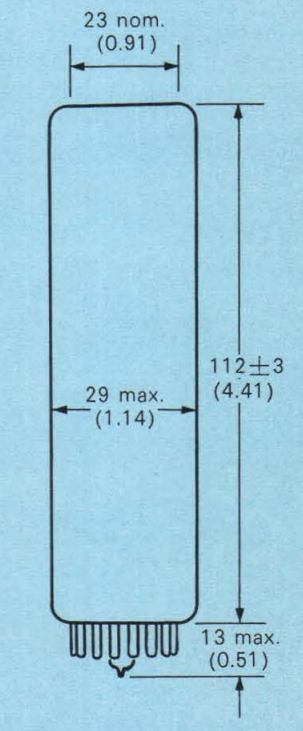


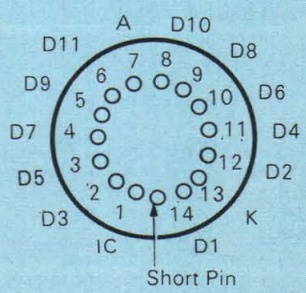
SPECTRAL RESPONSE 9824



OVERALL SENSITIVITY vs OVERALL VOLTAGE







Pin connections Type D125, 9824
B14B Socket
(Viewed from below)

All dimensions are in millimetres with inches shown in parentheses.

New 38mm (1½in) diameter tubes having S20 or bialkali photocathode and 10 dynodes

Provisional Data

- End-on low potassium borosilicate envelope with option of quartz (Spectrosil) window
- Fast response—3 n. sec. rise time
- Choice of plain glass (B14B) or overcapped (B12) base
- Bialkali photocathode (9633) for high blue sensitivity and very low dark current or trialkali (9683) for extended red

These new tubes are intended for use in applications where the high performance EMI 9635, 9750, 9558, 9658, 9659 tubes are not required. Typical applications include general low level photometry and laser detection.

Spectral coverage of the tubes with borosilicate window is about 310 to 650nm (bialkali) and about 310nm to beyond 850nm (trialkali). The U.V. response can be extended to approximately 170nm by using tubes with quartz windows.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm (except 9633); cathode sensitivity measurements with filters appropriate to the type of photocathode; the overall voltage for 20A/lm and the relevant dark current (at 20°C).
   A Corning glass filter (CS-5-58 ground to half stock thickness) is used to give a measure of the 'blue' sensitivity; a Corning glass filter (CS-2-62), which passes all radiation longer than approximately 600nm, to indicate 'red' sensitivity (except 9633), and a Wratten 87 filter, which passes all radiation longer than approximately 800 nm, to indicate sensitivity in the near infra red region (except 9633).
2. Test data is obtained with K to d1 held at 100 volts and the standard dynode chain.*
3. Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 1 μA.

*For recommended dynode chains, refer to groups D′, E′, F′ on page 14 of the EMI Photomultiplier Tube Catalogue ref. P001/fP70 (available on request).

RATINGS

		9633	9683
Overall sensitivity: rated		20A/lm	20A/lm
	maximum	50A/lm	50A/lm
Voltage, cathode to d1: recommended		100V	100V
maximum		150V	150V
Voltage, anode to cathode: maximum		1600V	1600V
Anode current (mean): maximum		0.5mA	0.5mA
Anode dissipation: maximum		0.5W	0.5W
Cathode current: maximum (using whole area)		0.1μA	1.5μA
Anode pulse rise time: typical		2.5 n. sec.	2.5 n. sec.
Anode pulse f.w.h.m.: typical		6.0 n. sec.	6.0 n. sec.
Transit time: typical		25 n. sec.	25 n. sec.
Capacitance, anode to all dynodes: typical		7pF	7pF
Operating temperature: maximum		60°C	60°C
minimum		−5°C	−180°C
Dark current shot noise equivalent input*	Lumens	2.3×10^{-13}	4×10^{-13}
	Watts	2.3×10^{-16}	1.4×10^{-15}

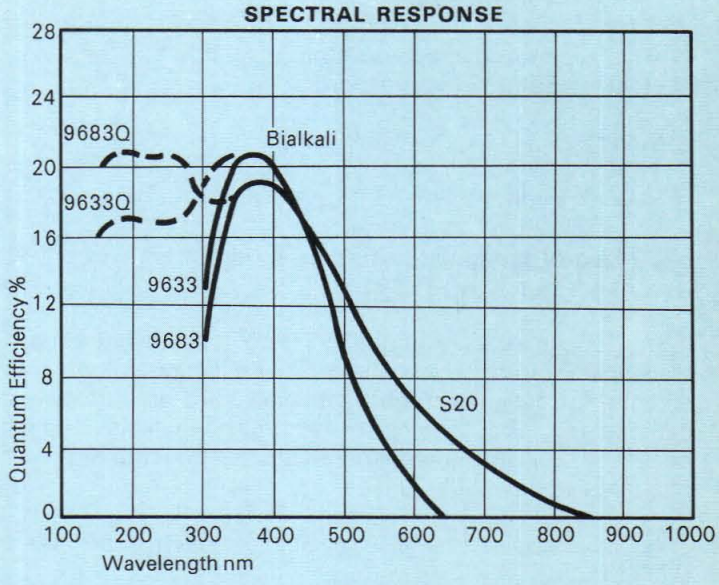
* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

MECHANICAL CHARACTERISTICS

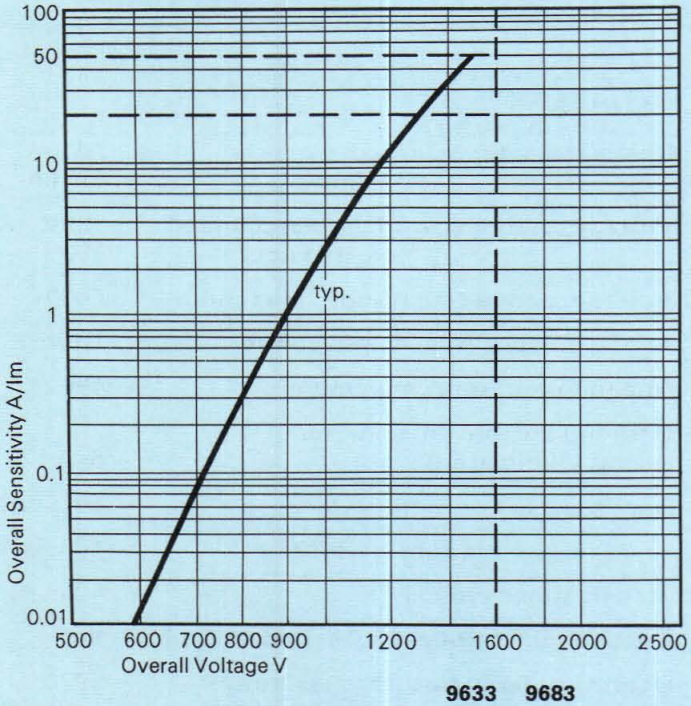
Envelope diameter	Maximum	40 mm (1.58 in)
Cathode diameter	Nominal	25 mm (0.98 in)
Cathode type		9683 trialkali (S20) 9633 bialkali (KCs)
Window material		9633B, 9633KB, 9683B, 9683KB borosilicate 9633QB, 9633QKB, 9683QB, 9683QKB, quartz (Spectrosil)
Dynodes		10 compact focused with BeCu surfaces
Base		9633B, 9633QB, 9683B, 9683QB, B14B (socket supplied) 9633KB, 9633QKB, 9683KB, 9683QKB, B12 (socket extra)

Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					20A/lm				50A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9633B 9633QB	—	60	—	8.0	1300	—	0.2	—	1600	—	0.5
9683B 9683QB	—	200	—	—	1250	—	2.0	—	1500	—	5.0

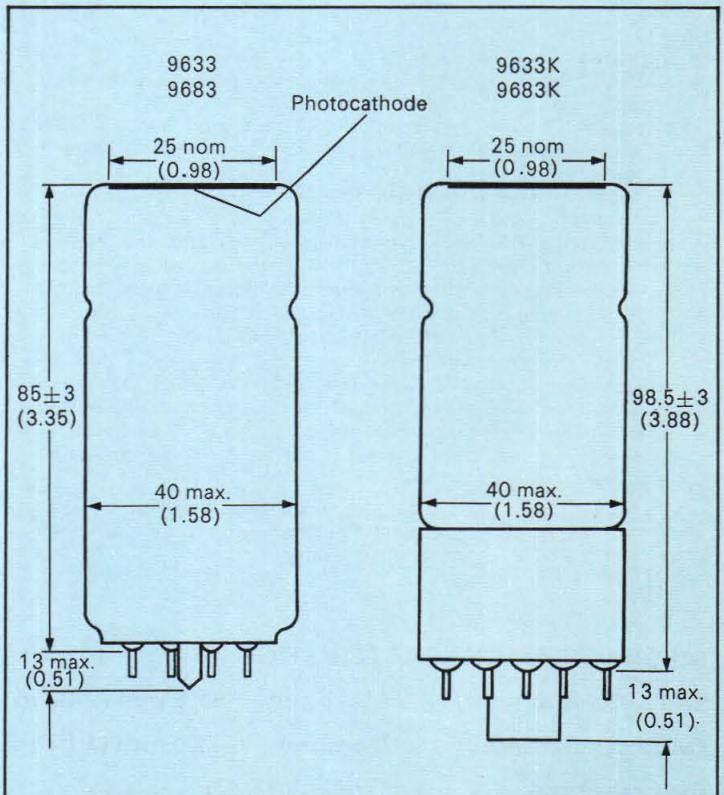
SPECTRAL RESPONSE



OVERALL SENSITIVITY vs OVERALL VOLTAGE



9633 9683



All dimensions are in millimetres with inches shown in parentheses.

PIN CONNECTIONS (viewed from below starting left of short pin or key)

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	socket
9633 9683	d1	d3	d5	d7	d9	A	d10	d8	d6	d4	d2	—	K	—	B14A
9633K 9683K	d1	d3	d5	d7	d9	A	d10	d8	d6	d4	d2	K	—	—	B12A

New 50mm (2in) diameter tubes with trialkali (S20) photocathode and 6 dynodes

Provisional Data

- Wide spectral coverage—310nm to 850nm (170 to 850nm quartz version)
- Small size—113 mm overall length
- Low dark current
- Surface of triangular prisms on inside of end window to enhance quantum efficiency.

This tube is a variant of the EMI 9658 type having a shorter envelope and 6 dynodes. The main application will be in the detection of relatively high light levels such as from laser or cathode ray tube sources, or generally where low gain is beneficial. The small number of dynodes also reduces the rate of change in gain with voltage.

An overcapped version is available, which is designated D214KB.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity with filters interposed (detailed below); the overall voltage for 1A/lm and the relevant dark current (at 20°C).
   A Corning glass filter (CS-5-58 ground to half stock thickness) is used to give a measure of the 'blue' sensitivity; a Corning glass filter (CS-2-62), which passes all radiation longer than 600 nm, to indicate 'red' sensitivity, and a Wratten 87 filter, which passes all radiation longer than approximately 800nm, to indicate sensitivity in the near infra-red region.
2. Test data is obtained with K to d1 held at 150V and a 'linear' dynode chain.*
3. Generally, tubes should be operated at, or near their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.

*For recommended dynode chains, refer to groups A, B, C on page 14 of the EMI Photomultiplier Tube Catalogue ref. P001/fP70 (available on request).

