EMI

Electron Tube and Microelectronics Division

EMI ELECTRON TUBES having NATO stock numbers

NATO Stock No.5960–99–	Commercial No.	Description	CV No.
000–0298		Vacuum switch selected for Admiralty - AP2030	298 o
000–0337	9661	30 mm 9-stage photomultiplier side window tube	337
000–0418	MX2	90 mm electrostatic oscilloscope tube	418 x
000–0429	MX20	30 mm radar display tube	429 o
000–0487	MX18	254 mm radar display tube	487 v
000–1530	MX38	150 mm cathode ray tube	1530 o
000–1738	MX30	150 mm film scanning tube	1738 x
000–1952	MX22	305 mm flat-screen radar display tube	1952 v
000–1965	MX21	305 mm high-definition radar display tube	1965 o
000–2222	MX17	90 mm electrostatic oscilloscope tube	2222 o
000–2278	MX25	230 mm radar display tube	2278 v
000–2305	MX31	305 mm radar display tube	2305 o
000–2314	MX23	As 000–0429 (MX20) with modified screen	2314 o
000–2316	6097B	50 mm 11-stage photomultiplier tube	2316 v
000–2317	6097C	50 mm 11-stage photomultiplier tube	2317 o
000–2352	MX40	Cathode ray tube	2352 o
000–2372	MX33	Cathode ray tube	2372 o
000–2388	MX24	535 mm radar display tube	2388 v
000–2415	MX37	As 000–1530 (MX38), but long persistence screen	2415 v
000–2428	25110	Photodiode	2428 o
000–2447	MX20	Blue screen version of CV429 (MX20)	2447 o
000–2469	MX27	127 mm cathode ray tube	2469 v
000–2472	MX19	254 mm cathode ray tube	2472 v
000–5163	MX14	430 mm cathode ray tube (commercial spec. only)	5163 c
037–2729	MX32	90 mm projection tube	6101 v
037–3146	MX49	430 mm radar display tube	5941 c
037–3168	9664	30 mm 9-stage photomultiplier tube	5963 v
037–3909	9514B	50 mm 13-stage photomultiplier tube	9639 c
037–5097	6097B	50 mm 11-stage photomultiplier tube	10110 v
037–5309	9531B	90 mm 11-stage photomultiplier tube	10383 c
037–6035	9730	26 mm rugged vidicon camera tube	6243

Notes:
- v Shown in qualified product list
- x Qualification approval not required
- o Not in qualified product list
- c To commercial specification

CV numbers are now discontinued but have been included for ease of reference.

PRODUCT RANGE OF EMI ELECTRON TUBE AND MICROELECTRONICS DIVISION

The **EMI ELECTRON TUBE DIVISION** manufactures a wide range of special electron tubes for equipment used in broadcasting, radar, nuclear, scientific and medical 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, broadcast television and environmental monitoring.

✱ 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. An intensifier vidicon, the Ebitron, covers the range moonlight to daylight.

A range of high performance printed circuit scanning coils are also produced.

✱ 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, instrumentation and flying spot applications.

✱ SPECIAL PRODUCTS Ext. 2076

EMI manufactures the Printicon monoscope, a small all-electrostatic character generator. Two types of spectroscopic lamp are available, hollow cathode and electrodeless discharge tubes, together with a microwave power generator.

Radar/TV scan converter storage tubes have recently entered our product range.

✱ 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.

The **EMI MICROELECTRONICS DIVISION** provides for the increasing demands made upon the ability of electrical and electronic equipment designers to meet high density packaging, reliability, weight and cost requirements. This can only be achieved by taking full advantage of modern fabrication and design methods. The EMI Microelectronics Division offers these facilities to its customers in the following product areas:–

✱ Thin and Thick Film Passive Networks

Thin and Thick Film Hybrid Integrated Circuits

Flexible Printed Wiring

Single-sided, Double-sided and Through-plated Printed Circuit Boards

Multilayer Printed Circuit Boards Ext. 2463 or 594

Production facilities have been built up over several years to meet the need for economic batch and large volume manufacture. The production unit is supported by a comprehensive Circuit Design and Draughting Group and a Quality Control Division.

A continuous R. & D. programme ensures that full advantage is taken of the latest technological developments in manufacturing processes. Microcircuit design is aided by the use of a computer programmed to predict thermal contours.

Continuous on-line monitoring of all processes is maintained during all stages of production and testing.

The environmental test facilities available within EMI Electronics together with the calibration and standardisation procedures, have been approved by D Q A B and the Air Registration Board.

✱ CUSTOMER ENGINEERING SERVICE Ext. 2463 or 594

A team of engineers fully experienced in both circuit and systems design is available to assist customers in applying microelectronic techniques to the solution of particular problems. This facility covers all aspects of system design, the rationalization of integrated circuits, thermal management and packaging.

FLEXIBILITY

The EMI Microelectronics Division is an integrated unit, with design and manufacturing facilities not allied to any particular aspect of microelectronics technology. The resulting flexibility enables the achievement of the optimum design package to meet customers' needs.

NOTE: For further information please telephone the extension shown opposite each product and service.

G911d

EMI Electronics Ltd Electron Tube and Microelectronics Division
Hayes Middlesex England Telephone: 01-573 3888
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PHOTOMULTIPLIER TUBES
HOUSINGS AND ACCESSORIES

EMI

TYPE 9821B

Photomultiplier Tube

PROVISIONAL DATA

CHARACTERISTICS

Mechanical

Maximum envelope diameter		78 mm
Seated height	uncapped: capped	158 ± 3 mm 175 ± 3 mm
Nominal cathode diameter		60 mm
Cathode type		Bialkali (KCs)
Window material		Borosilicate
Dynodes	number: type: secondary emitter:	12 (10 stage available) Linear focused BeO(Cs)
Base		B19A (uncapped) or B20 (capped)

Electrical

Tube Type	QE 380 nm Typ.	Cathode Sensitivity (μA/lm)		Corning Blue		200 A/lm				Overall Sensitivity 2000 A/lm	
		Min.	Typ.	Min.	Typ.	V.Overall Typ.	V.Overall Max.	Dark Current nA Typ.	Dark Current nA Max.	V.Overall Typ.	Dark Current nA Typ.
9821	25%	–	75	7·0	9·5	2050	2500	3	15	2550	30

Anode pulse rise time:	typical maximum	2·1 –	n.sec n.sec
Anode pulse f.w.h.m.:	typical maximum	3·2 –	n.sec n.sec
Electron transit time:	typical	35	n.sec
Operating temperature:	maximum minimum	+ 60 –20	°C °C
Capacitance, anode to all dynodes	uncapped: 4 pF capped:	5	pF
Energy resolution	^{137}Cs, 69 mm x 69 mm crystal NaI-T1 typical	8·0%	

Ratings

Overall sensitivity	rated maximum	200 2000	A/lm A/lm
Cathode to d1 voltage:	recommended maximum	450 600	V V
Cathode to anode voltage	maximum subject to not exceeding	3000 2000	V A/lm
Inter-dynode voltage	maximum	550	V
Anode to last dynode voltage	maximum	550	V
Maximum anode current (mean)		0.2	mA
Maximum anode dissipation		0.1	W
Maximum cathode current (assuming whole cathode used)		0.3	μA

Circuit notes

General notes on the design of dynode chains are given in the introductory article in the EMI photomultiplier catalogue P001/fP70, available on request. Any comments below, however, are relevant to the dynode chain for the particular tube described on this data sheet.

Focus (F) may be connected to D1 for normal operation.
Tube may be gated off by application of −50 volts w.r.t. cathode to this electrode.

Operating notes

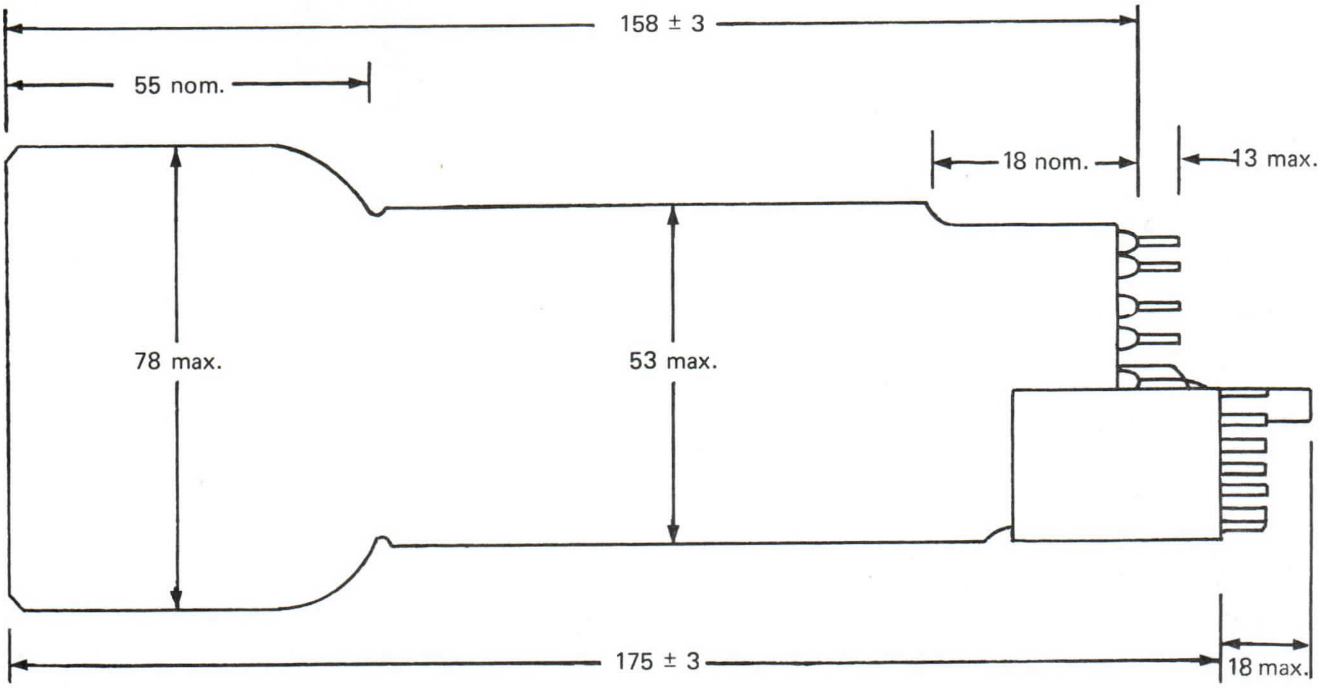
1. Each tube is individually calibrated and supplied with a test ticket giving the cathode sensitivity in μA/lm and/or cathode sensitivity measurements with filters appropriate to the type of photocathode. The overall voltage and dark current (at 20°C) corresponding to the rated overall sensitivity are also given.

When a Corning blue figure is given a Corning glass filter, CS–5–58 ground to half stock thickness, is interposed between the standard source, giving 0·001 lumens at 2857°K, and the photocathode. In the case of red sensitive photocathodes, additional cathode sensitivity figures are given relative to glass filters, types Cs–2–62 and Wratten 87, which pass all radiation of wavelength longer than approximately 600 nm and 800 nm respectively.

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

3. For optimum stability under dc conditions, the mean anode current should not exceed 1·0 μA.

4. For general notes on the operation of Photomultiplier Tubes see EMI Photomultiplier Supplement catalogue ref P001S/a72, page 1 and the EMI Photomultiplier Catalogue ref P001/fP70, both available on request.



Pin connections. Tube viewed from below counting clockwise from short pin or key.

Pin No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Base Type
Electrode		D1	D1	D3	D5	D7	D9	D11	–	A	D12	D10	D8	D6	D4	D2	–	–	F	K	B20
	–	D1	D1	D3	D5	D7	D9	D11	A	D12	D10	D8	D6	D4	D2	–	–	F	K		B19A

For further information on this product please telephone Extension 2076

EMI

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P146/A
DS.1207

TYPE PM25A

POWER SUPPLY

The Power Supply Type PM25A has been specifically designed for use with photomultiplier tubes and for other applications where a highly stable and compact power unit is required.

The PM25A:

- delivers 100 V to 2500 V at 5 mA max.
- has dual output polarity facility
- has adjustable output voltage resettable within fine limits
- has freedom from switch-on surges
- is compact – 216 mm x 127 mm x 229 mm

The output voltage range covered by this unit is 100 V to 2500 V and is adjustable to give any voltage within this range. This is achieved by means of a 12-way switch which gives voltage changes in 200 V steps. For fine control a 3-turn potentiometer is used which adjusts the volts up to 300 V above the 12-way switch setting; the potentiometer is scaled in 1 V divisions.

Either polarity may be obtained by using one of the two specially wired connectors. Both these connectors have coaxial wire leads attached and are included with the unit. This method of polarity selection considerably reduces the risk of accidental polarity change that could occur if switch selection was used.

The high specification and very economical price have been achieved by the use of hybrid techniques. A stabiliser valve and a time delay are used which eliminate the danger of switch-on surges that can cause considerable damage to a photomultiplier. Except for this valve, solid state components are used throughout to give a compact, reliable unit having good stability with time and temperature variations.

ELECTRICAL SPECIFICATIONS

Output voltage	100 to 2500 V
Polarity	Positive or negative w.r.t. chassis by connection of output socket.
Maximum current	5 mA
Overload protection	Current limit at 6 mA, autoreset. Foldback to approx. 2·5 mA on short circuit. Lamp indicates limiting.
Load regulation	10 ppm from a no load to a full load change.
Line regulation	10 ppm for a 10% change of mains voltage.
Ripple and noise	2 mV peak to peak.
Meter	70 mm (2·75 in.). Scale length accuracy 3%.
Mains supply	200 to 250 V or 100 to 125 V, 48 to 66 Hz. 50 VA @ 240 V rms ac.
Resolution	110 mV (200 volt steps + 3-turn pot.)
Accuracy (with variable control at zero)	1%
Accuracy of fine control	3% of indication.
Temperature coefficient	100 ppm/°C typ.
Drift with time (at constant line, load and temperature)	50 ppm/hr typ. 100 ppm/day typ.
Output voltage float potential w.r.t. chassis (either terminal)	250 V dc max.
Maximum ambient temp. Working Storage	 45°C 70°C
Net weight	3·6 Kg (8 lb).
Output connector	Belling Lee L1390 series.
Output lead	UR 70

For further information on this product please telephone Extension 2073.

EMI

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P144/2C
DS.1147

10th Anniversary year

CATALOG 103

PHOTOMULTIPLIER TUBE HOUSINGS AND ACCESSORIES

PRODUCTS FOR RESEARCH, INC.
78 Holten Street · Danvers, Massachusetts 01923

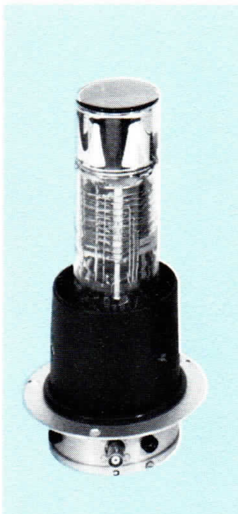
IMPROVED PHOTOMULTIPLIER TUBE OPERATION

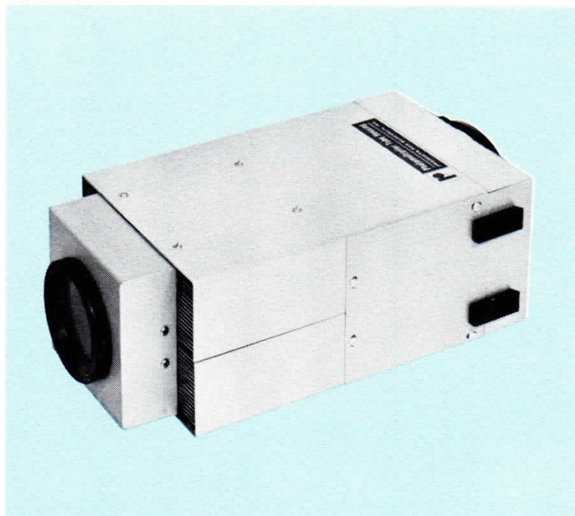
is the sole business of Products for Research, Inc.; and the company manufactures a complete line of standard photomultiplier tube housings, both cooled and uncooled. Also, essential accessories like interchangeable tube socket assemblies, power supplies and other items described in this catalogue.

To more precisely meet requirements of a particular system, Products for Research will depart from the routine and develop units that represent variations from the products described here (see Ordering Information on rear cover) for individual or O.E.M. accounts.

CONTENTS:

AIR-COOLED THERMOELECTRIC REFRIGERATED PHOTOMULTIPLIER TUBE CHAMBER





FEATURES

- ☐ NO LIQUID COOLANTS
- ☐ CONTINUOUS OPERATION
- ☐ ELECTRO/MAGNETIC SHIELDING
- ☐ NO WINDOW DEWING
- ☐ RUGGED

The TE-102 uncontrolled and TE-102TS temperature regulated chamber is the workhorse of the family — offering maximum operating flexibility and convenience.

Thermoelectric heat pumps allow continuous operation without the need of supplemental cooling materials such as dry-ice.

Automatic temperature stabilizing circuitry, available on the TE-102TS, makes this unit ideally suited for remote station application, as tube cathode temperature will be held constant to within $\pm$0.5 °C at the selected temperature.

A magnetic shield completely surrounds the tube envelope and is electrically connected to the cathode pin of the tube socket allowing electrostatic shielding for operating voltages up to 3000 V dc.

Maximum flexibility is offered with the interchangeable tube socket feature — a removable assembly with dynode resistor string, tube socket, and anode/cathode connectors all contained within the assembly housing.

The viewing window is of sealed double pane construction thereby eliminating dewing of either the tube face or the window surfaces, and the over-all chamber tightness completely eliminates frost build-up for months of continuous operation.

Available RF Shielded - See RF Shielding Section of catalogue.

Available with 3KV high voltage power supply Model S504 - See High Voltage Section.

SPECIFICATIONS

OPERATIONAL

Input 115V 60 cps 85 Watts to power supply.

Nom. ambient 22°C (72°F).

Min. tube cathode temp. at Nom. ambient is –20°C.

Tube cathode temperature is continuously adjustable from +20°C to –20°C on TE-102TS unit with a cathode temp. stability of ± 0.5°C from set point.

Cathode high voltage input 3000V max.

Standard dynode resistors – Nominal 100K to 200K values.

Plexiglas viewing window, 80% transmission from 3660A to 11,250 A.

MECHANICAL

Size – 7" wide x 5" high x 14-1/2" long.

Weight – 12 pounds. NOTE: power supply mounted in a separate cabinet weighs approximately 20 pounds.

Mounting – The unit is bottom mounted. (Optionally front mounted by the addition of a front mounting adapter.

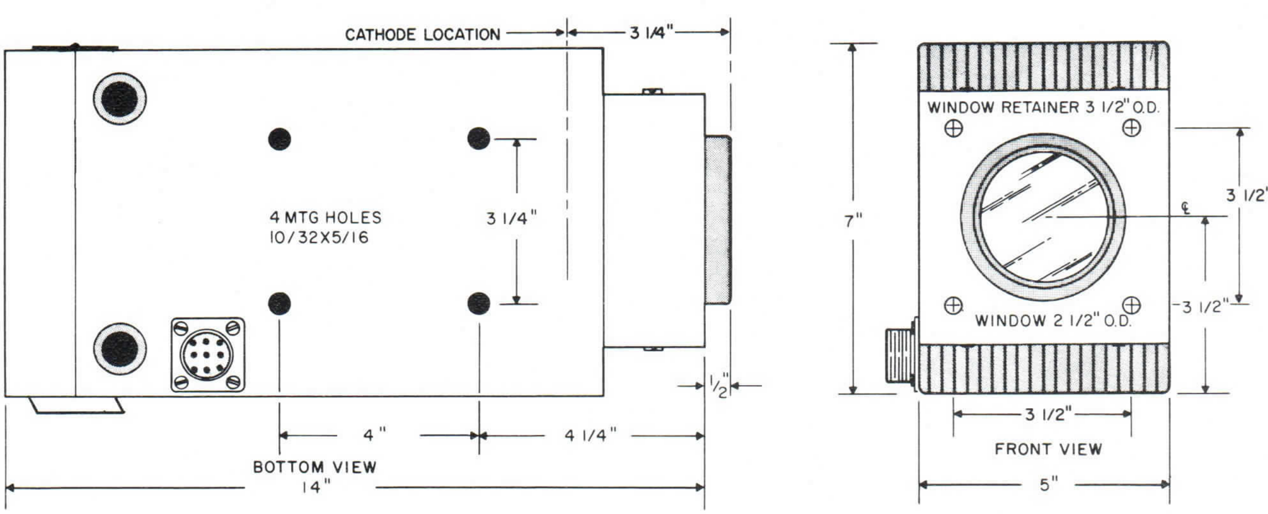
Material – Aluminum finished bright anodize.

Anode connector – BNC

Cathode connector – Approved high voltage coaxial.

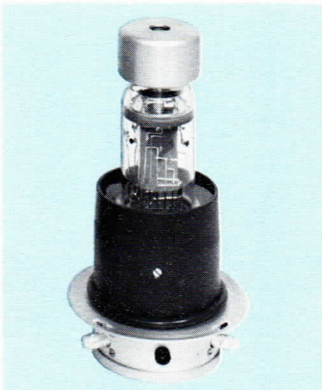
Interchangeable tube socket assembly is mounted through the rear of the chamber by hinged fan housing.

Cathode cool down time is 2 hrs to stability at –20°C.

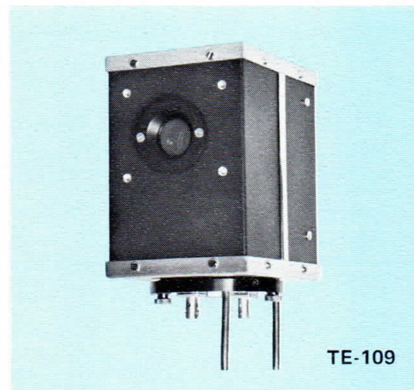


Prices noted on current, effective Price List include socket assembly wired for tube operation with standard dynode string. Housings may be modified to meet special requirements. Standard front mounting ring available - See Accessory Section for options.

WATER-COOLED THERMOELECTRIC REFRIGERATED PHOTOMULTIPLIER TUBE CHAMBERS




TE-104


TE-109

FEATURES

- −30°C TEMPERATURE
- DEW-FREE OPERATION
- ELECTRO/MAGNETIC SHIELDING
- RUGGED DESIGN
- INTERCHANGEABLE TUBE SOCKET ASSEMBLY
- ± 0.5 TUBE CATHODE TEMPERATURE STABILITY

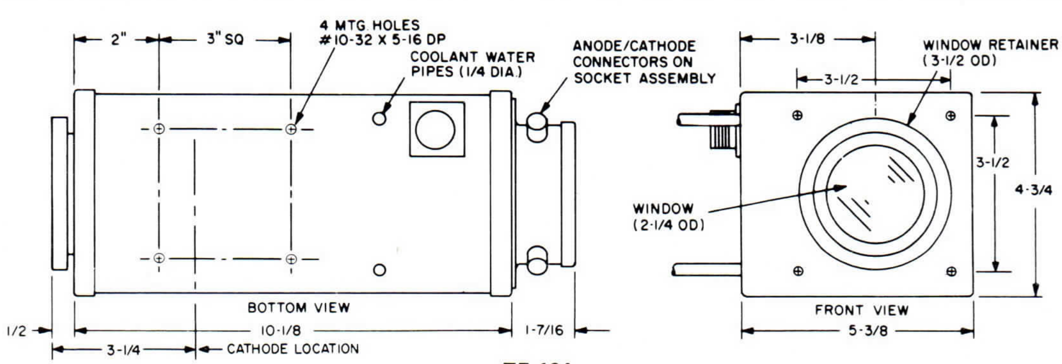
Both the TE-104 and TE-109 PMT chambers and their respective temperature regulated versions (TE-104TS and TE-109TS) are designed to provide a complete environmental housing for photomultiplier tube operation.

This unique design permits quick interchange of tubes in just several minutes. Model TE-104 accepts any 2″ diameter or smaller end window PMT and the Model TE-109 accepts any 1½″ or smaller side window PMT. The interchangeable tube socket assemblies contain the tube socket, dynode resistor string and quick-connect anode and cathode connectors.

Operation is completely automatic requiring no service during extended periods of use. A magnetic metal shield, operating at cathode potential, provides the optimum in electrostatic/magnetic shielding for the tube while the hermetically sealed inner chamber prevents tube or chamber frosting. A thermopane window serves as a thermal insulating path which will not frost during use. However, window back heating may be required on days of high humidity to prevent formation of condensation on the outer surface which would restrict the optically clear light path to the tube cathode. This option is available and supplied as a PR-201 No-Dew Adapter. The rugged design will withstand severe handling without damage as there are no moving parts and operation can be in any plane. Tap water is utilized to cool the thermoelectric heat exchanger through ¼″ plastic tubing coupled between the chamber and water source.

Available RF Shielded - See RF Shielding Section of catalogue.

Available with 3KV high voltage power supply - See High Voltage Section.



TE-104

Standard front mounting ring available - See Accessory Section for options.

SPECIFICATIONS

OPERATIONAL

Input 115V 60 cps 80 Watts to power supply.

Max. ambient – 52°C (125°F).

Max. coolant water temperature – 24°C (75°F).

Min. coolant water flow rate – 10 GPH.

Min. tube cathode temperature
–20° (with coolant water at 24°C (75°C) and ambient 52°C (125°F))
–30°C (with coolant water at 12°C (53°F))

Tube cathode temperature stability ±0.5°C at the selected temperature

Continuously selectable temperature range from –20°C to coolant water temperature

Cathode high voltage input 3000V max.

Dynode resistors – Nominal 100K to 200K ohm values

Plexiglas viewing window, 80% transmission from 3660 A to 11,250 A.

MECHANICAL

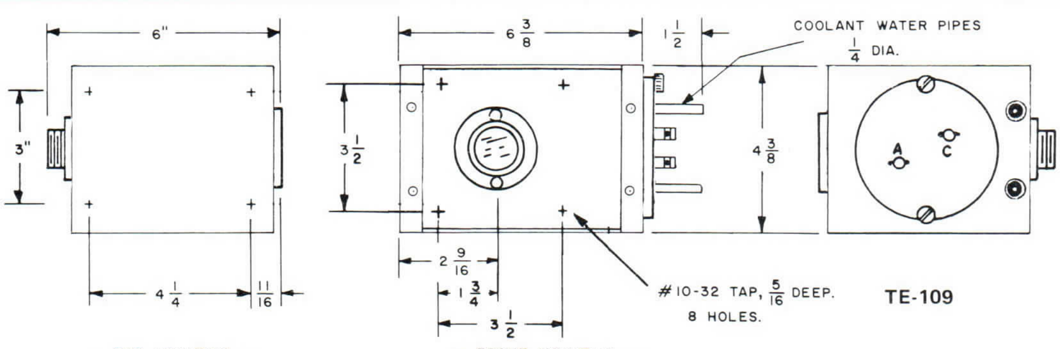
	TE-104/104TS	TE-109/109TS
Size:	4-3/4" W x 5-3/8" H x 10-1/8" L with an additional 1-5/16" protrusion of the interchangeable tube socket assembly.	4-3/8" W x 5-1/4" L x 6-3/8" H with an additional 1" protrusion of the interchangeable tube socket assembly.
Weight:	9½ lbs.	5½ lbs.
	Note: Power supply mounted in separate cabinet for both TE-104 and TE-109 weighs approximately 20 lbs.	
Mounting:	Bottom mounted (optionally front mounted by three 1/4–20 bolts on 2-3/4" radius with one hole top center and the other two spaced 105° either side.)	Face mounted (optionally top mounted by four 10–32 screws).

Material:	Aluminum
Anode connector:	BNC
Cathode connedtor:	Approved high voltage, coaxial

Interchangeable tube socket assembly is mounted through rear of the chamber in case of TE-104 and through bottom of chamber with TE-109.

Cathode cool-down time is 2 hours to stability at –20°C.

NOTE - RCA 4526 must be ordered as RCA 4526 M3 to be mounted in chamber. Extended socket req'd. Consult factory.



Prices noted on current, effective Price List include socket assembly wired for tube operation with standard dynode string. Housings may be modified to meet special requirements.

Standard front mounting ring available - See Accessory Section for options.

DRY-ICE REFRIGERATED PHOTOMULTIPLIER TUBE CHAMBERS

TE-200

TE-220

FEATURES

- DRY-ICE COOLANT
- TOTALLY FROST-FREE LIGHT PATH TO CATHODE OF PM TUBE
- ELECTRO/MAGNETIC SHIELDING
- RUGGED DESIGN
- INTERCHANGEABLE TUBE SOCKET ASSEMBLY
- $\pm$ 1°C TUBE CATHODE TEMPERATURE STABILITY
- LIGHT WEIGHT
- TEMPERATURE READOUT

Models TE-200 and TE-220 refrigerated chambers provide a complete environmental housing for PM tube operation utilizing a slurry of dry-ice and alcohol as the cooling medium.

The unique design allows quick interchange of tubes with just several minutes of installation time. The TE-200 accepts any 2'' diameter or smaller end window tube. The TE-220 accepts any side or dormer window tube. The interchangeable tube socket assemblies contain the tube socket, dynode resistor string, and quick connect anode and cathode connectors.

A magnetic shield, operating at cathode potential, provides the optimum in electrostatic/magnetic shielding for the tube while the hermetically sealed inner chamber prevents frost build-up on the tube envelope. A double pane insulating window serves as a thermal isolating light path which will not frost during use, however, a heated window retainer ring is necessary to prevent formation of condensation which would restrict the optically clear light path to the tube cathode. This no dew ring and power supply is provided with the chamber as standard equipment.

The rugged design will withstand severe handling without damage and operation can be maintained from a horizontal position through an arc up to 90 degrees from horizontal without loss of coolant material. Nose down operation can be provided when required on TE-200 only. TE-220 operates from horizontal to 45° up only.

Available RF Shielded - See RF Shielding Section of catalogue.

SPECIFICATIONS

OPERATIONAL

Tube cathode operating temperature
– 74°C, ± 1°C stability for
ambients from +40 to 0°C.

Coolant used is dry-ice and methyl alcohol.

Maximum cooling period without addition of new ice in a maximum ambient of 30°C is:
8 hours for TE-200 6 hours for TE-220

Standard Dynode Resistors
Nominal 100K to 200K ohm values.

Cathode HV input – 3000V max.

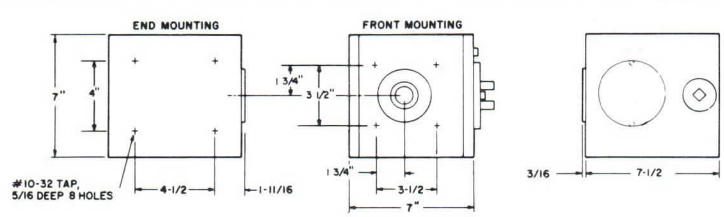
Pyrex viewing window, 80% transmission from 3400A to 21,000A.

MECHANICAL

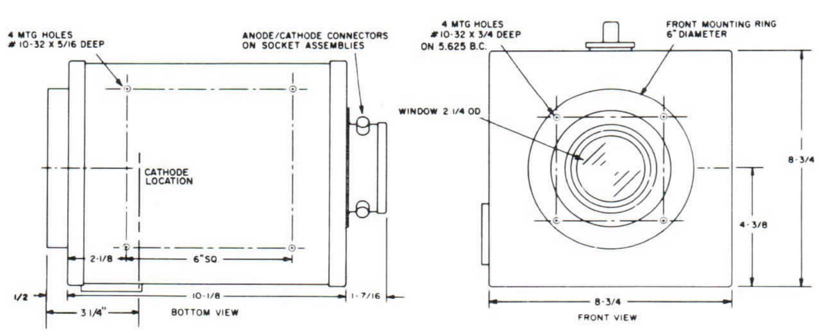
	TE-200	TE-220
Size:	8-3/4" W x 8-3/4" H x 10-1/8" D with a 1-7/16" rear protrusion of the interchangeable tube socket assembly.	7" W x 7" H x 7-1/2" D with a 1" protrusion of the interchangeable tube socket assembly.
Weight:	10 lbs. (less coolant) 12 lbs. (with coolant)	7 lbs. (less coolant) 9 lbs. (with coolant)
Mounting:	Bottom mounted via 4 holes on 6" centers and tapped 10-32 x x 5/16" deep.	Bottom mounted via 4 holes on 4 x 4-1/2" centers and tapped 10-32 x 5/16" deep.
Tube Installation:	From rear of chamber by removal of tube socket assembly.	From top of chamber by removal of tube socket assembly.

Anode Connector: BNC
Cathode Connector: Approved high voltage, coaxial
Cathode Cool down time: 1 hour to stability at –74°C

Note: No dew power supply operates from 115 v 50/60 Hz source and is enclosed in a 3" x 4" x 5" case complete with switch, fuse and pilot light.



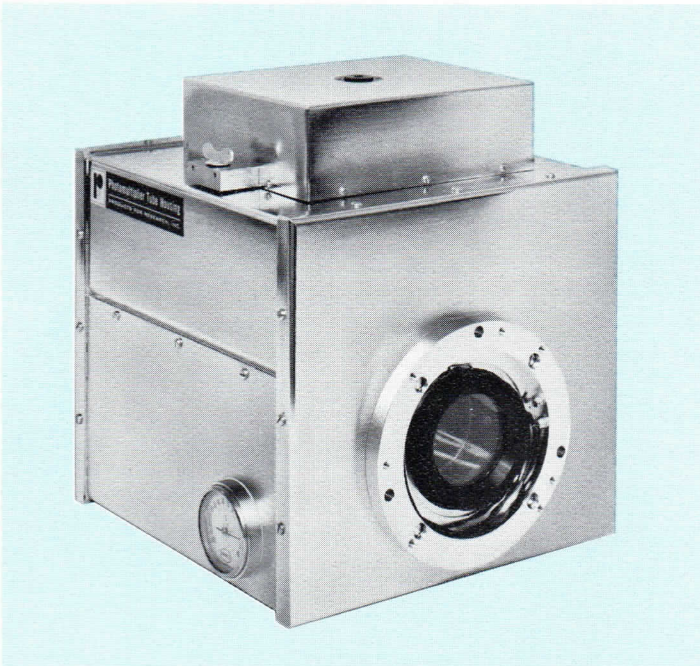
TE-220



TE-200

Available with standard front mounting ring - See Accessory Section for options.

DRY-ICE REFRIGERATED PHOTOMULTIPLIER OR VIDICON TUBE CHAMBER



FEATURES

- ☐ RF SHIELDED
- ☐ DRY ICE COOLANT
- ☐ TOTALLY FROST FREE LIGHT PATH TO CATHODE OF P.M. TUBE
- ☐ ELECTRO/MAGNETIC SHIELDING
- ☐ OPERATION IN ANY POSITION
- ☐ INTERCHANGEABLE TUBE SOCKET ASSEMBLY
- ☐ TEMPERATURE READOUT

The TE-241RF dry ice cooled photomultiplier chamber is designed to meet the high RF shielding needs of wide dynamic range single photon counting techniques, and has the added feature of a 15 hour holding time on one charge of dry ice.

All 2″ diameter and smaller end window P.M. tubes can be accommodated for operation in the −75°C environment which offers a 15 hour stability of ±1°C.

A mu-metal shield operating at cathode potential provides the optimum in electrostatic/magnetic shielding for the tube while the hermetically sealed inner chamber prevents frost build-up on the tube envelope. A heated double pane insulating window serves as a thermal isolating light path which will not frost or dew during use.

The rugged design will withstand severe handling without damage and operation can be maintained in any position as the coolant is a charge of crushed dry-ice mechanically held against the heat exchanger while in operation.

Variants of the TE-241 (TE-242, etc.) are specially modified for housing 1″ and smaller vidicons complete with deflection and focus coil. These units are not RF or magnetically shielded since this is either unnecessary or undesirable for vidicon applications.

SPECIFICATIONS

Tube cathode operating temperature -75°C, ±1°C stability for ambients to +40°C.

Coolant used to be dry-ice.

Max. cooling period without addition of new ice — 15 hours in a max. ambient of 30°C.

Standard dynode resistors — Normal 100K to 200K values.

Anode connector — TNC.

Cathode connector — approved high voltage coaxial

Cathode HV input — 3000V Max.

Pyrex glass viewing window, 80% transmission from 3400A to 21,000A.

MECHANICAL

Size — 10-1/4"W X 12-1/2"H X 12-5/16"D

Weight — 16 lbs. (less coolant)

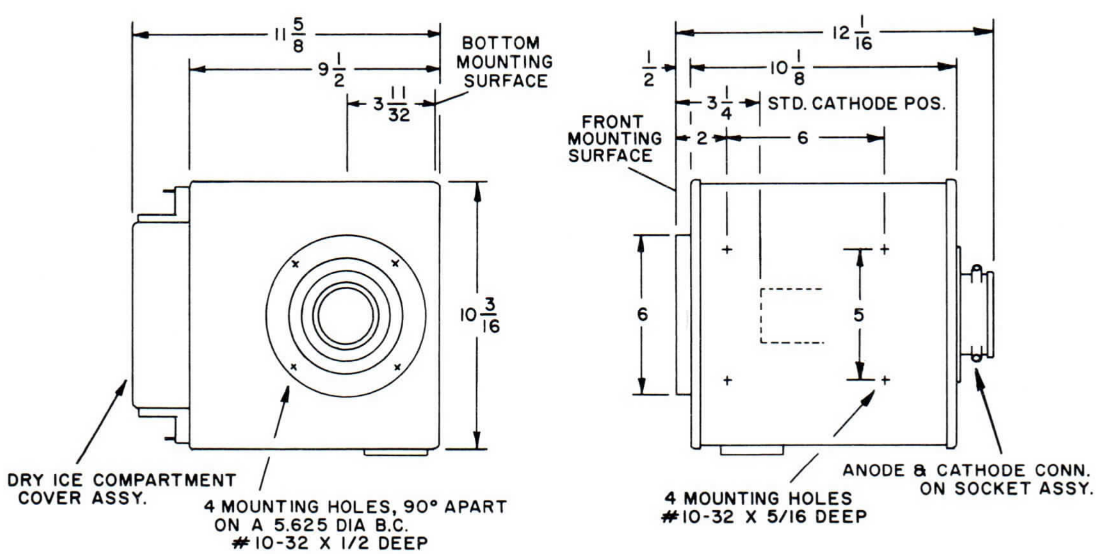
Mounting — Bottom or front mounted.

Aluminum outer case, Nickel plated.

Tube installation from rear of chamber along with tube socket assembly.

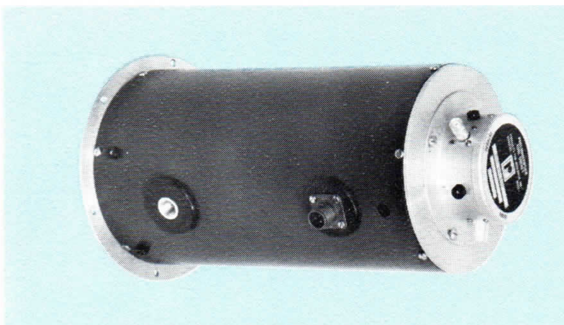
Cathode cool down time is 1 hr. to stability at -75°C.

No dew power supply operates from 115V 50/60 Hz source and is enclosed in a 3" X 4" X 5" case complete with switch, fuse, and pilot light.



Prices noted on current, effective Price List include socket assembly wired for tube operation with standard dynode string. Housings may be modified to meet special requirements.

LIQUID NITROGEN
REFRIGERATED PHOTOMULTIPLIER TUBE CHAMBER



FEATURES

- LIQUID NITROGEN COOLANT
- TOTALLY FROST FREE LIGHT PATH TO CATHODE OF PHOTOMULTIPLIER TUBE
- ELECTRO/MAGNETIC SHIELDING
- RUGGED DESIGN
- INTERCHANGEABLE TUBE SOCKET ASSEMBLY
- $\pm$ 2°C TUBE CATHODE TEMPERATURE STABILITY
- ADJUSTABLE OPERATING TEMPERATURE
- TEMPERATURE READOUT

The TE-114 refrigerated chamber is designed to provide a moisture free, cryogenic cold, environment for PM Tube operation, utilizing liquid nitrogen (LN_2) as the coolant medium. Automatic temperature control circuitry allows tube cathode temperature selection over a range from -50^0C to -100^0C while maintaining stability of $\pm 2^0$C at the selected operating point. 0^0C minimum temperature option available on special order with $\pm 5^0$C stability above -50^0C point.