MECHANICAL CHARACTERISTICS

Envelope diameter	**Maximum**	**51.5 mm (2.02 in)**
Cathode diameter	**Nominal**	**40.0 mm (1.57 in)**
Cathode type	**Trialkali (S20)**	
Window material	**Borosilicate**	
Dynodes	**6 venetian blind with CsSb surfaces**	
Base	**B19A low loss pressed glass (socket supplied)**	

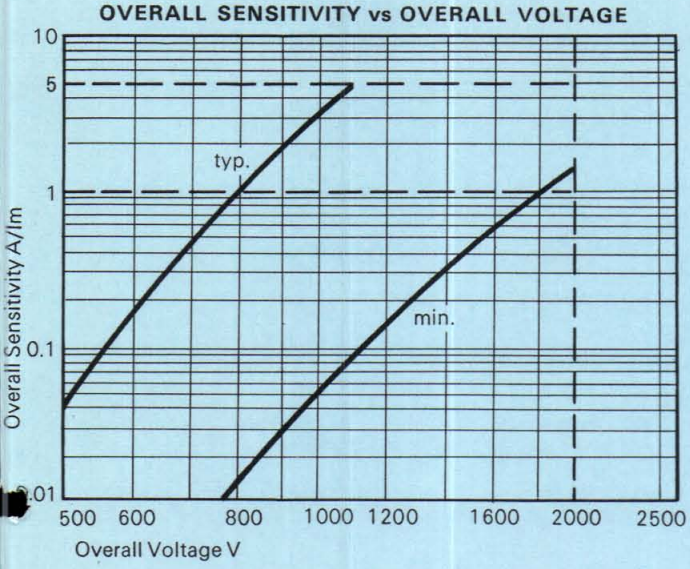
RATINGS

Overall sensitivity: rated	**1A/lm**
maximum	**5A/lm**
Voltage, cathode to d1: recommended	**150V**
maximum	**300V**
Voltage, anode to cathode: maximum	**2000V**
Anode current (mean): maximum	**1mA**
Anode dissipation: maximum	**1W**
Cathode current: maximum (using whole area)	**5μA**
Anode pulse rise time: typical	**10 n. sec.**
Anode pulse f.w.h.m.: typical	**14 n. sec.**
Transit time: typical	**40 n. sec.**
Capacitance, anode to all dynodes: typical	**8pF**
Operating temperature: maximum	**60°C**
minimum	**—180°C**
Dark current shot noise equivalent input* Lumens	**0.8×10^{-13}**
'Watts	**4.3×10^{-16}**

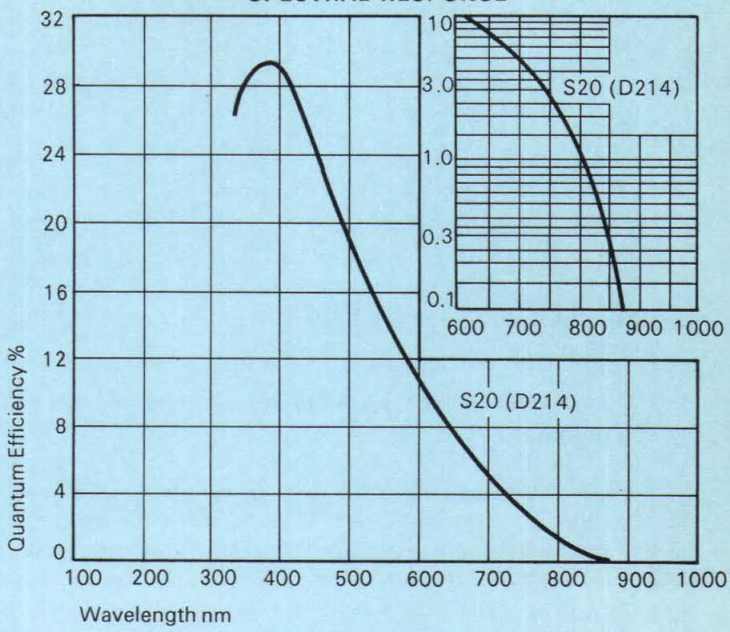
* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

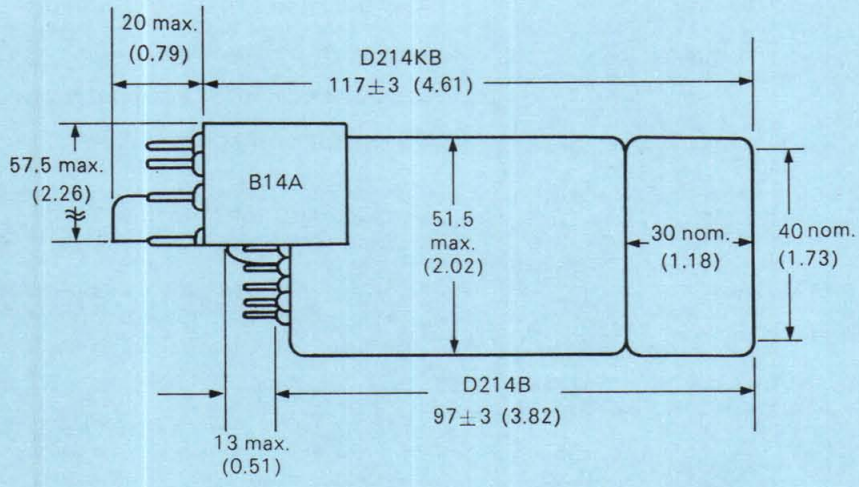
Tube Type Number	Cathode Sensitivity		Overall Sensitivity					
			1A/lm				5A/lm	
	μA/lm		V. Overall		Dark Current nA		V. Overall	Dark Current nA
	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ. Max.	Typ.
D214B	200	350	800	1800	0.5	5.0	1100 —	2.5

OVERALL SENSITIVITY vs OVERALL VOLTAGE



SPECTRAL RESPONSE





All dimensions in millimetres (inches in parenthesis).

PIN CONNECTIONS (viewed from below starting left of short pin or key)

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	socket
D214B	d1	—	—	—	—	—	—	A	—	d6	d5	d4	d3	d2	—	—	—	—	K	**B19A**
D214KB	i.c.	i.c.	i.c.	i.c.	i.c.	A	i.c.	d6	d5	d4	d3	d2	K	d1	—	—	—	—	—	**B14A**

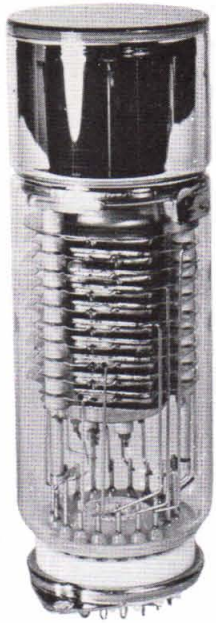
i.c.—internal connection

New 50mm (2in) diameter tube with trialkali(S20) photocathode and 11 dynodes

- □ High sensitivity in the blue and green parts of the spectrum
- □ S20 photocathode which has high conductivity and freedom from "lag" effects
- □ Physically interchangeable with other 50 mm tube in EMI S20 range

The tube is an addition to the existing range of EMI 50 mm tubes with S20 photocathodes. It is intended for use in the blue or green channels of colour flying spot equipment where high signal to noise ratio, under high light level conditions, is important. The main application is in telecine machines for broadcast use.

Depending upon availability, the 9658F may be supplied as an alternative. This tube meets the same performance specification and has identical external dimensions and pin connections.



RATINGS

Overall sensitivity: rated		**200A/lm**
maximum		**2000A/lm**
Voltage, cathode to d1: recommended		**300V**
maximum		**350V**
Voltage, anode to cathode: maximum		**2200V**
Anode current (mean): maximum		**1mA**
Anode dissipation: maximum		**1W**
Cathode current: maximum (using whole area)		**5μA**
Anode pulse rise time: typical		**10 n. sec.**
Anode pulse f.w.h.m.: typical		**15 n. sec.**
Transit time: typical		**55 n. sec.**
Capacitance, anode to all dynodes: typical		**8pF**
Operating temperature: maximum		**60 °C**
minimum		**—180 °C**
Dark current shot noise equivalent input*	**Lumens**	**1.5×10^{-13}**
	Watts	**3.7×10^{-16}**

* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

MECHANICAL CHARACTERISTICS

Envelope diameter	**Maximum 51.5 mm (2.02 in)**
Cathode diameter	**Nominal 9558F 44 mm (1.73 in) (9658F 40 mm)**
Cathode type	**Trialkali (S20)**
Window material	**Borosilicate**
Dynodes	**11 Venetian blind with CsSb surfaces**
Base	**B19A low loss pressed glass (socket supplied)**

Notes

1 Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity with filters interposed (detailed below); the overall voltage for 200A/lm and the relevant dark current (at 20°C).
A Corning glass filter (CS-5-58 ground to half stock thickness) is used to give a measure of the 'blue' sensitivity; a Corning glass filter (CS-2-62), which passes all radiation longer than 600nm, to indicate 'red' sensitivity, and a Wratten 87 filter, which passes all radiation longer than approximately 800nm, to indicate sensitivity in the near infra-red region.
Suitability for use in the blue or green channel depends upon a comparison between Corning red and Corning blue filter readings and tube tickets are marked accordingly.

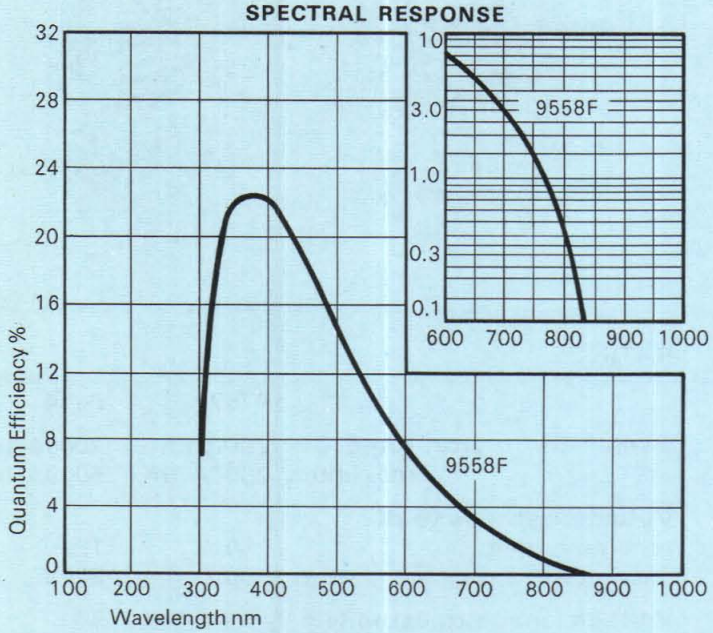
2 Test data is obtained with K to d1 held at 150V and the 'standard' dynode chain.*

3 Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.

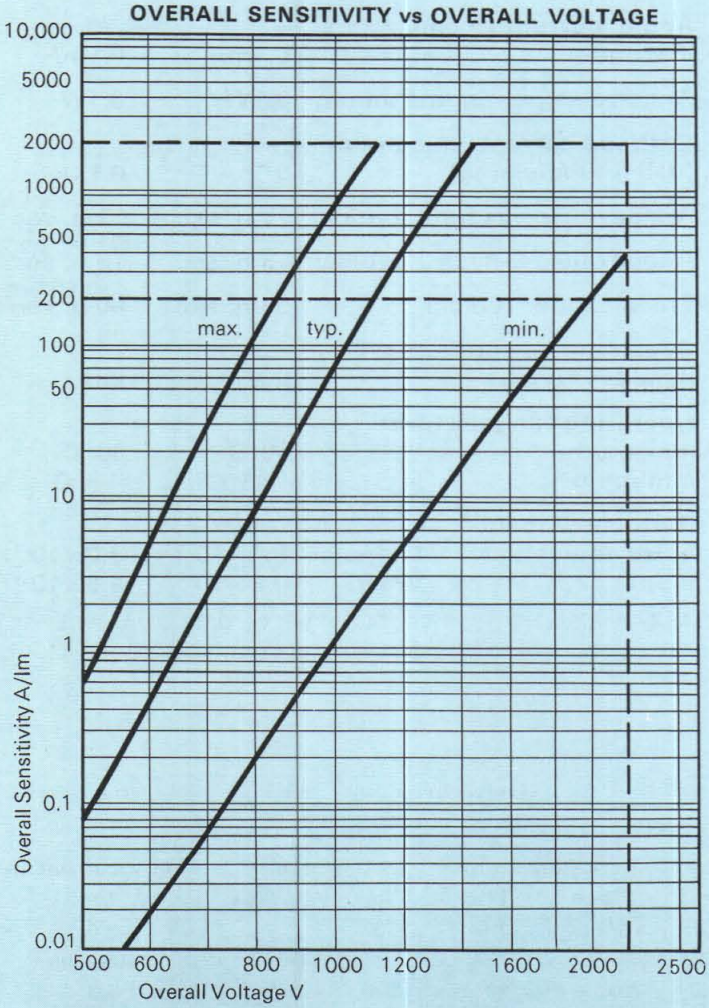
*For recommended dynode chains, refer to groups H, I, J on page 14 of the EMI Photomultiplier Tube Catalogue ref. P001/fP70 (available on request).