This unique design is arranged to allow quick interchange of tubes permitting any 2" dia. or smaller end-window PM tube to be installed in the chamber in several minutes. The interchangeable tube socket assemblies contain the tube socket, dynode resistor string, and quick connect anode and cathode connectors.

Operation is completely automatic requiring no service even with extended periods of use. A magnetic shield operating at cathode potential provides the optimum in electrostatic/magnetic shielding for the tube while the hermetically sealed inner chamber prevents tube or chamber frosting. A double pane insulating window functions completely frost free, thereby insuring a clear light signal path to the photocathode at all times. A heated window ring prevents dewing of the external surface of the window. The rugged design will withstand severe handling without damage as there are no moving parts and operation can be in any plane.

This chamber is supplied complete with LN2 transfer line and head plus control solenoid arranged for use with customer supplied unpressurized 15 liter through 50 liter dewar. An optional transfer system plus control solenoid can be supplied for use with 160 liter pressurized dewar.

Available with 3KV high voltage power supply Model S504 - H. V. Power Supply Section.

SPECIFICATIONS

OPERATIONAL

Input 115V 50/60 cps 50 Watts to controller.

Nom. ambient 30°C (86°F).

Min. tube cathode temp. at Nom. ambient is −100°C.

Tube cathode temperature is continuously adjustable from −50°C to −100°C with a cathode temp. stability of ± 2°C from set point.

Cathode high voltage input 3000V max.

Standard dynode resistors — nominal 100K to 200K values.

Liquid nitrogen consumption — approx. 1.25 liter/HR at −100° C operation.

Pyrex glass viewing window, 80% transmission from 3400A to 21,000A.

MECHANICAL

Size 6" O.D. x 10¾" long with an additional 1-3/8" for the cap of the socket assembly.

Weight — 9 pounds. NOTE: The controller mounted in separate cabinet weighs approximately 14 pounds.

Mounting — the unit is front mounted, with 6 bolts on a 6½" dia. bolt circle.

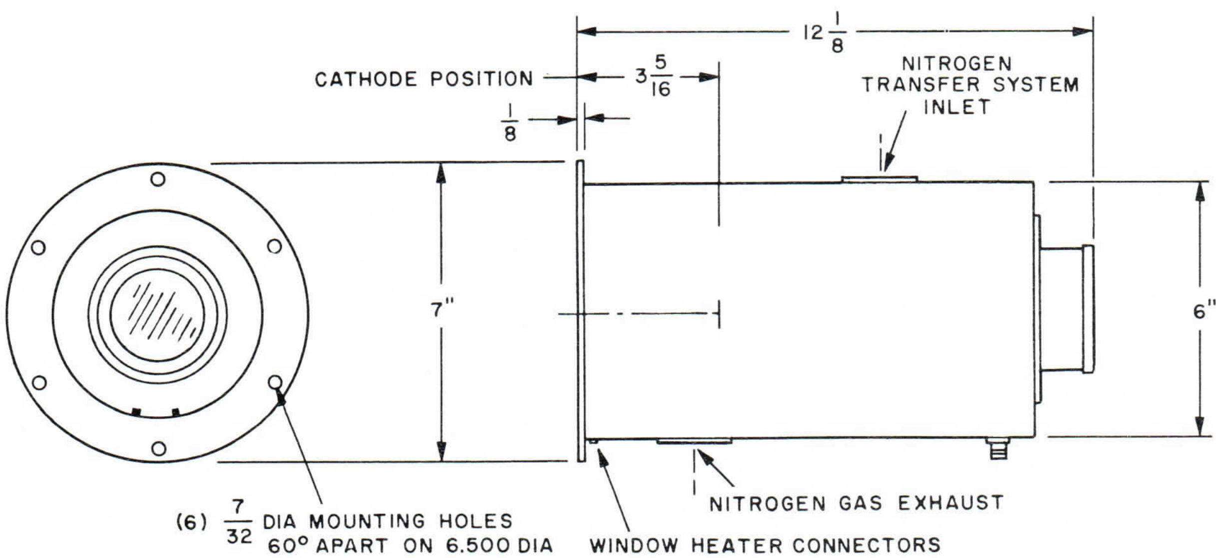
Material — Aluminum finished with durable textured gray baked enamel.

Anode connector — BNC

Cathode connector — approved high voltage coaxial.

Interchangeable tube socket assembly is mounted through the rear of the chamber.

Cathode cool down time is 15 min. to stability at −50°C.



When ordering either shutter or filter wheel accessories the TE-114 chamber must be identified to insure mating adapter flange is included.

CARNOT CYCLE REFRIGERATED PHOTOMULTIPLIER TUBE AND VIDICON TUBE HOUSING

FEATURES

- -50°C OPERATION
- ±2°C STABILITY (-5°C to -50°C)
- NO SUPPLEMENTAL COOLANTS
- TOTALLY FROST FREE LIGHT PATH TO CATHODE OF P.M. TUBE
- ELECTRO/MAGNETIC SHIELDING
- OPERATION IN ANY POSITION
- INTERCHANGEABLE TUBE SOCKET ASSEMBLY
- TEMPERATURE READOUT

This unique cooled housing offers both temperature stabilized operation from −5°C to −50°C and nominal −50°C operation without the use of supplemental cooling materials such as Dry Ice. Operation of the housing can be in any plane as there are no moving parts. The compressor unit associated with the housing is normally supplied for 115 V, 60 Hz operation and connected to the housing via a 5′ flexible coolant line. A double pane fully evacuated window cell plus an integral window heater assures a frost and dew free light path to the photocathode as well as a hermetic seal at the front of the housing. Bottom or front mounting is standard. Note: 220 V, 50 Hz is optional as well as coolant line lengths up to 25′ and RF shielding or window optics for special applications. It is offered in the TE-149 series as a PM tube cooler and in the TE-150 series as a Vidicon tube cooler.

The TE-149/TE-149TS photomultiplier housing accepts any 2″ diameter or smaller end window tube, and is a complete system consisting of an electrostatic/magnetic shield of high permeability 0.040″ thick Co-Netic AA magnetic material extended 1/2 cathode diameter in front of cathode. The interchangeable tube socket assembly contains the tube socket, dynode resistor string, and conventional anode/cathode coaxial connectors, plus "O" rings for rear chamber hermetic seal.

The TE-150/TE-150TS Vidicon housing is arranged to accept most popular 1″ or smaller Vidicon tubes and deflection yokes which are held in firm thermal contact with the inner cold wall that is non-magnetic, as magnetic shielding would be detrimental to performance. A special socket assembly interlocks with the deflection yoke to allow precise rotational adjustment of the Vidicon face plate with respect to the housing mounting surface. Provision is made to permit close coupling of a pre-amplifier to the Vidicon target ring which floats electrically free from all inner chamber parts. Feed-thru pin connectors are located on the socket assembly inner plate to facilitate ease of electrical entry to the Vidicon socket and deflection yoke.

1/74

PRODUCTS FOR RESEARCH, INC.
78 HOLTEN STREET, DANVERS, MASSACHUSETTS 01923

SPECIFICATIONS

OPTIONAL

Input 115V 60 CPS 3.5 Amps (10 Amp starting current) Nominal Ambient 30°C (86°F)

Min. tube Cathode temp. −50°C at Nominal Ambient

Tube Cathode temperature is continuously adjustable from −5°C to −50°C with temperature stability of ± 2°C on TE-149TS and TE-150TS

Cathode high voltage 3000 V max.

Standard dynode resistors — nominal 100K to 220K values

Pyrex viewing window, 80% transmission — 3400A to 21,000A

MECHANICAL

Size of Cooling Chamber — 8 3/4 W x 8 3/4 H x 10 1/8 D with a 1 7/16 rear protrusion of socket assembly.

Size of Compressor Unit — 9 1/2 W x 10 H x 14 long

Weight — Cooling Chamber - 12 lbs.
Compressor Unit - 40 lbs.

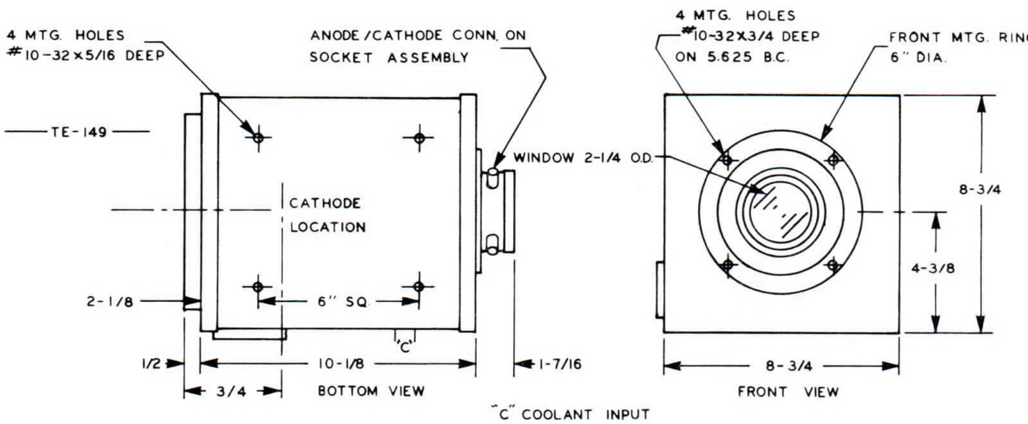
Mounting — the unit is front mounted or bottom mounted; see drawing below

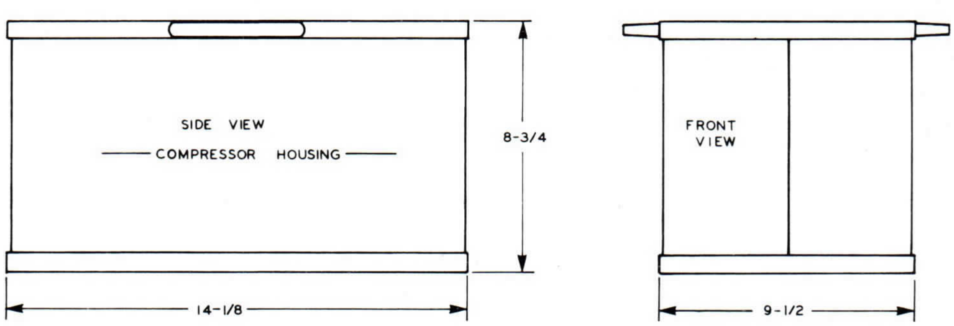
Anode Conn. — BNC

Cathode Conn. — Approved high voltage Coaxial

Cathode Cool down time — 2 hrs.

Window No-Dew power source included in Compressor Cabinet.





Prices noted on current, effective Price List include socket assembly wired for tube operation with standard dynode string. Housings may be modified to meet special requirements.

Note: Tube type must be specified on all orders.

RF SHIELDED AMBIENT TEMPERATURE PHOTOMULTIPLIER HOUSINGS

The PR-1400 RF and PR-1401 RF housings are specifically designed to incorporate all important features for optimum PM tube performance within one low cost ambient housing type. The PR-1400 RF accommodates 2" and 1 1/2" diameter PM tubes while the PR-1401 RF specifically houses 1 1/8" diameter and smaller PM tubes. Both housings offer common basic features, namely:

- RF shielding (rigorously tested with Broad Band high gain photon counting equipment).
- Electrostatic shielding at cathode potential.
- Magnetic shielding (with 0.040 thick high permeability Co-Netic AA material extending 1/2 cathode diameter in front of photocathode).
- Cathode centered by an opaque insulating ring (improvement over teflon).

Universal Front Mounting Flange (interchangeable with most SSR, PPI, and GENCOM housings). Flange can be removed for special applications without the magnetic shield or centering ring being affected. A standard filter holder is installed in the mounting flange.

Tube socket assembly is completely wired and potted for optimum RF performance.
Standard MHV high voltage connector and BNC signal connector are an integral part of the socket assembly.

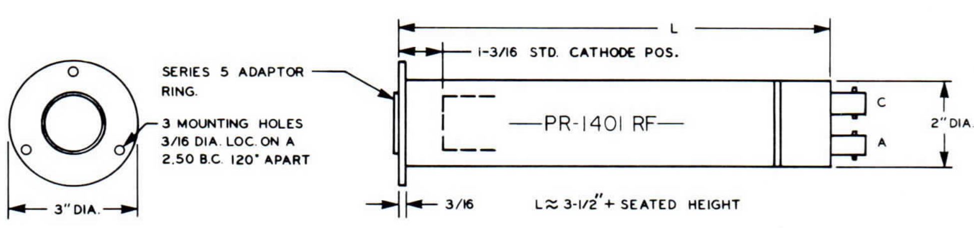
"O" ring seals insure light integrity.

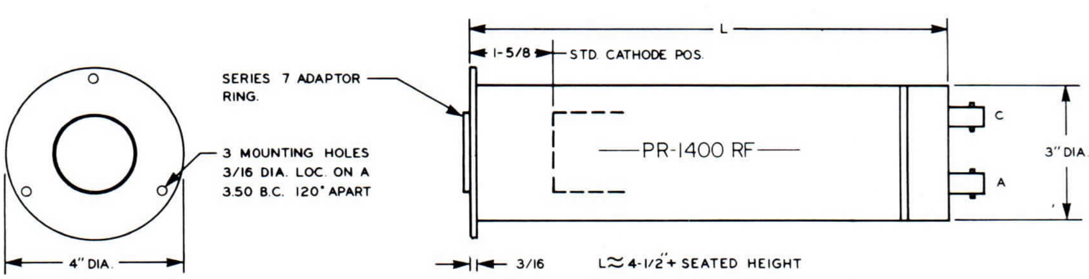
PM tubes from any manufacturer operate in these chambers.

Magnetic defocusing assembly (PR-411) fits completely within the housing cylinder and does not interfere with mounting.

Custom Cathode location and/or SHV or TNC connectors are available on special request at no additional charge.

Note: Tube type must be specified on order.

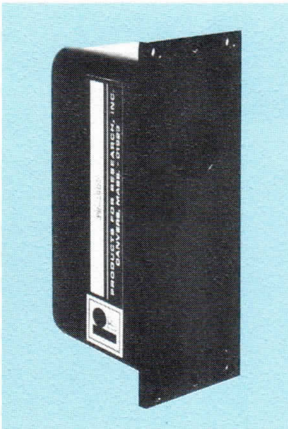




6/74

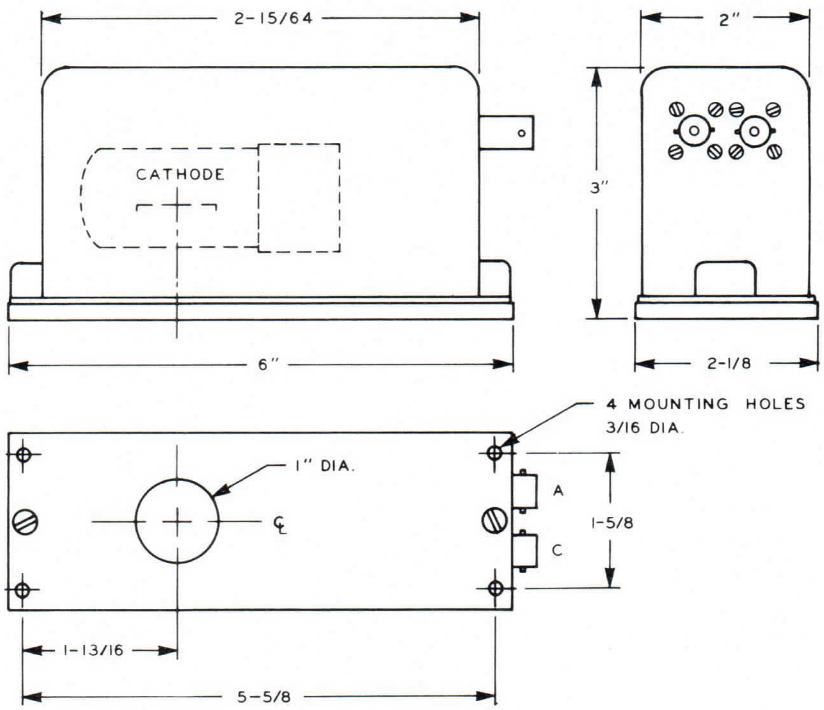
PRODUCTS FOR RESEARCH, INC.
78 HOLTEN STREET, DANVERS, MASSACHUSETTS 01923

PR-1402
PR-1402 RF



The PR-1402 and PR-1402 RF housings are a low cost high performance type for the typical side window tubes such as the 1P21. Special low loss sockets and an "O" ring seal between cover and base insure optimum tube performance. BNC and MHV connectors with mates are used for Anode and Cathode connections. A 0.040" thick high permeability Co-Netic AA Magnetic Shield and/or RF Shielding are optional for a small increase in price over the standard unit.

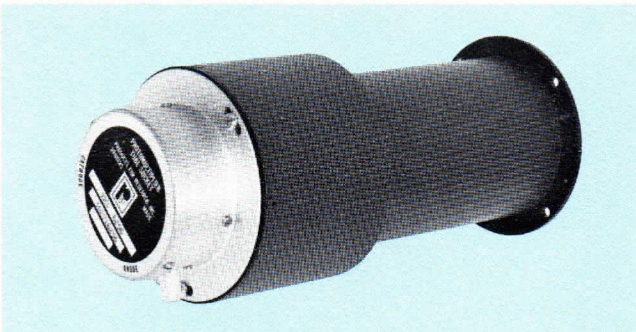
Note: Use PR-1402SH or PR-1402SH RF when ordering magnetic shield.

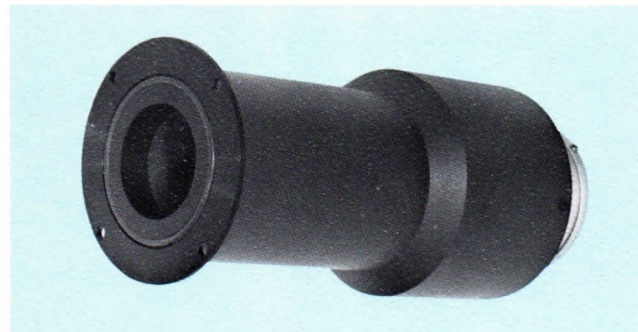


SMALL SHUTTER PR-305

This small shutter assembly PR-305 is designed to fit most ambient temperature housings manufactured by Products for Research, SSR, PPI, and GENCOM. The same light tight integrity is insured on this design as on our larger PR-302 shutter. Mounting is by the 3 holes, 7/32 diameter, spaced 120° apart on a 3.50 bolt circle.

AMBIENT TEMPERATURE PHOTOMULTIPLIER TUBE HOUSING





The PR-2200 photomultiplier tube housing consists of a light-tight enclosure complete with electrostatic and magnetic shield and has an interchangeable tube socket assembly. Designed to provide high performance, this socket assembly is usable with all PFR refrigerated chambers in this catalog.

A light-tight enclosure of aluminum arranged for front mounting has an "O" ring seal to insure light-tight coupling to any instrument . An over-all baked enamel paint affords a durable lasting finish.

Electrostatic/magnetic shielding is accomplished by the use of a high permeability magnetic cylinder electrically connected to the input high voltage of the tube socket assembly and electrically isolated from the basic housing.

The tube socket assembly complete with custom dynode resistor string, an approved high voltage connector, and a BNC coaxial signal connector is foam filled to prevent entrance of dirt and moisture.

Available RF Shielded - See RF Shielding Section of catalogue.

SPECIFICATIONS

OPERATIONAL

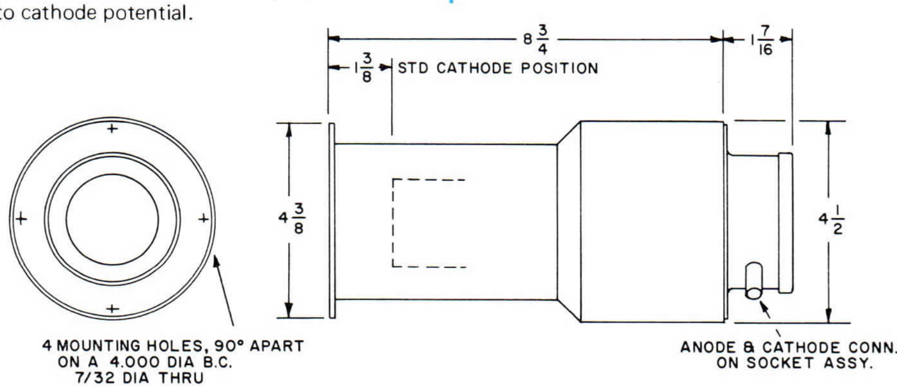
Anode Connector – BNC
Cathode Connector – Approved high voltage coaxial.
Cathode H. V. input – 3000V max.
Standard dynode resistors – nominal 100K to 200K values.
Magnetic Shield – 0.050 high permeability material.
Electrostatic Shield – electrically connected to cathode potential.

MECHANICAL

Size – 10-1/2" long x 3-1/2" diameter
Weight – 3-1/2 lbs.
Mounting – front circular plate with "O" ring seal – 4 bolt holes for No. 10 screws.

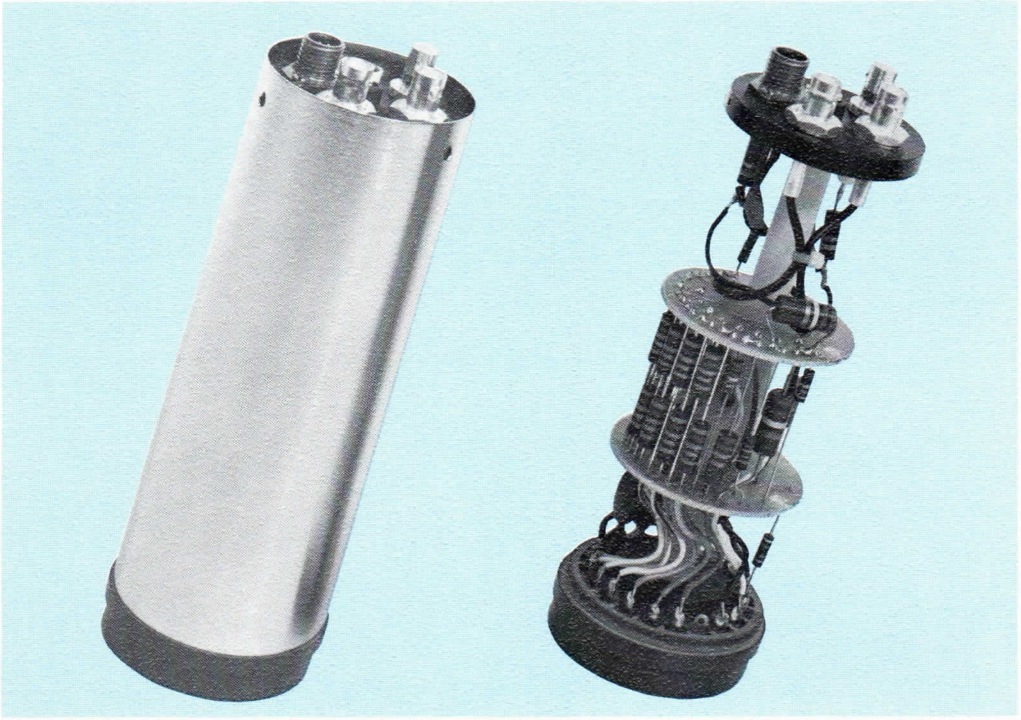
Aluminum outer case.

Tube installation is from rear of unit by removal of socket assembly.

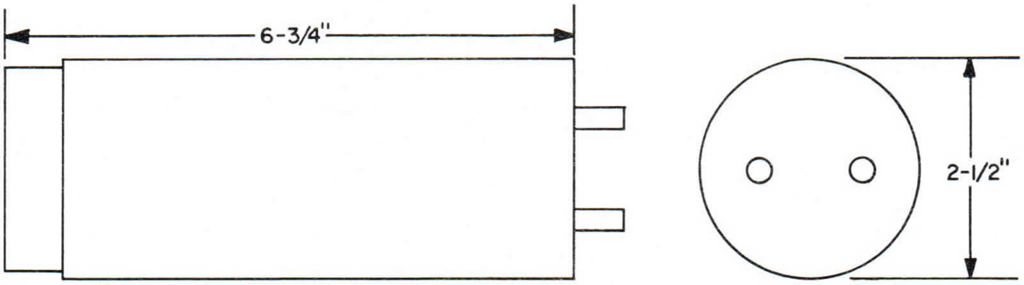


Interfacing adapter ring available for mounting PR-302 shutter or filter changer. See Options Section.

NUCLEAR BASE



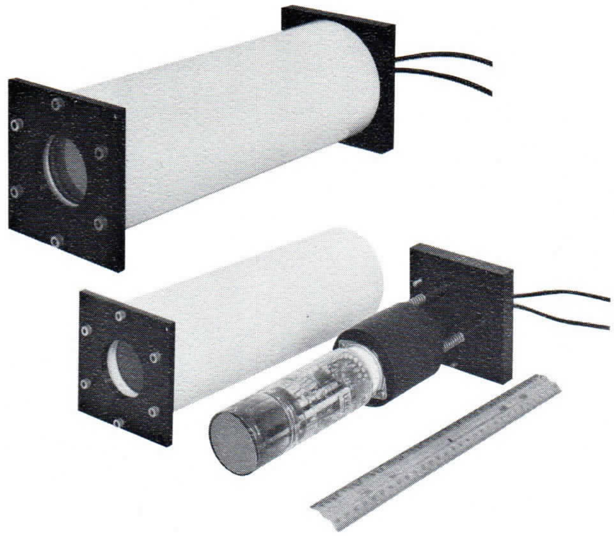
The PR-225 Series of nuclear bases are specifically designed for use in high speed, high energy nuclear counting work. The universal printed circuit board permits simple cordwood construction of the complex bleeder string necessary for proper performance of the high speed linear focused tubes, from all manufacturers, used in this applications.



NOTE - Tube type must be specified when ordering.

The PR-219/220/221 are a natural for customized circuits as only the structural parts plus unwired printed circuit boards are supplied.

PHOTOMULTIPLIER TUBE OCEANOGRAPHIC HOUSING



- ☐ DESIGNED FOR USE IN PRESSURIZED ENVIRONMENTS
- ☐ HERMETICALLY SEALED
- ☐ RUGGED
- ☐ INTERCHANGEABLE TUBE SOCKET ASSEMBLIES
- ☐ 200 FT DEPTH CAPABILITY
- ☐ 2500V CATHODE VOLTAGE LIMIT
- ☐ SUPERIOR FLEXIBILITY FOR ADAPTION TO INDIVIDUAL EXPERIMENT

The PR-217 photomultiplier tube housing has been designed to allow PM tube operation at ocean depths down to 200 feet, and will accommodate all end window tubes of 2" diameter and smaller. The severe mechanical impact and shock conditions of underwater usage have been accounted for in the rugged design which includes an internal photomultiplier tube support. The front and rear flanges have been standardized to accommodate the multiplicity of bridals and harness necessary for all operations.

Light controlling filters desired for specific applications can be externally mounted along with remotely controlled shutter mechanisms and window optics.

SPECIFICATIONS

MECHANICAL

Housing Material — Aluminum (alloy 6061-T6).

Finish — Black anodize with external high visibility paint overcoat.

Hardware — Stainless steel (316)

Mechanical Joints — Machined flange with "O" ring seal.

Cable Connection — Special compression gland on RG 58 coaxial cable at feed-through point.

Cables — Input H.V. and output signal cables are RG 58 coaxial leads supplied as an optional extra.

ELECTRICAL

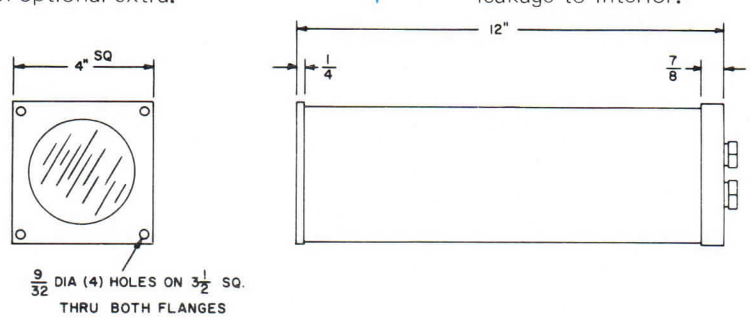
Cathode Potential — 2500V Max. using RG 58 coaxial cable.

Anode Signal — Retrieved via RG 58 coaxial cable.

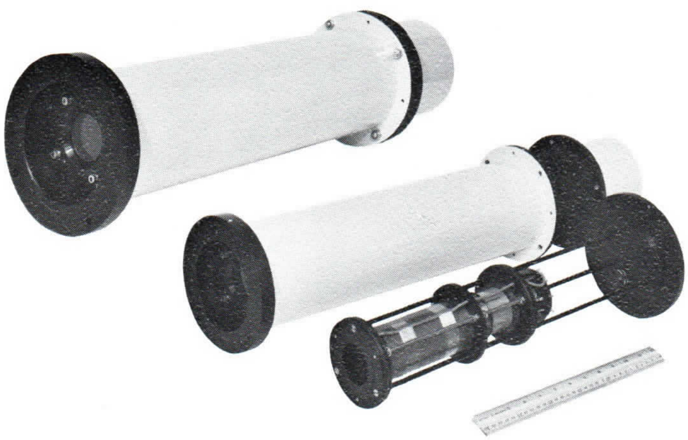
PERFORMANCE

Window Transmission — In excess of 80% over the range 3600A^0 to 11,250A^0 (Lime — Soda glass tempered).

Pressure Capability — Overall housing capable of 250 PSI without moisture leakage to interior.



PHOTOMULTIPLIER TUBE OCEANOGRAPHIC HOUSING



- ☐ DESIGNED FOR USE IN PRESSURIZED ENVIRONMENTS
- ☐ HERMETICALLY SEALED
- ☐ RUGGED
- ☐ INTERCHANGEABLE TUBE SOCKET ASSEMBLIES
- ☐ 1000 FT DEPTH CAPABILITY
- ☐ FULL ELECTROSTATIC AND MAGNETIC SHIELDING
- ☐ 2500V CATHODE VOLTAGE LIMIT
- ☐ SUPERIOR FLEXIBILITY FOR ADAPTION TO INDIVIDUAL EXPERIMENT

The PR-210 photomultiplier tube housing has been designed to allow PM tube operation at ocean depths down to 1000 feet, and will accommodate all end window tubes of 2" diameter and smaller. The severe mechanical impact and shock conditions of underwater usage have been accounted for in the rugged design which includes an internal shock mounted photomultiplier tube support frame. The housing overall length is not considered as a fixed dimension due to the many varied amplifier and power supply requirements associated with ocean research programs, whereas, the front and rear flanges have been standardized to accommodate the multiplicity of bridals and harness necessary for all operations.

Light controlling filters desired for specific applications can be either internally or externally mounted along with remotely controlled shutter mechanisms and window optics.

SPECIFICATIONS

MECHANICAL

Housing Material — Aluminum (alloy 6061-T6).

Finish — Black anodize with external high visibility paint overcoat.

Hardware — Stainless steel (316)

Fabricated Joints — Dip brazed.

Mechanical Joints — Machined flange with "O" ring seal.

Cable Connection — Special molded gland on cable under "O" ring compression at feed-through point.

Shock Mounting of Inner Frame — Low durometer "O" rings secured to the edge of annular rings spaced periodically down the length of the frame.

Length — Dimension X on the outline drawing can vary between 19" and 25½" dependent on application.

ELECTRICAL

Cathode Potential — 2500V Max.

Magnetic Shield — .050 thick high permiability steel (mu-metal) cylinder 5¼" long projecting 1" forward from cathode.

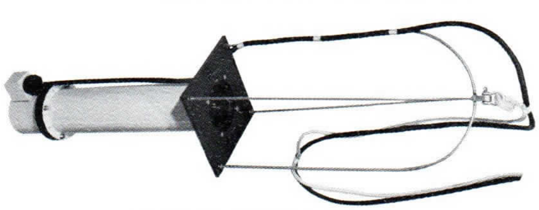
Electrostatic Shield — Direct connection between cathode voltage terminal and magnetic shield.

PERFORMANCE

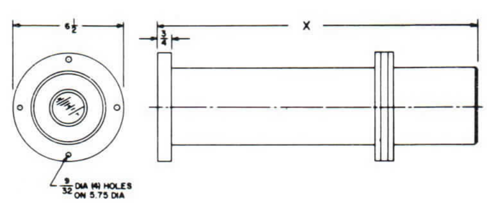
Window Transmission — In excess of 80% over the range 3600A⁰ to 11,250A⁰ (Lime — Soda glass tempered).

Pressure Capability — Overall housing capable of 1500 PSI without moisture leakage to interior.

Moisture Control — Color indicator desiccant in holder having inspection window inside end bell of chamber.

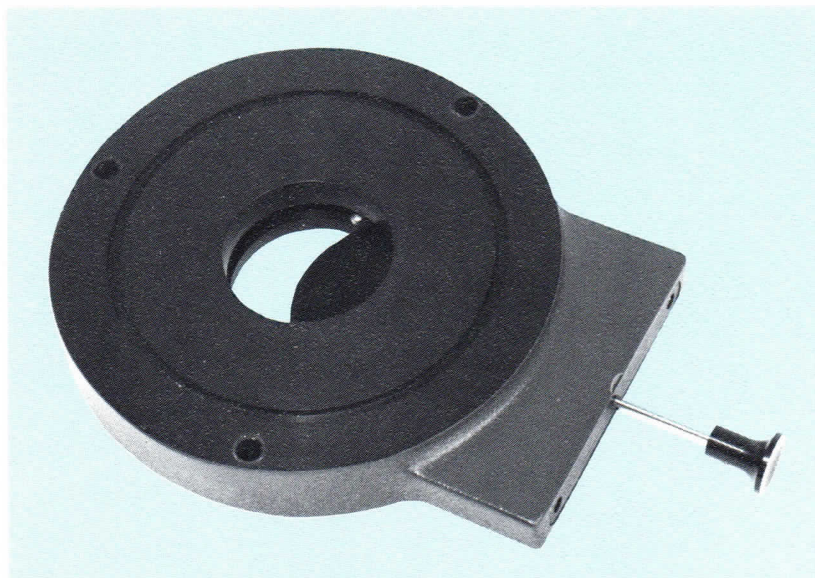


TYPICAL NOSE-UP BRIDAL



OUTLINE DIMENSIONS

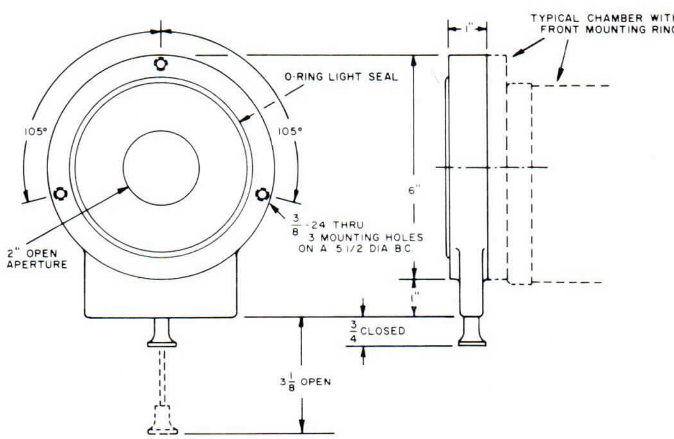
SHUTTER ASSEMBLY FOR PHOTOMULTIPLIER TUBE CHAMBER



The PR-302 shutter assembly has been designed to offer a light tight, mechanically operated, closure for the window end of our P.M. tube chambers. A standard front mounting ring is a necessary option when mounting this shutter assembly to a chamber.

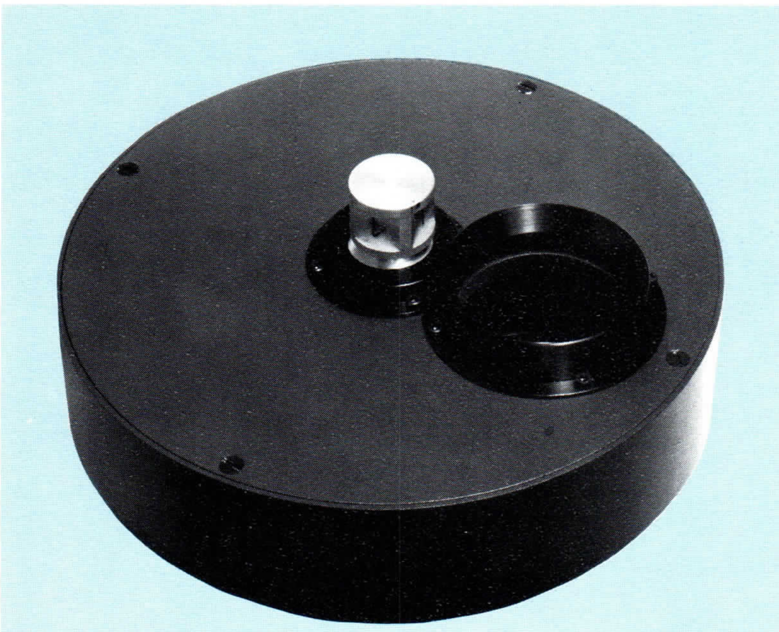
The sliding plunger actuates a black-out disc traveling in an off-set track causing positive pressure against an "O" ring when fully closed.

Construction of this shutter assembly is entirely of aluminum that has been either black anodized or painted dark gray textured enamel dependent on the surface of the part involved.



Please indicate chamber model to which shutter will be attached and need for front mounting adapter, if necessary.

FILTER WHEEL



PR-300

- ☐ LIGHT TIGHT
- ☐ 4 POSITION 2″ CAPACITY FILTERS (PR-300)
- ☐ 8 POSITION 1″ CAPACITY FILTERS (PR-304)

The PR-300 filter wheel unit has been developed to fill the need for a simple multiple filter housing which can be mounted in front of a light detecting device and permit operation in areas where stray light must not strike the detector. Our unique method of index control affords a complete light tight seal once the selected filter has been rotated to position in front of the input/exit opening.

Installation of filters is accomplished by removing the rear plate from the housing and securing the filters under the retainer ring for any of the 4 filter positions. Filters of 2″ dia. or 2″ x 2″ square or smaller with thickness up to 3/8 inch can be accommodated.

A lens mounting ring attached to the front face of the housing provides a means to install necessary optics in front of the filter position.

The housing is fabricated primarily of aluminum which has been painted with a durable baking enamel. All internal parts are flat Black enamel. The weight is approximately 4 pounds. Outline dimensions are 8″ diameter by 1¾″ thick not inclusive of selector knob or lens mounting ring.

HIGH VOLTAGE PHOTOMULTIPLIER TUBE SUPPLY

S504 RACK

S502 BENCH

S504 BENCH

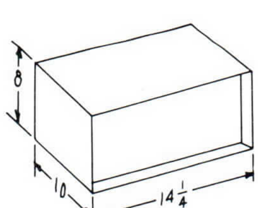
- ☐ 0 - 3000V AT 5 MA DC
- ☐ 15V DC STEPS
- ☐ 0.001% LINE REGULATION
- ☐ 50 PPM/°C TEMP. COEFFICIENT
- ☐ INTEGRAL WITH P.M. TUBE COOLER SUPPLY
- ☐ SHORT CIRCUIT PROOF SELF RESTORING

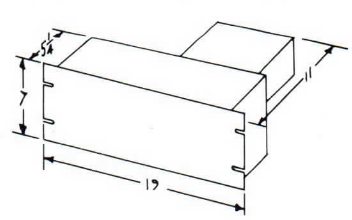
The S502, S504 series high voltage power supplies are designed to meet the demands of currently available high gain PM tubes, with the 0 to 3000 V DC range being adequate for the great majority of tubes.