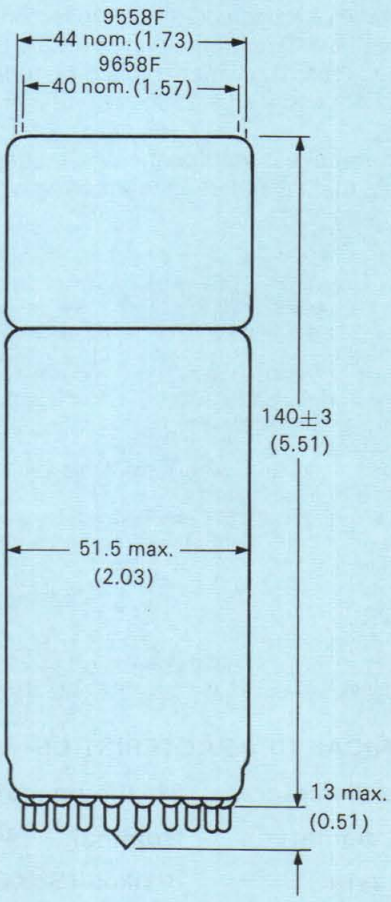
Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					200A/lm				2000A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9558F	100	150	7.0	9.0	1100	2000	5.0	50	1450	—	50

SPECTRAL RESPONSE

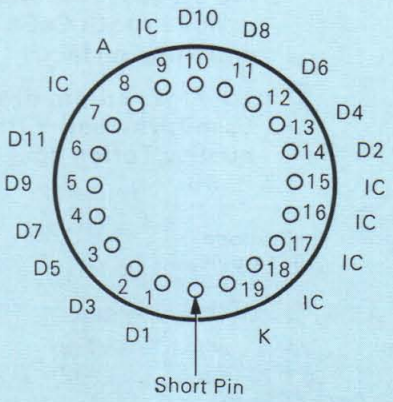


OVERALL SENSITIVITY vs OVERALL VOLTAGE





All dimensions are in millimetres with inches shown in parentheses



Pin Connections Types 9558, 9658
B19A Socket (Viewed from below)

New 50mm (2in) diameter tubes with bialkali photocathode and 11 or 13 dynodes

- High 'blue' response and very low dark current
- 9804B high gain, typically 4×10^7 at 1000V
- 9757B medium gain, typically 4×10^6 at 950V

The 9757B and 9804B are intended to replace the 6097S and 9514S types. Being physically interchangeable, they offer the advantage of an immediate improvement in blue response together with a dark current level as low as that obtained from the 'S' type tubes. The venetian blind dynode structures utilise highly efficient and stable CsSb secondary emitting surfaces.

The main applications for the new tubes are in low level photometry, nuclear radiation monitoring and thermoluminescent dosimetry.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity measured with a Corning blue CS-5-58 filter (polished to half stock thickness) interposed; the overall voltage for 200A/lm (9757) or 2000A/lm (9804) and the relevant dark current (at 20°C). The quantum efficiency at 420nm can be estimated by multiplying the Corning blue reading by 2.5.
2. Test data is obtained with K to d1 held at 150 volts and the 'standard' dynode chain.*
3. Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.

*For recommended dynode chains, refer to groups H, I, J, (9757) or K, L, M (9804) on page 14 of the EMI Photomultiplier Catalogue ref. P001/fP70 (available on request).

MECHANICAL CHARACTERISTICS

Envelope diameter	Maximum	51.5 mm (2.02 in)
Cathode diameter	Nominal	44 mm (1.73 in)
Cathode type	Bialkali (SbKCs)	
Window material	Borosilicate	
Dynodes	9757 (11 stages); 9804 (13 stages): venetian blind dynodes with CsSb secondary emitting surfaces	
Base	Low loss 15-pin pressed glass base furnished with high quality Teflon socket type B15B	

RATINGS

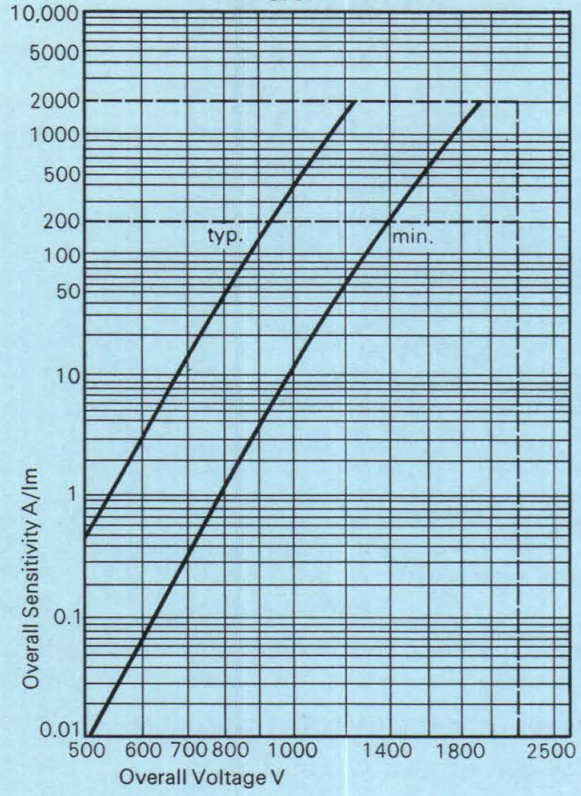
		9757	9804
Overall sensitivity: rated		200A/lm	2000A/lm
	maximum	2000A/lm	5000A/lm
Voltage, cathode to d1: recommended		150V	150V
maximum		300V	300V
Voltage, anode to cathode: maximum		1800V	2500V
Anode current (mean): maximum		0.1mA	0.1mA
Anode dissipation: maximum		0.1W	0.1W
Cathode current: maximum (using whole area)		0.1μA	0.1μA
Anode pulse rise time: typical		11 n. sec.	11 n. sec.
Anode pulse f.w.h.m.: typical		15 n. sec.	16 n. sec.
Transit time: typical		55 n. sec.	60 n. sec.
Capacitance, anode to all dynodes: typical		8pF	8pF
Operating temperature: maximum		60°C	60°C
minimum		—5°C	—5°C
Dark current shot noise equivalent input*	Lumens	8.0×10^{-14}	8.0×10^{-14}
	Watts	4.8×10^{-17}	4.8×10^{-17}

* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

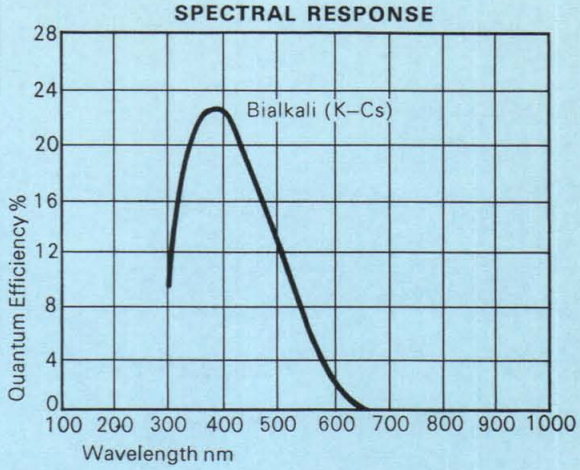
Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					200A/lm				2000A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9757B	—	50	5.0	9.0	950	1400	0.2	1.0	1250	—	2.0
					2000A/lm						5000A/lm
9804B	—	50	5.0	9.0	1000	1700	2.0	10	1100	—	5.0

The maximum dark current count rate is 1000 electrons/second.

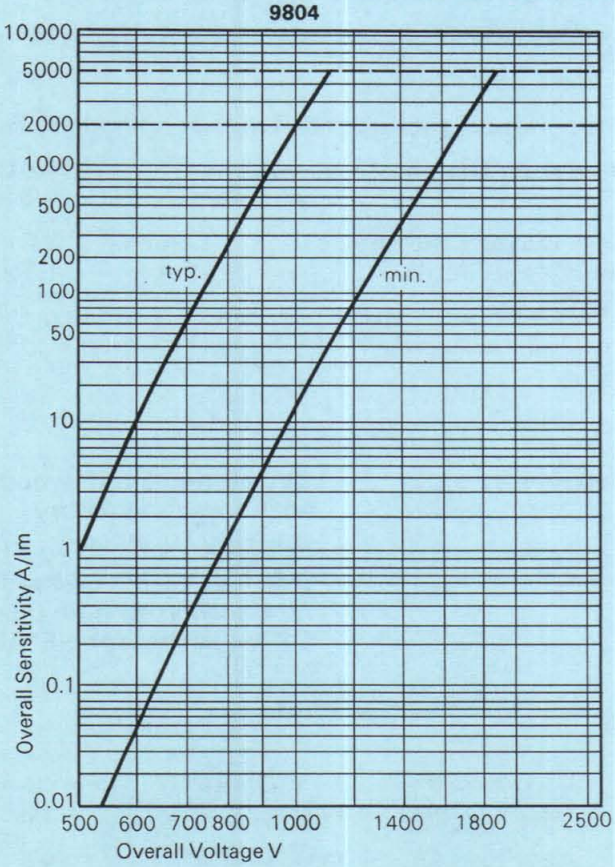
OVERALL SENSITIVITY vs OVERALL VOLTAGE
9757

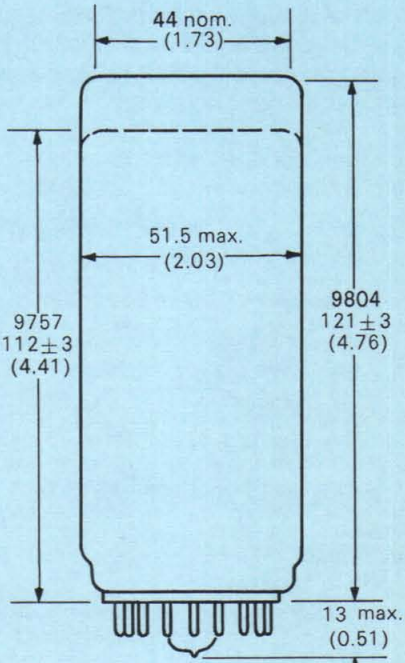


SPECTRAL RESPONSE

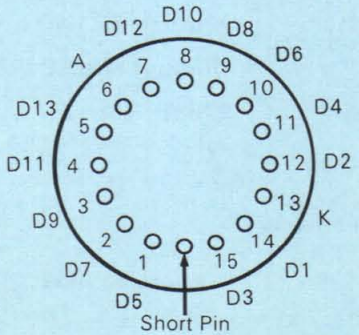


OVERALL SENSITIVITY vs OVERALL VOLTAGE
9804



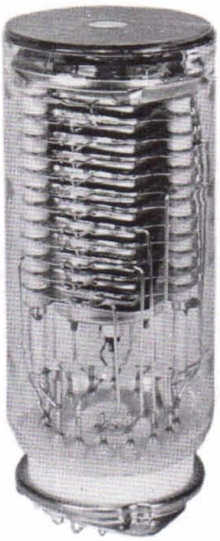


All dimensions are in millimetres with inches shown in parentheses



Pin Connections Types 9757* 9804
B15B Socket (Viewed from below)
*Pins 5&7 IC

New 13 stage 50mm (2in) diameter tubes with bialkali photocathode having an effective diameter of 10mm



- □ High 'blue' response with extremely low dark current
- □ High gain, typically 4×10^7 at 1150V
- □ Choice of borosilicate (310nm to 650nm) or quartz (170nm to 650nm) windows

This tube is intended to replace the 9502S and 6256S types with which it is physically interchangeable. It has a unique K-d_1 geometry, together with a venetian blind dynode structure having highly stable and efficient CsSb secondary emitting surfaces. This combination of dynode system and bialkali photocathode makes the 9789 capable of giving very high values of gain together with extremely low dark currents.

Main applications include very low level photometry, photon counting and astronomy.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity measured with a Corning blue CS-5-58 filter (polished to half stock thickness) interposed; the overall voltage for 200A/lm and the relevant dark current (at 20°C). The quantum efficiency at 420nm can be estimated by multiplying the Corning blue reading by 2.5.
2. Test data is obtained with K to d1 held at 150 volts and the 'standard' dynode chain.*
3. Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.

*For recommended dynode chains, refer to groups K, L, M, on page 14 of the EMI Photomultiplier Catalogue ref. P001/fP70 (available on request).

RATINGS

Overall sensitivity: rated		**2000A/lm**
maximum		**5000A/lm**
Voltage, cathode to d1: recommended		**150V**
maximum		**300V**
Voltage, anode to cathode: maximum		**2100V**
Anode current (mean): maximum		**1mA**
Anode dissipation: maximum		**1W**
Cathode current: maximum (using whole area)		**0.3μA**
Anode pulse rise time: typical		**10 n. sec.**
Anode pulse f.w.h.m.: typical		**15 n. sec.**
Transit time: typical		**55 n. sec.**
Capacitance, anode to all dynodes: typical		**8pF**
Operating temperature: maximum		**60 °C**
minimum		**—5 °C**
Dark current shot noise equivalent input*	**Lumens**	**2.5×10^{-14}**
	Watts	**1.5×10^{-17}**

* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

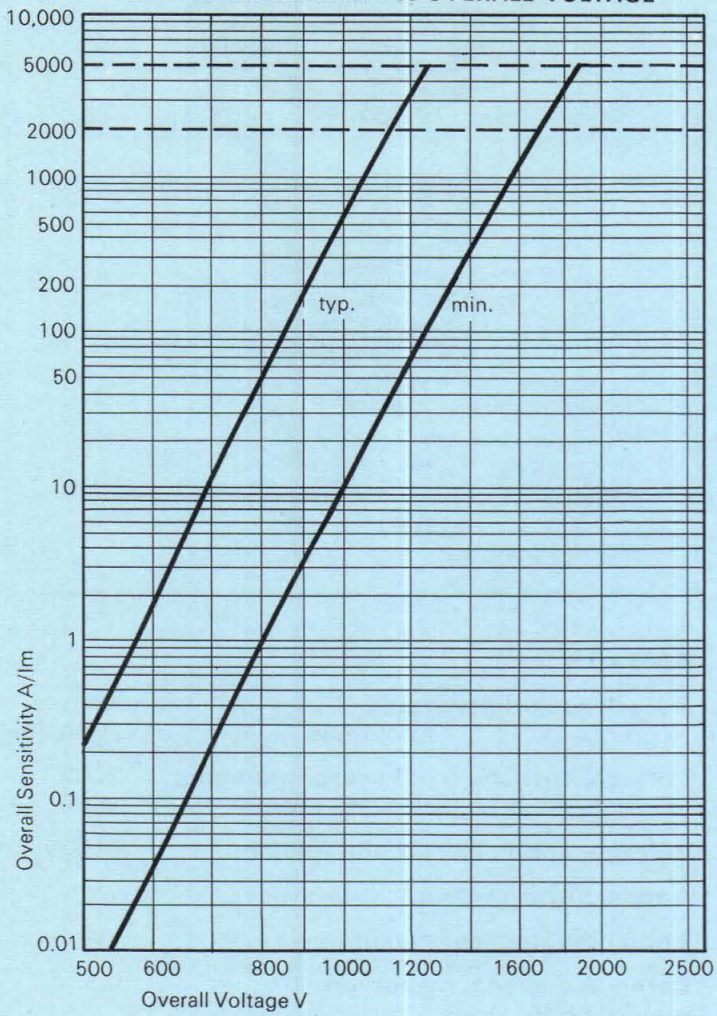
MECHANICAL CHARACTERISTICS

Envelope diameter	**Maximum**	**51.5 mm (2.02 in)**	**Dynodes**	**13 venetian blind dynodes with CsSb secondary emitting surfaces**
Cathode diameter	**Minimum**	**10 mm (0.39 in)**		
Cathode type	**Bialkali (SbKCs)**		**Base**	**Low loss 15-pin pressed glass furnished with high quality Teflon socket type B15B**
Window material	**9789B Borosilicate, 9789QB Spectrosil (fused silica)**			

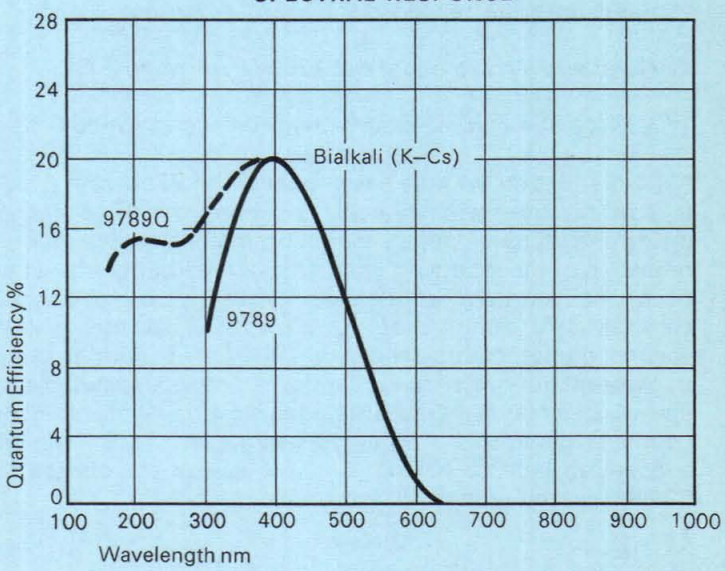
Tube Type Number	Cathode Sensitivity				Overall Sensitivity 2000A/lm				Overall Sensitivity 5000A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9789B 9789QB	—	50	5.0	8.0	1150	1700	0.2	1.0	1300	—	0.5

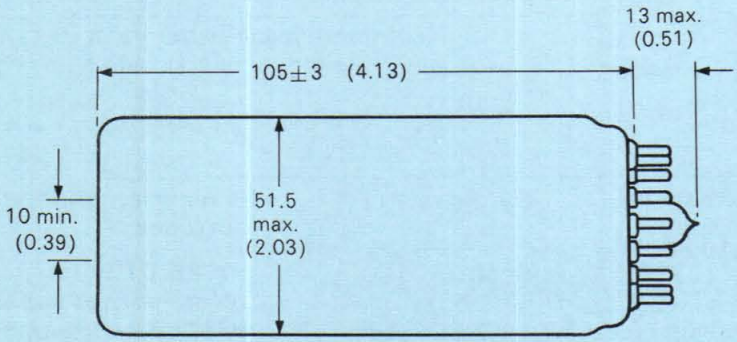
The maximum dark current count rate is 50 electrons/second.

OVERALL SENSITIVITY vs OVERALL VOLTAGE

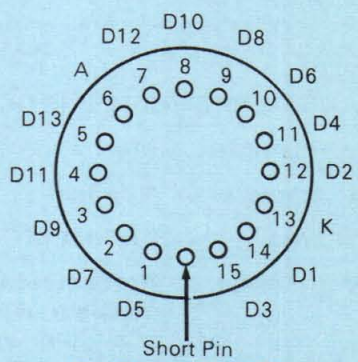


SPECTRAL RESPONSE





All dimensions are in millimetres with inches shown in parentheses



Pin Connections Type

9789

B15B Socket

(Viewed from below)

New 75mm (3in) diameter tubes with bialkali photocathode and an internal end window surface of triangular prisms

Provisional Data

- Very high 'blue' response and low dark current
- Good energy resolution, e.g. 12.5% f.w.h.m. to ^{57}Co
- Surface of triangular prisms on inside of end window

The 9778 is a new tube based on the EMI 9758 with which it is physically interchangeable. However the 9778 has an inside end window surface which promotes multiple internal reflection of the incoming light. This gives a better utilisation of the incident light but its main purpose for use in gamma cameras is to eliminate abrupt changes of sensitivity with varying angles of incidence, which exist in normal semi-transparent tubes with plane windows. The tube is suitable for use in gamma cameras and other low level scintillation counters, gamma and X-ray spectrometers. Tubes can be supplied in batches having a narrow spread of voltages for 50A/lm overall sensitivity.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity measured with a Corning blue CS-5-58 filter (polished to half stock thickness) interposed; the overall voltage for 50A/lm and the relevant dark current (at 20°C). The quantum efficiency at 420nm can be estimated by multiplying the Corning blue reading by 2.5.
2. Test data is obtained with K to d1 held at 300 volts and the 'standard' dynode chain.*
3. Generally, tubes should be operated at, or near, their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
4. For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.

*For recommended dynode chains, refer to groups D, E, F on page 14 of the EMI Photomultiplier Catalogue ref. P001/fP70 (available on request).

RATINGS

Overall sensitivity: rated		**50A/lm**
maximum		**200A/lm**
Voltage, cathode to d1: recommended		**300V**
maximum		**350V**
Voltage, anode to cathode: maximum		**2100V**
Anode current (mean): maximum		**1mA**
Anode dissipation: maximum		**1W**
Cathode current: maximum (using whole area)		**0.5μA**
Anode pulse rise time: typical		**12 n. sec.**
Anode pulse f.w.h.m.: typical		**50 n. sec.**
Transit time: typical		**70 n. sec.**
Capacitance, anode to all dynodes: typical		**8pF**
Operating temperature: maximum		**60 °C**
minimum		**—5 °C**
Dark current shot noise equivalent input*	**Lumens**	**2×10^{-13}**
	Watts	**2×10^{-16}**

* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

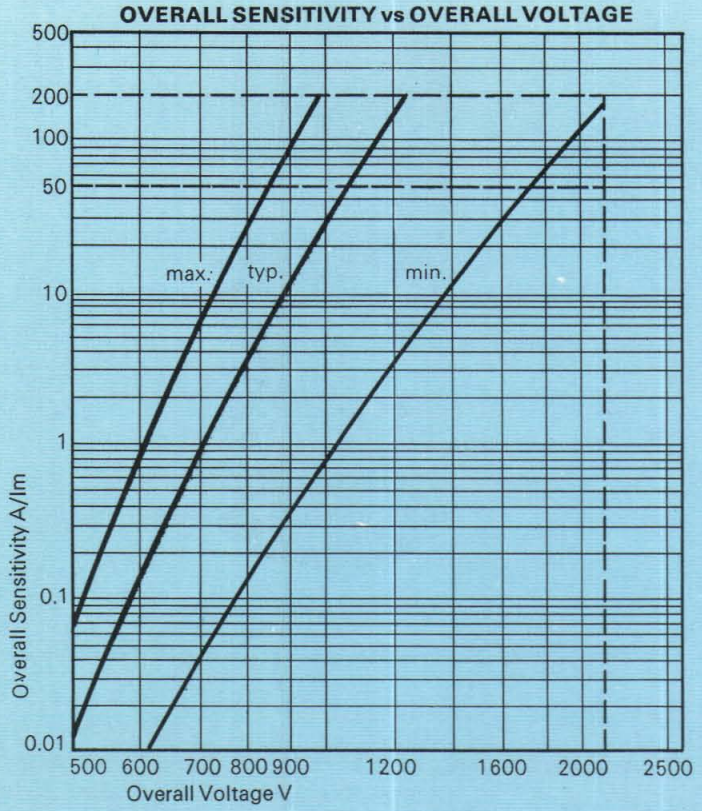
MECHANICAL CHARACTERISTICS

Envelope diameter	**Maximum**	**78 mm (3.07 in)**
Cathode diameter	**Nominal**	**65 mm (2.56 in)**
Cathode type	**Bialkali (KCs)**	
Window material	**Borosilicate (internal surface consists of 3 mm square base triangular prisms)**	

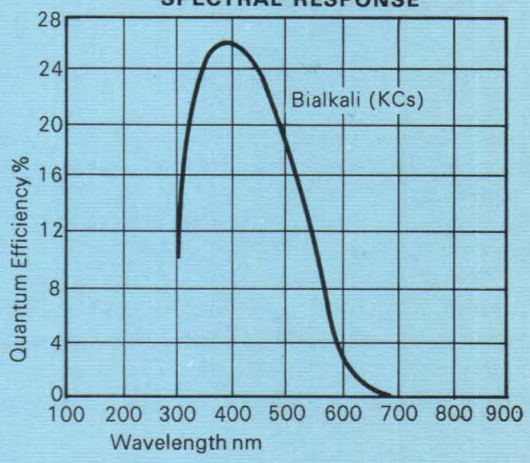
Dynodes	**9 venetian blind with CsSb surfaces**
Base	**9778B B19A low loss pressed glass (socket supplied) 9778KB overcapped B14A (socket extra)**

Tube Type Number	Cathode Sensitivity				Overall Sensitivity						
					50A/lm				200A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9778B		85	7.0	11.0	1050	1750	0.5	50	1250	—	2.0