This equipment is designed with the intent of maximum convenience to the operator. Both the S502 and S504 supplies are provided with a unitized high voltage module which allows simple field interchange. Variations on the voltage and current output are available on special request. The S504 supply is integrated into the standard cabinet or 19" relay rack of our liquid nitrogen or thermoelectric cooler power supply, thereby affording the convenience of only one piece of equipment to accomplish two tasks plus the saving in cost of a separate cabinet. For those applications where a cooler power supply is not utilized, such as with our dry-ice chambers, the S502 high voltage supply is available. The S502 contains the same interchangeable high voltage module to facilitate field service.

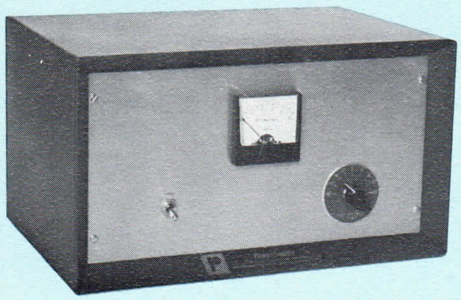
SPECIFICATIONS

Output Voltage	0 to -3000 Volts D.C. in 15 Volts steps
Output Current	0 to 5 MA
Input	115/230 V + 10%, 50 - 400 Hz
Load Regulations:	
No load to full load	0.01%
No load to 1 MA	0.002%
No load to 10 μA (typical for PMT)	0.00002%
Ripple:	
@ 5 MA load	0.001% Pk to Pk sinusoidal
@ 1 MA load (typical for PMT voltage divider)	0.0002% Pk to Pk sinusoidal
@ 100 μA load	0.00002% Pk to Pk sinusoidal
Line Regulation	0.001% for ±10% line change
Temperature Coefficient	50 PPM/°C. after warm up over operating temperature range 0 - 50°C.
Protection	Short circuit proof, self restoring
Connections	Remote Monitor a. low impedance D.C. Ammeter will read 40 μA/1 KV b. high impedance (400 k ohms/ volt) D.C. Voltmeter will read 1V/1 KV H.V. output - UG 931/U

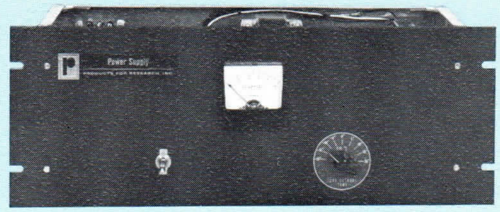




THERMOELECTRIC POWER SUPPLIES



STANDARD BENCH MOUNT

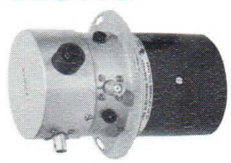


19" RELAY RACK MOUNT

All thermoelectric cooled chambers can be provided with either the standard bench mount power supply or the special option 19" relay rack power supply having a 7 1/4" high front panel.

SPECIAL SOCKET OPTIONS

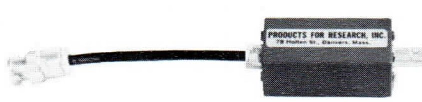
Ventilated cap style socket assy — customer has access to dynode resistors



Extended cap style socket assy — customer has room for pre-amp installation

RF socket assy — nickle plate

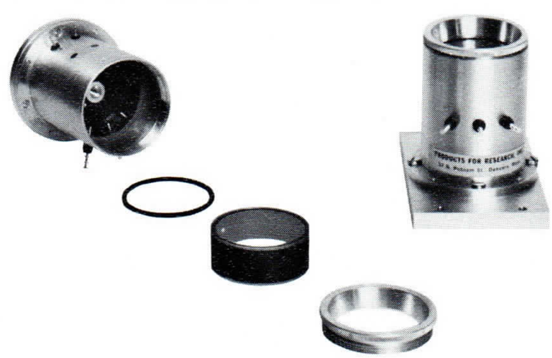
"ADD-A-LOAD"



Design of the "Add-A-Load" unit permits direct "close" coupling to the Anode Connector on all photomultiplier tube chambers, and the wide range of load resistors affords great flexibility to the user.

PHOTODIODE COOLER

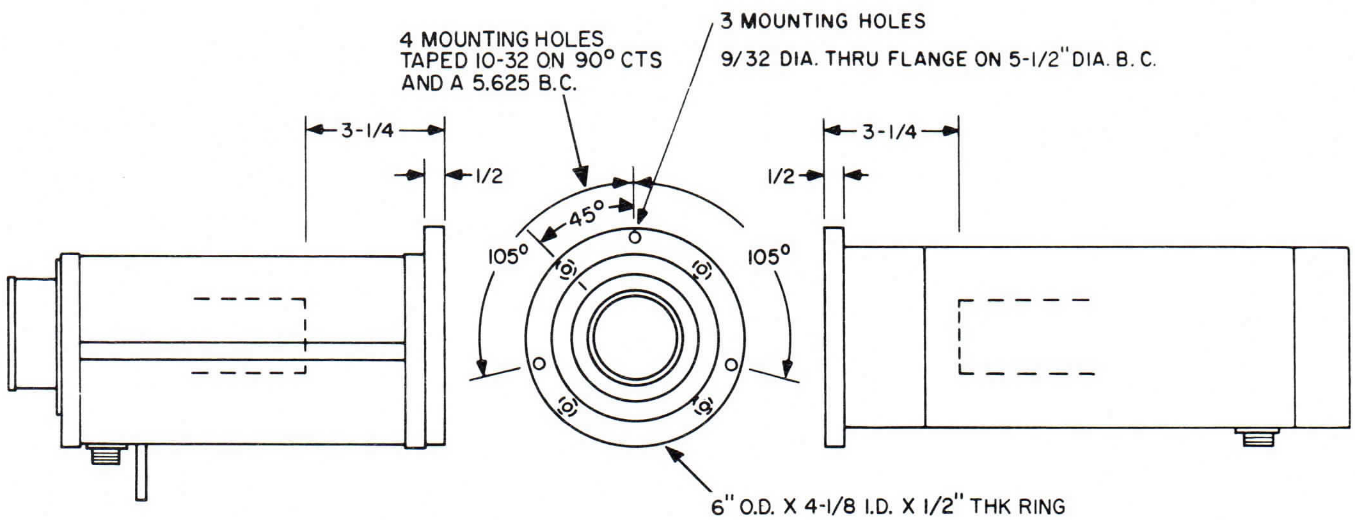
This particular cooled chamber is designed to be built into customer equipment; however, minor modifications will permit self-sustaining operation. The thermopane viewing windows, thermoelectrically cooled diode mounting post and Teflon circuit feed-thru terminals permit continuous duty uses. Ease of diode interchange is standard.



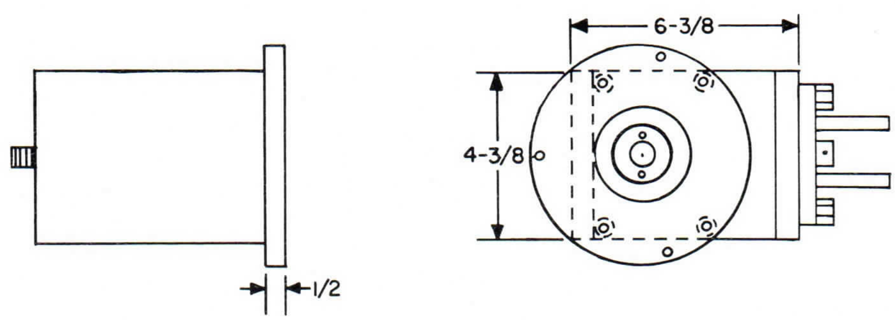
PR-411 DEFOCUSING MAGNET

Reduces effective cathode of most 2" PM tubes when used with PR2200 or any cooled chamber

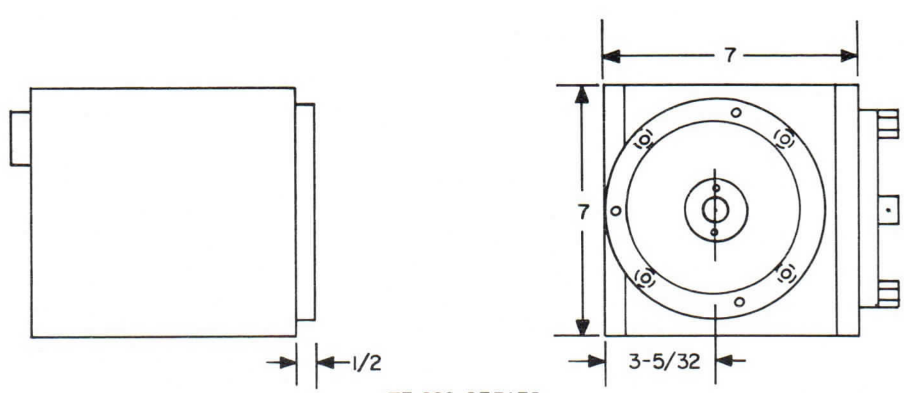
FRONT MOUNTING ADAPTERS



TE-104 SERIES   FRONT VIEW TYPICAL   TE-102 SERIES



TE-109 SERIES



TE-220 SERIES

RF SHIELDING

Products for Research, Inc. can now offer many of its fine photomultiplier tube housings completely RFI shielded and noise free for broadband photon counting applications. Not only has the outer case been RFI gasketed, but the socket assembly circuit has been modified to decouple all inputs; and, on all cooled models, the temperature controller has been replaced with a custom designed proportional control unit. All RF units are rigorously tested using a broadband photon counter with a high frequency noise source to insure RF leakage is negligible.

UNITS – designated by the suffix "RF" (example TE-104TS-RF) which can be provided with RFI shielding are listed below.

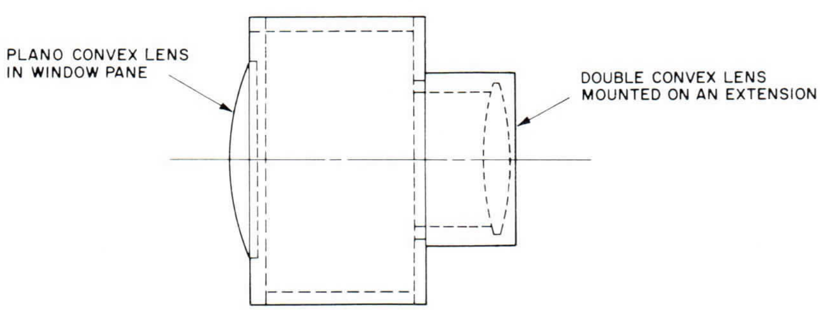
TE-102
TE-102TS
TE-104
TE-104TS
TE-109
TE-109TS
TE-200
TE-220
PR-2200

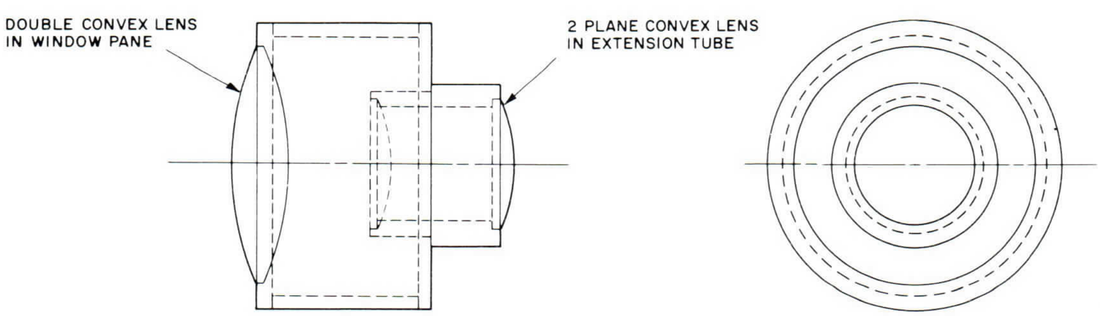
Note: TE-241RF is standard

WINDOW OPTICS

The chamber thermopane viewing window can readily be converted to a collimating or imaging optical system on all Products for Research chambers. Light transmission characteristics are controlled by the optical grade of the lens.

TYPICAL LENS MOUNTING





PHOTOMULTIPLIER TUBE PERFORMANCE IMPROVEMENT WITH CONTROL OF OPERATING ENVIRONMENT

A significant factor in obtaining improved performance from photomultiplier tubes is control of the tube's operating environment. Two basic factors, (1) the quality of information desired and (2) the energy level of the source being observed, determine the degree of sophistication necessary in controlling the PMT environment. The most important factors which may be controlled are:

a. Tube cathode and dynode temperature
b. Light tightness of over-all housing
c. Magnetic field shielding
d. Electrostatic field shielding
e. Tube performance due to housing design (electrical leakage, window dewing, scintillation)

TUBE CATHODE AND DYNODE TEMPERATURE

The cathode and dynode materials of the photomultiplier tube are made of various materials from which electrons can be easily parted with relatively low energy levels. As a result, materials of this type tend to release electrons readily with increases in temperature. Source signal levels of a small magnitude may well be unreadable with room ambient photomultiplier tube usage due to the high level of dark current present at this temperature.

The entire dark current is not due to heat. A component of the dark current is true thermionic emission from the cathode material, while the remainder must be defined as non-thermionic emission in nature. Cooling of the cathode will reduce thermionic emission but not the non-thermionic component. The dark current from any specific cathode material will vary widely from tube to tube. Thus, there is no clearly defined line to predict the value of dark current at a particular cathode voltage and temperature. Figure 1 illustrates relative dark currents as a function of temperature in the case of four popular tube types.

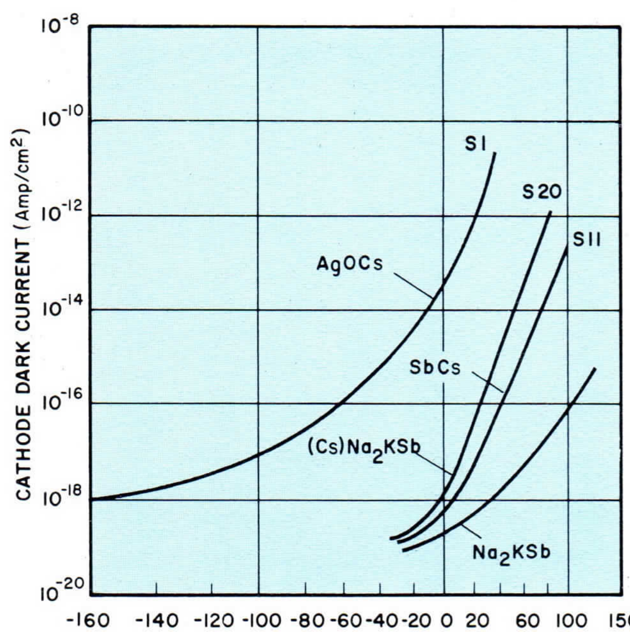


FIGURE 1 PERFORMANCE CHARACTERISTICS OF POPULAR PHOTOMULTIPLIER TUBES WITH COOLING

TYPICAL PMT PERFORMANCE WITH COOLING

All photomultiplier tubes operate well in the thermoelectric cooling chamber (Model TE-102) without any degradation of output.

The S1 tube provides optimum performance when cooled with dry-ice and alcohol or with liquid nitrogen.

Bialkali tubes operate best at about 0°C for linear DC measurements.

Trialkali tubes (S20) provide best performance when operated at from −20°C to −30°C. Practically, −100°C should be considered as the lower limit for these tubes.

The chart below indicates approximate improvement in orders of magnitude reduction of dark current which may be expected with cooling to indicated temperatures:

TEMP.	TUBE			
	S1	TRIALKALI (S20)	BIALKALI	S4/S11
0°C	1	1	1	1
−20°C	2½	2½	Abnormally	2
−70°C 1	5	2½	High Cathode	2½
−100°C	6	2½	Resistance	2½

UNIFORM COOLING is important because serious damage can be done to a photomultiplier tube by cooling only its cathode or window end. Not only will gain stability be affected but, due to the large temperature difference between dynodes and cathode, a vapor-pressure differential can exist causing Cesium deposition at the cathode and, consequently, a steady increase in dark current until the tube is no longer useful. Additional reasons for cooling the entire tube structure are to prevent radiant heating of the cathode from warm bodies in close proximity to the cathode and reduction of electron release from the dynodes themselves due to thermionic emission.

Temperature Stability of the Cathode Ambient Air

Photomultiplier tubes settle down to provide the very lowest noise performance when they are held in a CONSTANT environment. And, when tubes are cooled to improve performance, the most convenient means is the thermoelectric cooling chamber (PFR Model TE-102TS, Page 6.) It requires no fluids or additives and, with a flip of the switch, will maintain stable temperature over extended periods of time without requiring any attention.

Surprisingly, many so-called light-tight housings are far from the desired absolute light-tight point. Light sufficient to distort data evaluation has been found entering photomultiplier tube housings via light-pipe action along the tube socket connecting leads. This is especially true where white Teflon insulation is used. Also, certain of the black plastic materials are actually not homogenously black and will allow small amounts of light transmission into chamber interiors.

LIGHT TIGHTNESS OF THE OVER-ALL HOUSING

Measurement repeatability is dependent upon temperature stability of the cathode since tube gain is related to dynode temperature. A gain stability of ±½% per degree C is not uncommon. However, this temperature coefficient is non-linear over the spectral response range of the tube and could well be negative in the lower spectral region with a non-linear movement into the positive for the higher spectral regions.

MAGNETIC FIELD SHIELDING

It is important that electrons released from the cathode travel to the first dynode and not be deflected prior to reaching this target as the signal strength in this particular area of the tube has considerable effect on the over-all signal-to-noise ratio. Magnetic fields generated from near-by electrical equipment or even the earth's field can be sufficient to cause electron deflection; hence, the tube should be enclosed in a highly efficient magnetic shield capable of reducing field effect at the frequency predominant in the area.

ELECTROSTATIC FIELD SHIELDING

Electrostatic potentials in the vicinity of the tube cathode, differing greatly from that of the cathode, will deflect released electrons to a degree whereby they will strike the glass side walls of the tube, possibly causing a fluorescence within the glass. This fluorescence, of course, feeds back to the cathode causing an error signal. A close-fitting conductive sleeve around the tube envelope, energized to tube cathode potential, will relieve this problem.

TUBE PERFORMANCE DUE TO HOUSING DESIGN

Several miscellaneous factors of tube housing design can also affect tube performance.

WINDOW DEWING is a common problem in refrigerated chambers. An evacuated thermopane-type window construction of proper design is, without question, the best for frost and dew-free operation. Next best is a purged thermopane window utilizing one of the readily available laboratory gases as the purge agent. One shortcoming of this approach is the dew point of the gas used. For example, standard laboratory gas has a dew point approximately −80°F (−62°C) and research grade laboratory gases have dew points falling in the region of −105°F (−75°C). Since the moisture in the gas will condense at its dew point, use of purged windows is limited to temperatures warmer than the gas dew point for dew-free operation.

The selection of glass materials to be used in front of photomultiplier tubes has a bearing on the operational parameters because the presence of Cerenkov Radiation in thick pieces of glass will be noticeable as an error signal from the tube. In addition, the transmission characteristics of the glass are directly related to the wavelength of light being measured (Figure 2). Plexiglas is an excellent material for work done in the visible light range. Brass and stainless steel of certain types have radio-active elements which can cause scintillations within the glass of the tube envelope when in close proximity to the tube.

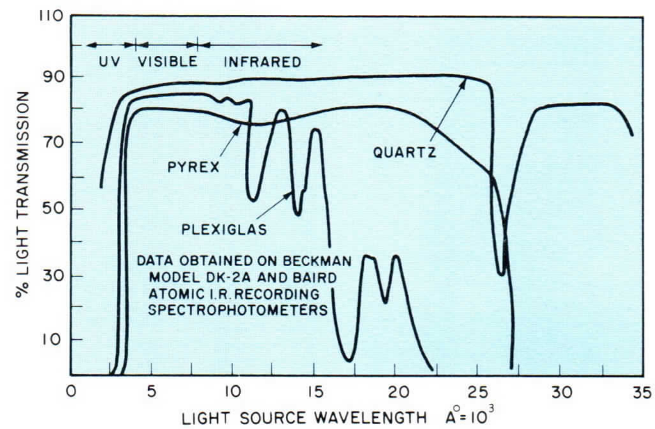


FIGURE 2
INSULATING WINDOW LIGHT TRANSMISSION CURVES

Tube sockets manufactured from mica-filed bakelite are inherently noisier than DIALLYL PHTHALATE or Teflon. Unbased tubes utilizing Teflon sockets are the best performers with respect to low noise. Washing the tube base down with acetone or Freon prior to insertion in the socket is a good practice. Dirt particles on surface of the electrostatic field will emit corona from their peaks that can be readily picked up by the photomultiplier tube. Masking tape pads make a fine device for cleaning the interior of photomultiplier tube chambers.

ELECTRICAL LEAKAGE either at the tube socket or along the dynode leads can show up as an error signal and is easily held to an insignificant level through the use of potting materials and Teflon sleeving.

SCINTILLATION of an unwanted nature may also occur if silica-gel dessicants are used near photomultiplier tubes. Certain of these crystals may be thermo- or tribo-luminescent or contain radio-active contaminants.

Attention to the several considerations noted here can have significant effects on the results obtained by photomultiplier tubes in applications where it is desired to improve performance with cooling techniques.

USE OF HEAT PUMPS WITH PHOTOMULTIPLIER TUBE HOUSINGS

Integral use of thermoelectric heat pumps with photomultiplier tube housings is one of the most versatile methods developed for providing optimum performance. Continuous operation without the need for monitoring plus precise temperature control of the tube cathode and completely dew-free operation are among the major advantages offered by Products for Research photomultiplier refrigerated environmental chambers. These chambers are a complete electromechanical housing having a magnetic shield surrounding the tube envelope and electrically connected to the cathode circuit of the chamber, encapsulated dynode resistor string, and necessary input/output connectors. The user must provide only line power to the power supply, high voltage power to the tube, and amplifier circuitry for the signal read-out. The use-proven design is exceptionally rugged and all parts have been selected to insure long-life performance.

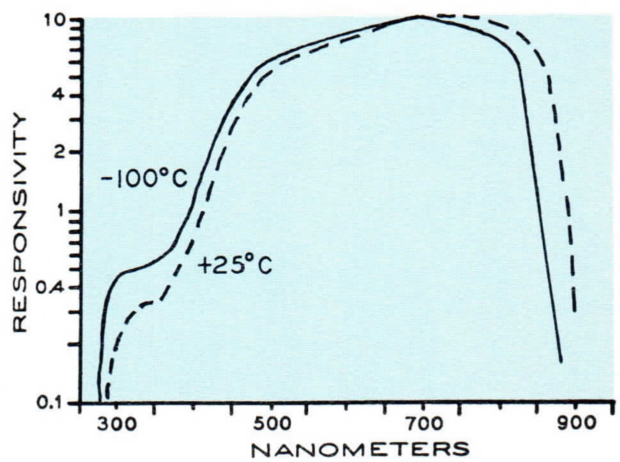
Ambient Air

Chamber performance is limited by ambient air temperatures which is why all specifications in this catalog refer to a +25°C maximum ambient. This temperature is a maximum to allow chamber performance within the specified cooling limits. A cooler ambient, however, will allow performance in excess of published specifications; and a warmer temperature will degrade the performance. The upper limit temperature permits operation to 160°F without damage to the chamber.

In addition to its thermoelectric cooling chambers, Products for Research, Inc. manufactures chambers with the same basic electro-mechanical construction but which use external coolant materials with temperatures down −100°C. Dry ice with methyl alcohol and liquid nitrogen are typical coolant materials suitable for use in the chambers described on pages 4 and 10.

TEMPERATURE EFFECTS ON WAVELENGTH RESPONSE

The more you cool a photomultiplier tube, the better performance—right? Wrong! Experimental data now shows that cooling should be limited to a specific temperature where the optimum performance is achieved.



MOISTURE CONTROL IN COOLED HOUSINGS

Chambers operated continuously for six (6) to eight (8) months should be subjected to a bake-out period to drive off contaminating moisture collected within the chamber.

Proceed as follows:

(a) Remove window retainer ring and window cell.

(b) Remove tube socket assembly and place P.M. tube in safe storage.

(c) Disconnect D.C. power supply/controller.

(d) Place chamber, tube socket assembly, window cell and retainer ring in an oven for eight (8) hours set to 40° C (104° F) maximum.

After bake-out, lubricate all "O" Rings with "O" Ring lub or vacuum grease, reassemble chamber, clean base of P.M. tube and put back into operation.

STANDARD OPTIONS FOR PMT REFRIGERATED CHAMBERS

All units are delivered complete and wired for operation with tube socket, dynode resistor string and power supply unless otherwise specified. The following options may be specified at additional cost per PFR Price List:

	102/102TS	104/104TS	109/109TS	114	200/241	220
1. Pyrex glass insulating window	X	X	X	std	std	X
2. Quart glass insulating window	X	X	X	X	X	X
3. Temperature controller	XX	XX	XX	std	no	no
4. Additional interchangeable tube-socket ass'y.	X	X	X	X	X	X
5. Non-standard dynode resistors	XXX	XXX	XXX	XXX	XXX	XXX
6. Front mounting adapter	X	X	std	std	std	X
7. S-504 high voltage supply	X	X	X	X	S-502	S502
8. Power supply arranged for 19" relay rack mount.	X	X	X	X	no	no
9. PR-201 No-Dew attachment	X	X	X	std	std	std

X — options available XX — add TS to the Model number XXX — specify desired values on order

In addition, non-standard options may also be ordered:

- ☐ Potting of small amplifiers in the interchangeable tube socket assemblies
- ☐ Incorporation of optical system elements in one or more panes of window assembly.
- ☐ Temperature controller regulation of cathode temperature at values below specifications for cool ambient conditions
- ☐ Other useful adaptations which permit our chamber to mate most functionally with your particular system.

	PR-1000	PR-1100	PR-1101	PR-1102	PR-2200
1. Magnetic Shielding (add suffix SH to part No.	X	X	X	n/a	included
2. Additional interchangeable tube-socket ass'y	X	X	X	X	X

CUSTOM EQUIPMENT

To provide optimum cooling and/or housing for any photomultiplier tubes, Products for Research will develop custom PMT housings that meet your specific system requirements.

Examples of such custom assemblies include the customized Model TE-102 (illustrated here) which permitted front end attachment to a special tripod mounted spectrophotometer. Additional information on this and other PFR custom chambers is available on request.

ORDERING INFORMATION

Please be sure to specify photomultiplier TUBE TYPE with ordering information. If you have any questions regarding selection of equipment for optimal performance with specific tubes, please call: (617) 774-3250.

Generally, products covered in this catalog are available within 30 days. Prices are in accordance with the current Products for Research Price List.

NOTE: Equipment described here may be modified to more closely meet specific system requirements. For example, the dynode string resistors may be of any value and a load resistor may be included within the socket assembly along with a small pre-amp. Please contact our Sales Department for information on special orders.

WARRANTY

All Products for Research photomultiplier tube housings and chambers are guaranteed against defects in materials and workmanship for a period of two (2) years from time of shipment.

REPRESENTED BY:

DISTRIBUTED BY
E.M.I. ELECTRONICS LTD.,
ELECTRON TUBE DIVISION
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PRODUCTS FOR RESEARCH, INC.
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PRINTED IN U.S.A.

SILICON AVALANCHE
PHOTODIODES

Silicon Avalanche Photodiodes

The EMI range of silicon avalanche photodiodes carries type numbers in the S30500 series. Even type numbers (S30500, S30502, etc.) are single chip diodes and odd type numbers are the respective double chip counterparts which have identical optical performance but have the advantage of being easier to control in environments of changing temperature; the double chip combination is discussed below.

The S30500 has an active area of 0.5 mm diameter, a useful photocurrent multiplication ratio (M) of about 200 and a low leakage current. It is primarily intended as a low light level detector in the near infra red region of the electromagnetic spectrum (d.c. peak efficiency is 900 nm approximately with useful response from 580 and 1100 nm). The speed of response is another feature of the device although the bandwidth for the longer wavelengths is limited by the slow collection of carriers released in the zero field absorption region surrounding the depletion region. The output signal therefore consists of two components. At the peak response 900 nm, the fast component risetime (10% to 90%) is less than 0.5 ns and the slow component is just over 1 μs. The ratio of fast to total amplitudes is approximately 100% at 700 nm, 40% at 900 nm and 23% at 1060 nm.

The main application for this detector is in laser rangefinding systems operating at 0.9 or 1.06 μ where fast response to a pulse with a steep leading edge is required and the slow component output is unimportant. Another successful application for this photodiode is as a detector of very fast pulses in laser doppler systems. It has also been found possible to use an avalanche photodiode as a superheterodyne modulation frequency changing detector by coupling an oscillator to the bias supply, thereby beating the light modulation signal to a difference frequency signal which can be handled by narrower band amplifiers. Experiments have shown that the S30500 can detect the modulation of an 833 nm light beam up to modulation frequencies in excess of 1 GHz using this technique. This would not be possible with ordinary non-avalanche PIN photodiodes as their sensitivity/voltage dependence is too low.

The S30502 is based on the S30500 but uses a smaller effective active area of 0.28 mm diameter which is of advantage in some rangefinder systems. This reduction, however, is achieved by physical masking and the photodiode does not therefore have lower leakage current.

A developmental photodiode type S30508 is of similar construction to the S30500 but has an increased active area of 2.5 mm diameter.

A new manufacturing technique has been adopted to produce the S30504 and S30506 epitaxial avalanche photodiodes. The device structure has been altered to ensure that all signal carriers are collected with the minimum delay thereby ensuring high frequency operation into the gigahertz region. This performance is maintained for all wavelengths of radiation. The S30504 has a high photocurrent gain up to 300 typically for stable operation and requires only a low bias voltage of 80 volts. The active area is 100 microns in diameter and is therefore well suited for use in fibre line communication systems. At 850 nm risetimes (10% to 90%) are less than 0.5 ns and decay times (100% to 0%) are under 20 ns. A 'pill' package encapsulation with provision for close coupling to a fibre optic line will soon be introduced. The S30506 has a 0.5 mm diameter active area and a similar risetime of 0.5 ns with a decay time of less than 10 ns. At present stable gains of 100 times are readily achieved.

There are many advantages associated with avalanche photodiodes but the problem of maintaining a stable operating point was one which had to be overcome. This has been achieved by the introduction of a range of double chip avalanche photodiodes. In this configuration, two near identical chips are mounted in the same can; one chip is masked from incident radiation and is operated near breakdown to draw a constant current. A change in temperature will alter the bias voltage at the control diode and this change may be used to regulate the bias applied to the active chip. This mode of stabilisation may be used successfully in many applications, including C.W., a feature of considerable value in general detector circuit design. This type of controller is also able to operate effectively over the full device temperature range which, for the EMI range of devices, is -70°C to $+125^{\circ}$C.

In contrast to the double chip device, single chip avalanche devices can only be readily stabilised against temperature variation if the signal and dark current components of the device output can be separated. This can be achieved by gating in some cases, or, if the light input occurs for only a very short time compared with the pulse repetition period, the signal component can be ignored. Laser rangefinders are an example of the latter case.

There are many questions which are often asked regarding the successful operation and application of avalanche photodiodes and by far the most popular is 'Why use an avalanche photodiode in the first place?'. The simple answer is that one must consider a photodetector as part of a system. A useful figure of merit describing photodetectors is the noise equivalent power (NEP) and it is clearly advantageous for a device to have as low a value of NEP as possible. It is possible to obtain small PIN non-avalanche photodiodes having very low NEP's: however, to use the signal from the device, an amplifier is required but as soon as the device is coupled into such a system, the limitation emphasis changes from device noise to amplifier noise as the latter is generally several orders greater. It is apparent that system signal to noise ratio (SSNR) would be improved if the device could be made to give a greater signal, even though its noise level may approach that of the following amplifier. An avalanche photodiode achieves this. In fact, as signal power multiplies as M^2, noise power multiplies as $M^{2.3}$ but the device SNR degradation is negligible in terms of SSNR so long as device avalanche noise is less than amplifier noise. Genuine improvements of 100 and over can be obtained in SSNR thus demonstrating the value of an avalanche device over an ordinary PIN photodiode.

A range of associated units for use with our avalanche photodiodes are available e.g. pre-amplifier, main amplifier, bias controller and complete amplifier and controller modules including a diode mount. When a suitable double chip photodiode is added, the module becomes a complete photodetector unit.

For further information on this product please telephone Extension Ext.2551

EMI

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Telephone: 01–573 3888 Cables: Emitube, London. Telex: London 935261
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International leaders in music, electronics and leisure.

D619/B
DS.1154

Types S30500 & S30501

Photodiode

EMI SILICON AVALANCHE PHOTODIODE

TYPES S30500 AND S30501

The S30500 is an avalanche multiplying silicon photodiode designed for stable operation near the avalanche breakdown region. The low noise avalanche multiplication of carriers within the device results in a much enhanced system signal to noise ratio by a factor of about 100 times using a suitable low noise pre-amplifier. The active area of the photodiode is $0.2mm^2$ and the standard encapsulation is a low-profile TO-5 can incorporating an optical quality glass window giving at least a 90° field of view ($0.6\,\pi$ steradians).

The S30501 is a double-chip silicon avalanche photodiode. The detector chip is similar to the S30500 and the second chip used to provide a reference for controlling the detector bias-voltage is selected for close electrical characteristics. Both chips are mounted in a low-profile TO-5 can, the reference chip being masked against incident light. The key feature of this double-chip arrangement is that the same bias-controller may be used for all applications from d.c. to the maximum frequency of the device, over a wide temperature range.

The small overall size, robust construction and high sensitivity of the S30500 and S30501 photodiodes make them suitable for many applications. In particular, these photodiodes may be used as a fast pulse detector in rangefinder systems and as a replacement for vacuum devices having S1 responses. They may also be used as a heterodyne frequency changing detector of modulated light by modulating the bias-voltage from a local oscillator. In the near future, it is expected that miniature control circuits and pre-amplifiers will be added to our range. Enquiries for these, and for special photodiodes or for the S30500 or S30501 to a defence standard specification, are welcomed.

CHARACTERISTICS

Mechanical

Construction	The diodes are hermetically sealed in type TO-5 cans with optical quality crown zinc glass windows
Field of view	90° minimum ($0.6\,\pi$ steradians)
Sensitive area	0.5 mm diameter circle (approx. 0.2 mm^2).
Centrality of active area	0.25 mm max. with respect to can
Overall dimensions	See outline diagram
Lead connections	Viewed from lead side of can, clockwise from tag: 1. Detector diode cathode (positive for reverse bias) 2. Not connected in S30500, reference diode cathode in S30501 (positive for reverse bias) 3. Anodes connected to can

Electrical (Performance at temperature of 25°C)

Photocurrent multiplication (M)	Minimum 100 (see note 1)
Operating voltages	In the range 160V to 220V (see note 2)
Leakage current	Surface leakage (typically) 30nA at M = 100 Bulk leakage 0.1nA at M = 1 (50V)
Sensitivity	For multiplication (M) of 100 (see note 3).

Wavelength in nm	Responsivity in A/W Fast	Total
694	17	17
900	15	37
1065	4	14

Electrical *(continued)*

Risetime (10% to 90%)	Less than 0.5 ns (fast), approx. 1 μs (slow) (see note 3).
Capacitance	5.5 pf max.
Forward characteristic	1V forward bias gives forward current not less than 8×10^{-3} A
Noise	No microplasma evident for M = 100. Noise power dependence on gain not worse than M^2:[4]
Temperature coefficient of breakdown voltage	Less than +250 mV per °C
Noise equivalent power	Typically 3×10^{-9} watts at wavelength of 1060 nm in bandwidth of 0.1 of 15 MHz (see note 3)

Associated Circuitry

Our photodiodes are tested using a pre-amplifier having a r.m.s. noise equivalent input current of approximately 10 nA. (0.1 to 15 MHz).

Absolute Maximum Ratings

(Limiting values are absolute in accordance with IEC 134)

Maximum continuous power dissipation at 25°C case temperature . . . 50 mW

Maximum operational temperature range . . . . . . –70°C to +125°C.

Notes:

1. The noise performance of each device is tested as follows with a pre-amplifier of approx. 10 nA r.m.s. noise equivalent input current (measured in 0.1 – 15 MHz bandwidth) the diode bias is increased from 50V (where M = 1) until a multiplication M = 100 is observed, using a pulsed 900 nm emitter as a source. At this bias, the system noise shall not be greater than a 14 nA r.m.s. noise equivalent input current. Generally speaking, for M = 100, the system noise is well within this figure and typically diodes reach this noise figure at multiplications of 150 to 200.

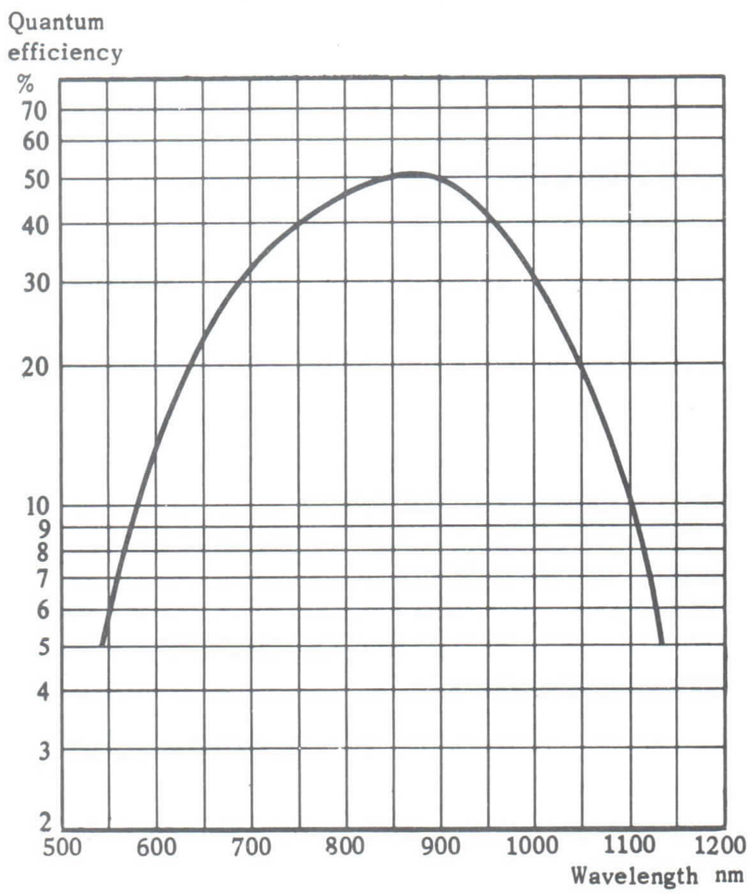
2. The recommended operating bias voltage for each photodiode is given on the test sheet supplied with each device.

3. The response of the detector to a fast light pulse of 1.5 μs duration is examined at three wavelengths. At each wavelength, the ratio of the amplitude of the fast component to the maximum amplitude is noted to derive the fast responsivity quoted, referring to the plotted spectral response as a datum. The slower component of the response is caused by the slow collection of carriers released by the penetration of light into the zero field absorption region. The depth of this penetration increases with wavelength.

4. For a discussion of silicon avalanche photodiode noise and system noise equivalent power, see 'The Measurement of Multiplied Noise in Low Noise Silicon Avalanche Photodiodes and its Effect on Achievable NEP' by J.A.Raines, SERL Technical Journal, Vol.121, No.1, Feb.1971.

5. The use of the S30500 as a detector in fibre optic systems is described in the paper 'Pulse Dispersion in Glass Fibres' by W.A.Gambling, D.N.Payne, H.Sunak, of Southampton University, in Electronics Letters, 9th September 1971, Vol.8, No.18, Page 549.