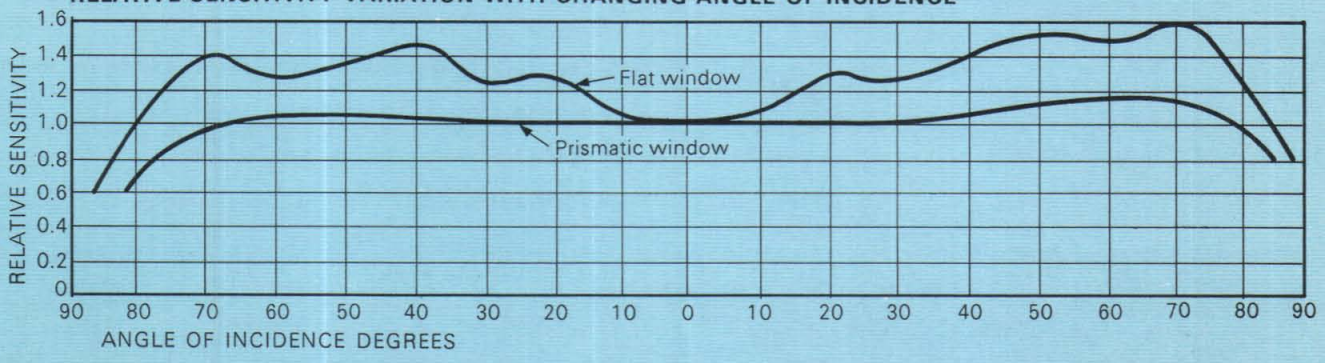
OVERALL SENSITIVITY vs OVERALL VOLTAGE

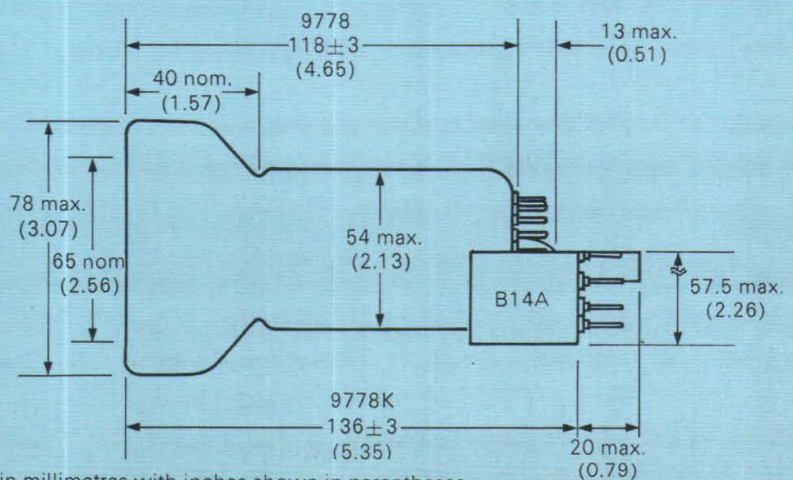


SPECTRAL RESPONSE



RELATIVE SENSITIVITY VARIATION WITH CHANGING ANGLE OF INCIDENCE





All dimensions are in millimetres with inches shown in parentheses.

PIN CONNECTIONS (viewed from below starting left of short pin or key)

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	**socket**
9778B	i.c.	d1	d2	d3	d4	d5	d6	d7	d8	i.c.	d9	A	i.c.	i.c.	i.c.	i.c.	i.c.	i.c.	K	**B19A**
9778KB	d1	d2	d3	d4	d5	d6	d7	d8	i.c.	d9	A	i.c.	i.c.	K	—	—	—	—	—	**B14A**

i.c.—internal connection

New 50mm (2in) diameter tube with bialkali photocathode on a curved end window

Provisional Data

- □ High blue sensitivity and low dark current
- □ Curved end window with matt surface on outer face for coupling to liquid scintillation spectrometer reflective chambers
- □ Low background from low potassium glass

The 9820 is a new tube based on the EMI 9813, which has a linear focused dynode system for fast response and a high efficiency bialkali photocathode. The tube is intended for liquid scintillation counting in coincidence arrangements and will give a high ^3H efficiency with a low background. The use of low potassium glass for the envelope and window ensures that the background associated with the tube is kept to a minimum. Tubes can be supplied in pairs for use in coincidence systems.

Notes

1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode 'blue' sensitivity measured with a Corning glass filter (CS-5-58 ground to half stock thickness) from which the quantum efficiency at 420nm can be estimated by multiplying by 2.50; the overall voltage for 200A/lm and the relevant dark current (at 20°C).
2. Test data is obtained with K to d1 held at 300 volts and a linear test dynode chain.
3. F (focus) should be connected to d1 for normal operation.
4. Generally, tubes should be operated at or near their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.
5. For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.
6. The glass envelope is coated with a screen which is connected to the cathode pin and over-wound with 3M's electrical tape, to ensure optimum dark current performance. Special care should be taken if the tube is operated with the cathode at high negative potential.

DYNODE CHAIN DESIGN

For best results a linear dynode chain should be used. The circuit shown on page 26 is recommended but with resistance R used between each pair of stages from d3 onwards.

RATINGS

Overall sensitivity: rated		**200A/lm**
maximum		**2000A/lm**
Voltage, cathode to d1: recommended		**300V**
maximum		**500V**
Voltage between dynodes: maximum		**550V**
Voltage, anode to last dynode: maximum		**550V**
Voltage, anode to cathode: maximum		**2500V**
Anode current (mean) maximum		**0.1mA**
Anode dissipation: maximum		**0.1W**
Cathode current: maximum (using whole area)		**0.3μA**
Anode pulse rise time: typical		**2.0 n. sec.**
Anode pulse f.w.h.m.: typical		**2.9 n. sec.**
Transit time: typical		**40 n. sec.**
Capacitance, anode to all dynodes: typical		**5pF**
Operating temperature: maximum		**60°C**
minimum		**—20°C**
Dark current shot noise equivalent input*	**Lumens**	**1.6×10^{-13}**
	Watts	**1.3×10^{-16}**

* Calculated from typical performance data using Q.E. at λ peak and assuming Δf of 1 Hz and enhancement factor of unity.

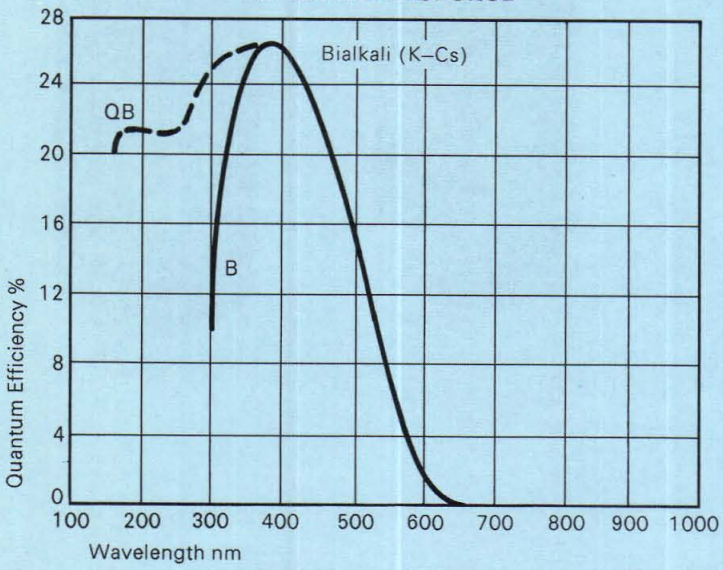
MECHANICAL CHARACTERISTICS

Envelope diameter	**Maximum 53 mm (2.09 in)**
Cathode diameter	**Nominal 46 mm (1.81 in)**
Cathode type	**Bialkali (KCsSb)**
Window material	**Borosilicate or Spectrosil**
Dynodes	**12 linear focused with CsSb surfaces**
Base	**B19A low loss pressed glass (socket supplied)**

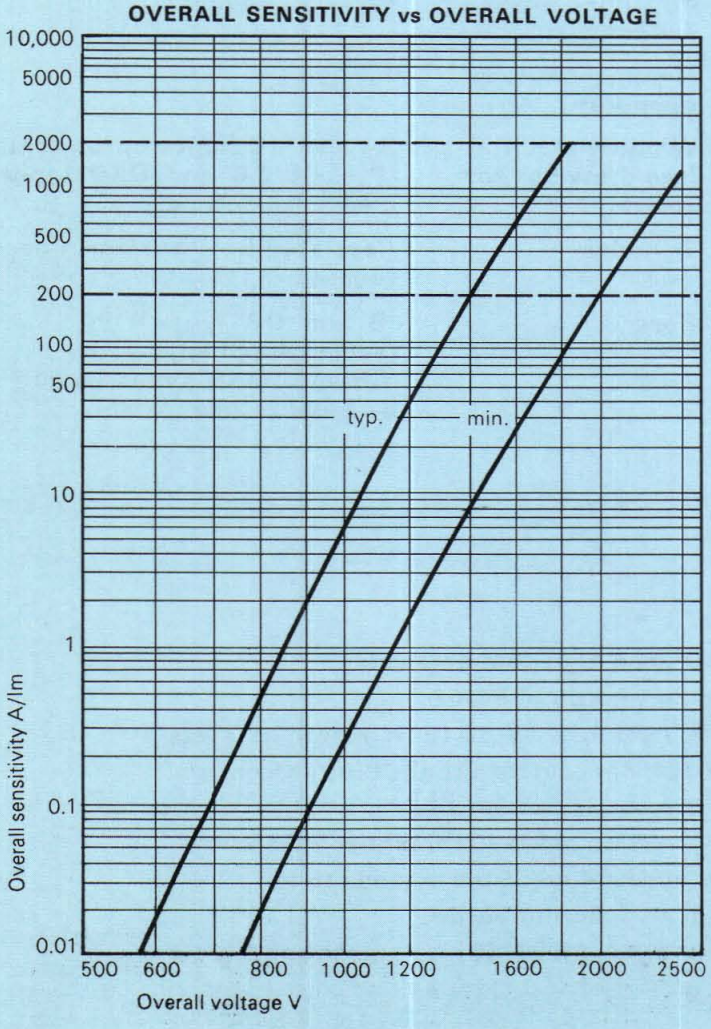
Tube Type Number	Cathode Sensitivity				Overall Sensitivity φ						
					200A/lm				2000A/lm		
	μA/lm		Corning Blue		V. Overall		Dark Current nA		V. Overall		Dark Current nA
	Min.	Typ.	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.
9820B QB	—	65	7.0	10.0	1400	2000	1.0	4.0	1800	—	10

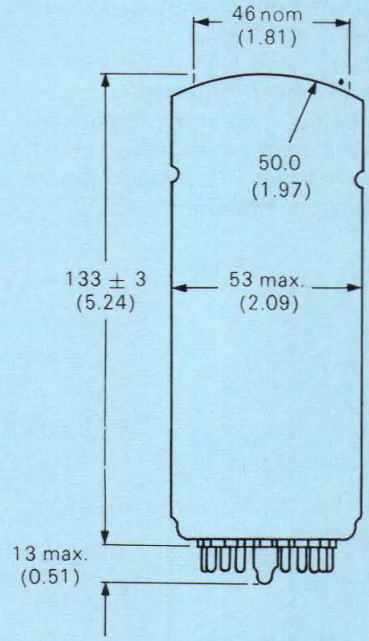
φ measured using linear dynode chain.

SPECTRAL RESPONSE

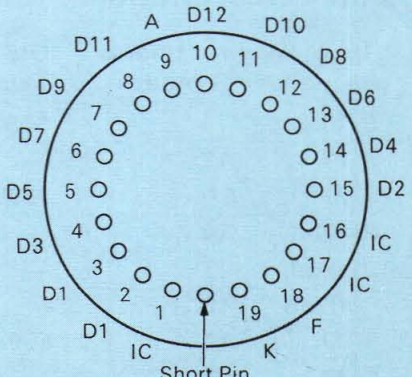


OVERALL SENSITIVITY vs OVERALL VOLTAGE





All dimensions in millimetres (inches in parenthesis).



Pin Connections Type 9820
B19A Socket
(Viewed from below)

50 mm (2 in) diameter fast linear focused tubes with S11, bialkali, or S20 photocathodes

- Semi-transparent curved photocathode surface on end window which is flat externally
- Linear focused dynode structure with caesiated Be O surfaces for high gain and good stability
- Spectral responses S-11, S-13, Bialkali or S-20
- 10, 12 or 14 dynode stages
- Flexibility of envelope configuration, i.e. B19A(uncapped) or B20–102 (overcapped) base; borosilicate (Pyrex) or quartz (Spectrosil) end window material

The 2 in. diameter tubes 9810–9818 are designed for applications requiring very fast response times such as the detection and measurement of short lived nuclear events and pulsed light sources.

This new series has been introduced to replace the 9594 range. Apart from being more comprehensive, it incorporates design modifications to give improved reliability and performance. The external dimensions and pin connections are unchanged to preserve interchangeability.

MECHANICAL CHARACTERISTICS

Maximum envelope diameter	**All types 53 mm (2.09 in)**
Nominal cathode diameter	**All types 46 mm (1.81 in)**
Window material (see drawings for shapes)	**'B' and 'KB' types borosilicate (Pyrex): 'QB' and 'QKB' types quartz (Spectrosil)**
Dynodes	**Caesiated Be O surface, linear focused**
Base	**'B' and 'QB' types B19A (socket supplied) 'KB' and 'QKB' types Jedec B20–102 (socket extra)**

PRELIMINARY SELECTION GUIDE

Basic Type*	Spectral Response	Number of Dynodes	Old Type	Remarks
9810B	**S-11**	**14**	**9594UB**	**General purpose high gain parent type**
9811B	**S-11**	**12**	**—**	**Medium gain version of 9810B**
9812B	**S-11**	**10**	**9595UB**	**Lower gain version of 9810B for higher light levels**
9813B	**Bialkali**	**14**	**—**	**High gain, low dark current, high "blue" response**
9814B	**Bialkali**	**12**	**—**	**Medium gain version of 9813B**
9815B	**Bialkali**	**10**	**—**	**Lower gain version of 9813B for higher light levels**
9816B	**S-20**	**14**	**9597UB**	**High gain, spectral response extends to IR**
9817B	**S-20**	**12**	**—**	**Medium gain version of 9816B**
9818B	**S-20**	**10**	**9596UB**	**Lower gain version of 9816B, for higher light levels**

*Versions with quartz end window and/or overcapped are available in which case Q and/or K respectively are added to the type number, e.g. 9813QKB.

Notes

1 a) Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm; cathode sensitivity measurements with filters appropriate to type of photocathode; the overall voltages for 50A/lm (10-stage tubes only), 200 A/lm (12-stage tubes only), 5000 A/lm (14-stage tubes only), and the relevant dark current (at 20°C).
A Corning glass filter (CS-5-58 ground to half stock thickness) is used to give a measure of the "blue" sensitivity; a Corning glass filter (CS-2-62), which passes all radiation longer than approximately 600nm, to indicate "red" sensitivity, and a Wratten 87 filter, which passes all radiation longer than approximately 800nm, to indicate sensitivity in the near infra-red region.

b) Test data is obtained with K to d1 held at 300 volts and the non-linear test dynode chain.

c) F (focus) should be connected to d1 for normal operation.

d) Generally, tubes should be operated at or near their rated overall sensitivity. Care should be taken not to exceed the maximum rated sensitivity or voltage.

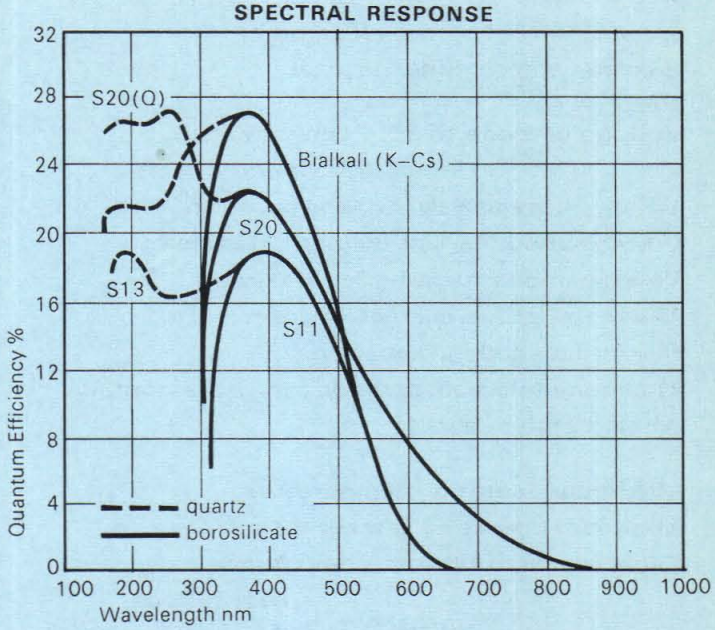
2 For optimum stability under d.c. conditions, the mean anode current should not exceed 10μA.

3 The glass envelope is coated with a screen which is connected to the cathode pin and over-wound with 3M's electrical tape, to ensure optimum dark current performance. Special care should be taken if the tube is operated with the cathode at high negative potential.

4 Overall sensitivity is greatly affected by variations in overall voltage, particularly in the case of tubes with a large number of dynodes.

5 In order to obtain a high value of peak output current, it is necessary to provide high voltages between the last dynode stages. The EMI test dynode chain is recommended for optimum results.

SPECTRAL RESPONSE

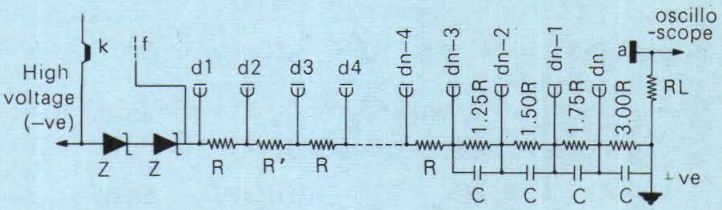


Tube type No.*	Cathode Sensitivity μA/lm		Overall Sensitivity 5000A/lm				Overall Sensitivity 10,000A/lm	
			V Overall		Dark Current nA		V Overall	Dark Current nA
	Min.	Typ.	Typ.	Max.	Typ.	Max.	Typ.	Typ.
9810B†	50	75	2250	2700	100	1000	2380	200
9810B‡			1980	—			2080	
9813B†	§	§	2350	2700	10	100	2480	20
9813B‡			2050	—			2160	
9816B†	100	170	2150	2700	50	1000	2270	100
9816B‡			1900	—			2000	
			Overall Sensitivity 200A/lm				Overall Sensitivity 2000A/lm	
9811B†	50	75	2050	2500	15	100	2600	150
9811B‡			1750	—			2220	
9814B†	§	§	2150	2500	2	8	2750	20
9814B‡			1850	—			2350	
9817B†	100	170	1950	2500	10	100	2470	100
9817B‡			1650	—			2070	
			Overall Sensitivity 50A/lm				Overall Sensitivity 500A/lm	
9812B†	50	75	1850	2300	2	50	2500	20
9812B‡			1560	—			2100	
9815B†	§	§	1950	2300	1	5	2620	10
9815B‡			1640	—			2200	
9818B†	100	170	1750	2300	2	50	2350	20
9818B‡			1470	—			1970	

* Tube characteristics apply equally to overcapped and quartz versions.
† Non-linear dynode chain.
‡ Linear dynode chain.
§ Types 9813, 9814 9815 have a minimum Corning blue cathode sensitivity of 7.0 and typical of 10.0.

DYNODE CHAIN DESIGN

The EMI (Non-linear) test dynode chain is shown below:



R' = 1.4R for normal operation but may be varied between R and 1.4R without significant change in performance

RL = 50 Ω — n = number of dynodes

Z = IS4150A (150V) — c = 1000pF

The value of R should be chosen to provide a series current, in the divider chain, of at least 10 times the mean expected anode current. To maintain linearity when high current anode pulses are being drawn, the voltages supplying the final dynodes should be increased, and if resistors are being used they should be decoupled by suitably large value capacitors. The photomultiplier output socket will also affect operation under pulsed conditions.

General notes on design aspects are given in the Introduction of the EMI photomultiplier catalogue P001/fP70, available on request.

RATINGS

PARAMETER	TUBE TYPE (All versions)		
	9810	9811	9812
	9813	9814	9815
	9816	9817	9818
Overall sensitivity: Rated	5,000 A/lm	200 A/lm	50 A/lm
Maximum	10,000 A/lm	2,000 A/lm	500 A/lm
Anode pulse rise time: Typical	2.4	2.0	1.6
(n. sec) Maximum	3.0	2.5	2.2
Anode Pulse f.w.h.m.: Typical	3.6	2.8	2.5
(n. sec) Maximum	4.4	4.0	3.5
Electron transit time: Typical (n. sec)	45	39	32
Voltage cathode to d1: Recommended	300	300	300
Maximum	500	500	500
Voltage between dynodes: Maximum	550	550	550
Voltage anode to last dynode: Maximum	550	550	550
Voltage anode to cathode: Maximum	3000	2800	2500
Maximum anode current (mean):	0.2mA	0.2mA	0.1mA
Maximum anode dissipation:	0.1W	0.1W	0.05W
Maximum tolerable cathode current (assuming	S-11 types	0.3 μA	
whole cathode used)	S-20 types	5 μA	
	Bialkali types	0.3 μA	
Maximum operating temperature:	60°C	60°C	60°C
Minimum operating temperature:	—80°C*	—80°C*	—80°C*
Capacitance to all electrodes: Anode	B types 5pf	KB types 7pf	
Last dynode	B types 7pf	KB types 9pf	
Energy resolution using Na I (Tl) crystal measured on type 9813	f.w.h.m. typically 7.5% for ^{137}Cs		
	P/V typically 6.0:1 for ^{60}Co		

* —20°C for 9813, 9814 and 9815

DARK CURRENT SHOT NOISE EQUIVALENT INPUT*

Type	9810	9811	9812	9813	9814	9815	9816	9817	9818
Lumens	2.9×10^{-13}	5.7×10^{-13}	4.1×10^{-13}	9.5×10^{-14}	2.1×10^{-13}	3.0×10^{-13}	1.4×10^{-13}	3.1×10^{-13}	2.7×10^{-13}
Watts	3.6×10^{-16}	6.9×10^{-16}	5.0×10^{-16}	8.1×10^{-17}	1.9×10^{-16}	2.5×10^{-16}	3.4×10^{-16}	7.7×10^{-16}	2.0×10^{-15}

*Calculated from typical performance data using Q.E. at λ peak and assuming △f of 1Hz and enhancement factor of unity.

TUBE REPLACEMENT GUIDE

RCA	EMI*	PHILIPS	EMI†
4459	9817KB	56AVP	9810KB
6810	9810KB	56TUVP	9816QKB
6810A	9810KB	56DVP	9813KB
7264	9810KB	56DUVP	9813QKB
7265	9816KB	PHILIPS	EMI*
7326	9818KB	XP1000	9812KB
7746	9812KB	XP1001	9812KB
7850	9811KB	XP1002	9818KB
8575	9814QB	XP1003	9818QKB

*nearest equivalent given – see data for differences
†direct plug-in replacement (focus voltage will need adjustment)

NOTES ON TIME CHARACTERISTICS

The anode pulse rise time is the time taken for the output pulse to rise from 10% to 90% of the peak when the photocathode of the tube is illuminated by a flash of light of very short duration.

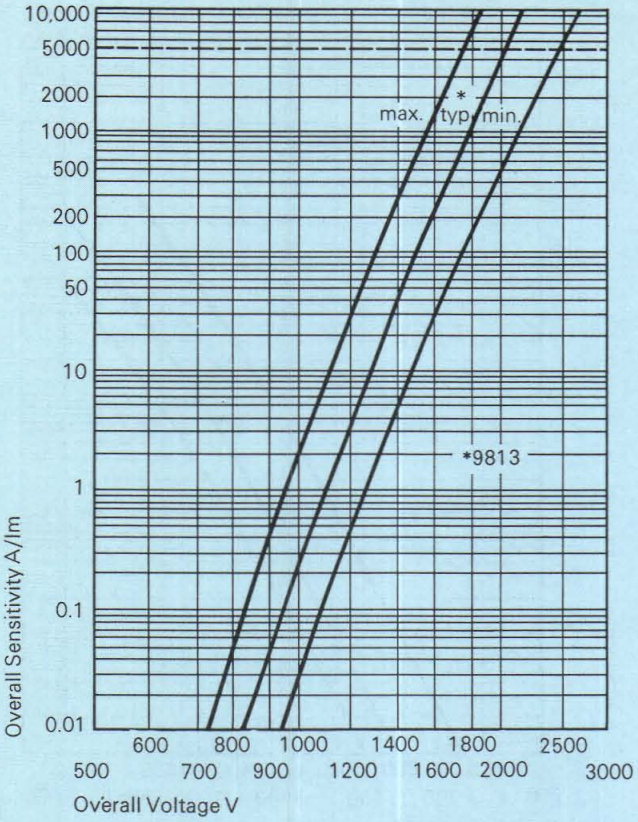
The anode pulse f.w.h.m. is the full width of the output pulse measured at half maximum amplitude.