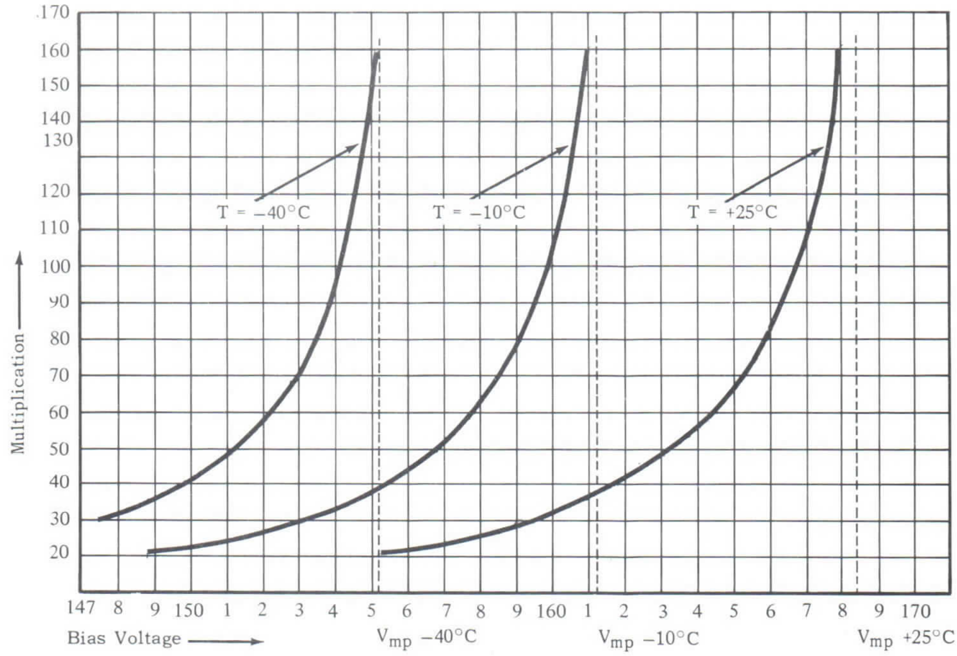
Quantum Efficiency Curve



Note: Measurements made for continuous-wave radiation derived for M = 1

EMI Silicon Avalanche Photodiodes Types S30500 and S30501

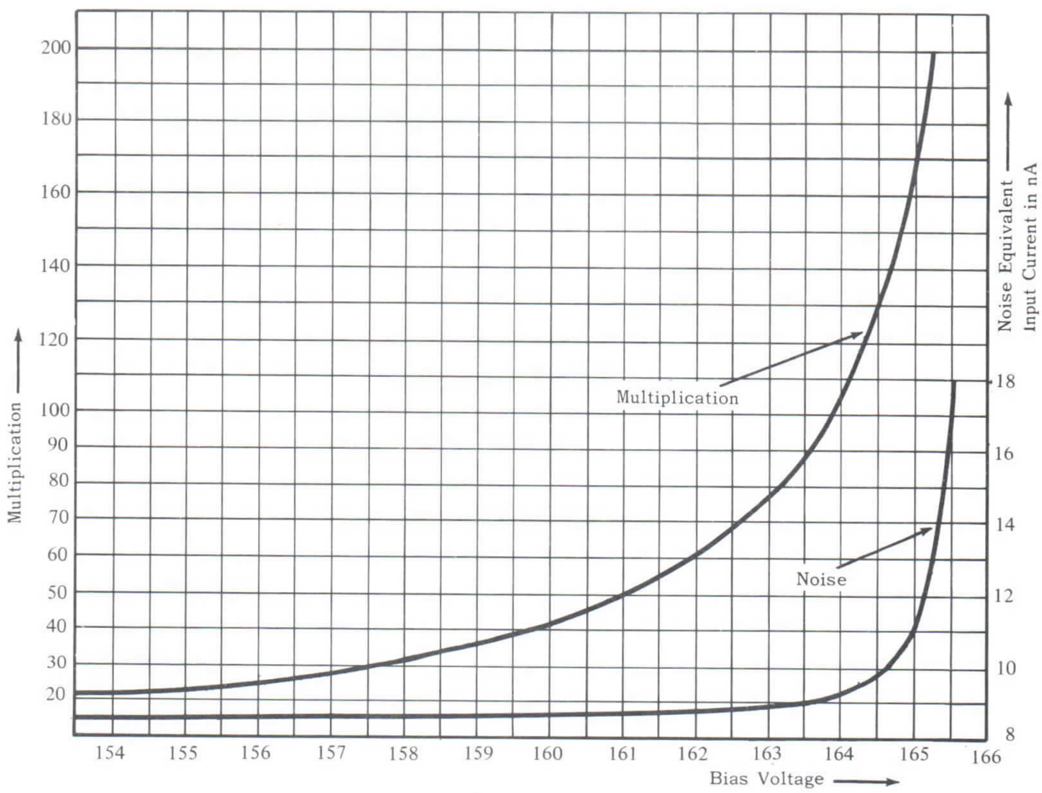
Typical Graphs of Multiplication v Bias at three temperatures

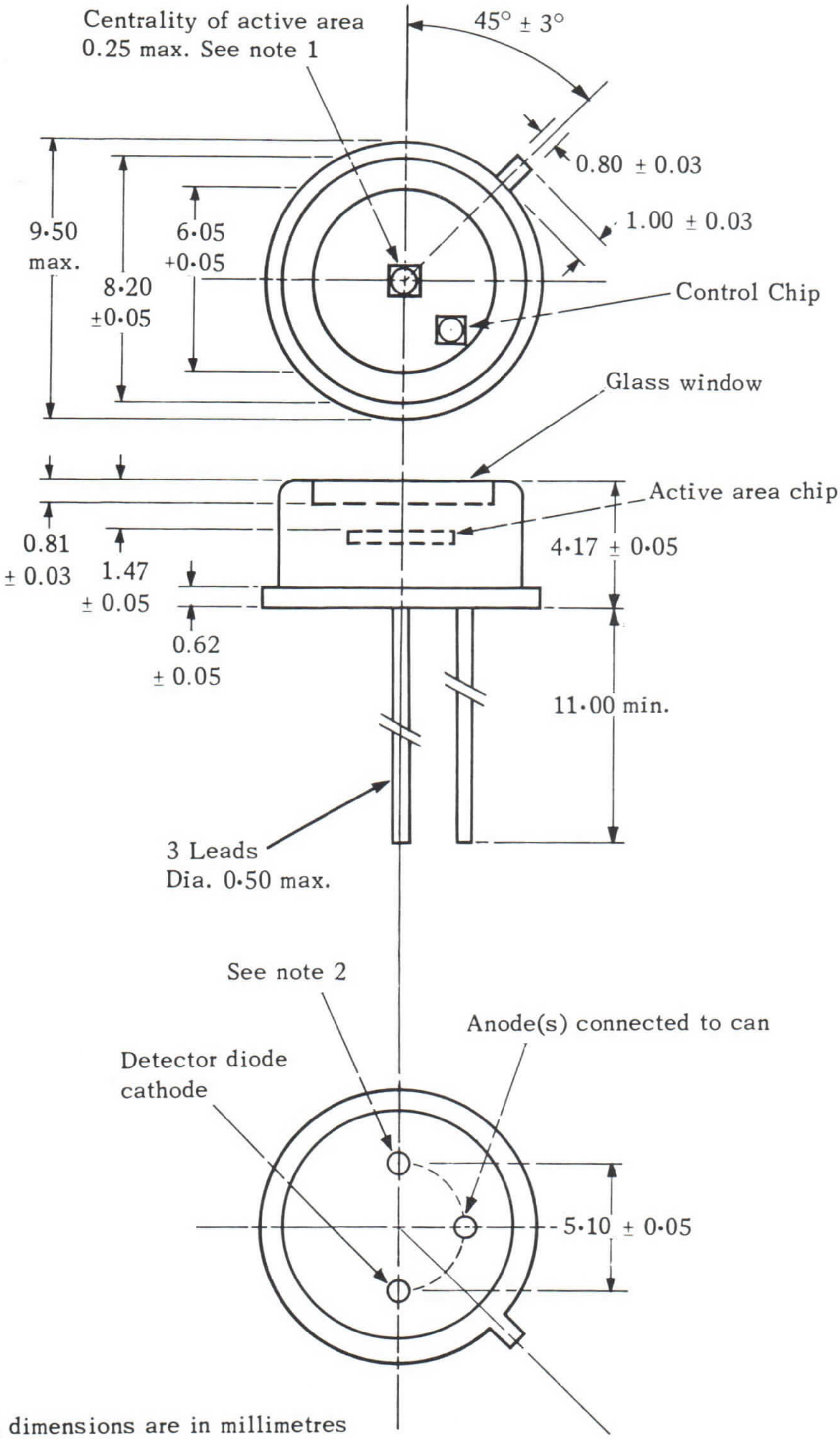


Note: V_{mp} is that bias at which the on set of microplasma breakdown is observed (measured at a mean rate of 5 microplasma pulses per second)

EMI Silicon Avalanche Photodiodes Types S30500 and S30501

Typical Curves of Multiplication and Noise Current at 23°C





All dimensions are in millimetres

Note 1 Diameter of active area 0.50 ±0.05 in S30500 and S30501. 0.1 nominal in S30504 and S30505.

Note 2 Blank in S30500 and S30504. Reference diode cathode in S30501 and S30505.

For further information concerning this product please telephone Extension 2551

D615/e
DS. 1077

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Types S30504 & S30505

Photodiode

EMI EPITAXIAL SILICON AVALANCHE PHOTODIODE
Types S30504 and S30505

The S30504 is an avalanche multiplying silicon photodiode using epitaxial material designed for stable operation near the avalanche breakdown region. The low noise avalanche multiplication of carriers within the device results in a much enhanced system signal to noise ratio by a factor of about 200 times using a suitable low noise pre-amplifier. The construction of these photodiodes ensures that practically all carriers are collected with the minimum delay giving risetimes well under a nanosecond. The active area of the photodiode is 8 x 10^{-3} mm^2 and the standard encapsulation is a low-profile TO-5 can incorporating an optical quality glass window giving at least 90° field of view (0.6 π steradians). A "pill package" encapsulation will shortly be introduced.

The S30505 is a double chip epitaxial silicon avalanche photodiode. The detector chip is similar to the S30504 and the second chip, used to provide a reference to control the detector bias voltage, is selected for close electrical characteristics to the detector. Both chips are mounted in a low-profile TO-5 can, the reference chip being masked against incident light. The key feature of this double chip arrangement is that the same bias controller may be used for all applications from d.c. to the maximum frequency of the device, over a wide temperature range.

The small overall size, robust construction and high sensitivity of the S30504 and S30505 photodiodes make them suitable for many applications. In particular, these photodiodes may be used as a fast pulse detector in rangefinder systems and as a detector in a very wide band fibre optic communication system. They may also be used as a heterodyne frequency changing detector of modulated light by modulating the bias voltage from a local oscillator. In the near future, it is expected that miniature control circuits and pre-amplifiers will be added to our range. Enquiries for these and for special photodiodes designed to couple into fibre optic lines, are welcomed.

CHARACTERISTICS

Mechanical

Construction	The diodes are hermetically sealed in type TO-5 cans with optical quality crown zinc glass windows.
Field of view	90° minimum (0.6 π steradians)
Sensitive area	0.1 mm diameter circle (approx. 8 x 10^{-3}mm^2).
Centrality of active area	0.25 mm max. with respect to can.
Overall dimensions	See outline diagram.
Lead connections	Viewed from lead side of can, clockwise from tag: 1. Detector diode cathode (positive for reverse bias). 2. Not connected in S30504, reference diode cathode in S30505 (positive for reverse bias). 3. Anodes connected to can.

Electrical (Performance at temperature of 25°C).

Photocurrent multiplication (M)	Minimum 200 (see note 1)
Operating voltages	In the range 60V to 90V (see note 2).
Leakage current	Surface leakage (typically) 2nA at M = 200. Bulk leakage (typically) 0.01nA at M = 1 (20V)
Sensitivity	For multiplication (M) of 200 (see note 3) Wavelength in nm: 900 — Responsivity in A/W: 24 approx.
Risetime (10% to 90%)	Less than 0.5ns limited by inductance in TO5 encapsulation (see note 3).
Capacitance	2.0pf max.
Forward characteristic	1V forward bias gives forward current not less than 8×10^{-3}A.
Noise	No microplasma evident for M = 200. Noise power dependence on gain not worse than $M^{2.4}$
Temperature co-efficient of breakdown voltage	Less than +200mV per °C.

Associated Circuitry

These photodiodes are tested using a pre-amplifier having an r.m.s. noise equivalent input current of approximately 10nA (0.1 to 15 MHz).

Absolute Maximum Ratings

(Limiting values are absolute in accordance with IEC 134)

Maximum continuous power dissipation at 25°C case temperature . . . 50mW

Maximum operational temperature range . . . . . . −70°C to +125°C

Notes:

1. The noise performance of each device is tested as follows. With a pre-amplifier of approximately 10nA r.m.s. noise equivalent input current (measured in 0.1 to 15 MHz bandwidth), the diode bias is increased from 20V until a multiplication M = 200 is observed, using a pulsed 900nm emitter as source. At this bias the system noise is amplifier limited. The diode bias can be increased until a multiplication M = 300 is obtained. At this bias, the system noise is, generally speaking, still amplifier limited but will not be greater than a 14nA r.m.s. noise equivalent input current.

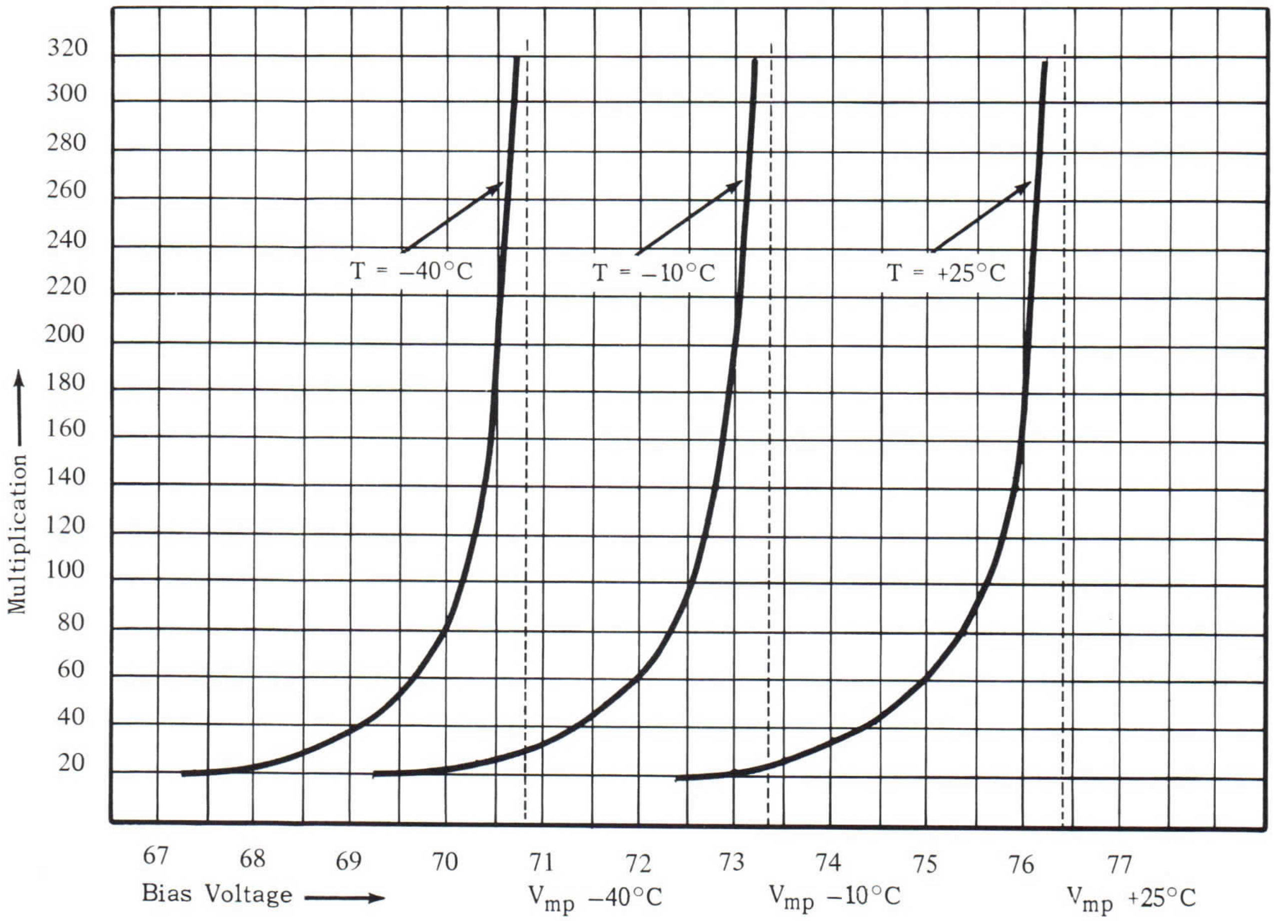
2. The recommended bias voltage for each diode is given on the test sheet supplied with each device.

3. The epitaxial construction of this photodiode removes the slow component of the response to fast light pulses which is present in partially depleted P-N junction photodiodes such as the S30500. This improvement becomes significant at and above radiation wavelengths of 800nm due to the increasing optical absorption length.

4. It is estimated that the fast response of the S30504 will give useful performance up to approximately 3 GHz in the TO5 encapsulation. Enquiries about pill-package or stripline encapsulation will be carefully considered.

EMI Epitaxial Silicon Avalanche Photodiodes Types S30504 and S30505

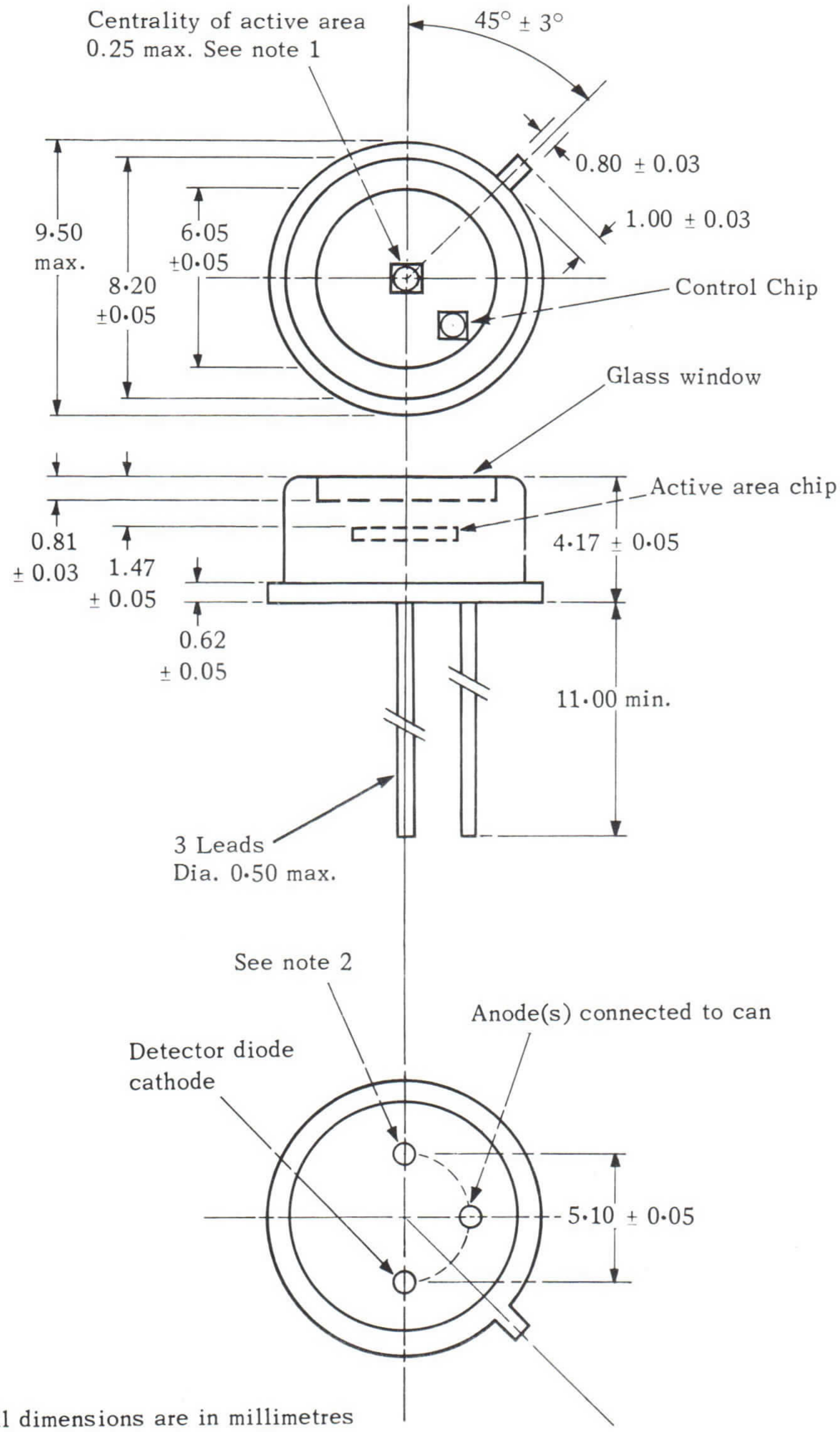
Typical Graphs of Multiplication v Bias at three temperatures



Note: V_{mp} is that bias at which the on set of microplasma breakdown is observed (measured at a mean rate of 5 microplasma pulses per second)

(See Dimensional Outline Drawing overleaf)

Dimensional Outline Drawing



All dimensions are in millimetres

Note 1 Diameter of active area 0.50 ±0.05 in S30500 and S30501. 0.1 nominal in S30504 and S30505.

Note 2 Blank in S30500 and S30504. Reference diode cathode in S30501 and S30505.

D617/a
DS. 1152

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Types C501 & C502

Provisional Data

Pre-Amplifier/Amplifier

PRE-AMPLIFIER TYPE C501 AND AMPLIFIER TYPE C502

Pre-Amplifier Type C501

DESCRIPTION: A low-noise high speed transimpedance amplifier suitable for use with current sources such as photodiodes and photomultipliers.

MECHANICAL DATA: The device is encapsulated in a plastic shell and connections are made to four tinned copper terminal wires on a 2.54 mm grid.

Weight (typical)	4 g
Maximum Outside Dimensions (excluding leads)	
Length	15.3 mm
Width	15.3 mm
Height	10.1 mm
Minimum lead length	12 mm

ABSOLUTE MAXIMUM RATINGS (At 25°C unless specified otherwise)

Supply voltage	+8 V
External load conductance (a.c. coupled)	20 mmho
External load conductance (d.c. coupled)	1 mmho
Operating temperature range	-55 to +125°C
Storage temperature range	-65 to +200°C
Continuous input current	2 mA
Soldering temperature (10 seconds)	240°C

TYPICAL ELECTRICAL CHARACTERISTICS (At 25°C unless specified otherwise)

Parameter	Test Conditions	Value
Supply current	Iin = 0 : R_L = 50Ω	4 mA
Input impedance	f = 20 KHz : R_L = 50Ω	100Ω
Output impedance	f = 20 KHz : Iin = 0	2Ω
Forward transfer impedance (Z_f)	f = 20 KHz : R_L = 50Ω	3900Ω
Bandwidth (-3 dB)	R_L = 50Ω	d.c. to 70 MHz
Temperature coefficient of output voltage	Iin = 4 μA : R_L = 50Ω	±0.001%/°C
Equivalent noise input current	R_L = 50Ω : See Note 1	2.5 pA $Hz^{-\frac{1}{2}}$

Note 1. EQUIVALENT NOISE INPUT CURRENT

The equivalent noise input current in a specific bandwidth is defined as the r.m.s. noise output voltage in that bandwidth divided by the pre-amplifier transimpedance.

Measurement of r.m.s. noise output voltage is made with the pre-amplifier input open circuited and the output fed via a bandpass filter to a wide band r.m.s. voltmeter.

The filter has a response which is 3 dB down at 3 KHz and 15 MHz and has a roll off of 6 dB per octave.

Application Notes

1. This amplifier provides an output voltage which is linearly proportional to input current:–

$$V_{out} = - I_{in} \times Z_f$$

   Enquiries for similar amplifiers with different values of Z_f are welcome.

2. The supply voltage should be decoupled as close to the amplifier as possible. Suggested values are 100Ω and 1 μF electrolytic plus 0.01 μF disc ceramic.

3. When used in areas of high electrical noise it may be necessary to provide electrical screening.

4. Pre-amplifier C501 is especially suitable for use in conjunction with amplifier C502.

★ ★ ★

Amplifier Type C502

DESCRIPTION: A wideband voltage amplifier suitable for use in video and photodetector signal amplification.

MECHANICAL DATA: The device is encapsulated in a plastic shell and connections are made to four tinned copper wires on a 2.54 mm grid.

Weight (typical)	7.3 g

Maximum Outside Dimensions (excluding leads)

Length	28.65 mm
Width	15.3 mm
Height	10.2 mm
Minimum lead length	12 mm

ABSOLUTE MAXIMUM RATINGS (At 25°C unless specified otherwise)

Supply voltage	+14 V
External load conductance (d.c. coupled)	1 mmho
Operating temperature range	-55 to +125°C
Storage temperature range	-65 to +200°C
Soldering temperature (10 seconds)	240°C

TYPICAL ELECTRICAL CHARACTERISTICS (At 25°C unless specified otherwise)

Parameter	Test Conditions		Value
Supply current	Vin = 0 :	R_L = 50Ω	22 mA
Input impedance	f = 20 KHz :	R_L = 50Ω	400Ω
Output impedance	f = 20 KHz :	Vin = 0	10Ω
Bandwidth (-3 dB)	R_L = 50Ω		d.c. to 70 MHz
Power ~~Voltage~~ gain (non-inverting)	f = 20 KHz :	Vin = 100 mV p-p	23 dB
	R_L = 50Ω :		(20 dB min.)
Equivalent noise input voltage	R_L = 50Ω :	See Note 1	1 nV $Hz^{-\frac{1}{2}}$

Note 1. EQUIVALENT NOISE INPUT VOLTAGE

The equivalent noise input voltage in a specific bandwidth is defined as the r.m.s. noise output voltage in that bandwidth divided by the amplifier gain.

Measurement of r.m.s. noise output voltage is made with the amplifier input open circuited and the output fed via a bandpass filter to a wide band r.m.s. voltmeter.

The filter has a response which is 3 dB down at 3 KHz and 15 MHz and has a roll off of 6 dB per octave.

Application Notes

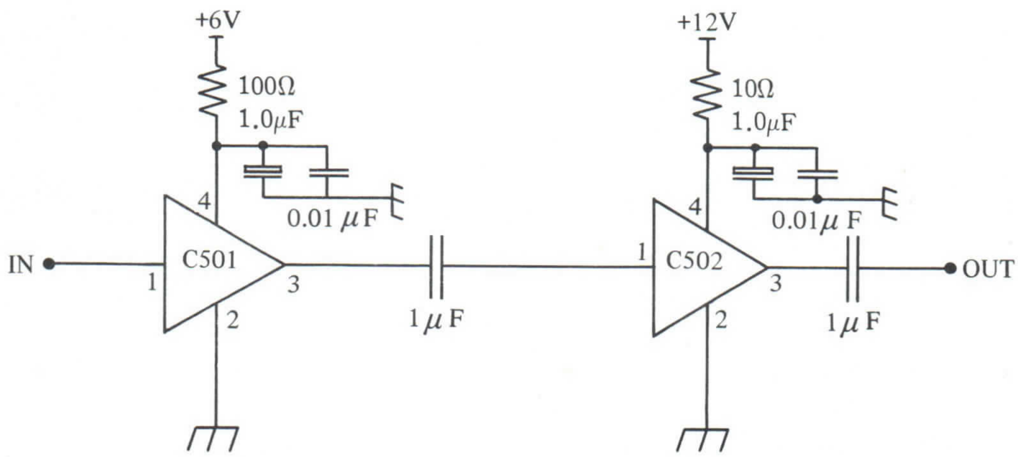
1. The supply voltage should be decoupled as close to the amplifier as possible.

   Suggested values are 10Ω and 1 μF electrolytic plus 0.01 μF disc ceramic.

2. When used in areas of high electrical noise it may be necessary to provide electrical screening.

3. Amplifier C502 is especially suitable for use in conjunction with pre-amplifier C501.

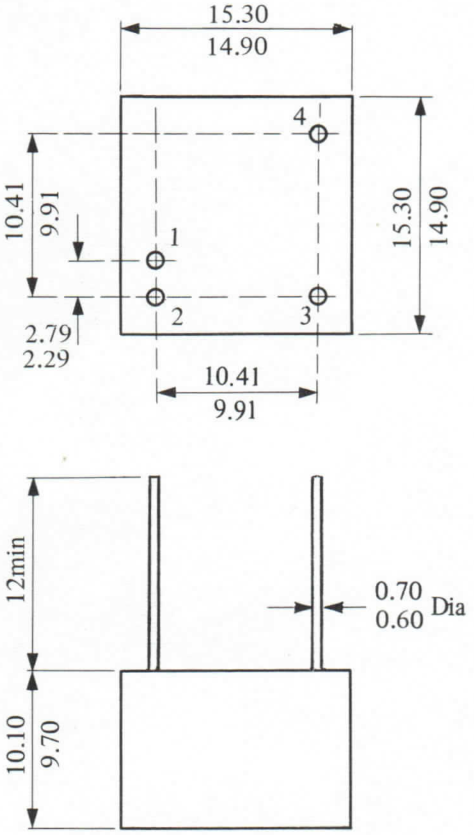
TYPICAL APPLICATION
C501 and C502



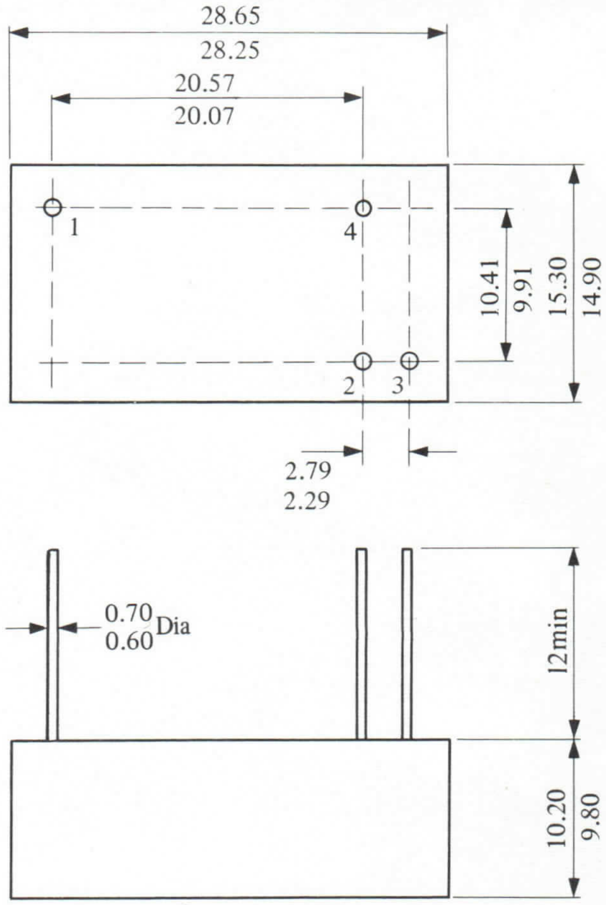
(See Dimensional Outline Drawings overleaf)

DIMENSIONAL OUTLINE DRAWINGS

PRE-AMPLIFIER
TYPE C501



AMPLIFIER
TYPE C502



ALL DIMENSIONS IN MILLIMETRES

TERMINALS

1. INPUT
2. EARTH
3. OUTPUT
4. V +

For further information on these products please telephone Extension 2076.

T496/4a
DS.1164

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Types C511 and C512

PROVISIONAL DATA

BIAS CONTROLLER FOR AVALANCHE PHOTODIODES

BIAS CONTROLLER FOR AVALANCHE PHOTODIODES

* Use C511 for EMI photodiodes S30501, S30503 and selected S30507
* Use C512 for EMI photodiode S30505
* Both types set and maintain stable avalanche gain over a temperature range -55°C to +100°C

Description

Bias controllers C511 and C512 are intended for use with double chip avalanche photodetectors, the breakdown voltage (V_{ref}) of the reference diode being used to regulate the photodiode bias voltage (V_b) and so maintain stable avalanche gain over a wide operating temperature range.

The reference diode is supplied from a controlled current source and the bias voltage output is current limited.

The avalanche gain is set by an external resistance (R_x), not supplied.

Mechanical data

Each device is encapsulated in a plastic shell and connections are made to five tinned copper wires on a 2.54 mm grid.

Typical weight:	25g

Maximum outside dimensions (excluding leads)

Length:	45.0 mm
Width:	17.6 mm
Height:	19.7 mm

Minimum lead length:	12 mm

Absolute maximum ratings

	C511	C512
Supply voltage range (V_{in}):	+250 to +350V	+ 150 to +250V
Operating temperature range:	-55 to + 100°C	-55 to +100°C
Storage temperature range:	-55 to +125°C	-55 to +125°C
Soldering temperature (10 seconds):	240°C	240°C
Reference diode breakdown voltage range (see Note 1):	+125 to +235V	+40 to +110V

S2808/C1
DS.1167

Typical electrical characteristics (At 25°C unless specified otherwise)

		C511	C512
All measurements are made with V_{in}	=	300V	200V
V_{ref}	=	180V	75V
V_b	=	V_{ref}	V_{ref} unless specified otherwise

	C511	C512
Supply current (I_{in}):	2.8 mA	2.6 mA
Reference diode current (I_{ref}):	225 μA	210 μA
Bias current limit (I_b max):	250 μA	250 μA
Bias voltage line regulation (see Note 2):	±0.025%	±0.025%
Bias voltage/Reference voltage tracking error (see Note 3):	±15mV	±25 mV
Bias voltage temperature regulation (see Note 4):	±0.5 mV/°C	±2 mV/°C
Bias supply output impedance (see Note 5):	7 KΩ	7 KΩ
External resistor (R_x) for $V_b = V_{ref}$ (see Note 6)	50 KΩ	100 KΩ
External resistor (R_x) for V_b = V_{ref}-6 volts with C511 (see Note 6): = V_{ref}-4 volts with C512	500 KΩ	500 KΩ

Note 1 Reference diode breakdown voltage range

Because of the significant temperature coefficient of breakdown voltage of avalanche photodiodes, care must be taken to ensure that the reference diode breakdown voltage remains within the specified range.

Note 2 Bias voltage line regulation

Bias voltage line regulation is defined as:—

$$\frac{\Delta \ V_b}{\Delta \ V_{in}} \times 100\%$$

where ΔV_{in} is the supply voltage range

Note 3 Bias voltage/Reference voltage tracking error

Bias and reference voltages are related by the expression

$$(V_{ref} - V_b) = kV_{ref}$$

where k is a constant dependent on gain setting. Bias voltage/reference voltage tracking error is the error in $(V_{ref} - V_b)$ over the V_{ref} working range.

Note 4 Bias voltage temperature regulation

Bias voltage temperature regulation is defined as:—

$$\frac{\Delta \ (V_{ref} - V_b)}{\Delta T} \text{ volts/°C}$$

where ΔT is [100 — (—55)] °C

Note 5 Bias supply output impedance

Bias supply output impedance is defined as:–

$$\frac{\Delta \quad (V_{ref} - V_b)}{\Delta \; I_b} \quad \text{ohms}$$

where $\Delta \; I_b$ is $(2 - 0) \; \mu A$

Note 6 External resistor (R_x)

An external $^1/_8$ watt resistor (not supplied) is required to set V_b with respect to V_{ref} and should be connected between the gain control terminal (4) and the ground terminal (3).

It is important that this resistor should either be low temperature coefficient ($\ngtr$ 50p.p.m/°C) or be maintained at a constant temperature. All measurements in this data sheet are made with R_x maintained at a constant temperature.

Control of avalanche gain can be conveniently obtained by using a multi-turn potentiometer or a series combination of a multi-turn potentiometer and a fixed resistor as a variable R_x.

Note 7 Supply decoupling

Supplies to both the reference and signal diodes of the avalanche photodetector should be decoupled as close to the detector as possible.

Note 8 Short circuit and open circuit protection

Bias controllers C511 and C512 are able to withstand continuous short circuiting or open circuiting of the bias output and gain control circuits.

The reference diode circuit may be continuously open circuited but short circuiting is only permissible for periods of up to 30 seconds beyond which excessive and probably harmful internal heating of the device will occur.

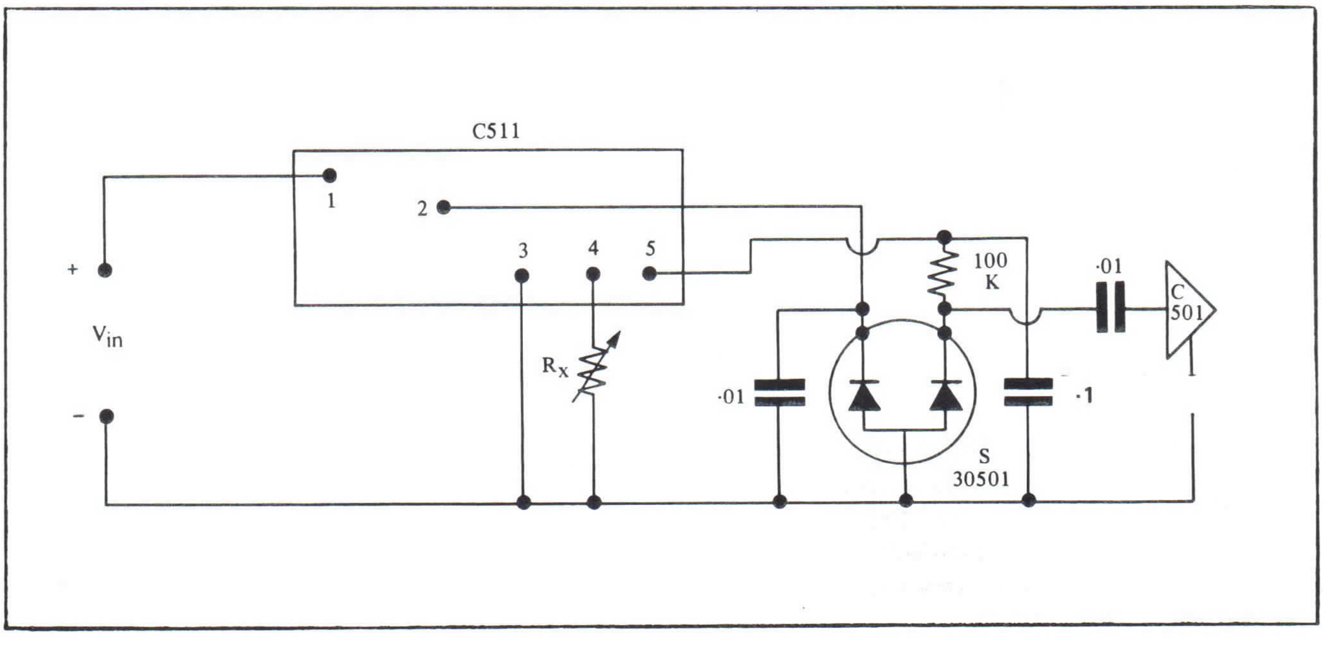
The supply input circuit is reverse polarity protected.