The electron transit time is the time difference between the arrival of a flash of light at the photocathode and the instant when the output pulse is a maximum.

In each case the whole photocathode is illuminated by a point source situated about 50 mm above its centre. Measurements referred to in the "electrical ratings" were made at the maximum rated voltage for 10 and 12 stage tubes and the standard rated voltage for 14 stage tubes.

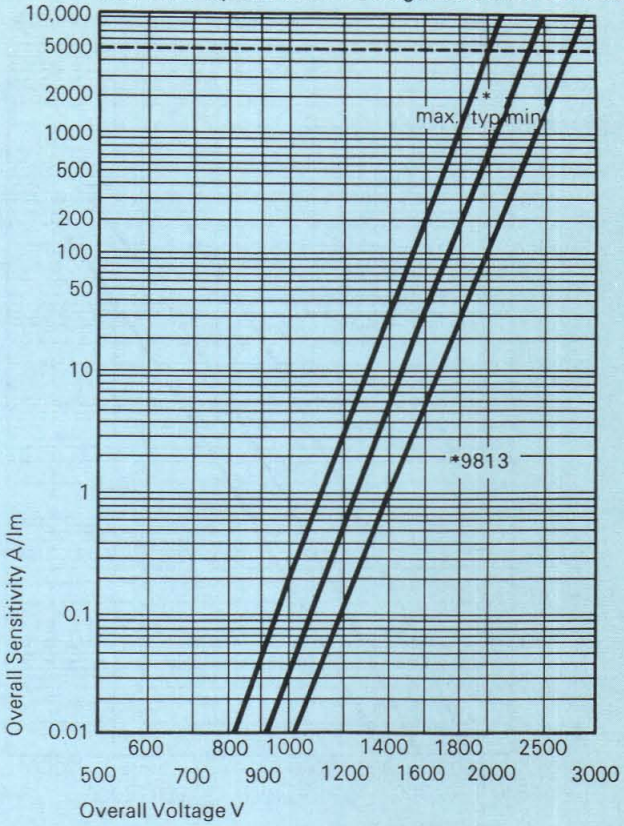
OVERALL SENSITIVITY vs OVERALL VOLTAGE

Linear dynode chain 14 stage tubes 9810 9813 9816



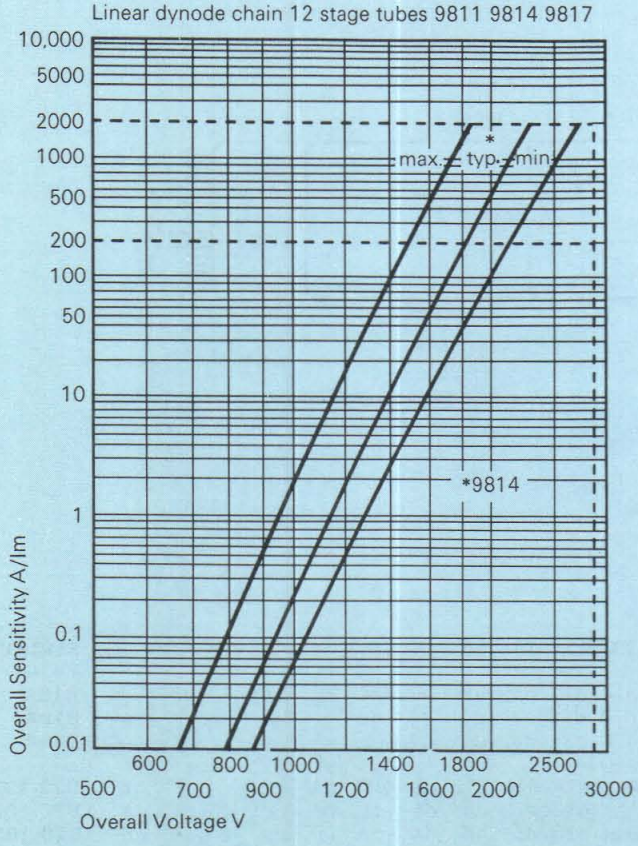
OVERALL SENSITIVITY vs OVERALL VOLTAGE

Non-linear dynode chain 14-stage tubes 9810 9813 9816



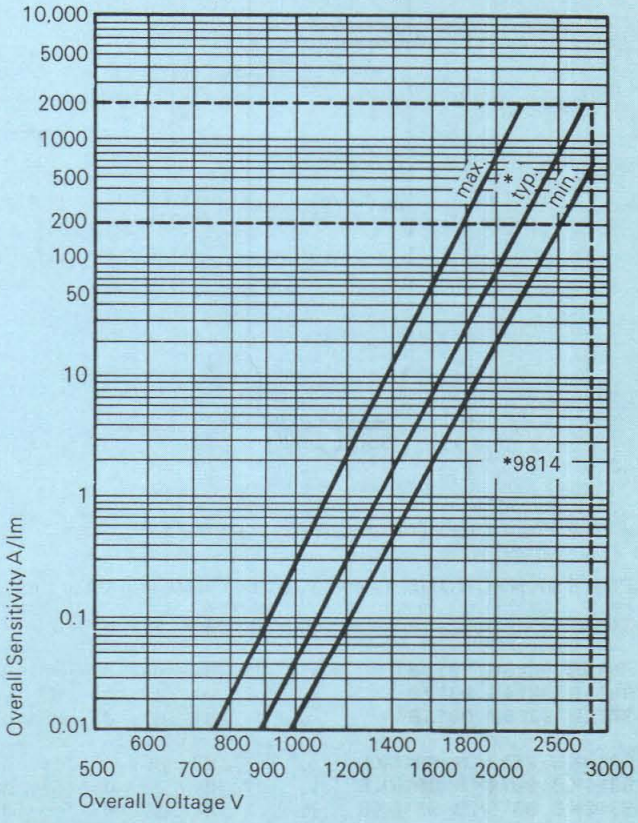
OVERALL SENSITIVITY vs OVERALL VOLTAGE

Linear dynode chain 12 stage tubes 9811 9814 9817



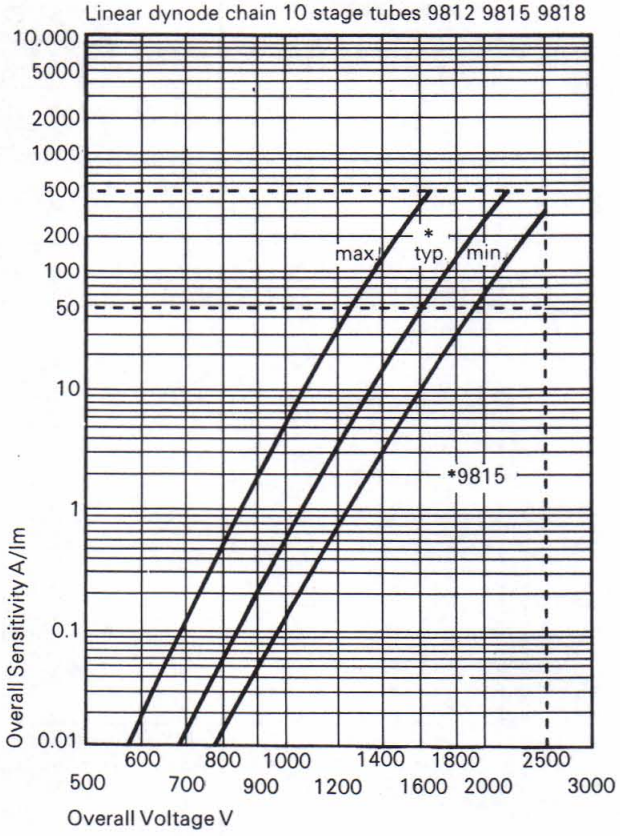
OVERALL SENSITIVITY vs OVERALL VOLTAGE

Non-linear dynode chain 12 stage tubes 9811 9814 9817



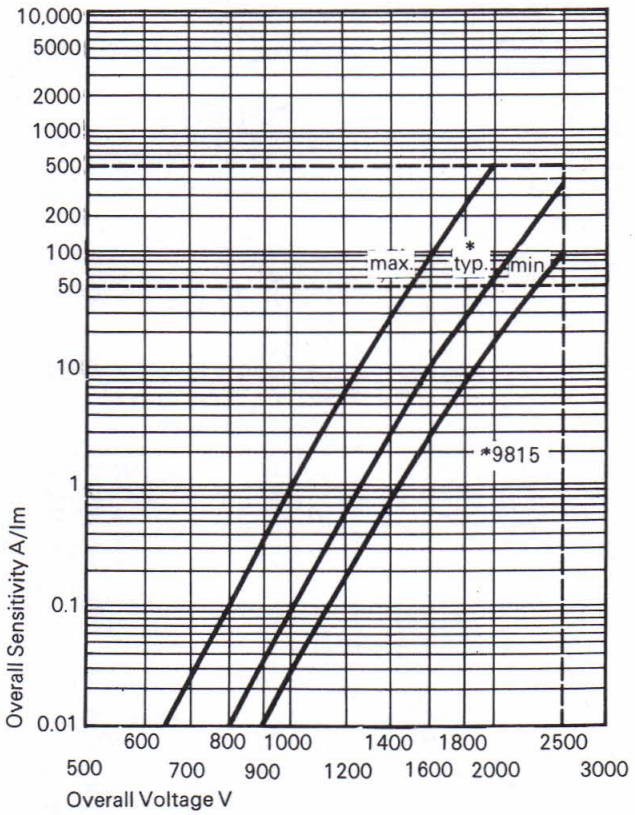
OVERALL SENSITIVITY vs OVERALL VOLTAGE

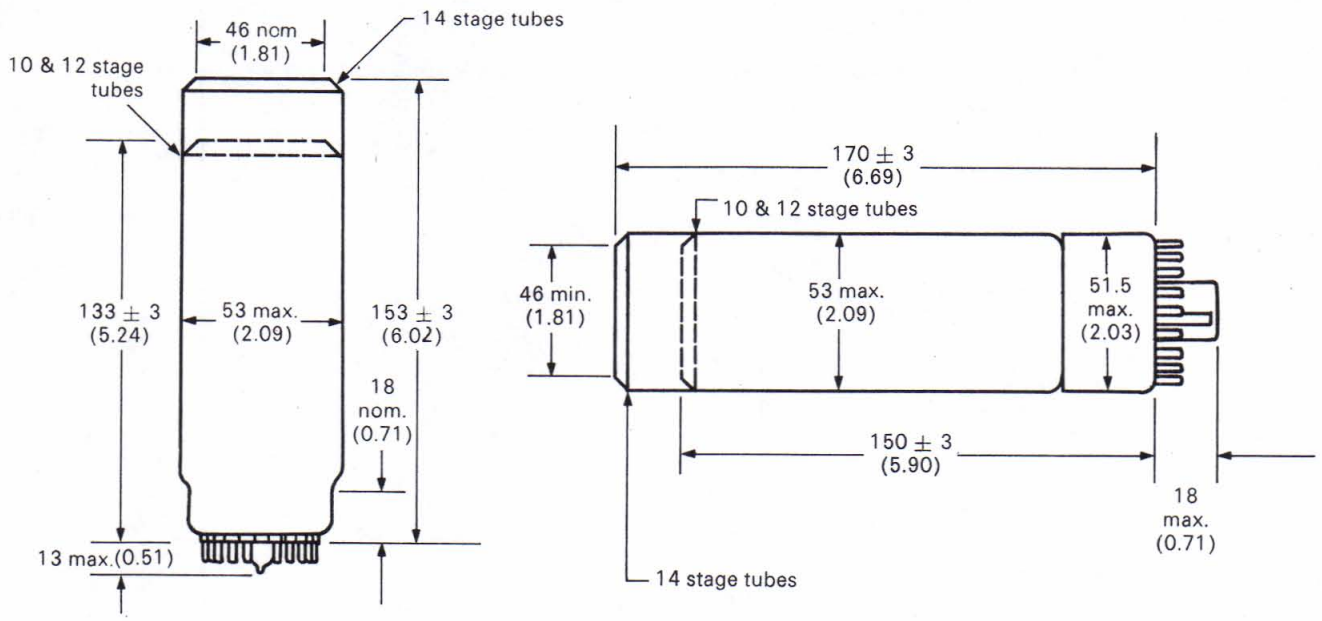
Linear dynode chain 10 stage tubes 9812 9815 9818



OVERALL SENSITIVITY vs OVERALL VOLTAGE

Non-linear dynode chain 10 stage tubes 9812 9815 9818





All dimensions in millimetres (inches in parenthesis).

PIN CONNECTIONS (viewed from below starting left of short pin or key)

Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	SOCKET
9810B 9813B 9816B	ic	d1	d3	d5	d7	d9	d11	d13	A	d14	d12	d10	d8	d6	d4	d2	ic	F	K	—	**B19A**
9811B 9814B 9817B	ic	d1	d1	d3	d5	d7	d9	d11	A	d12	d10	d8	d6	d4	d2	ic	ic	F	K	—	**B19A**
9812B 9815B 9818B	ic	d1	d1	d1	d3	d5	d7	d9	A	d10	d8	d6	d4	d2	ic	ic	ic	F	K	—	**B19A**
9810KB 9813KB 9816KB	ic	d1	d3	d5	d7	d9	d11	d13	ic	A	d14	d12	d10	d8	d6	d4	d2	ic	F	K	**B20-102**
9811KB 9814KB 9817KB	ic	d1	d1	d3	d5	d7	d9	d11	ic	A	d12	d10	d8	d6	d4	d2	ic	ic	F	K	**B20-102**
9812KB 9815KB 9818KB	ic	d1	d1	d1	d3	d5	d7	d9	ic	A	d10	d8	d6	d4	d2	ic	ic	ic	F	K	**B20-102**

Magnetic Focusing Assemblies Types C121, C122

The EMI magnetic focusing assemblies are designed to provide a reduction of the effective cathode area and a corresponding decrease in the cathode dark current in end window photomultiplier tubes. This results in improvements in the signal/dark current ratio and so in the limit of detection of low intensity light. The two versions available, type C121 and C122, produce effective cathode diameters of approximately 6 mm and 12 mm respectively and are for use with 50 mm diameter photomultiplier tubes.

The magnetic field produced by the assembly deflects electrons from the edge of the cathode and the side walls away from the dynode system so that they are not multiplied. As a result, a considerable reduction in dark current is achieved.

The magnets can be used successfully where a small diameter incident beam is convenient or where the incident radiation can be focused on to a small area of the photocathode. They are designed for use with thermoelectric and dry ice photomultiplier tube housings manufactured by Products for Research Inc, as well as for custom built assemblies.

CHARACTERISTICS

			Type C121	Type C122
Outside diameter	**max.**	**mm**	**51.8**	**51.8**
Depth of assembly	**max.**	**mm**	**12.0**	**17.0**
Effective cathode dia. (see note 1)	**nom.**	**mm**	**6.0**	**12.0**
Approx. dark current as a percentage of unfocused dark current (see note 5)			**5**	**20**

NOTES

1 The nominal effective cathode diameter (see below) in millimetres is denoted by the figure after the stroke in the type number. The standard types are the C121/6 and the C122/12 providing effective cathode diameters of 6 mm and 12 mm respectively.
The effective cathode diameter is the full width of half-maximum amplitude of the anode output as a small spot of light is swept across the cathode.

2 The assembly must be positioned so that the surface which is flush with outer collar is against the photomultiplier window. It may then be held in place with adhesive tape. Alternatively, when the thermoelectric or dry ice housings, manufactured by Products for Research Inc, are to be used, the assembly should be fitted inside the corrugated pressure sleeve in the housing immediately in front of the photomultiplier window.

3 A mu-metal shield should be used with the magnet for optimum performance and ideally both should be maintained at cathode potential. If this is not possible, the assembly should be left unconnected and should not be earthed if the anode is at earth potential.

4 Care should be exercised when handling these magnets and they should not be stored in close contact with one another.

5 The figures quoted for the 'focused' dark current as a percentage of the 'unfocused' dark current are for a 9558B operated at an overall sensitivity of 200A/lm. The percentage reduction obtained will vary from tube to tube and will depend on the particular type of photocathode employed.

Information on other new tubes and other products

Other new tubes

As a result of a continuous development programme and a policy to design tubes to suit the ever increasing number of applications, new variants of existing types may be added to the range at any time. At the time of printing this supplement, several new versions are planned for immediate introduction and it is hoped that the following brief details will serve as a guide until full information is printed. The parent types, where referred to, are described in the EMI photomultiplier catalogue reference P001/fP70 available free on request.

9836 This is a 50mm (2 in) diameter tube having the same basic construction and specification as the 9656 series except that the end window is made from lime soda glass instead of borosilicate. It is intended for use in equipment where the lower boron content and thus lower neutron absorption of soda glass may be critical.

9769 This is a 50mm (2 in) diameter tube based on the 9656 but having 9 dynodes instead of 10. The main application is in scintillation counter assemblies where good linearity is required and high gain is not necessary. The tube will operate satisfactorily when plugged directly into sockets wired for the 9656 or other 10 stage tubes.

9840 This is a 50mm (2 in) diameter tube having dimensions and specifications similar to the 9750 but it incorporates an internal end window surface of triangular prisms as used in the 9778 described in this supplement. Like the 9778, the 9840 is designed for high resolution gamma cameras.

Other products

PHOTOMULTIPLIER TUBE POWER SUPPLY PM 25A

A photomultiplier tube stabilised power supply will be available from EMI when this supplement is printed. It incorporates design features which we consider important for successful photomultiplier tube operation particularly under laboratory conditions. The following is an extract from the specifications:- output variable over the range 100-2500 volts at 5 mA – dual polarity, resettable to within 1 volt, output stability 1 part in 10^5 for 10% mains change, dimensions 8½ in. x 5 in. x 9 in., mains input 100/125 or 200/240 volts 48—66 Hz. For further information telephone Extension 2126 or write.

Electron tube range

The EMI ELECTRON TUBE DIVISION manufactures a wide range of special electron tubes for equipment used in broadcasting, radar, nuclear and scientific applications.

☐ PHOTOMULTIPLIER TUBES Ext. 2074
Photomultiplier tubes which convert very low levels of illumination into usable electric currents are used extensively in astronomy, spectrophotometry, scintillation counting, spectrometry and broadcast television.

☐ PHOTOMULTIPLIER TUBE HOUSINGS Ext. 2283
A range of cooled and uncooled photomultiplier tube housings, including thermoelectric, dry ice and liquid nitrogen versions are available for optimum photomultiplier tube operation.

☐ CAMERA TUBES Ext. 2078
There is a wide range of vidicons, including all-electrostatic, available in various grades from general surveillance to broadcast studio.

☐ IMAGE INTENSIFIERS Ext. 2075
The image intensifier tube, capable of multiplying light up to a million times, is important for such applications as microscopy and astronomy.

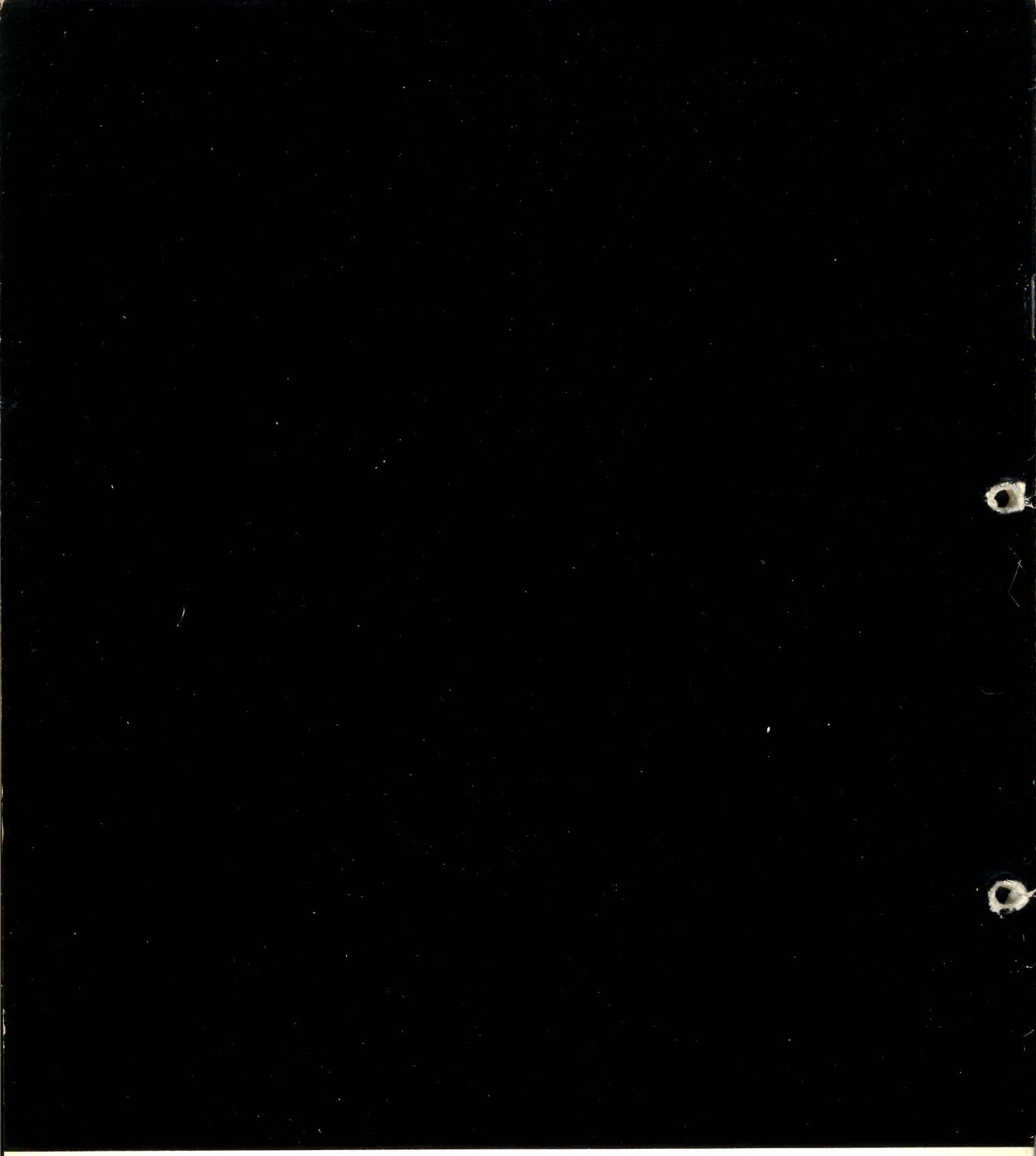
☐ CATHODE RAY TUBES Ext. 2073
EMI activities in pioneering television have generated a range of specialised cathode ray tubes for radar and telecine work.

☐ SPECIAL PRODUCTS Ext. 2551
EMI manufactures the Printicon, a small all electrostatic monoscope; the Ebitron, a low light level intensifier-vidicon camera tube and spectroscopic lamps. Two types of spectroscopic lamp are available, hollow cathode and electrodeless discharge tubes together with a microwave power generator. A range of printed circuit scanning coils and complete scanning assemblies for 13 mm, 26 mm and 30 mm vidicon camera tubes is also produced.

☐ SOLID STATE PHOTODIODES Ext. 2126
These include a range of linear and avalanche silicon photodiodes including fast and rugged types having wide spectral response.

☐ PRECISION MICROMESH Ext. 2073
The very fine metallic mesh currently employed in EMI vacuum tubes is also used in various other branches of industry and science, such as microscopy, mass spectrometry, biology, filtering and optics.

The EMI Electron Tube Division has great experience and comprehensive facilities in research, development and manufacture of light sensing and light emitting devices and allied equipment.



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