Note 9 Suitable photodetectors

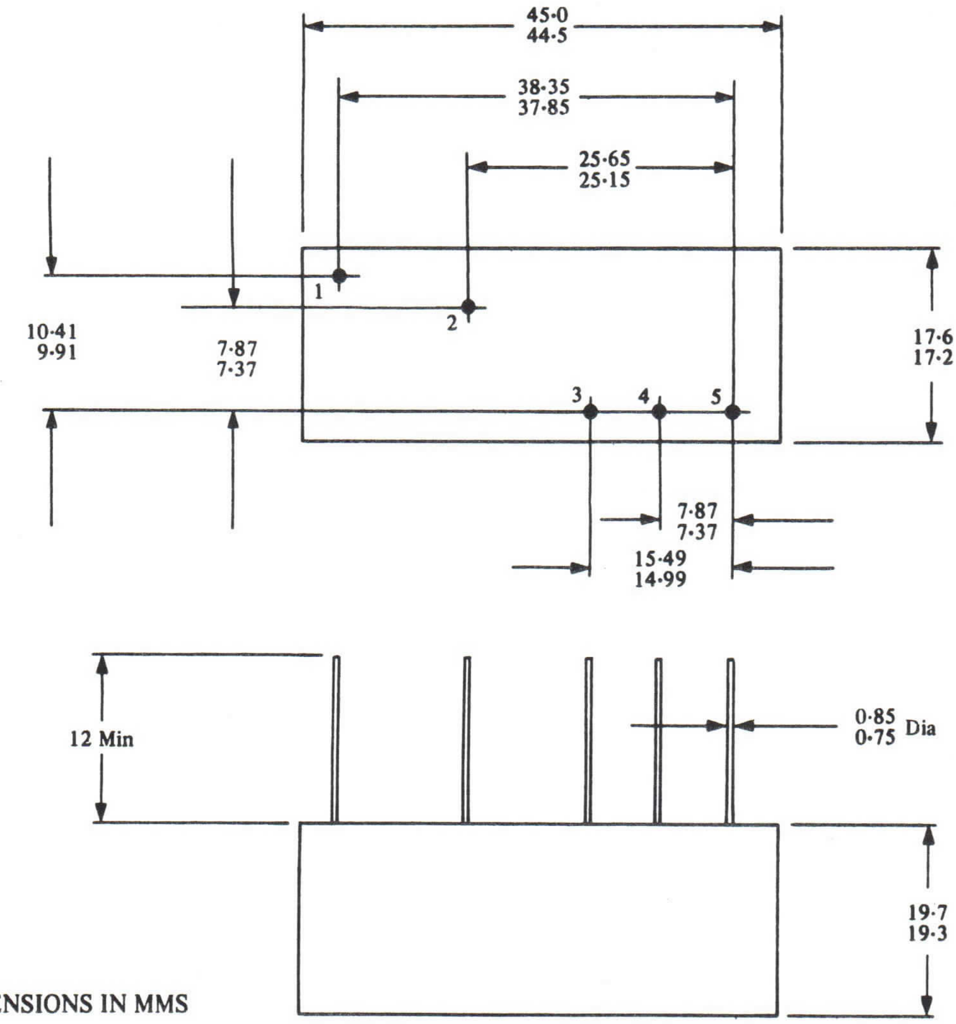
Whilst intended primarily for use in conjunction with EMI avalanche photodetectors these bias controllers can be used with any double chip avalanche photodetector having a reference diode breakdown voltage within the specified range. A pair of separate avalanche photodiodes may also be used so long as the diodes are closely matched for breakdown voltage and temperature coefficient of breakdown voltage and are maintained at the same temperature.

	Type C511	Type C512
EMI avalanche photodiode types	S30501 and S30503 (and selected S30507)	S30505

Typical application



BIAS CONTROLLER C511



DIMENSIONS IN MMS

TERMINALS

1 Supply (V_{in}) + ve
2 V_{ref} + ve
3 Ground
4 Gain control
5 V_b + ve

NOTE: For further information please phone Extension 2551

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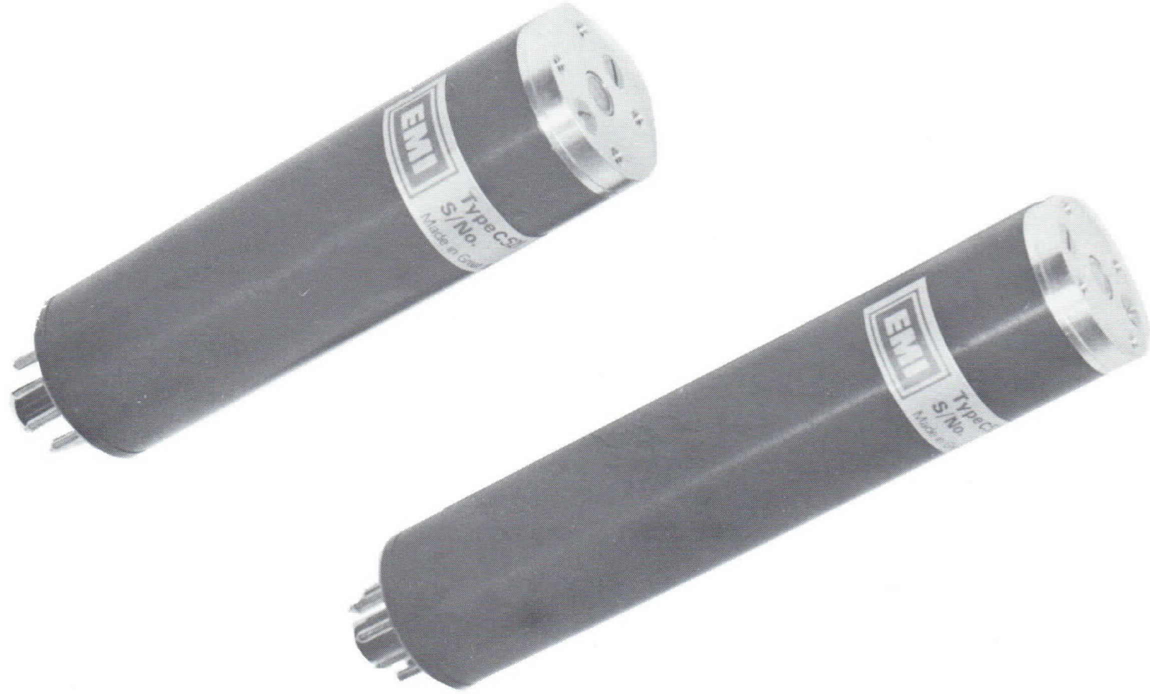
EMI

Types C531, C532, C533 and C534

Photodetector Unit

PHOTODETECTOR UNITS

C531, C532, C533 and C534



Description

Each unit consists of an amplifier-controller module coupled to a double chip silicon avalanche photodiode and forms a complete, high sensitivity photodetector system. Avalanche gain can be externally adjusted and is then stabilized against changes in supply voltages and over a wide range of temperatures.

	Comprising	
Photodetector Unit	Amplifier-Controller Module	Avalanche Photodiode
C531/1	C521	S30501
C531/3	C521	S30503
C532/1	C522	S30501
C532/3	C522	S30503
C533	C523	S30505
C534	C524	S30505

Mechanical Data

Each unit is housed in a black anodised aluminium cylinder and connections are made to an eight pin plug for which a mating socket (International Octal) is provided. The photodiode is mounted in a three pin socket (TO-5) situated on the front of the unit and provision is made for attaching external components such as lenses and filters.

Dimensions

	C531 and C533	
Maximum length		128 mm
Maximum diameter		32.5 mm
Typical weight		100 g
	C532 and C534	
Maximum length		163 mm
Maximum diameter		32.5 mm
Typical weight		120 g

Absolute Maximum and Minimum Ratings

	C531 and C532	
Bias controller supply voltage (V_{in})		+290V to +310V
	C533 and C534	
Bias controller supply voltage (V_{in})		+190V to +210V
	All Types	
Amplifier supply voltage (V_{amp})		+14V to +16V
Amplifier external lead conductance		20 mmho
Operating temperature range		–40°C to +75°C
Storage temperature range		–40°C to +125°C

Typical Electrical Characteristics (at 25°C unless specified otherwise)

Parameter	Test Condition	C531 C533	C532 C534	Unit
Amplifier supply current	V_{amp} = 15	12.5	50	mA
Bias controller supply current	V_{in} = 300 for C531, C532 V_{in} = 200 for C533, C534	3	3	mA
Low frequency cut off (–3 dB)	R_L = 50 Ω	4	4	kHz
Output impedance	Input open circuit f = 1 MHz	2.5	5.0	Ω
Forward transfer impedance Z_F	R_L = 50 Ω f = 1 MHz	3.6	30.0	kΩ

Typical Optical Characteristics

Test Conditions: 25°C
λ = 900 nm
M = 100 (avalanche multiplication)
R_L= 50 Ω

Parameter		C531	C532	C533	C534	Unit
Responsivity	(*R*)	9.6×10^4	8.2×10^5	9.6×10^4	8.2×10^5	VW^{-1}
Risetime		7	7	7	7	nS
Noise equivalent power (NEP) (See note 1)		1.3×10^{-13}	1.3×10^{-13}	2.0×10^{-13}	2.0×10^{-13}	$W\,Hz^{-1/2}$
Detectivity (D*) (See note 2)	530501	3.4×10^{11}	3.4×10^{11}			$cmW^{-1}Hz^{1/2}$
	530503	1.9×10^{11}	1.9×10^{11}			
	530505			4.4×10^{10}	4.4×10^{10}	
Temperature variation of *R* (See note 3) (–40 to +75°C)		±10	±10	±20	±20	%
Spectral response for Q.E. > 10% (refer to appropriate photodiode data)			580 to 1100			nm

Note 1

Noise equivalent power is derived using the expression:—

$$\mathrm{NEP} = V_N / Z_F \, R \, (\Delta F)^{1/2}$$

where V_N is the r.m.s. output noise voltage measured through a CR filter whose response is 3dB down at 10kHz and 15MHz, giving an effective square bandwidth of ΔF = 23.5MHz; Z_F is the forward transfer impedance of the module amplifier and R is the total (slow + fast component) responsivity (in AW^{-1}) of the photodiode. The diode is kept dark during the measurement.

Note 2

The detectivity quoted here is:—

$$D^* = A^{1/2}/\mathrm{NEP}$$

where NEP has been defined in Note 1 and A is the active area of the photodiode. The latter is given below for the relevant devices.

Avalanche Photodiode	Active Diameter (mm)	Active Area (mm^2)
S30501	0.5	1.96×10^{-1}
S30503	0.28	6.15×10^{-2}
S30505	0.1	7.85×10^{-3}

Note 3 — Avalanche Gain Setting

An external $^1/_8$ W resistor (not supplied) is required to set the avalanche multiplication of the photodiode. This is connected between pins 2 (gain) and 3 (ground) on the octal plug.

It is important that this resistor should be either low temperature coefficient ($\not>$ 50 ppm/°C) or maintained at constant temperature. All measurements in this data sheet were made with a 50 ppm/°C resistor at (23 ± 3) °C.

Accurate setting of avalanche gain is best achieved with a multi-turn potentiometer.

Note 4 — Short Circuit and Open Circuit Protection

The gain control (pin 2, octal plug) and signal diode terminal (TO-5 socket) are able to withstand continuous short, or open, circuiting. The reference diode terminal may be open circuited but short circuiting is only permissible for periods of up to 30 seconds, after which the excessive internal heating of the bias controller may cause damage.

Both amplifier and bias controller sections of the unit are reverse polarity protected.

It should be stressed that under no circumstances should a photodiode be plugged in or out while the high voltage supply is switched on. To avoid this happening accidentally, it is advisable to operate the module only when the clamping ring is in position.

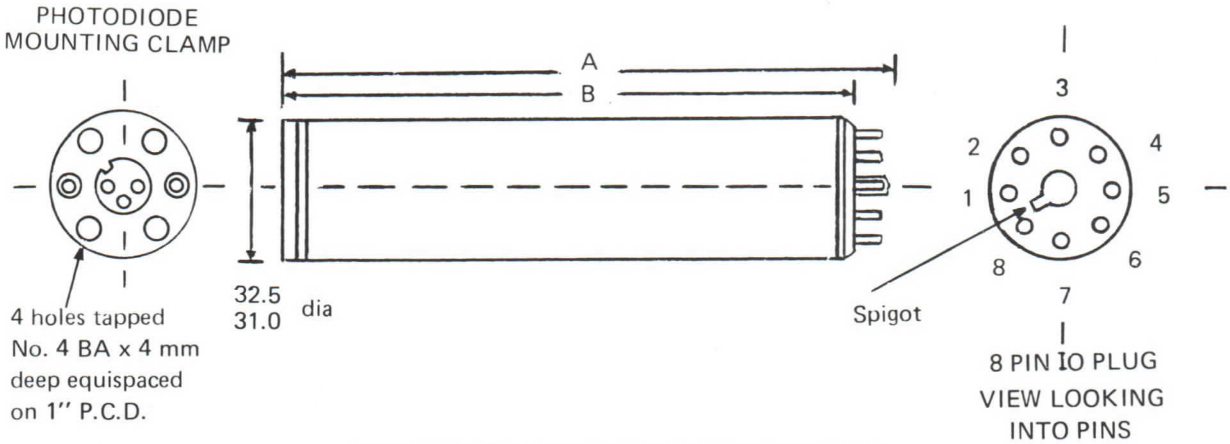
Note 5 — Photodetector Mounting

Unscrew the two 4 BA countersunk headed screws and remove the aluminium clamping ring. Trim the photodiode leads to between 5 — 8 mm in length and insert the photodiode into the three pin socket. Replace the clamping ring and tighten the screws.

Four No. 4 BA x 4 mm deep tapped holes, equispaced on a 1" diameter circle are provided in the clamping ring for attachment of external components such as lenses and filters.

OUTLINE DRAWING

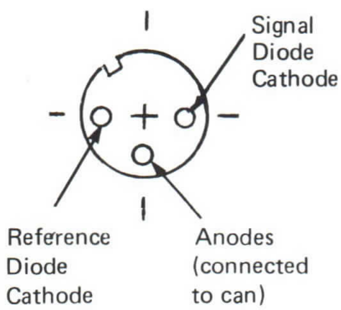
C520 SERIES ELECTRONIC MODULES
C530 SERIES PHOTODETECTOR UNITS



DIMENSION	C521 C523 C531 C533	C522 C524 C532 C534
A	128 126	163 161
B	113.5 111.5	148.5 146.5

ALL DIMENSIONS IN mm

PHOTODIODE SOCKET (TO-5)
(ENLARGED VIEW)



PIN CONNECTIONS

PIN	C521 C522 C531 C532	C523 C524 C533 C534
1	V_{amp}	V_{amp}
2	GAIN	GAIN
3	GROUND	GROUND
4	SIG. OUT	SIG. OUT
5	V_{in}	NC
6	NC	V_{in}
7	NC	NC
8	NC	NC

For further information please telephone Extension 2551

D627/4A
DS.1201

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CAMERA TUBES
AND SCANNING COILS

EMI

Vidicon Camera Tube Types

EMI VIDICON CAMERA TUBE TYPES

STANDARD 26 mm (1 in) SEPARATE MESH VIDICONS

Suitable for broadcast and closed circuit applications

Standard length 6.3 V 90 mA	Standard length 6.3 V 300 mA	Short length 6.3 V 90 mA	Description and application
9677S1	9728S1		High grade tube for Broadcast Studio use.
9677S2	9728S2	9706S2	General tube for Broadcast and Educational Studio use.
9677F1	9728F1		High grade tube for Broadcast Telecine use.
9677F2	9728F2	9706F2	General tube for Broadcast and Educational Telecine use.
9677BX	9728BX		High grade tube for use with Medical X-Ray equipment.
9677B	9728B		High grade tube for Industrial use under low light level.
9677C	9728C	9706C	General Industrial tube.
9677M	9728M	9706M	Tube to a relaxed blemish specification.
9677 Amateur	9728 Amateur		Economical tube for experimental use.

SPECIAL PURPOSE 26 mm (1 in) SEPARATE MESH VIDICONS

Tubes with special faceplates, targets or other features making them suitable for particular applications. Generally available in two grades, 1 and 2, the latter to a relaxed blemish specification.

9677D	(90 mA heater)	Tubes with fibre optic faceplates for direct optical coupling.
9728D	(300 mA heater)	
9677Q	(90 mA heater)	Tubes with quartz faceplates for use in fields of nuclear radiation.
9728Q	(300 mA heater)	
9677UV	(90 mA heater)	Tubes with quartz faceplates and unity gamma ultra violet sensitive targets. The red response is negligible (2500 Å to 6000 Å).
9728UV	(300 mA heater)	
9730*	(90 mA heater)	Short length rugged construction.
9745	(90 mA heater)	Tube with electrostatic deflection and focus.
9745D	(90 mA heater)	Electrostatic tube with fibre optic faceplate for direct optical coupling.
9745Q	(90 mA heater)	Electrostatic tube with quartz faceplate for use in field of nuclear radiation.

18 mm ($^2/_3$ in) SEPARATE MESH VIDICONS

9831S	(90 mA heater)	Broadcast and Educational Studio use.
9831F	(90 mA heater)	Broadcast and Educational Telecine use.
9831	(90 mA heater)	General purpose tube for use in compact closed circuit television cameras.
9831D	(90 mA heater)	Tube with fibre optic faceplate for direct optical coupling.
9831Q	(90 mA heater)	Tube with quartz faceplate for use in field of high nuclear radiation.
9831UV	(90 mA heater)	Tube with quartz faceplate and unity gamma ultra violet sensitive target.

13 mm (½ in) SEPARATE MESH VIDICONS *

9737	(90 mA heater)	Similar to 9738, with a unity gamma fine grain target for slow scan applications such as star tracking.
9738	(90 mA heater)	Rugged construction for general use. The resolution capability is exceptionally high for this size of vidicon.
9738D	(90 mA heater)	Tube with fibre optic faceplate for direct optical coupling.
9738N	(90 mA heater)	Similar to 9738 but meeting a specific rugged specification.
9738Q	(90 mA heater)	Tube with quartz faceplate for use in field of high nuclear radiation.
9738UV	(90 mA heater)	Tube with quartz faceplate and unity gamma ultra violet sensitive target.

DEVELOPMENTAL VIDICONS

Samples of various types of developmental tubes are available, e.g. very short length magnetic and electrostatic, 13 mm diameter electrostatic, etc. Enquiries regarding these or similar tubes are welcomed.

* Mesh connection brought out adjacent to target connection.

Vidicon Tube Intercha

Tube to be replaced			Suggested EMI replacement (Separate mesh construction)			
Type No.	Heater current at 6.3 V. mA	Integral or separate mesh	Direct replacement type	Similar replacement type	Heater current at 6.3 V. mA	Refer to notes
C102A	300	SM	9728C	–	300	–
C102B	95	SM	9677C	–	90	–
C103A	300	SM	9728S2	–	300	–
C103B	95	SM	9677S2	–	90	–
C104A	300	SM	9728F2	–	300	–
C104B	95	SM	9677F1	–	90	–
C105A	300	SM	9728Q	–	300	–
C105B	95	SM	9677Q	–	90	–
C9132	300	IM	–	9728C	300	2
C9132A	300	SM	9728C	–	300	–
C9133	300	IM	–	9728S2	300	2
C9133A	300	SM	9728S2	–	300	–
E1170	95	SM	9831	–	90	–
HS200	600	IM	–	9728C or M	300	1 & 2
HS200A	600	IM	–	9728S2	300	1 & 2
HS201	600	IM	–	9728B	300	1 & 2
HS201A	600	IM	–	9728B	300	1 & 2
M7075	95	SM	9831	–	90	–
OB2	90	IM	–	9677M	90	2
OB7	90	IM	–	9677M	90	2
P810	600	IM	–	9728M	300	1 & 2
P826	600	IM	–	9728 Amateur	300	1 & 2
P841	600	SM	–	9728S2	300	1
P841X	600	SM	–	9728BX	300	1
P842	95	SM	9677S2	–	90	–
P842X	95	SM	9677BX	–	90	–
P843	600	SM	–	9728F2	300	1
P844	95	SM	9677F2	–	90	–
P846	600	SM	–	9728S1	300	1
P847	95	SM	9677S1	–	90	–
P848	600	SM	–	9728C	300	1
P848D	600	SM	–	9728M	300	1
P849	95	SM	9677C	–	90	–
P849D	95	SM	9677M	–	90	–
P860	600	IM	–	9728S2	300	1 & 2
P862	95	IM	–	9677M	90	2
P863	95	SM	9730	–	90	–
P864	95	IM	–	9677C	90	2
P866	95	SM	9706S2	–	90	–
P888	95	SM	9738	–	90	–
P8030	300	SM	9728S2	–	300	–
P8031	300	SM	9728C	–	300	–
TH9806	150	IM	–	9677S2	90	1 & 2
TH9806PA	150	SM	–	9677S2	90	1
TH9807	150	IM	–	9677F2	90	1 & 2
TH9807PA	150	SM	–	9677F2	90	1
TH9808	150	IM	–	9677C	90	1 & 2
TH9808PA	150	SM	–	9677C	90	1
TH9808N	150	IM	–	9677Q	90	1 & 2
TH9812	150	IM	–	9677B	90	1 & 2
TH9812PA	150	SM	–	9677B	90	1
TH9814	150	IM	–	9706C	90	1 & 2
TH9814PA	150	SM	–	9706C	90	1
TH9815	150	IM	–	9677B	90	1 & 2
TH9815PA	150	SM	–	9677B	90	1
TH9817	150	IM	–	9677S1	90	1 & 2
TH9817PA	150	SM	–	9677S1	90	1
TH9818PA	150	SM	–	9677S2	90	1
TH9896	150	SM	–	9677UV	90	1

Tube to be replaced			Suggested EMI replacement (Separate mesh construction)			
Type No.	Heater current at 6.3 V. mA	Integral or separate mesh	Direct replacement type	Similar replacement type	Heater current at 6.3 V. mA	Refer to notes
XQ1001	300	SM	9728B	–	300	–
XQ1002	300	SM	9728S2	–	300	–
XQ1003	300	SM	9728C	–	300	–
XQ1004	300	SM	9728M	–	300	–
XQ1030	95	IM	–	9677M	90	2
XQ1040	95	SM	9677F2	–	90	–
XQ1041	95	SM	9677BX	–	90	–
XQ1042	95	SM	9677S2	–	90	–
XQ1043	95	SM	9677C	–	90	–
XQ1044	95	SM	9677M	–	90	–
XQ1050	300	SM	9728F2	–	300	–
XQ1051	300	SM	9728B	–	300	–
XQ1052	300	SM	9728S2	–	300	–
XQ1053	300	SM	9728C	–	300	–
XQ1054	300	SM	9728M	–	300	–
XQ1060	300	SM	9728BX	–	300	–
XQ1061	300	SM	9728S1 or S2	–	300	–
XQ1062	300	SM	9728C	–	300	–
XQ1063	300	SM	9728M	–	300	–
XQ1064	300	SM	9728 Amateur	–	300	–
XQ1065	300	SM	9728F1 or F2	–	300	–
XQ1066	300	SM	9728D1	–	300	–
XQ1067	300	SM	9728D2	–	300	–
XQ1160	300	SM	–	9730	90	1
XQ1161	300	SM	–	9730	90	1
XQ1240	95	SM	9677C	–	90	–
XQ1241	95	SM	9677M	–	90	–
XQ1300	95	IM	–	9831	90	2
XQ1310	95	SM	9831	–	90	–
20PE11	95	IM	–	9831	90	2
20PE13	95	SM	9831	–	90	–
2255AMR	300	SM	9728M	–	300	–
2255ENT	300	SM	9728 Amateur	–	300	–
2255F	300	SM	9728D	–	300	–
2255FIM	300	SM	9728F1 or F2	–	300	–
2255IND	300	SM	9728C	–	300	–
2255NOR	300	SM	9728S1 or S2	–	300	–
2255ROE	300	SM	9728BX	–	300	–
2255SF	300	SM	9728Q	–	300	–
2260AMR	95	SM	9677M	–	90	–
2260ENT	95	SM	9677 Amateur	–	90	–
2260FIM	95	SM	9677F1 or F2	–	90	–
2260IND	95	SM	9677C	–	90	–
2260NOR	95	SM	9677S1 or S2	–	90	–
2260ROE	95	SM	9677BX	–	90	–
4478	600	IM	–	9728M	300	1 & 2
4488	600	IM	–	9728M	300	1 & 2
7038	600	IM	–	9728F1 or F2	300	1 & 2
7226	150	IM	–	9677B or C	90	1 & 2
7262	95	IM	–	9706M	90	2
7262A	95	IM	–	9706C	90	2

ngeability Information

Tube to be replaced			Suggested EMI replacement (Separate mesh construction)			
Type No.	Heater current at 6.3 V. mA	Integral or separate mesh	Direct replacement type	Similar replacement type	Heater current at 6.3 V. mA	Refer to notes
7325	600	IM	–	9728C	300	1 & 2
7735	600	IM	–	9728M	300	1 & 2
7735A	600	IM	–	9728C or M	300	1 & 2
7735B	600	IM	–	9728S2	300	1 & 2
8484	600	IM	–	9728B	300	1 & 2
8507	600	SM	–	9728S2	300	1
8507A	600	SM	–	9728C	300	1
8541	95	SM	9677C	–	90	–
8541A	95	SM	9677S2	–	90	–
8572	600	SM	–	9728F2	300	1
8573A	95	SM	9706S2 or C	–	90	–
8604	95	SM	9677F2	–	90	–
8625	600	SM	–	9728S1	300	1
8626	95	SM	9677S1	–	90	–
8823	95	SM	9831	–	90	–
8844	95	SM	9831	–	90	–
9620	95	IM	–	9677M	90	2
9677P	90	SM	9677M	–	90	–
9677SC	90	SM	9677S1	–	90	–
9697	90	SM	9738	–	90	–

Tube to be replaced			Suggested EMI replacement (Separate mesh construction)			
Type No.	Heater current at 6.3 V. mA	Integral or separate mesh	Direct replacement type	Similar replacement type	Heater current at 6.3 V. mA	Refer to notes
10667F	600	IM	–	9728F2	300	1 & 2
10667G	600	IM	–	9728C	300	1 & 2
10667M	600	IM	–	9728M	300	1 & 2
10667S	600	IM	–	9728S2	300	1 & 2
10667SC	600	IM	–	9728S1	300	1 & 2
10667UV	600	IM	–	9728UV	300	1 & 2
55850AM	90	IM	–	9677M	90	2
55850F	90	IM	–	9677F2	90	2
55850N	90	IM	–	9677C	90	2
55850S	90	IM	–	9677S2	90	2
55850SR	90	IM	–	9677B	90	2
55851AM	90	SM	9677M	–	90	–
55851F	90	SM	9677F2	–	90	–
55851N	90	SM	9677C	–	90	–
55851S	90	SM	9677S2	–	90	–
55851SR	90	SM	9677B	–	90	–
55852AM	300	SM	9728M	–	300	–
55852F	300	SM	9728F2	–	300	–
55852N	300	SM	9728C	–	300	–
55852S	300	SM	9728S2	–	300	–
55852R	300	SM	9728B	–	300	–

Suggested Direct Replacement Types are tubes which will operate directly in equipment designed around the original types. The tubes may not, however, be identical in all respects, e.g., spectral response.

Suggested Similar Replacement Types are tubes which will operate in the majority of equipment designed around the original types. It may, however, be necessary to make some minor modification to the equipment.

Note 1 Care should be taken when using tubes of differing heater currents, that the supply arrangement is suitable.

Note 2 When using a separate mesh (SM) tube in place of an integral mesh (IM) tube, electrodes G3 and G4 should be strapped together on the tube socket, or the camera modified electrically for separate mesh operation.

For further information on the relative operation of the above types or for suggested alternatives to types not listed, please contact the Electron Tube Division at our address overleaf or by telephone 01–573 3888, Ext.2078. Full data sheets on EMI manufactured tubes are available on request.

Product Range of EMI Electron Tube Division . .

The EMI ELECTRON TUBE DIVISION
manufactures a wide range of special electron tubes for equipment used in broadcasting, radar, nuclear, scientific, industrial and medical 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, broadcast television and environmental monitoring.

☐ PHOTOMULTIPLIER TUBE HOUSINGS Ext.2073

A range of cooled and uncooled photomultiplier tube housings, including thermoelectric, dry ice and liquid nitrogen versions are available for optimum photomultiplier tube operation.

RF shielded housings have been introduced for wide band photon counting applications.

☐ PHOTOMULTIPLIER POWER SUPPLY Ext.2073

A new highly stable, compact power supply specifically designed for use with photomultiplier tubes and for other stringent applications is now available. The output voltage is continuously variable from 100 volts to 2,500 volts with an output current capability of 5 mA.

☐ PHOTOMULTIPLIER MAGNETIC FOCUSING ASSEMBLIES Ext.2073

Two magnetic focusing assemblies, designed to reduce the effective cathode area and thereby the dark current in 50 mm diameter photomultiplier tubes, have been introduced by the Division.

☐ PHOTOMULTIPLIER CALIBRATION SERVICE Ext.2074

A monochromator spectral calibration service for photomultiplier tubes is now offered. Readings of quantum efficiency in per cent and radiant sensitivity in mA/W at wavelength intervals of 20 nm are provided so that the spectral response curve for a particular tube can be plotted in either unit.

☐ CAMERA TUBES Ext.2078

A wide range of both magnetic and electrostatic vidicons in various grades from television broadcast to general surveillance. Of particular interest are the high quality tubes used in conjunction with medical X-ray intensifiers. Tubes with specialised faceplates and/or target layers are available.

For low light level work, an intensifier vidicon, the Ebitron, operates down to part moonlight conditions.

☐ CAMERA SCANNING COILS Ext.2078

A range of high performance printed circuit scanning coils for use with vidicon type tubes.

☐ CATHODE RAY TUBES Ext.2078

The EMI activity in the C.R.T. field extends over four decades. Our tubes are widely used in radar and TV flying spot scanning systems where major improvements have been achieved by the use of EMI phosphor developments. Enquiries for developmental tubes are welcomed.

☐ 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.

☐ IMAGE INTENSIFIERS AND ASSOCIATED EQUIPMENT Ext.2075

A range of high quality 2, 3 and 4 stage magnetically focused image intensifiers for a wide variety of scientific applications. The comprehensive range of associated equipment includes air cooled coils designed to be operated with a rack mounted control system. This provides manual and pre-set gain controls, various protection circuits and remote control facilities.

☐ HOLLOW CATHODE LAMPS Ext.2075

The wide range of EMI hollow cathode lamps is suitable for use in all atomic absorption spectrophotometers. All tubes are supplied with an octal base and fused silica windows for UV transmission.

☐ ELECTRODELESS DISCHARGE TUBES AND ASSOCIATED EQUIPMENT Ext.2075

7 mm and 10 mm diameter tubes for atomic fluorescence analysis. To obtain maximum environmental control, the key factor for high stability, EMI have designed a ¾ wavelength double skinned cavity for the 7 mm EDT together with a highly stable microwave generator.

☐ SOLID STATE PHOTODIODES Ext.2075

EMI manufacture a range of linear and avalanche silicon photodiodes including fast and rugged types having wide spectral response. Complete amplifier and control modules are available.

☐ SPECIAL PRODUCTS Ext.2076

The Electron Tube Division have wide experience in the development of light sensing and light emitting devices and are always pleased to consider requirements for Special Tubes outside the normal range. A variety of tube components and/or services is available to assist educational and research establishments, e.g.

- Image dissector tubes
- Scan converter tubes
- Storage tubes
- Character generator tubes
- Alkali metal generators
- Phosphor deposition
- Electron guns
- Dynode stacks
- Evaporated layers
- Developmental items

NOTE: For further information please telephone the extension shown opposite each product and service.

T402/P DS.537/1

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A member of the EMI Group of Companies.
International leaders in Electronics, Records and Entertainment.

Types 9677, 9706 & 9728

Vidicon Tube

MAGNETIC 26 mm VIDICON TUBES

The EMI High Resolution Vidicon Tubes 9677, 9706 and 9728 are intended for use in broadcast, medical and industrial television applications. They have separate mesh electrode structures and uniform target layers, giving a range of vidicons with excellent signal uniformity over a wide range of target potentials coupled with exceptionally high resolution.

The low wattage heaters (0·6 W) of the 9677 and 9706 make them suitable for use in transistorised cameras and also in cameras where heat dissipation must be kept to a minimum.

The higher wattage heater (1·9 W) of the 9728 is intended for use in cameras employing an 0·3 A series heater chain, or cameras deriving the heater supply from a 6·3 V transformer winding. Should the 9728 be used in a camera with an 0·6 A heater chain then the vidicon heater must be shunted by an appropriate resistor.

The 9677 and 9728 tubes are of standard length, while the 9706 is a shortened form intended for use in compact cameras. Apart from heater current and physical length the three types are identical.

The 9677, 9706 and 9728 vidicon tubes are available in a number of grades suitable for applications ranging from high quality broadcast to amateur use.

CHARACTERISTICS

Mechanical

Nominal length (including pins)	158·75 mm (6·250 in)	9677 and 9728
	130·05 mm (5·120 in)	9706
Nominal diameter of bulb	25·91 mm (1·020 in)	
Nominal diameter of target contact ring	28·58 mm (1·125 in)	
Base type, similar to	8 ME (JEDEC E8–11)	
Scanned area	12·7 mm x 9·6 mm (½ in x $^3/_8$ in)	See Note 1

Orientation of image	The horizontal scan should be parallel to a plane passing through the tube axis and the short pin.
Operating position	Any. See Note 2.
Weight (approximate)	57 g (2 oz) 9677 and 9728
	52 g (1.8 oz) 9706

Electrical

Focusing Method	Magnetic	
Deflection Method	Magnetic	
Alignment Method	Magnetic	
Heater Voltage	6·3 V	
Heater Current	90 mA ± 10%	9677 and 9706
	300 mA ± 10%	9728
Spectral Response	See Figure 3	
Signal Electrode Capacitance to all other electrodes	4·5pF	

Limiting Ratings (All potentials are shown relative to the tube cathode)

Heater voltage	5.7 V minimum	See Note 3
	6.9 V maximum	
Heater potential	20 V positive maximum	Under maximum surge condition
	100 V negative maximum	
Modulator G1 potential	−150 V negative bias	
	0 positive bias	
Limiter G2 potential	750 V maximum	
Wall anode G3 potential	750 V maximum	
Mesh G4 potential	1000 V maximum	
Signal Electrode potential	100 V maximum	See Note 4
Dark current	0·6 μA maximum	
Target illumination	10,000 lx maximum (tube not operating)	
Faceplate temperature	70°C maximum	

Typical Operating Conditions

Heater to cathode potential	± 10 V apart from blackout				
Modulator G1 potential	−35 V to −75 V				
Cut off potential	−60 V to −100 V				
Limiter G2 potential	300 V				
Wall anode G3 potential	280 V to 300 V		See Note 5		
Mesh G4 potential	420 V to 450 V		See Note 6		
Minimum blackout pulses when applied to G1	75 V negative pulses				
Minimum blackout pulses when applied to cathode	10 V positive pulses				
Axial magnetic field	0·004 T (40 gauss)		See Note 7		
Adjustable transverse alignment field	± 0·0004 T (± 4 gauss)				
Target illumination (highlights)	2	20	60	500	lux
Signal electrode voltage	35 to 80	15 to 60	10 to 40	10 to 20	V
Dark current	0.1	0.01	0·005	0.005	μA
Signal current	0.15	0.25	0.25—0.3	0.25—0.3	μA
Faceplate temperature	30°C				

Leakage Specification (Tube not operating)

between pin No.	and pin No.		Test potential	Leakage current
2,3,5,6,7	1 and 8	(negative)	100 V	100 μA max.
1,3,5,6,7,8,	2	(negative)	150 V	15 μA max.
1,2,3,6,7,8,	5	(positive)	500 V	50 μA max.
1,2,3,5,7,8	6	(positive)	500 V	5 μA max.
1,2,5,6,7,8 and signal plate	3	(positive)	500 V	5 μA max.

OPERATING NOTES

1. Scanned Area

The tube should be operated with the target area 12·7 mm x 9·6 mm (½ in x ⅜ in) completely scanned to obtain the best signal to noise ratio and resolution. Small changes in sensitivity and dark current occur in the scanned area over a long period of time so that it is important to use the same scanned area throughout the life of the tube.

2. Operating Position

When the tube is operated vertically with its face downwards care should be taken to avoid undue mechanical shock.

3. Heater

For optimum results and maximum life, the heater supply should be designed to give a nominal 6·3V and should be kept within the limits 6·1V to 6·5V. Under no circumstances should the heater voltage be allowed to exceed 9·5V under surge conditions. If this figure is likely to be exceeded on switching on, a surge limiting device must be incorporated.

4. Signal Electrode (Target)

The dark current should not be allowed to exceed 0·6 μA or a burnt-in picture may result. The signal electrode voltage supply should be limited to 100 V for this reason.

5. Wall Anode Potential

On no account should the wall anode G3 be operated at a higher potential than the mesh G4, otherwise an ion spot may be observed.

6. Resolution

From figures 1 and 2 it can be seen that an appreciable increase in depth of the modulation can be obtained when the mesh is only a few volts positive to the wall anode and under these conditions negligible increase in scanning power is required.

The resolution can be further increased by increasing the wall anode G3 potential and the corresponding mesh G4 potential, but this will require additional focus current and scan power.

For good resolution and minimum beam landing error the potential of the mesh should be at approx. 1·5 times the potential of the wall anode. This will ensure uniformity of sensitivity even at low target voltages.

The setting of the beam current in this tube is less critical than with an integral mesh vidicon, provided the mesh is positive with respect to the wall anode.

7. Field

The focusing field should be such that a north seeking pole is attracted to the faceplate of the tube.

Fig.1 TYPICAL CENTRE RESOLUTION

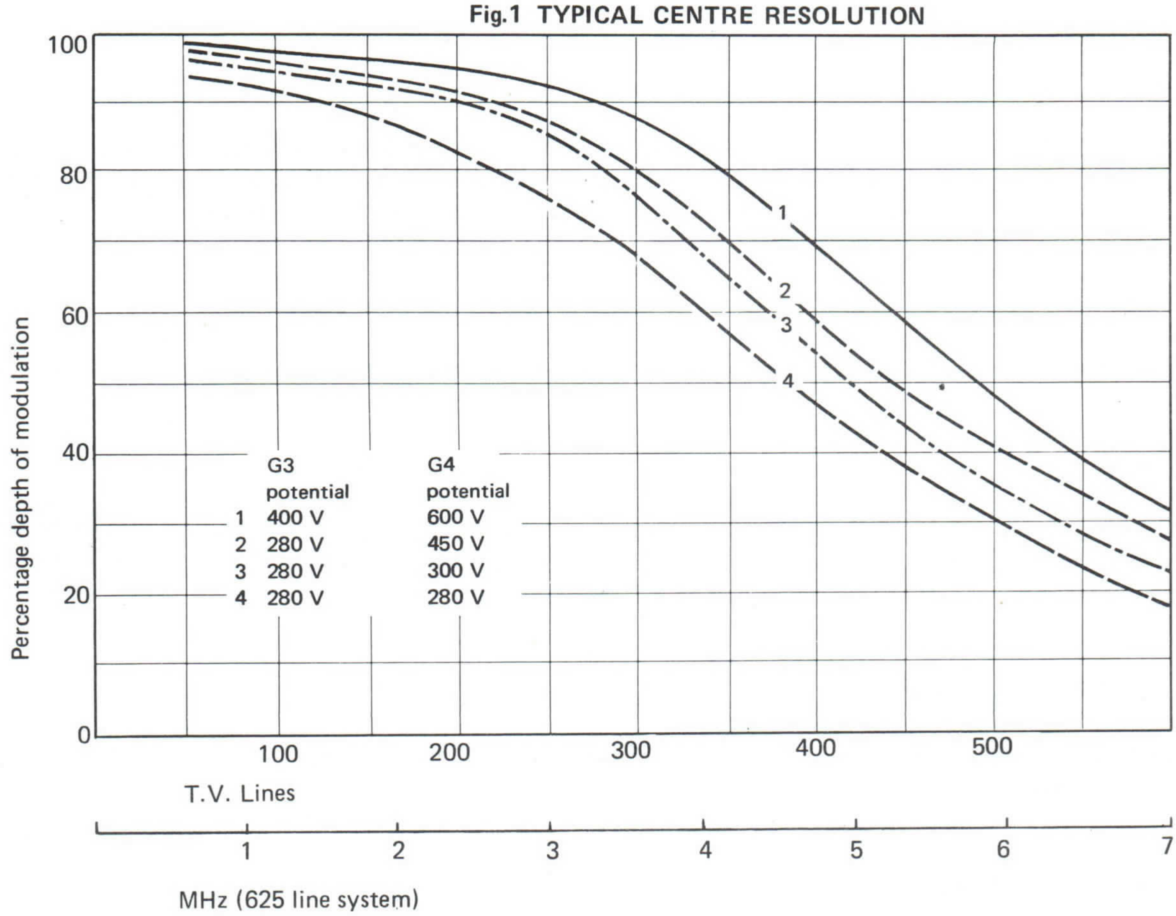


Fig.2 TYPICAL CORNER RESOLUTION
Measured at 15% from end of diagonals

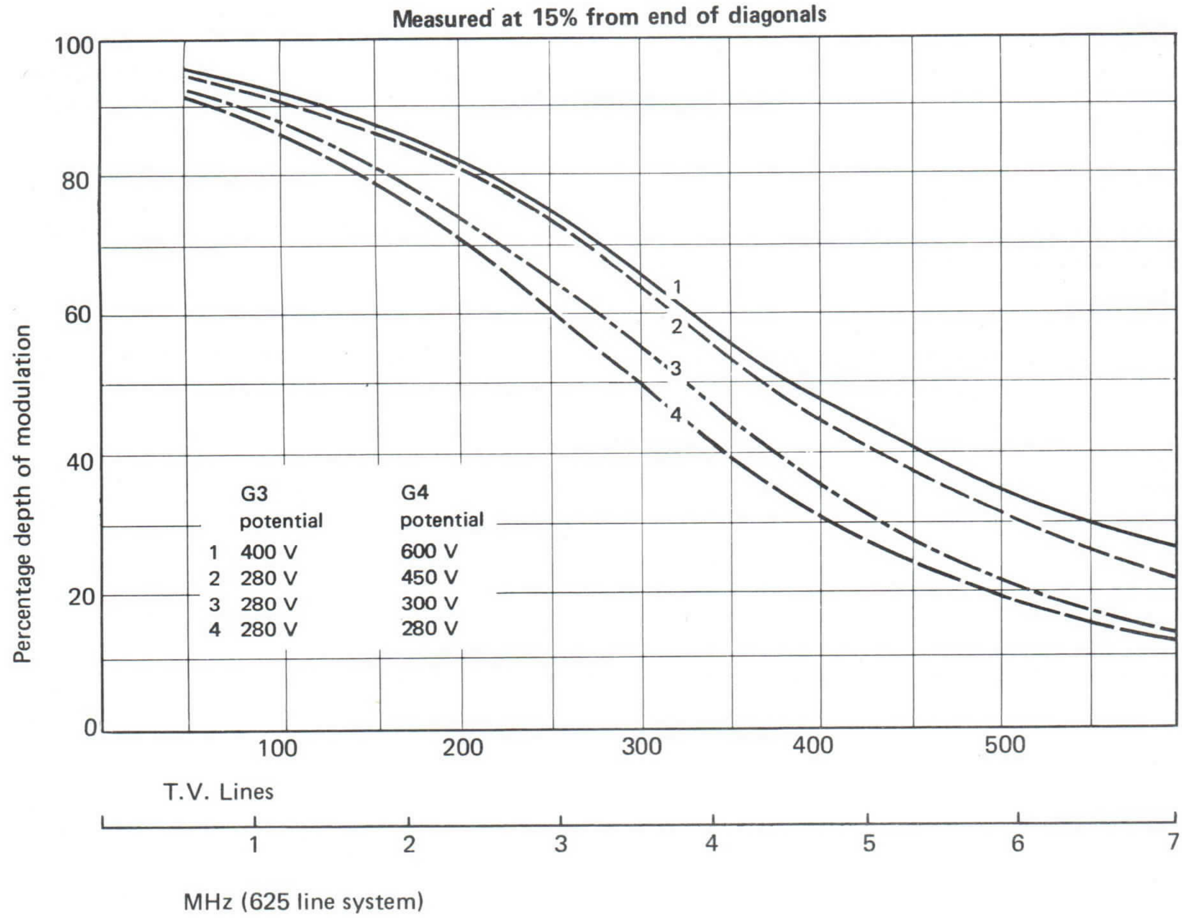


Fig.3 TYPICAL SPECTRAL RESPONSE

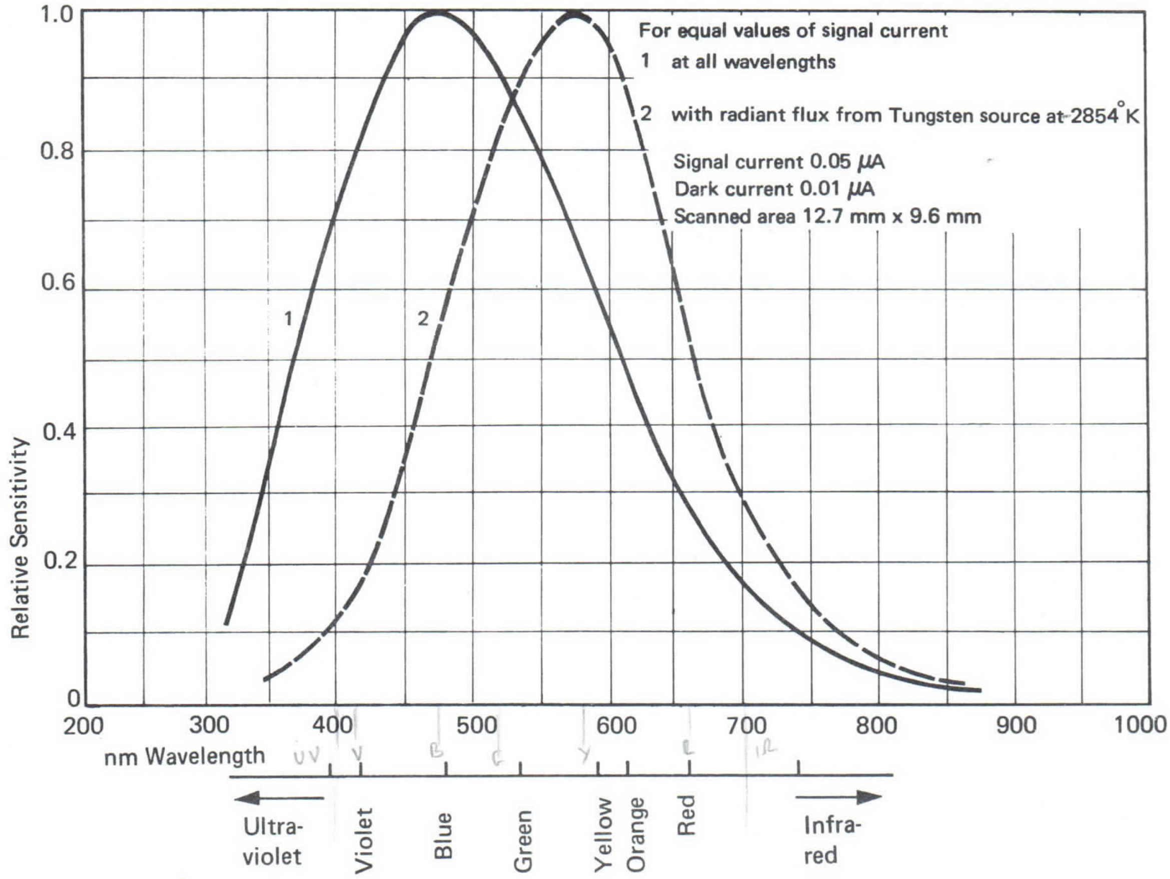


Fig.4 DARK CURRENT vs SIGNAL ELECTRODE POTENTIAL

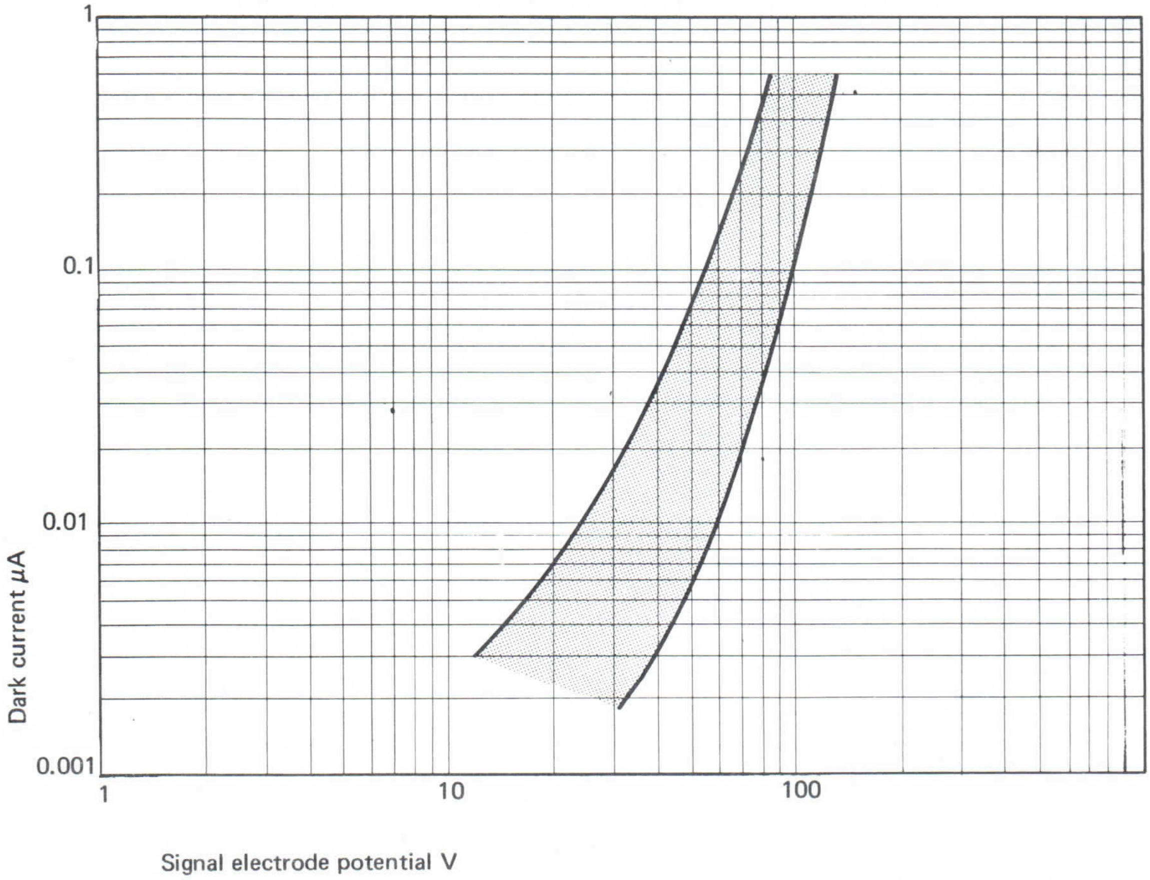


Fig.5 TYPICAL SIGNAL CURRENT vs ILLUMINATION

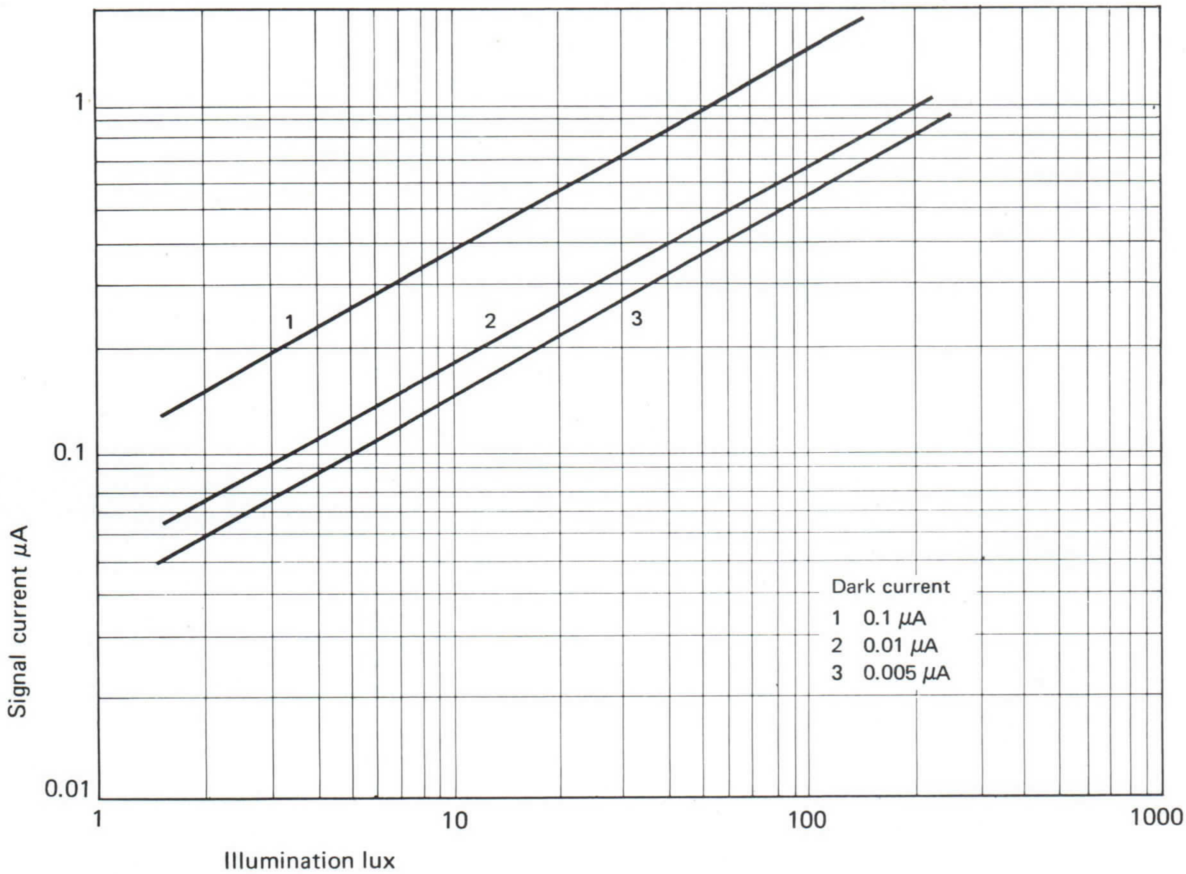
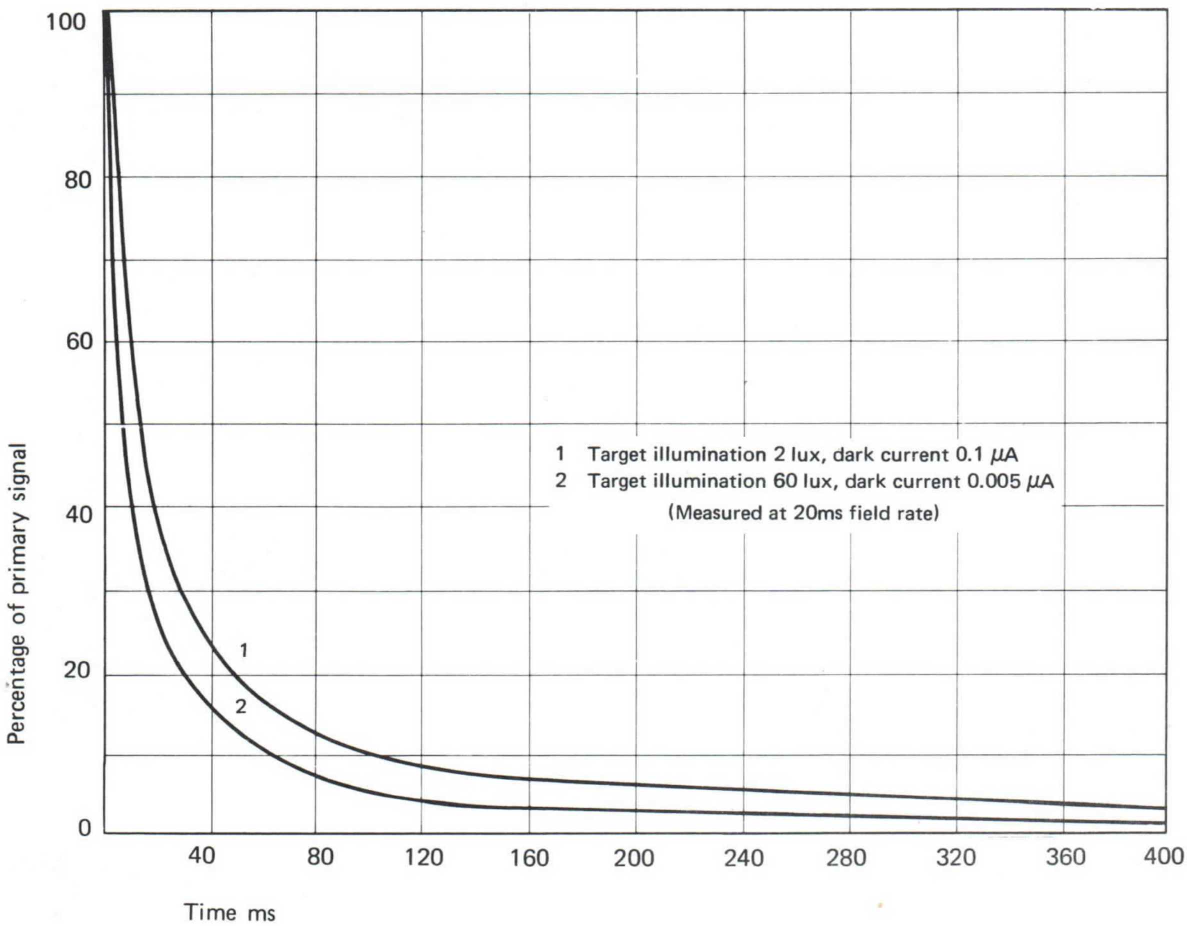
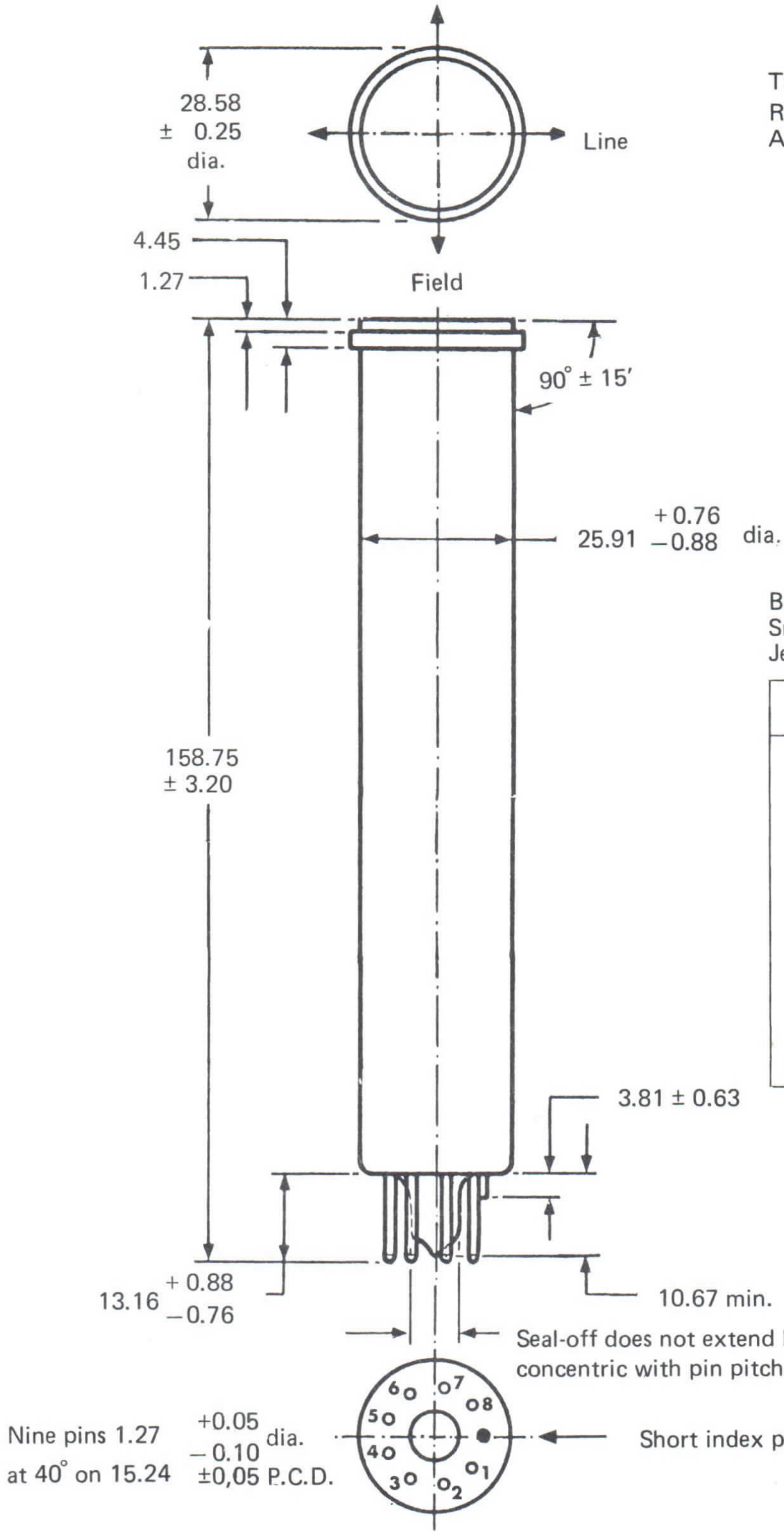


Fig.6 TYPICAL LAG CHARACTERISTICS



T419/6E
DS.780

Fig.7 DIMENSIONAL OUTLINE DRAWING FOR TYPES 9677 AND 9728



FACEPLATE

Thickness	2.362 ± 0.076
Refractive index	1.507 at 5876 Å
Area scanned	12.7 x 9.6

QUALITY CIRCLE

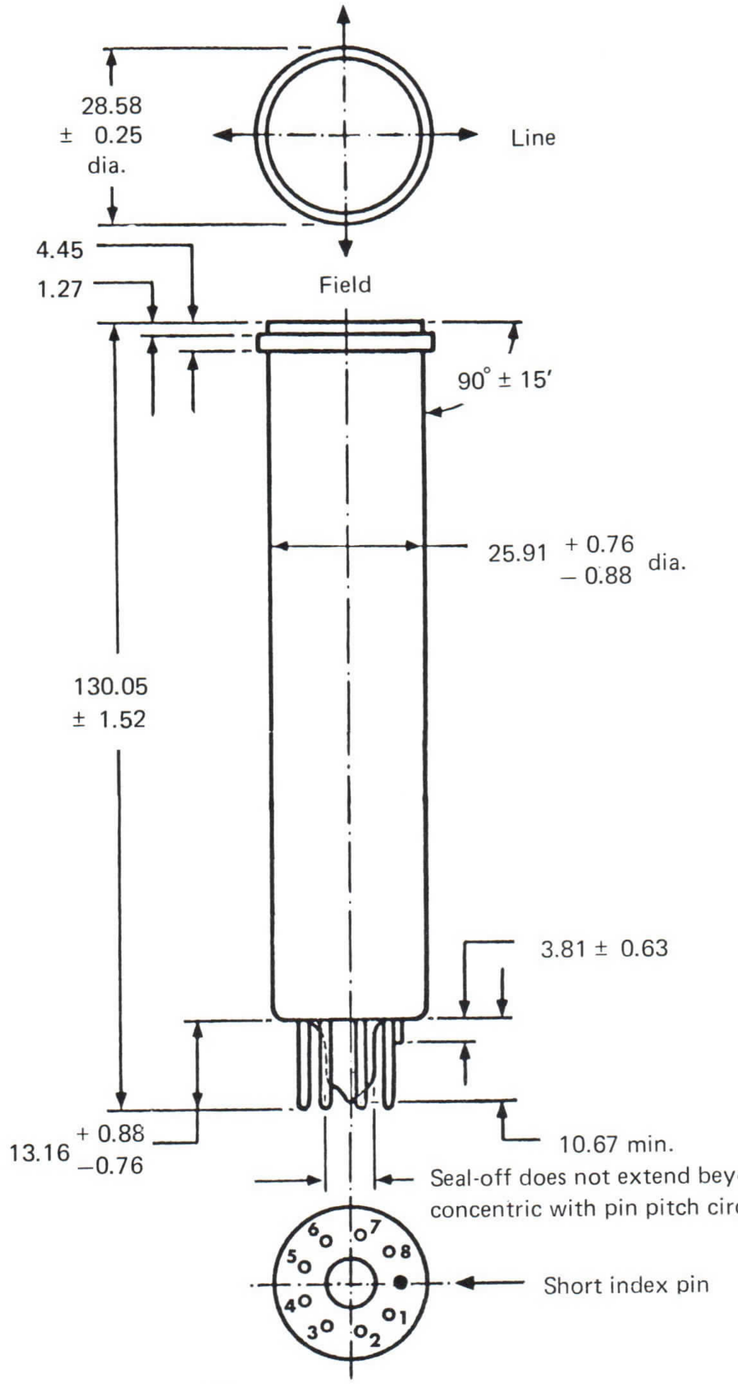
17.27 dia. min.

Base:
Small button ditetrar similar to Jedec E8–11.

Pin No.	Connection
1	Heater
2	Modulator G_1
3	Mesh G_4
4	Internally connected
5	Limiter G_2
6	Wall anode G_3
7	Cathode
8	Heater
Flange	Signal electrode
Short pin	Internally connected

All dimensions are in MILLIMETRES

Fig.8 DIMENSIONAL OUTLINE DRAWING FOR TYPE 9706



FACEPLATE

Thickness	2.362 ± 0.076
Refractive index	1.507 at 5876 Å
Area scanned	12.7 x 9.6

QUALITY CIRCLE

17.27 dia. min.

Base:
Small button ditetrar similar to Jedec E8-11.

Pin No.	Connection
1	Heater
2	Modulator G_1
3	Mesh G_4
4	Internally connected
5	Limiter G_2
6	Wall anode G_3
7	Cathode
8	Heater
Flange	Signal electrode
Short pin	Internally connected

Nine pins 1.27 $^{+0.05}_{-0.10}$ dia.
at 40° on 15.24 ± 0.05 P.C.D.

All dimensions are in MILLIMETRES

EMI

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International leaders in music, electronics and leisure.

T419/8E
DS.780

EMI

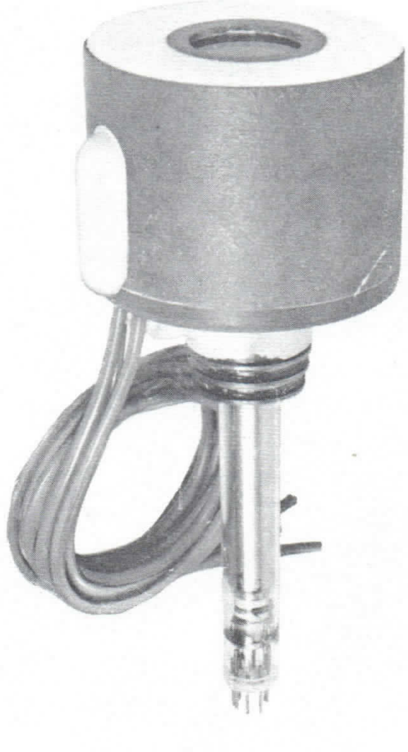
Type 9777

Ebitron – Intensifier Vidicon

EMI EBITRON – INTENSIFIER VIDICON TYPE 9777

The 9777 is an Intensifier Vidicon which uses an electron bombardment induced conductivity target to couple the intensifier section to the 13 mm vidicon scanning section. The high sensitivity photocathode (S20/S25) combined with a high target gain enables the tube to operate at low light levels with overall sensitivity of the order 60,000 μA/lm. The image section is all electrostatic with a useful photocathode size of 18.2 mm diagonal, making it suitable for use with standard 26 mm vidicon lenses. The scanning section is similar to a conventional 13 mm magnetic vidicon, which allows similar coils to be used. This combination of image and scanning sections gives a small, conveniently sized tube which, including scanning and focus coils, is no bigger than a conventional 26 mm vidicon including coils whilst giving a sensitivity approximately 350 times greater. The Ebitron is normally supplied with the image section potted with flying leads for the high voltage electrodes. (See lower photograph).

Resolution is similar to that obtained from a 13 mm magnetic vidicon. The tube has some lag at low light levels which decreases as the light level is increased. The very wide light level range over which the tube operates enables it to be used under almost any lighting conditions. Small area light overload may, if applied potentials are not adjusted to suit, cause some burn-in on the target, but unlike some other low light level tubes, the target will subsequently continue to operate. Permanent target damage may be caused by large area photocathode illuminations of 1000 lux or more.



Storage in the target is such that one can, if desired, obtain some useful information at lower light levels by cutting off the beam for complete frames subsequently to scan off larger stored charges, e.g. omitting alternate scans will double the target storage time and hence double the read out signal. Scanning off on every fourth or eighth etc. scan increases the signal by appropriate factors at the expense of a flickering display signal, but in some circumstances this is acceptable because of the lower light levels at which information can be obtained. Signals may be integrated on the target for periods of up to one minute at normal temperatures and from 10 to 30 minutes at –40°C depending on target voltage.

The image section can be gated by pulsing the image focus electrode from photocathode potential to the required operating potential. The image rear electrode is normally grounded and effectively screens the signal electrode from these pulses.

CHARACTERISTICS

Mechanical

Nominal length (including pins) – unpotted	156 mm (6.14 in)
Nominal length (including pins) – potted	157 mm (6.18 in)
Nominal diameter of image section – unpotted	59 mm (2.32 in)
Nominal diameter of image section – potted	64 mm (2.50 in) (plus leads – see figure 10)
Base type	Small button sevenar 7 pin
Photocathode size	18.2 mm diagonal
Target useful size	6.4 mm x 4.8 mm
Operating position	Any (see note 6)
Tube orientation	Viewed from photocathode end – flying leads at 3 o'clock
Weight	100 g unpotted 230 g potted
Faceplate thickness	2 ± 0.1 mm
Faceplate refractive index	1.5076 for sodium D line

Electrical

Image section	All electrostatic
Scanning section	All magnetic – using 13 mm vidicon coils
Alignment method (not normally used)	Magnetic
Heater voltage	6.3 V (see note 1)
Heater current	90 mA ± 10%
Spectral response	S20/S25
Signal electrode capacitance to all other electrodes	8 pF
Image focus electrode capacitance to all other electrodes	9 pF

Limiting Ratings (All voltages with respect to gun cathode) (Note 8)

Heater voltage	5.8 V to 6.8 V (see note 1)
Heater potential	–50 V to 10 V
Modulator Vg_1	–150 V to 0 V
Limiter Vg_2	350 V
Wall anode Vg_3	500 V (see note 2)
Vidicon mesh Vg_4	650 V
Target	50 V
Image rear electrode	+30 V
Image focus electrode	–15 kV
Image section mesh	–9 kV
Photocathode	–12 kV to –15 kV (see note 3)
Faceplate temperature	50°C

Typical Operating Conditions (with respect to gun cathode)

Heater to cathode	±10 V apart from blackout
Modulator Vg_1	−30 V
Limiter Vg_2	300 V
Wall anode Vg_3	370 V to 470 V (see note 2)
Vidicon mesh Vg_4	600 V
Target	10 V to 30 V (see note 7)
Minimum blackout pulses when applied to modulator	70 V negative pulses
Minimum blackout pulses when applied to cathode	10 V positive pulses
Axial magnetic focus field (scanning section)	0.0075 T (75 gauss)
Adjustable transverse alignment field (if used)	±0.0004 T (4 gauss)
Signal output current	0.2 μA peak white
Overall sensitivity	2,000 to 60,000 μA/lm (see note 4)
Photocathode	−14 kV
Image mesh	−8.4 kV
Image focus electrode (adjust on installation)	−12.6 kV (equal or positive to photocathode, to cut off image section)
Image section rear electrode	0 V

If the overall E.H.T. voltage is varied, the above proportionality with respect to the photocathode must be maintained – i.e. image mesh volts to be 60% of photocathode volts and image focus volts to be 89% ± 1% of photocathode volts.

Notes

1. **Heater Voltage.** The heater supply should be designed to give a nominal 6.3 V and should be kept within the limits 5.8 V to 6.8 V. Under no circumstances should the heater voltage be allowed to exceed 9.5 V. If this figure is likely to be exceeded on switching on, a surge limiting device must be incorporated.

2. **Wall Anode Potential.** On no account should the wall anode be operated at a higher potential than the mesh G4, otherwise an ion spot may be observed.

3. **Overall Volts.** Operation of this tube at less than −12 kV may cause permanent damage to the target.

4. **Overall Sensitivity.** The actual value is dependent on the target voltage setting.

5. **Resolution.** Operation at signal currents in excess of 0.2 μA will cause some loss of resolution.

6. **Operating Position.** When the tube is operated vertically with its face downwards, care should be taken to avoid undue mechanical shock.

7. **Target Potential.** Prolonged operation above voltages at which additional white spots appear may result in these extra blemishes becoming permanent.

8. **Limiting Values.** These are absolute in accordance with IEC 134.

9. **Special Faceplates.** Tubes can be supplied with sapphire faceplates for operation at wavelengths down to 150 nm or with fibre optic faceplates for direct coupling to an additional intensifier tube.

R9777 SIGNAL CURRENT IN nA vs FACEPLATE ILLUMINATION IN F.C. (EHT FIXED 14 KV)

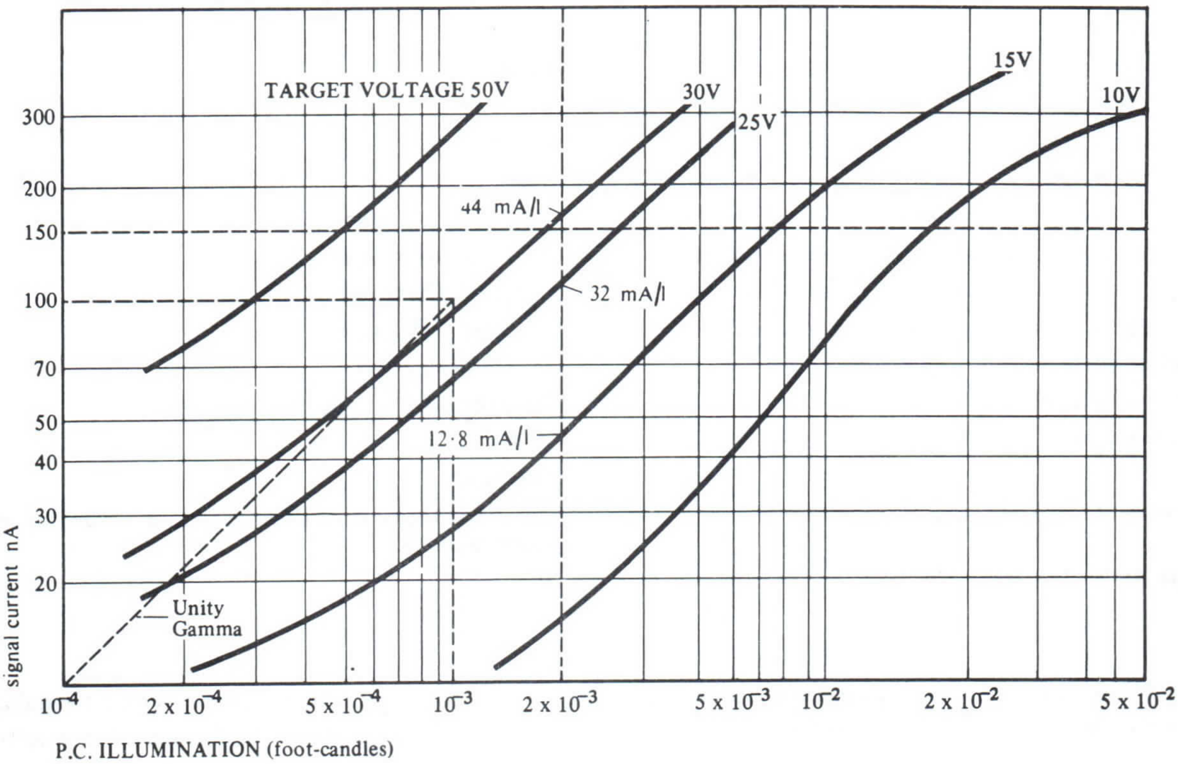


Fig.1

SIGNAL CURRENT AND OVERALL SENSITIVITY vs E.H.T. ON IMAGE SECTION

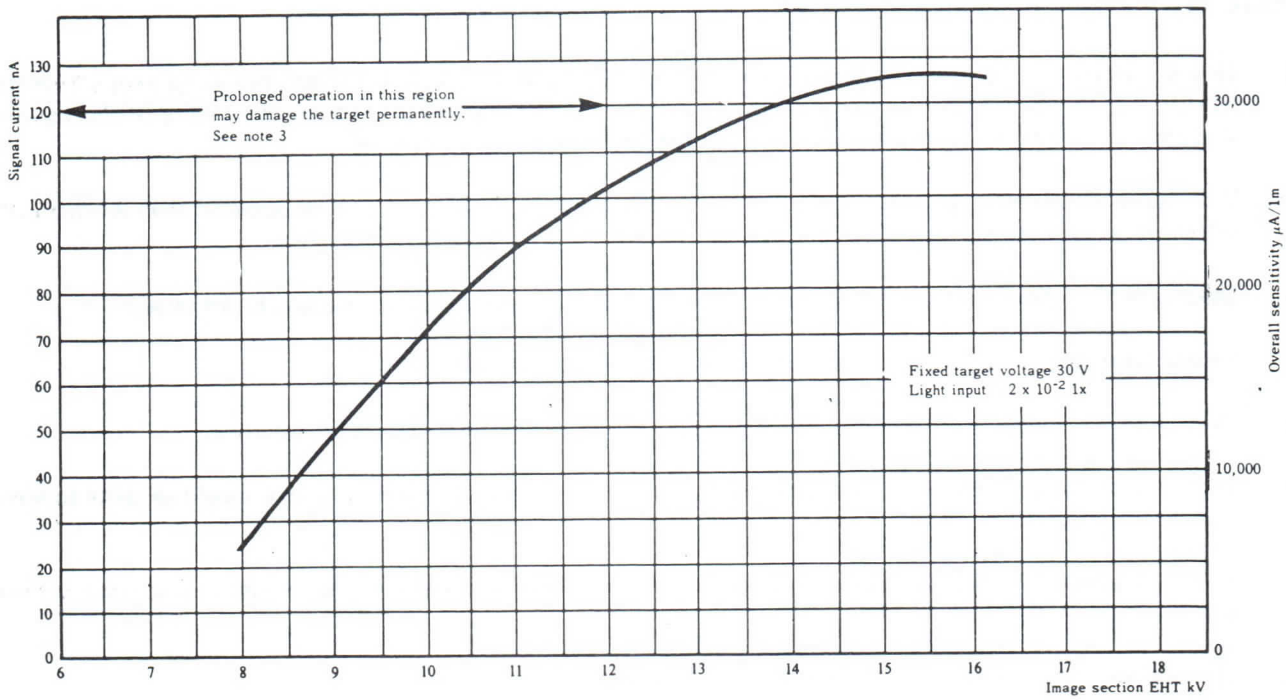


Fig.2

LAG vs PHOTOCATHODE ILLUMINATION

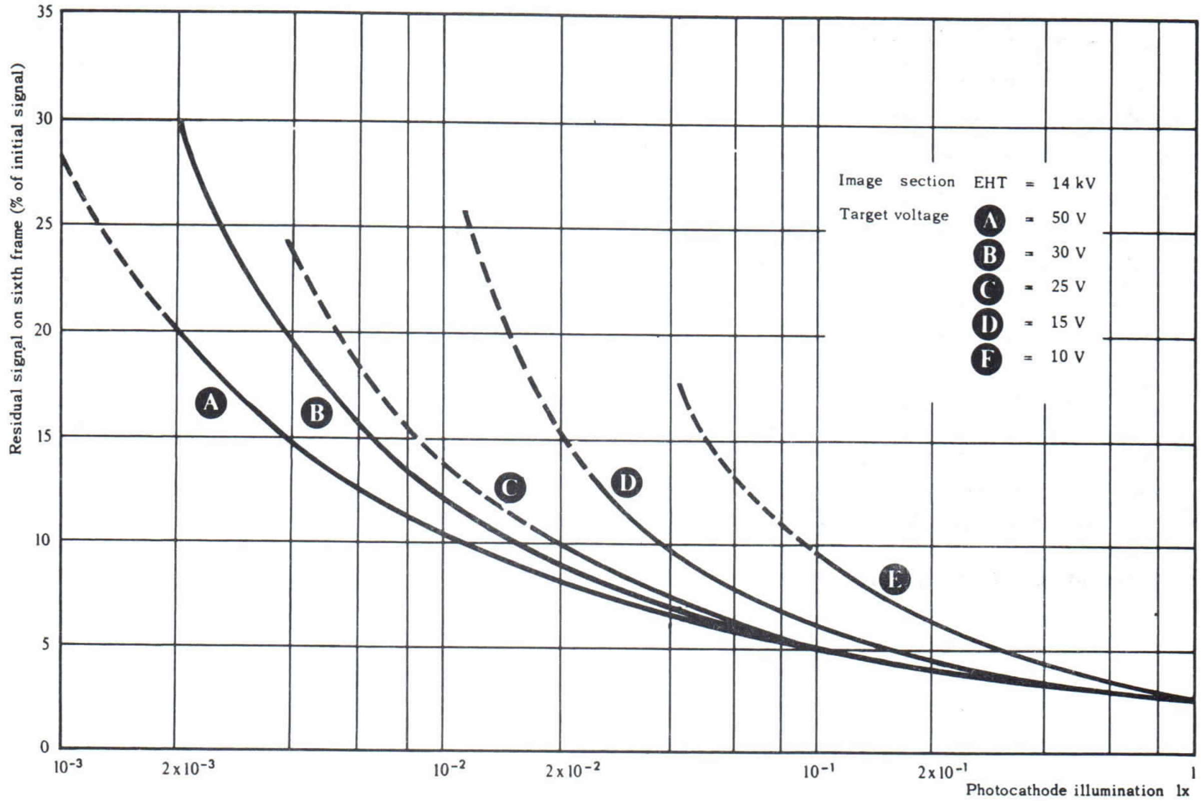


Fig.3

RESOLUTION OF EBITRON R9777

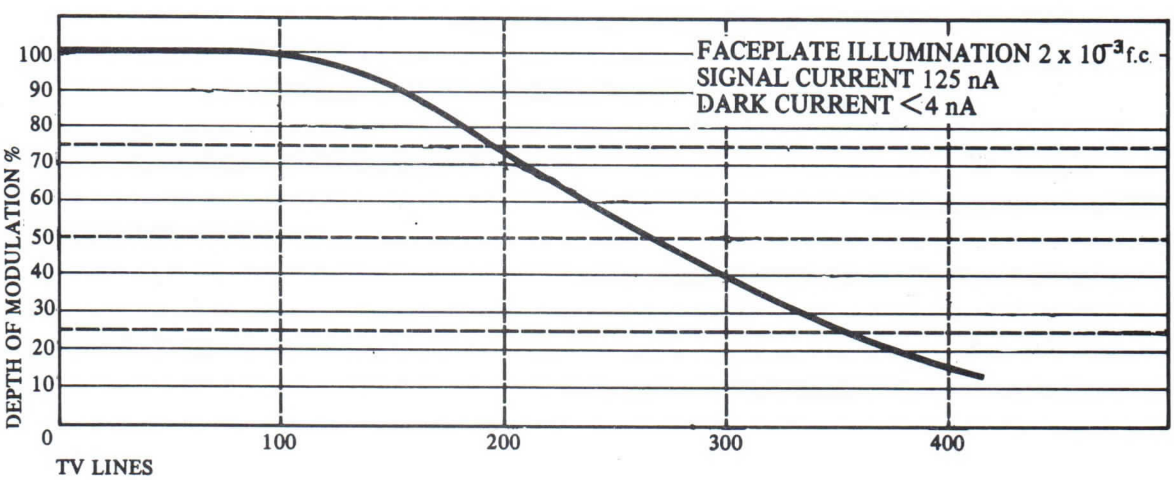


Fig.4

LIMITING RESOLUTION vs FACEPLATE ILLUMINATION
(APP. 200 μA SIGNAL CURRENT AT 2 x 10^{-3} f.c. AND ABOVE ON FACE)

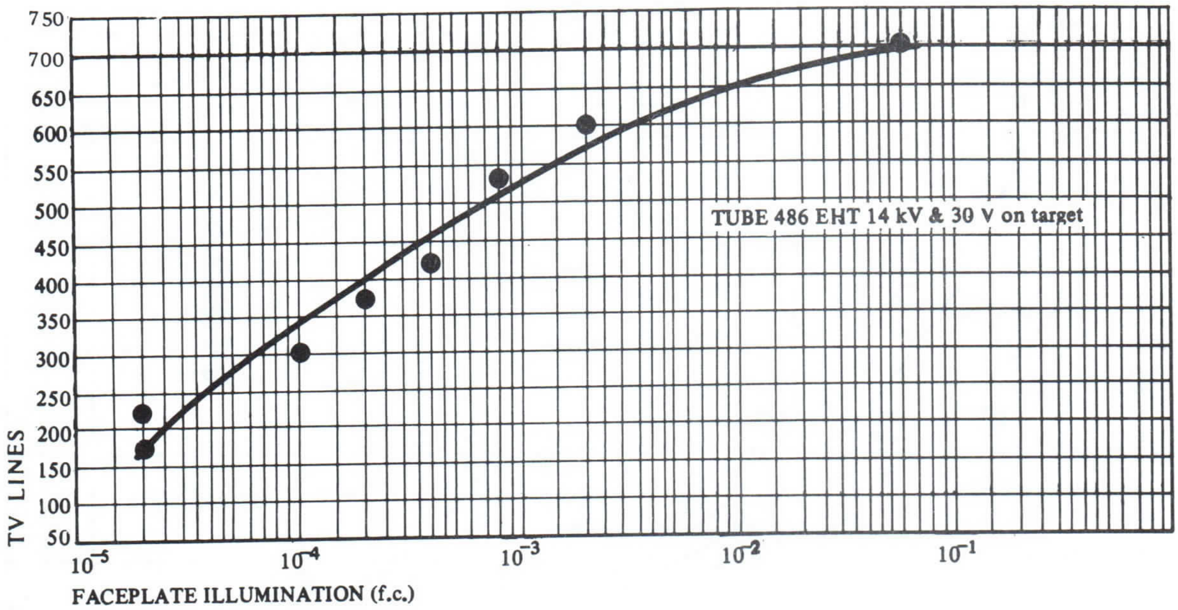


Fig.5

SPECTRAL RESPONSE

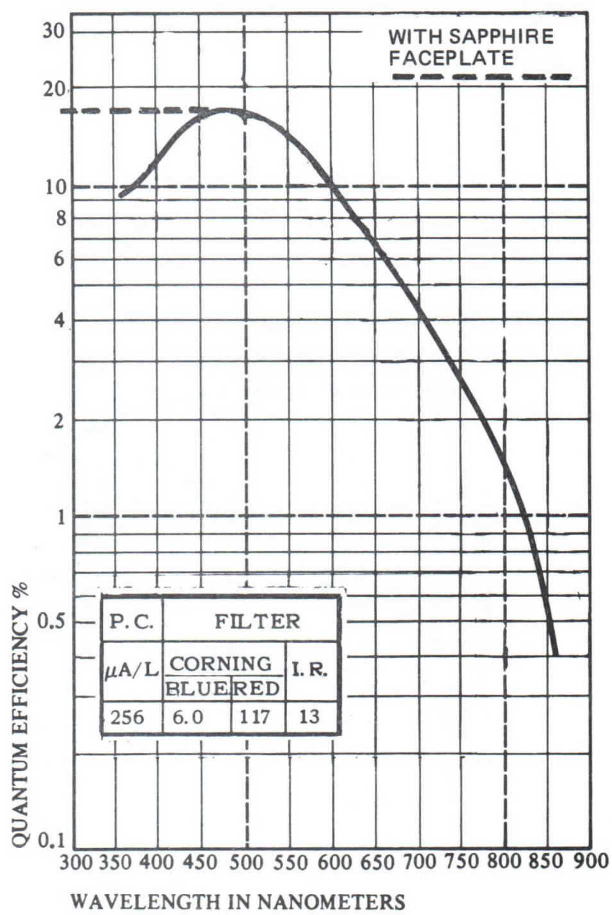


Fig.7

EBITRON DARK CURRENT
vs TARGET VOLTAGE

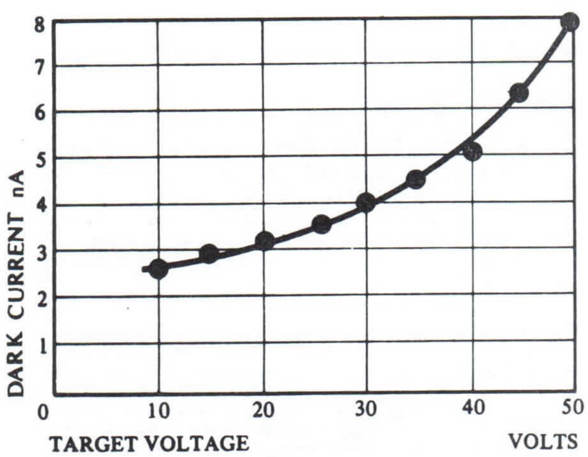


Fig.6

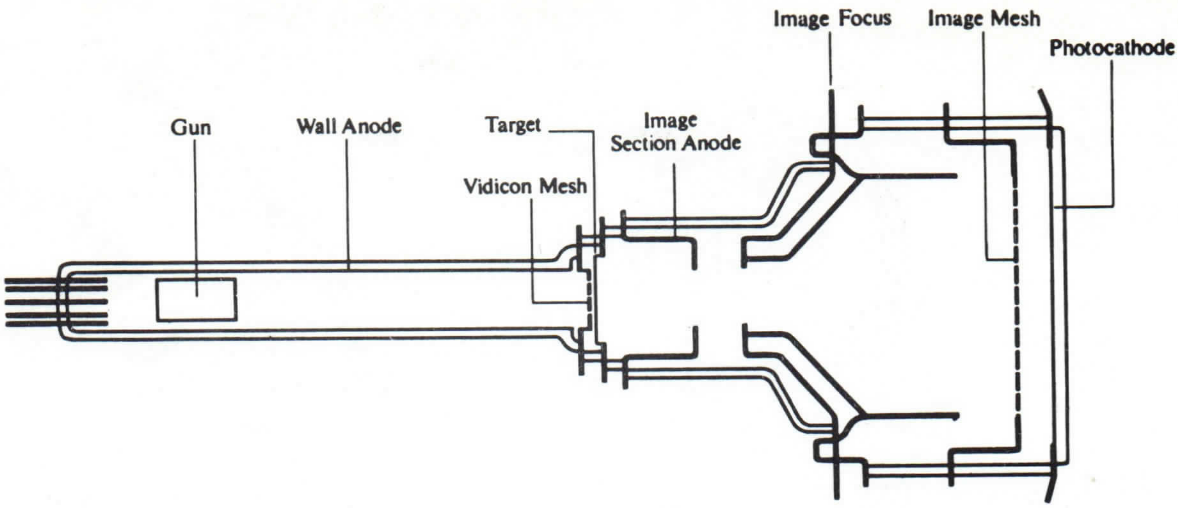
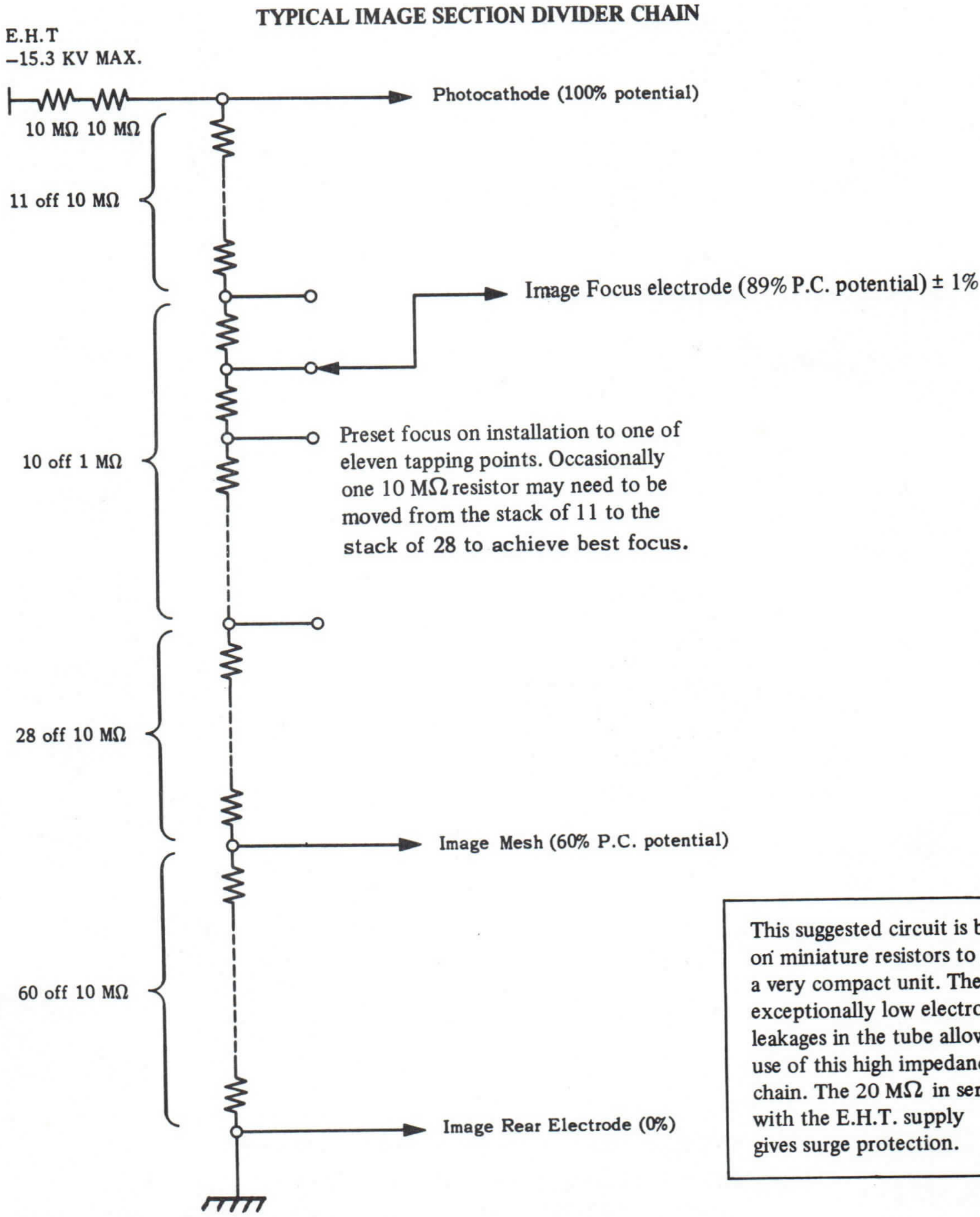


Fig.8

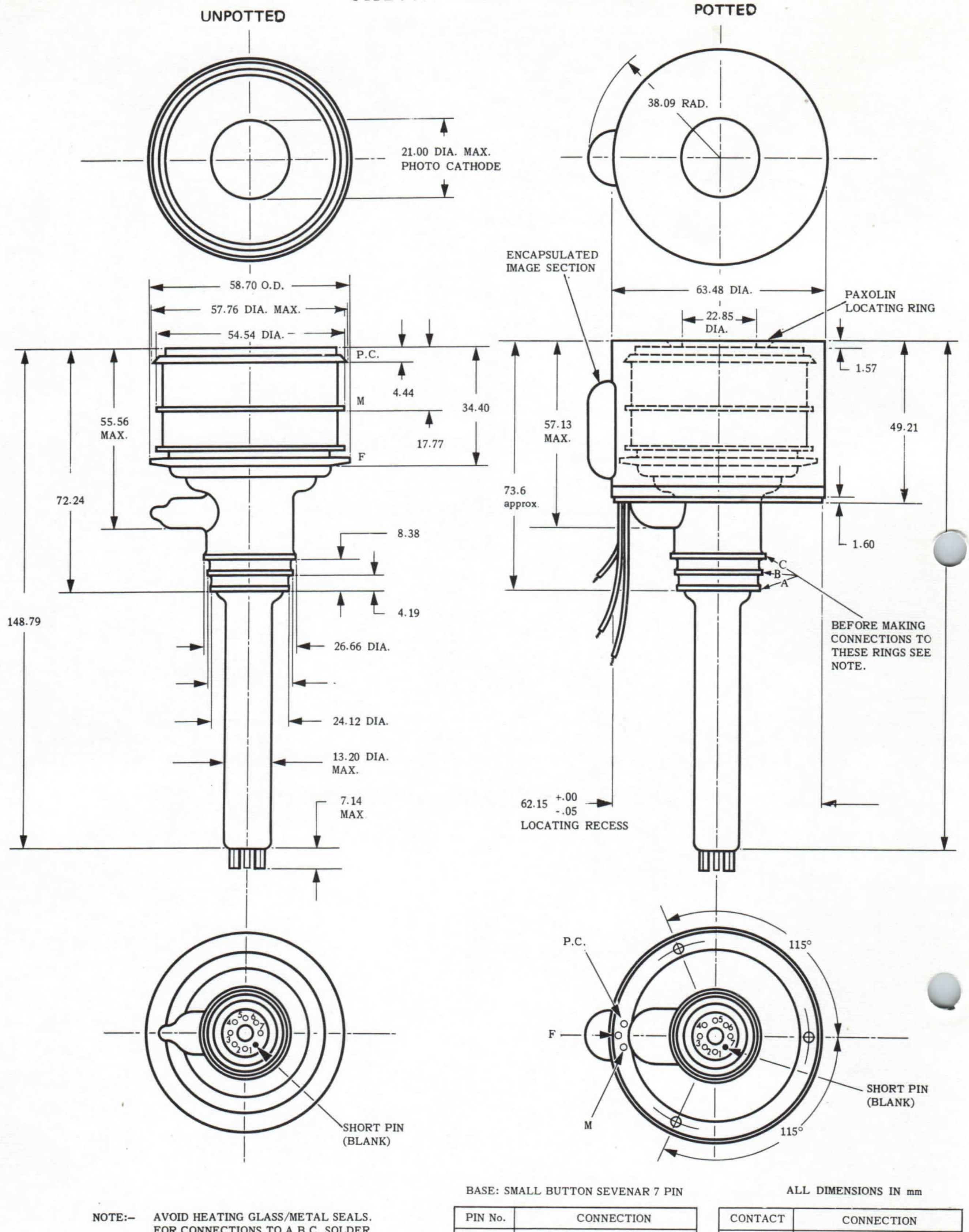
TYPICAL IMAGE SECTION DIVIDER CHAIN



This suggested circuit is based on miniature resistors to give a very compact unit. The exceptionally low electrode leakages in the tube allow the use of this high impedance chain. The 20 MΩ in series with the E.H.T. supply gives surge protection.

Fig.9

TYPE 9777 – OUTLINE DRAWING



BASE: SMALL BUTTON SEVENAR 7 PIN

ALL DIMENSIONS IN mm

NOTE:– AVOID HEATING GLASS/METAL SEALS. FOR CONNECTIONS TO A B C SOLDER TO THE TAPES THAT ARE CONNECTED TO THE RINGS B AND C POSITIONED IN LINE WITH PIN 1 & RING A POSITIONED IN LINE WITH PIN 3.

Fig.10

PIN No.	CONNECTION
1	HEATER
2	WALL ANODE
3	CATHODE
4	HEATER
5	LIMITER
6	CATHODE
7	MODULATOR

CONTACT	CONNECTION
A	VIDICON MESH
B	TARGET
C	REAR ELECTRODE
M	MESH
F	FOCUS ELECTRODE
PC	PHOTO CATHODE

EMI

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For further information on this product please telephone Extension 2076

T490/C
DS. 1079

EMI

THE EMI EBITRON CAMERA TUBE
WITH DAYLIGHT TO MOONLIGHT CAPABILITY

By R.A. Stephen B.Sc (Eng. London)
Electron Tube Division of
EMI Electronics Ltd.

DOCUMENT
REFERENCE
R/T024

THE EMI EBITRON CAMERA TUBE WITH DAYLIGHT TO MOONLIGHT CAPABILITY

Introduction

The Ebitron is a low light level television camera tube designed originally to operate at levels of illumination down to that given by ½ moonlight. The tube has a trialkali photocathode with extended red response. Electrons from the photocathode are focused on to a special target by a multi-element image section, operating at an overall EHT of 12 to 14 KV, and the target gives a gain of several hundred times. This gain is obtained by electron bombardment induced conductivity. The read-out section utilises a conventional ½ in. vidicon gun, together with standard ½ in. scanning and focus coils.

Historically, the tube was conceived in discussion between Mr. Jim Lodge of EMI Central Research Laboratories and the late Mr. Freddie Green of R.A.E., Farnborough. The basic premise was that there was a need to extend the operational availability of military television systems based on 1 in. vidicons, because operation was limited to the hours of good daylight. A tube capable of operation down to half moonlight would extend the capability of the systems significantly. The requirement was restricted in that the new tube could occupy no more space in the equipment than that occupied by a 1 in. vidicon and its associated coils. Figure 1 shows this arrangement.

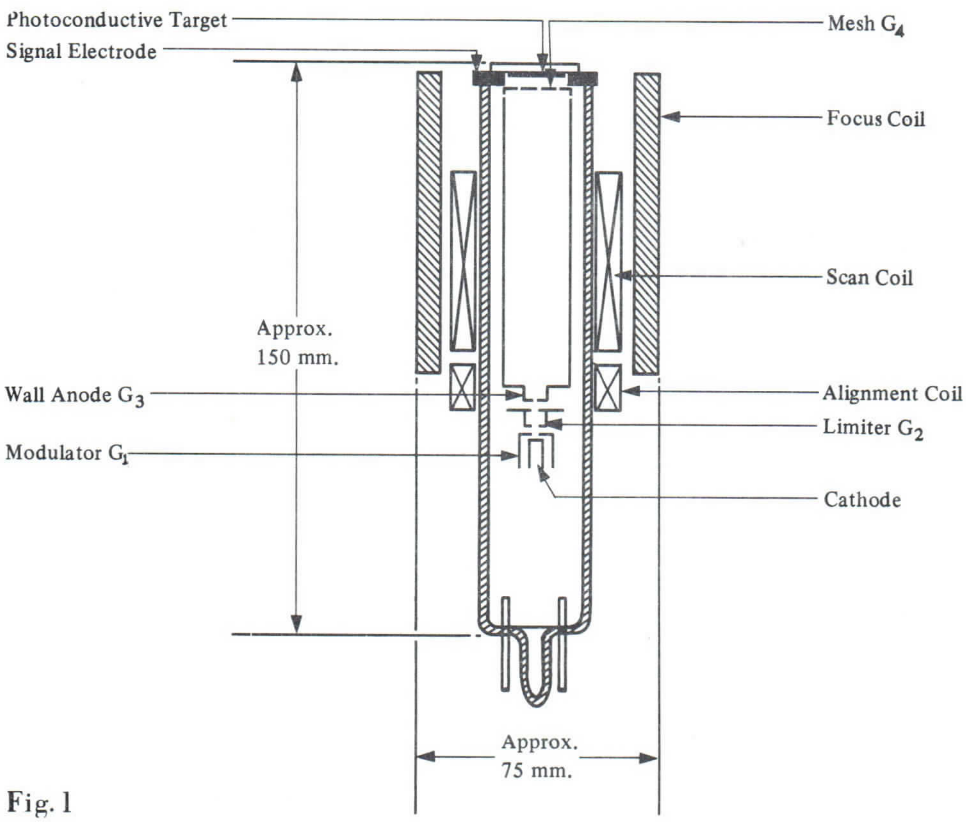
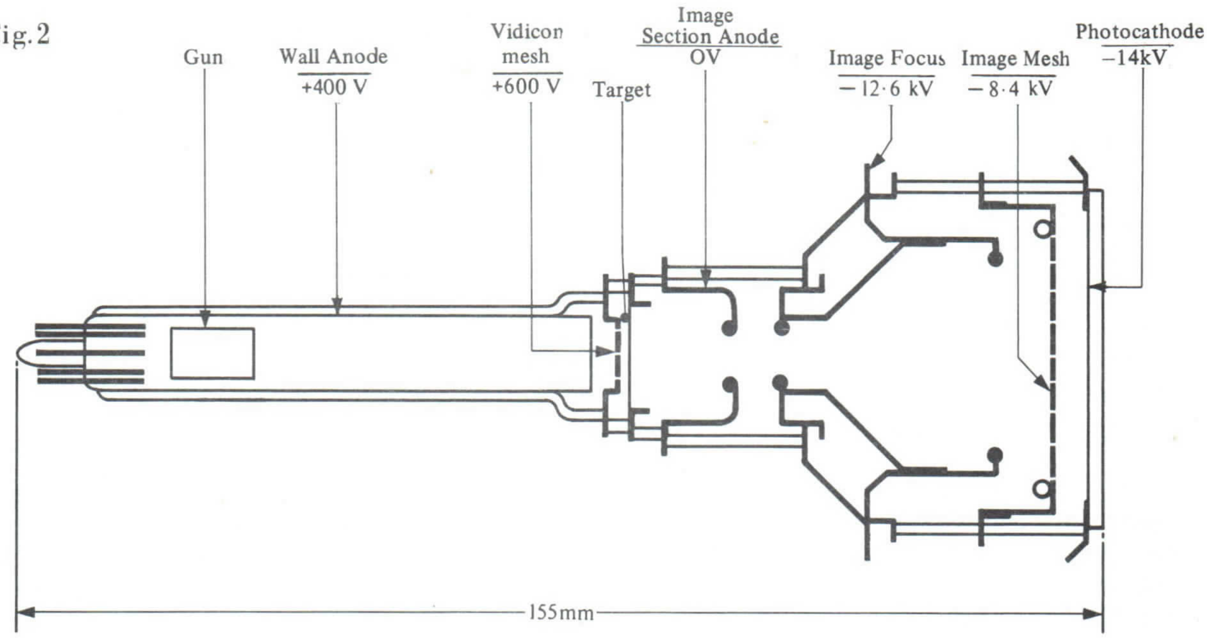


Fig. 1

The development of the basic form of the tube (see Figure 2) was carried out in EMI Central Research Laboratories. This work produced a tube which came close to meeting the requirements and formed a sound basis for the development, in Electron Tube Division, of the present version of the tube.

Fig. 2



Operating Principles

The principles of operation of the tube are as follows. The camera lens focuses the optical image of the scene on to the photocathode. Photoelectrons are emitted from the photocathode wherever light falls upon it. These electrons are accelerated towards a 1,000 TPI mesh mounted a short distance away. If the potential of the photocathode is at 100% of the negative EHT applied to the tube (to put the target near earth potential) then this mesh is operated at 60% of that EHT. The mesh transmission is slightly in excess of 50% so that roughly half of the emitted electrons are intercepted by the mesh. The remaining electrons pass through the mesh travelling with energy of about 6 KV into the field of the focus electrode, which is operated at about 90% of the EHT applied to the tube.

The electrons are therefore repelled by the focus electrode into a trajectory which, with the assistance of the very positive extraction field produced by the earthed rear focus electrode, takes them through a crossover near the focus electrode and through the apertures of the electrodes to reach the target. Careful adjustment of the potential of the first focus electrode ensures that the electron image is brought to a focus in the plane of the target. This form of electron optics gives good geometry and reasonable centre and edge resolution in a translation from a plane photocathode to a plane target.

The target consists of a thin film of aluminium oxide supporting, on the side remote from the photocathode, first a thin conductive layer of aluminium as a signal plate and then a much thicker layer of zinc sulphide.

This zinc sulphide, in common, to some extent, with most insulators and near insulators, becomes slightly more conductive when bombarded by high velocity electrons (hence electron bombardment induced conductivity). This is due to the generation of electron/hole pairs in the dissipation of the energy of the bombarding electrons.

In this process some electrons in the zinc sulphide acquire sufficient energy from the bombarding electrons to move from their stable orbits in the atomic structure of the material. When adequately excited the energy of the electrons is increased into the conduction band of energies. At the energy levels of the conduction band the electrons are able to move from atom to atom in the material.

An atom from which an electron is excited becomes positively charged because of the hole in its structure left by the missing electron. For simplicity this positively charged particle is called a hole.

Electrons and holes each have their own mobility within the structure of the material and will move in opposite directions to one another under the influence of the polarising field applied to the material. Many electrons will recombine with holes and the pairs will be lost; others will be caught in traps and give rise to lag, because eventually they escape from the traps to appear once more as free electrons and in due course give rise to signal.

Electrons arriving at the target from the photocathode have sufficient energy to pass through the aluminium oxide supporting film and the aluminium signal plate, into the zinc sulphide, to produce this conductive effect in the sulphide. The conductivity changes approximately in proportion to the intensity of bombardment and hence in proportion to the light in the various parts of the initial optical image.

The signal plate has up to 30 volts, positive to the gun cathode, applied to it. The electron beam from the gun scanning the free surface of the zinc sulphide holds that surface at cathode potential. Thus a polarising field is applied to the zinc sulphide. Changes in conductivity of the zinc sulphide result in the appearance of positively charged areas at the free surface during the storage period between scans. Beam electrons are able to land on these positively charged areas to discharge them, thus releasing as signal current corresponding electrons which have travelled through the zinc sulphide to the signal plate directed by the polarising field and which have been held there by the capacitance of the zinc sulphide layer.

Adjustment of the signal plate potential controls the voltage excursion of the positively charged areas at the free surface under given bombardment conditions. This gives a ready control of target gain by a factor of about 20 and therefore controls tube sensitivity by a similar factor.

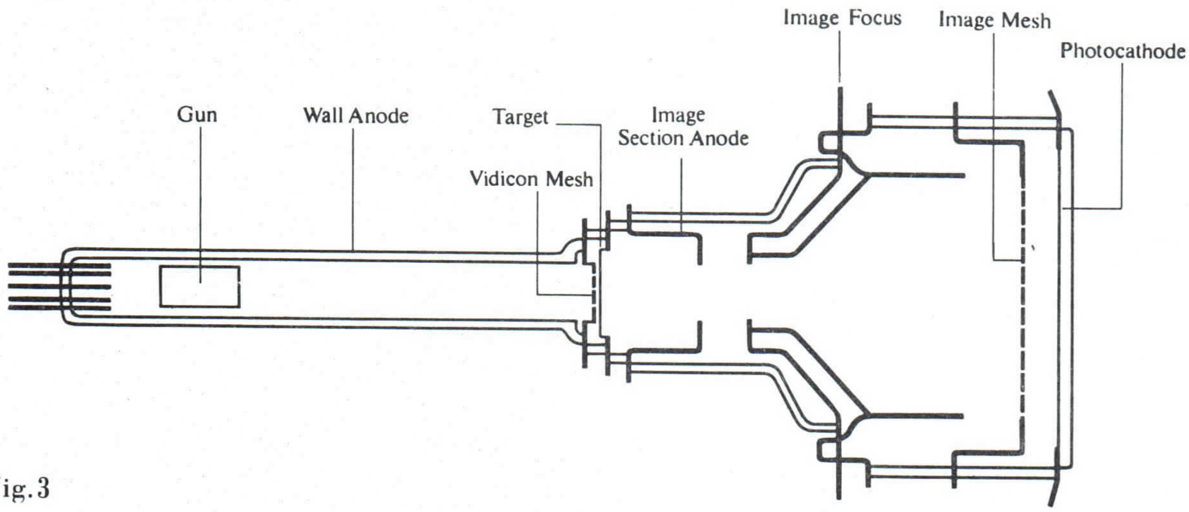


Fig.3

Electron Tube Division's Development

Electron Tube Division's task was to take the basic Research design and modify it to be:–

1. Easier to assemble
2. A more rugged structure
3. More reliable
4. More sensitive
5. Less laggy
6. Less costly

We also set out to improve the efficiency of target making and the quality of the target. The objectives have been substantially achieved and, following internal and external modifications, the tube now appears as shown in Figure 3. Effectively a glass cone replaces the metal cone enabling the weak glass/metal seal at the end of the metal cone to be replaced by a protected seal.

The photocathode is prepared on the inside of the faceplate of the tube. Originally the antimony bead and the sodium, potassium and caesium generators were housed within the conical region of the tube. The alkalis are now supplied from an external side arm. This is to eliminate the generators as a source of loose particles in the tube. The antimony comes from a retractable evaporator inserted through the pump stem.

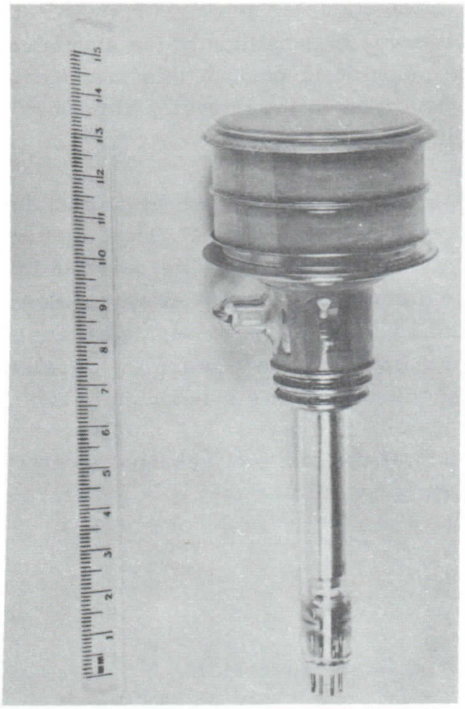


Fig. 4

Fig. 5

Vibration tests have shown that the glass itself will now break before seals themselves fail. The removal of the alkali generators with their loose particles also eliminates several other attendant problems from the tube. The wall anode was formerly a metal cylinder mounted on the end of the gun, but the glass of the gun neck is now shaped internally so that an evaporated wall coating produces the same wall anode field. The standard ½ in. vidicon rugged gun can therefore be used.

The focus electrode components within the tube have been redesigned to be completely self located and retained. This eliminates some awkward spot welds and makes tube assembly generally much easier, providing a larger hole to work through than did the original design.

Figure 4 shows a photograph of the tube. The image section is normally potted in a selastomer so that the tube can be used in a wide range of environments (including space) without breakdown of the applied 15 KV maximum EHT across the outside of the tube. The potted tube is shown in Figure 5. In this state the tube is largely hidden in the potting and looks little different from the original design. Developments in the methods used in potting the tubes have virtually eliminated failures at potting.

ILLUMINATION	APPROX. SCENE LUMINANCE foot lamberts	P.C. ILLUMINATION LENS f1. 80% TRANS. foot-candles
OVERCAST NIGHT SKY	10^{-5}	2×10^{-6}
CLEAR NIGHT SKY NO MOON	10^{-4}	2×10^{-5}
NAUTICAL TWILIGHT Lower Limit	10^{-3}	2×10^{-4}
¼ MOON	2×10^{-3}	4×10^{-4}
½ MOON	5×10^{-3}	10^{-3}
FULL MOON	10^{-2}	2×10^{-3}
Scotopic Vision ends Photopic Vision begins over about 1 order of magnitude about Full Moon		
CIVIL TWILIGHT Lower Limit	5×10^{-1}	10^{-1}
SUNRISE OR SUNSET	50	10
HEAVY OVERCAST DAY	500	100
UNOBSCURED SUN	10,000	4 at f22.

Fig. 6

Characteristics

Before turning to the tube output characteristics, perhaps one should refer to Figure 6, which gives values to the levels of ambient lighting conditions which are loosely referred to as moonlight etc. over the whole range from overcast night sky to full sunlight. It will be seen that the scene luminance over this range varies by a factor of 10^9. The tube itself, by adjustment of target voltage, and channel gain, which can be carried out automatically in the camera, will cover approximately from civil twilight down to a lower limit set by the individual tube sensitivity. Once the sun begins to rise, lens aperture adjustments and/or the use of N.D. filters are required to keep the photocathode illumination within limits acceptable to the tube.

R9777 SIGNAL CURRENT IN wA (TUBE NO 190) vs FACEPLATE ILLUMINATION IN F.C.
(EHT FIXED 14 KV)

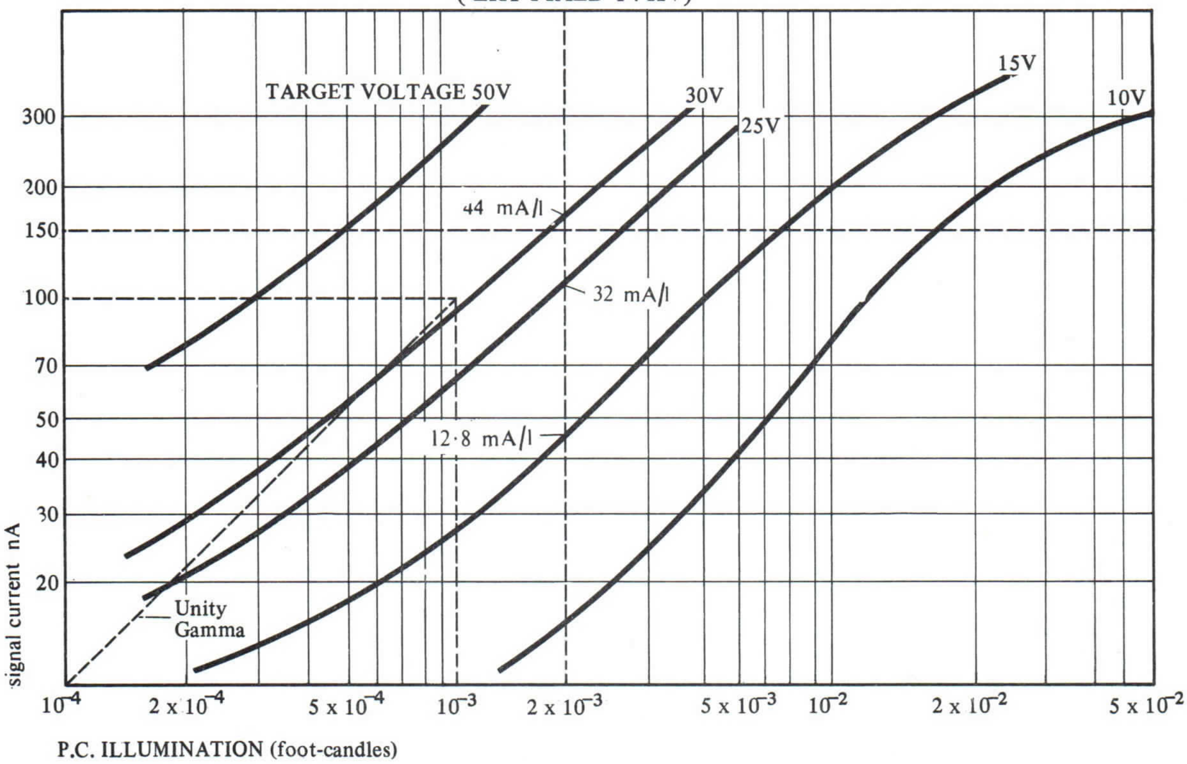


Fig. 7

Figure 7 shows signal current vs. photocathode illumination characteristics at various target voltages and fixed EHT. The sensitivity of this particular tube was a little below the present average tube sensitivity. The best tubes now have their 30 volt characteristic somewhere near the 50 V characteristic shown on this chart. In practice the tube is operated as far as possible at fixed signal current – about 200 nA.

Higher signal currents can often be obtained but are not recommended because the gun has difficulty in discharging very high signal currents and overload highlights would tend to be unstable.

Operation at target voltages above 30 V is not recommended except in low light emergency because the tube shows some undesirable side effects at higher target voltages.

Figure 8 shows the basic lag characteristic of the tube related to light falling on the photocathode and to target voltage. With 2×10^{-3} foot-candles on the face of the tube, minimum lag is normally obtained with a target gain in the region of 350. At higher values of gain, lag due to the donation of holes from the signal plate to the layer, tends to override the normally beneficial effects of a high polarising potential. This produces the somewhat distorted lag curves shown in Figure 9 where it will be seen that less lag can sometimes be obtained at 25 V rather than at 30 V for some light levels.

Higher sensitivity photocathodes now being obtained enable these higher gain targets to be used to advantage. Over the moonlight range, the lag performance and signal current can be maintained at lower than usual target voltage and the useful sensitivity range of the tube is extended at low light level by the combination of high photocathode sensitivity and higher gain.

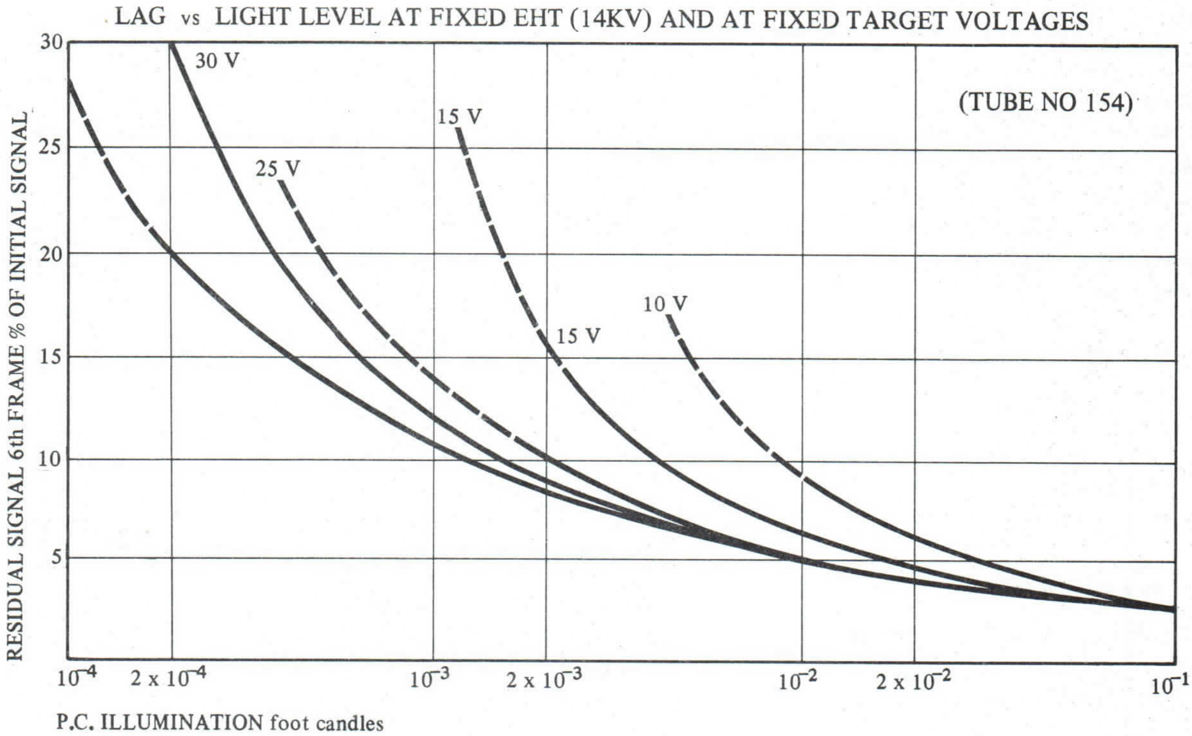


Fig.8

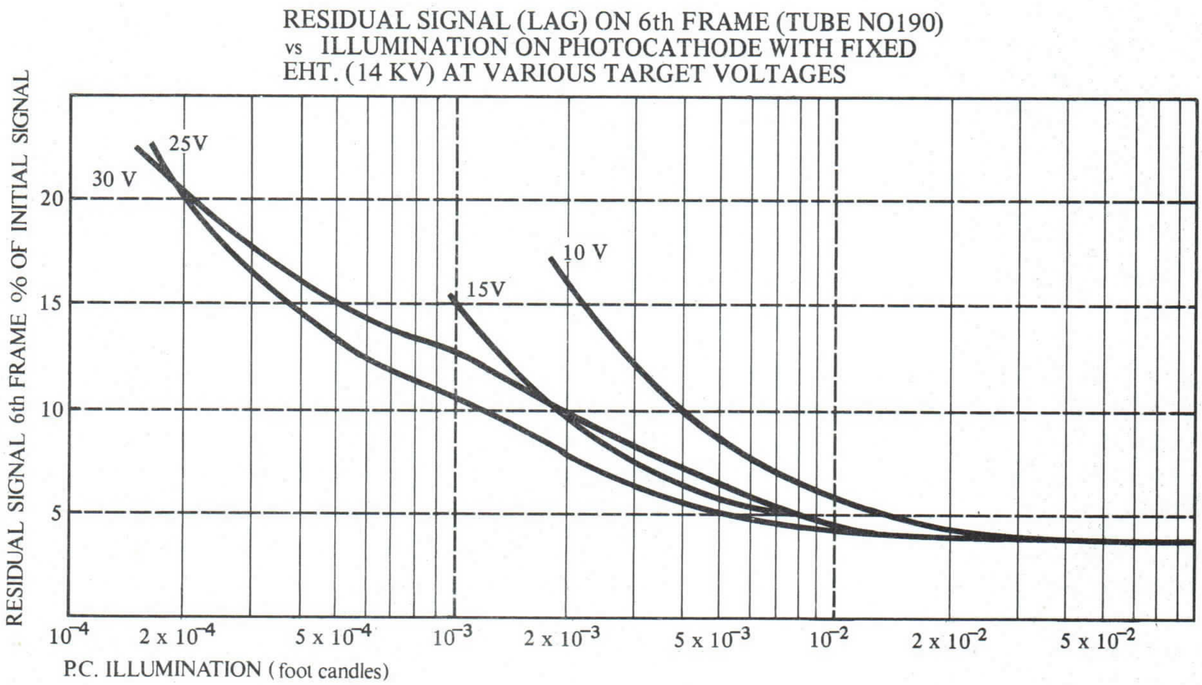


Fig.9

Figure 10 shows typical signal decay curves at 2×10^{-3} and 10^{-1} foot-candles faceplate illumination in comparison with the published curve for a ½ in. vidicon at considerably higher light levels.

Figure 11 shows a resolution curve for the tube. As can be seen it is at present not as good as a ½ in. vidicon but it is expected that this parameter will be improved.

Figure 12 shows a curve for static test of limiting resolution against faceplate illumination at constant signal current.

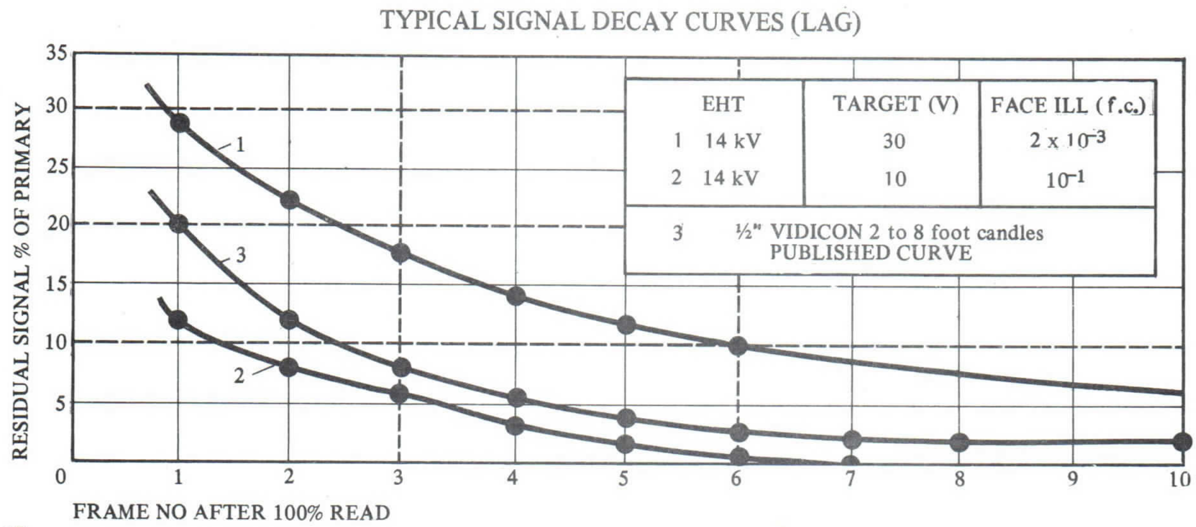


Fig. 10

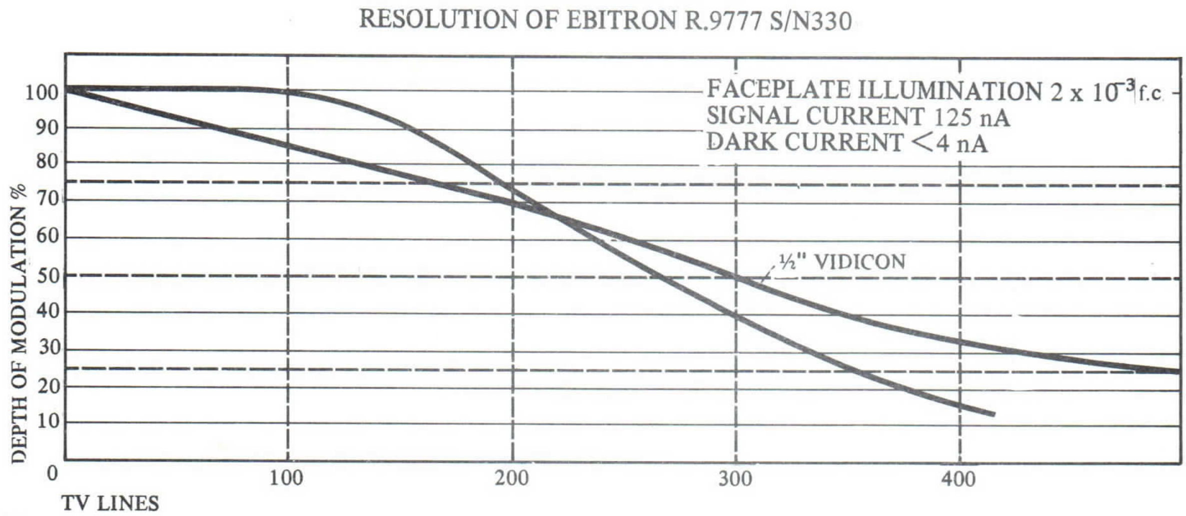


Fig. 11

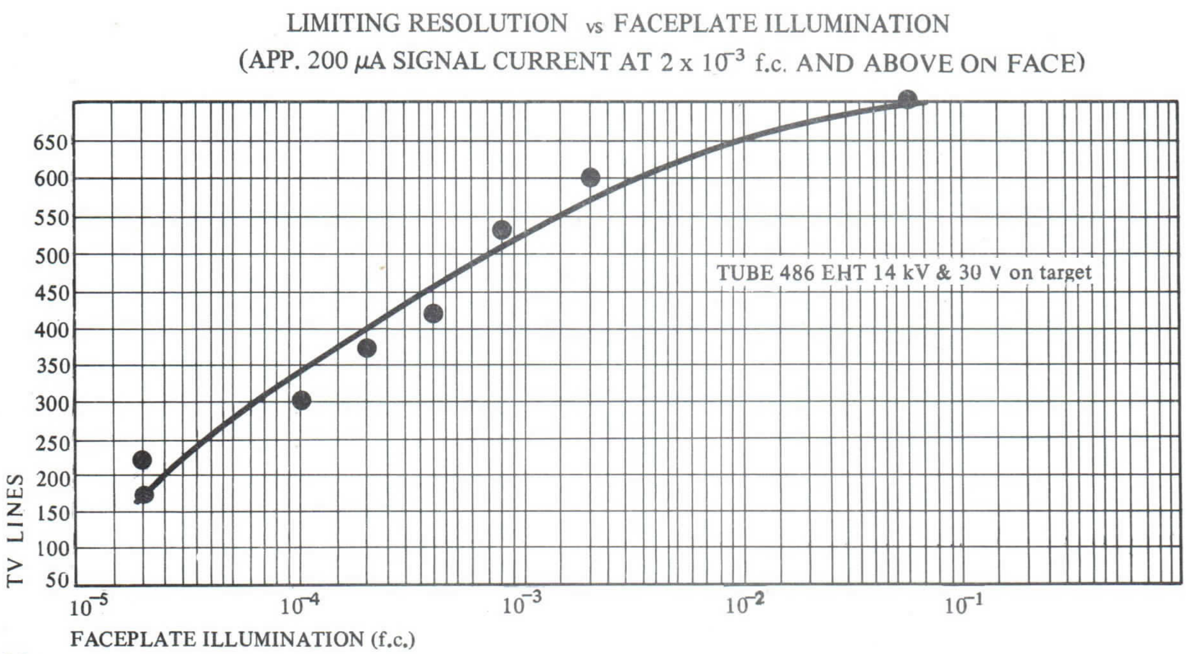


Fig. 12

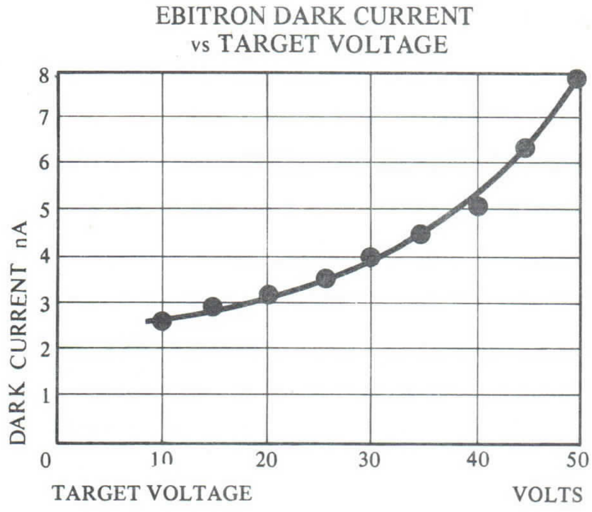


Fig. 13

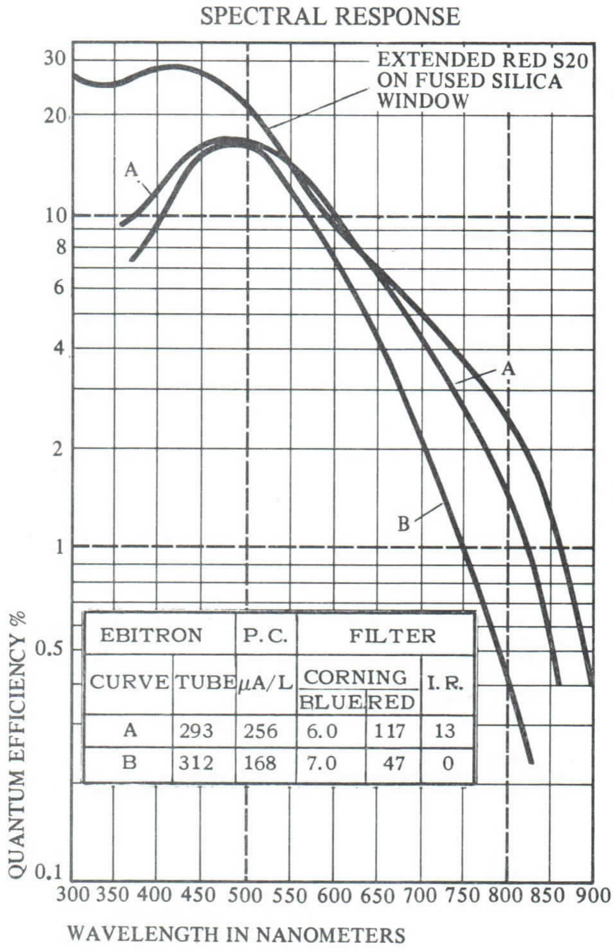


Fig. 14

Figure 13 shows how the dark current rises rapidly for target voltages over 30 V.

Figure 14 shows the spectral response curves for a good and a low photocathode sensitivity tube, compared with an extended red photocathode. The red response of EMI photocathodes is steadily being extended by progressive modification of processes and these curves may rapidly become out-dated.

Future Development

The future for the Ebitron looks very encouraging. Photocathode development is such that anything below 200 μA/1 is disappointing; 300 μA/1 may well be typical in the near future. This will also allow target gain to increase further without loss of the good lag property. The highest target gains at present approach 1,000 and this could become typical. At present tubes are often made with an overall sensitivity of 100 mA/1 and the sort of improvement mentioned should push the best tubes up into the 200 mA/1 region. Some of our 100 mA/1 tubes are already giving useful information in starlight conditions using the ploy of increased integration time obtained by omitting alternate reading frames.

Tube performance may be improved by developments in the preparation of the zinc sulphide, although new materials with higher gain and better lag characteristics may be introduced to replace the zinc sulphide. For some scientific systems a further stage of intensification is required with the Ebitron. In order that effective coupling may be made, the Ebitron is available with a fibre optic faceplate. This permits close matching with the fibre optic output of suitable intensifiers. It is possible to fit a sapphire window to the tube to extend operation into the UV if required. Figure 14 shows how the UV response is lifted.

Applications

Many new and interesting applications are being found for this tube in both the standard television scanning format and in unusual conditions of scanning. It is hoped that it will form the basis of many low light level TV systems in the years to come.

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PRINTED CIRCUIT SCANNING COILS

MANUFACTURING TECHNIQUE GIVING
COMPACT ASSEMBLIES WITH GOOD GEOMETRICAL
ACCURACY AND REPEATABILITY IN PRODUCTION

by

E. W. Bull, M.Sc.(Eng.), F.I.E.E., F.R.S.A.
EMI Research Laboratories

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R/T018 W72

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Printed Scanning Coils

Manufacturing technique giving compact assemblies with good geometrical accuracy and repeatability in production

*by E. W. Bull,** M.Sc.(Eng.), F.I.E.E., F.R.S.A.

A television system usually contains at least two sets of scanning coils, one at the camera and one at the receiver. These scanning coils determine to a large extent the geometry and edge resolution of the received picture. Since they may not much exceed one inch in diameter and yet the displayed picture may be 20 inches in diameter, the coil construction must by held to close limits. This is of particular importance in colour television, where three rasters have to be superimposed, and calls for extremely small tolerances.

Wire-wound deflecting systems usually consist of two pairs of coils arranged at right angles to one another. The four coils are wound separately, and since they are essentially pile wound, the overall dimensions of the assembly are dependent upon tolerances in wire size and winding tension. The coils when wound have to be mounted in pairs parallel to one another on either side of the axis of a central mounting tube. To achieve parallel mounting while avoiding twisting or relative axial displacement is an extremely difficult operation, and is at best something of a compromise. If both pairs of coils are mounted on central tubes one of which slides over the other, then one tube can be rotated until there is no mutual inductance between the sets of coils. Although this method of manufacture has been used since the early days of television the accuracy of the finished coil is very dependent upon the skill of the assembler, and is falling short of present requirements.

The idea of printing the conductors of a scanning coil[1] is not new—indeed it has been realised for many years that accurate coils could be produced by this method. Only during the past few years, however, have techniques and materials become available as a result of work on printed circuits in general. The basic material is a sheet of good quality insulating material such as Mylar (about 0.001 in. thick), coated on one or both sides with copper. The copper thickness may be between about 0.0015 in. and 0.005 in., according to the application. A pattern of conductors is formed by etching away unwanted copper, as is done in the preparation of printed circuit boards, the pattern being derived from a master transparency prepared photographically. Any number of identical sets of coil windings may be produced from the single master.

Spiral winding

The form in which the conductors are printed naturally tends to follow the spiral shape employed with wound coils, but a difficulty arises in that connection to the centre of the spiral cannot be made without crossing the outer conductors. This has been overcome[2] by printing another, reversed, spiral on the other side of the insulating base, and soldering through

* Research Laboratories, Electric & Musical Industries Ltd.

Fig. 1. Current paths in spiral coils: (a) upper and lower conductor patterns forming a set of coils, with lower pattern shown displaced to right; (b) composite current flow for the set.

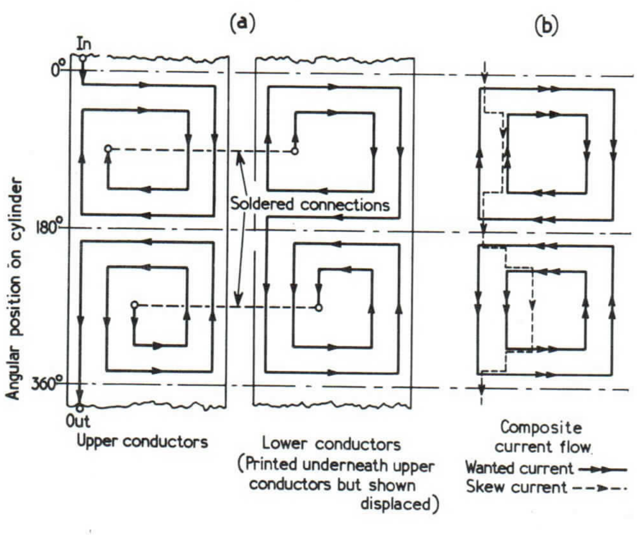
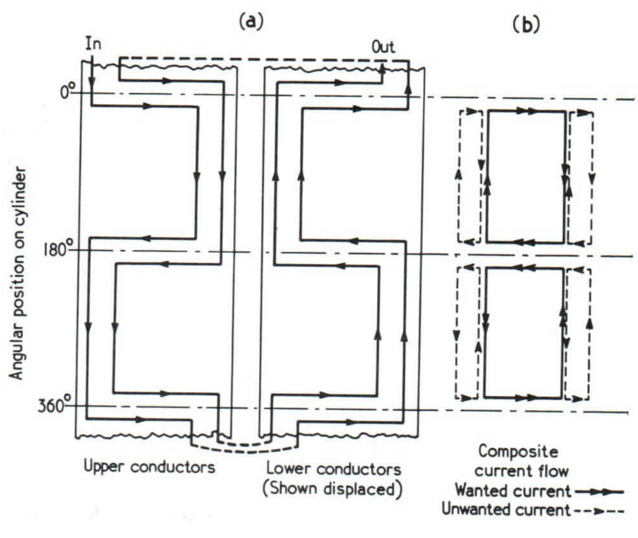


Fig. 2. Current paths in square wave coils: (a) upper and lower conductor patterns with lower pattern shown displaced to right; (b) composite current flow.



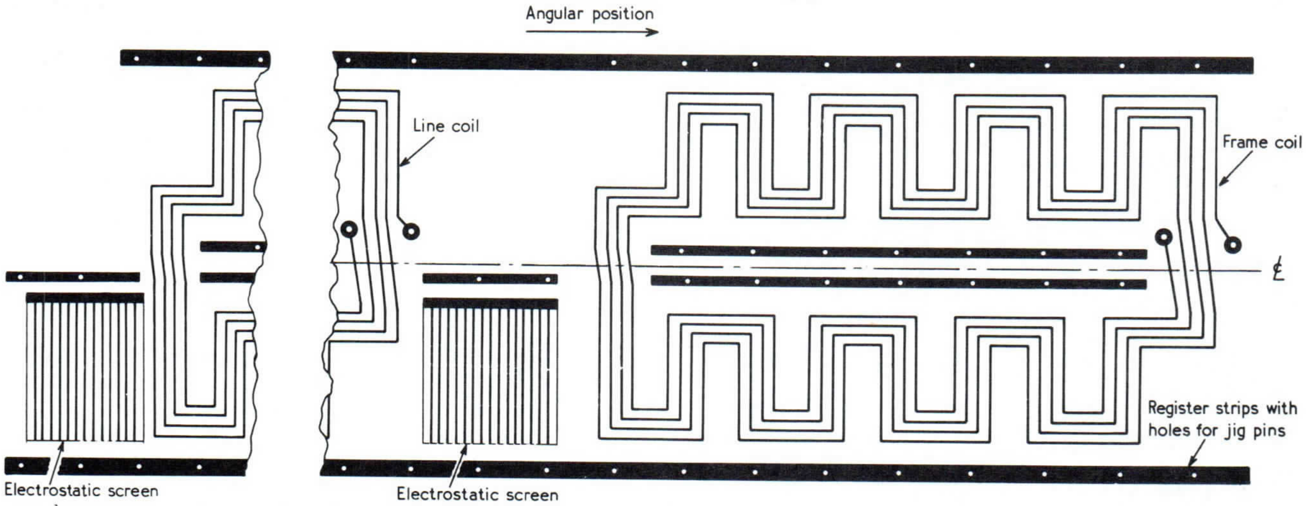


Fig. 3. Etched laminate strip before winding. The base material is folded along the centre line so that the upper wave pattern lies over the lower.

the insulating material to join the centres of the two spirals, as shown in Fig. 1(a). Both current leads now emerge at the outside of the double spiral and connections can be made to subsequent spirals arranged side by side in a long strip. The single conductor joining consecutive spirals makes the printed strip weak at this point and the conductor is liable to fracture unless carefully handled.

A more serious effect is the skew field produced by the spiral form of winding. In Fig. 1(b) the currents in the two spirals have been added, to produce the wanted currents (solid lines) together with unwanted currents (broken lines) which produce a skew component of field. This effect is of course present in wire wound coils but usually to a small extent. It can be reduced from Fig. 1 that the ampere turns producing skew field are $\frac{1}{n}$th of those producing wanted field (where n is the number of turns), so that if the number of turns is large the error is small. With a printed coil the number of turns in a layer may not exceed twenty, and distortion of field will occur.

Wave winding

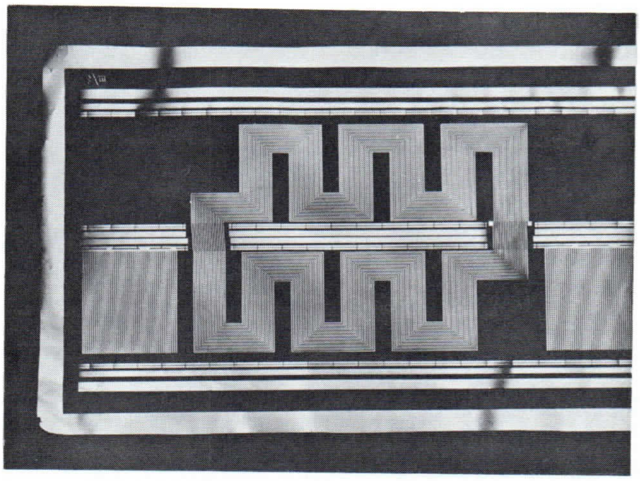
An alternative method[3] of arranging the conductors, in the form of a pair of square waves, overcomes several of the disadvantages of the spiral form, and is shown in Fig. 2(a) These conductors (only two are shown) may be deposited on opposite sides of a single insulator, or on separate insulators since no interconnection is needed at each layer, all connections being made only at the ends of the complete coil set. The conductor arrays are uniformly strong and have little tendency to fracture with handling. Fig. 2(b) shows the composite current paths, which do not have a skew component. The unwanted currents now produce a gradual fall of field along the axis.

Assembly of coils

Scanning coils usually require more turns than can be accommodated in a single layer of printed circuit, so that the conductor pattern has to be repeated several times along a strip and then wound in a spiral to present a cylindrical form. To preserve correct alignment of the conductors in successive layers the scale of the conductor pattern in the axial direction must increase in steps, being proportional to the winding radius. These increments have to be calculated from the thicknesses of the component layers, but as these may vary slightly it is useful to make a fairly generous allowance and apply a system of registration. For this purpose additional copper strips are printed alongside the active conductors, containing small holes at equiangular intervals, as shown in Fig. 3. When the strip is wound, a jig with radial pins engages the holes in the copper strips and thus ensures that there is no cumulative error in position. The layers may be held together by some form of adhesive to form a self-supporting structure, and the strips used as a register are finally removed.

Some of the most recent[4] ideas in the development of printed coils are illustrated in Fig. 3. The two wave windings are printed on the same base material side by side (shown one above the other in Fig. 3), together with their interconnections. The base material is subsequently cut (except where conductors are present) along the centre line, and then folded over along this line. A thin sheet of insulating material is inserted to avoid contact between the two copper faces. The cutting of the base material is necessary because the two waves are not of equal length when printed flat, but when wound in the form of a cylinder they will assume their correct angular positions. The coils for two co-ordinates of deflection, together with electrostatic screens between the windings are all printed

Photograph of a section of etched laminate corresponding to Fig. 3. (Picture taken with light shining through the base material.)



Not a new line in stoles, but illustrating the general appearance of a length of printed conductors before winding.

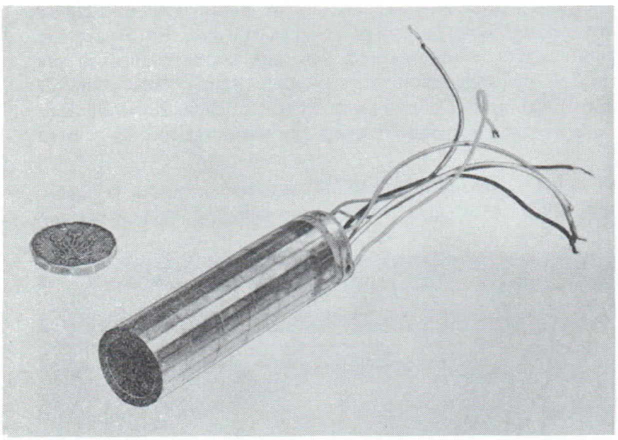


Fig. 4. Printed scanning coils for ½-in. vidicon camera tube. The overall diameter is ¾in.

on the same sheet of base material. The strip, when folded with a layer of insulating material inserted, is wound on a simple jig with projecting pins to engage the register holes. If an adhesive is applied during winding the coil system can be made self-supporting, and the register strips removed subsequently.

A number of printed coils for various sizes of vidicon camera tube have been made, two of which are shown in Figs. 4 and 5; and from measurements on these it is possible to assess the relative merits of printed and wire wound coils:

Advantages of printed coils

1. The geometrical accuracy is very good and dependent on the accuracy of the original "master", not on the skill of the assembler. Angular position of the vertical and horizontal axes can be held to less than 0.2 degree, and other errors are generally less than those inherent in the camera tube itself.
2. Variations from coil to coil are very small, and no selection into matching sets is required for colour cameras.
3. Very compact coil assemblies such as that shown in Fig. 4 can be made. This coil together with its focus coil is part of a television camera having an outside diameter of 0.9 in.

Disadvantages

1. Capacitances are higher due to the flat strip form of the conductors.
2. The winding space factor of the copper laminate is not as good as that of enamelled wire, but this can usually be counter-balanced by the omission of winding formers and winding tolerances.

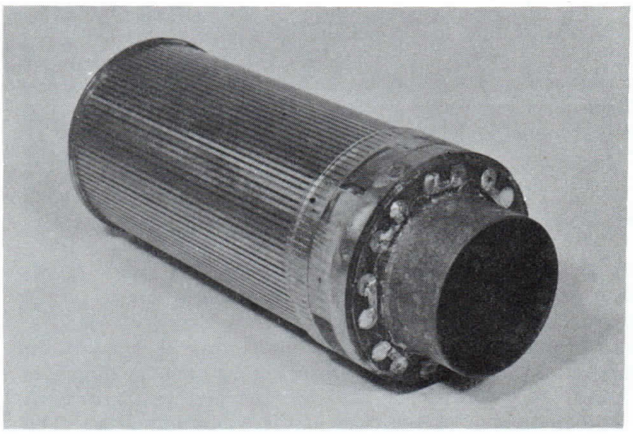


Fig. 5. Printed scanning coil for colour camera.

References

1. Brit. Patent 633,625. E. W. Bull and H. E. Holman, 1946.
2. Brit. Patent 795,469. Centre Cedel d'Etudes Scientifique, 1954.
3. Patent Application No. 32578/65. E. W. Bull.
4. Patent Application No. 8555/66. A. M. Sampeys, E. W. Bull.

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Printed in England

CATHODE RAY TUBES

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EMI CATHODE RAY TUBES

Production Tubes	Description	Phosphor	Type	
a) Radar Display Tubes				
MX14 (CV5163)	390 x 310 mm rectangular	008	(P26)	
MX18 (CV487)	251 mm dia.	GG6		
MX19 (CV2472)	251 mm dia. long persistence	G08		
MX20 (CV429)	305 mm dia.	009	(P19)	*
MX21 (CV1965)	305 mm dia.	009	(P19)	*
MX24 (CV2388)	549 mm dia. metal cone	009	(P19)	
MX32 (CV6101)	92 mm projection tube	BB4		*
MX37 (CV2415)	160 mm dia.	009	(P19)	
MX38 (CV1530)	160 mm dia.	G05	(P1)	
MX49 (CV5941)	390 x 310 mm rectangular E.S. focus	008	(P26)	
MX64	560 mm dia. flat face metal cone 53°	007	(P38)	
MX65	560 mm dia. flat face metal cone 70°	007	(P38)	
MX72 (CV6167)	305 mm dia. (originally TDX44)	007	(P38)	*
b) Flying Spot Scanning Tubes				
MX29	162 mm dia. monochrome film scanner	GG2	(P24)	
MX29S	As MX29 but with better overall focus	GG2	(P24)	
MX45	162 mm dia. high resolution film scanner	GG2	(P24)	
MX57/15	185 mm dia. tinted face standards converter	GG5	(P1)	***
MX57/T	185 mm dia. tinted face monochrome film scanner	GG2	(P24)	***
MX61	35 mm dia. character scanning tube	GG2	(P24)	
MX62	133 mm dia. character display tube	008	(P26)	
MX66	26 mm dia. miniature scanning E.S.	GGO		*
MX66D	Fibre Optic version of MX66	GGO		*
MX69	185 mm dia. colour negative film scanner	GG1		
MX70	26 mm dia magnetic miniature scanning	GGO		
MX70D	Fibre Optic version of MX70	GGO		
MX71	185 mm dia. colour positive film scanner	GGO		

Developmental devices are intended for evaluation and no obligation is assumed for future manufacture.

MX73	75 mm dia. domestic and educational (originally TDX29)	GGO	
MX74	127 mm dia. positive or negative scanner (originally TDX33)	GG1 or GGO	
MX75	100 mm dia. positive or negative scanner (originally TDX35)	GG1 or GGO	

c) Miscellaneous Tubes

MX2 (CV418)	89 mm dia. E.S. oscilloscope tube	GG3	(P31)
MX10	92 mm dia. high resolution film recording tube	BB2	(P11)
MX12	235 mm dia. photographic masking tube	WW2	(P4) *
MX17 (CV2222)	89 mm dia. E.S. oscilloscope tube	GG3	(P31)
MX27 (CV2469)	125 mm dia. general purpose display	GG5	(P1)
MX41	254 mm dia. T.V. Monitor tube	WW2	(P4)
MX48	36 mm dia. CRT short persistence light source	various	
MX63	127 x 101 mm rectangular rugged display tube	WW2	(P4)
MX67	100 mm dia. T.V. standards converter	GG5	(P1)

d) Developmental Tubes

TDX34	160 mm dia. document scanner	BBO	
TDX37	185 mm dia. high resolution character scanning tube	BBO	
TDX38	302 mm dia. high resolution character scanning tube	BBO	
TDX39	26 mm dia. high resolution Fibre Optic print out tube	GGO	
TDX40	90 mm dia. high resolution Fibre Optic slide scanner	BBO	
TDX41	127 mm dia. E.S. focused film scanner	GG1 or GGO	
TDX42	165 mm dia. 40° scanner pattern recognition tube	GGO	
TDX43	75 mm dia. general purpose oscilloscope tube	GG3	(P31)
TDX45	Lengthened version of MX66 with improved focus	GG3	(P31)
TDX46	150 x 200 mm rectangular data display tube		(P7) *

* Available with various phosphors - see data sheet

** Available with untinted face

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IMAGE INTENSIFIERS &
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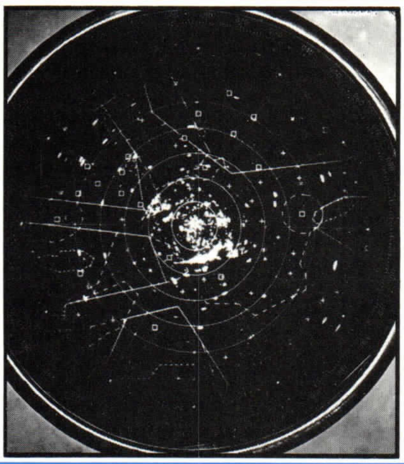
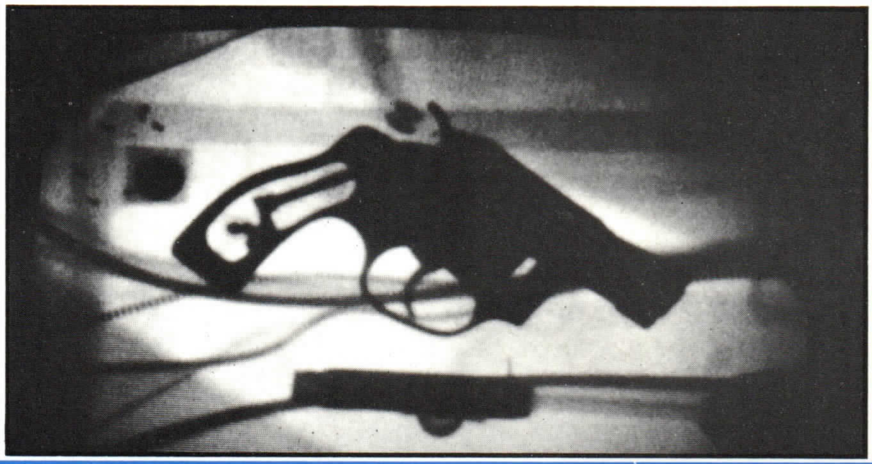
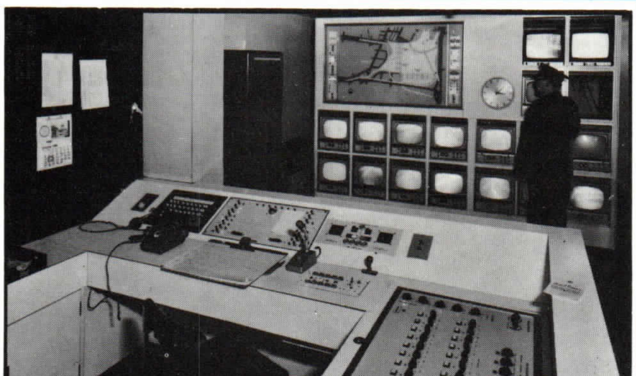
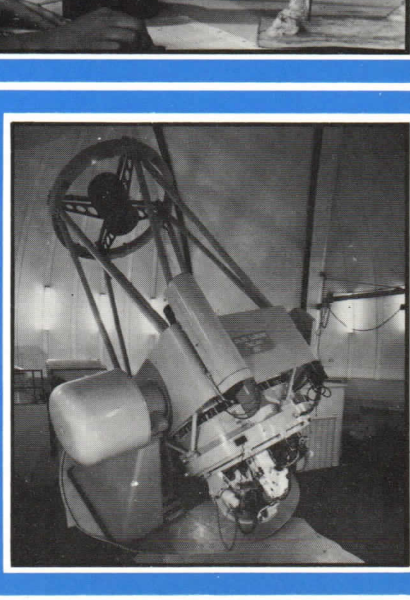
Image Intensifier Systems









Key to front cover photographs

A

An EMI 22in cathode ray tube being used to display converted radar information of aircraft movements over London, at the Civil Aviation Authorities air traffic control centre, West Drayton.

B

An EMI low light television camera using an EBITRON intensifier vidicon to produce a TV picture of X-ray images, is an essential part of a new baggage inspection system.

C

EMI vidicon tubes are used in the closed circuit TV cameras which feed traffic information to a bank of monitors in the police control centre at the Mersey tunnel.

D

Chinese ceramic horse of the Táng dynasty 618-906 AD, being checked for authenticity by the "thermoluminescent dating technique," at the Archaeological Research Laboratory of Oxford University. An EMI photomultiplier is used to measure the light intensity of the heated sample drilled from the object.

E

EMI silicon avalanche photodiodes are used in the Ferranti laser ranging system fitted to the Harrier jump jet and other tactical aircraft.

F

An EMI image intensifier is used to help record the images of distant stars and galaxies seen on the giant 98 inch Isaac Newton telescope at the Royal Greenwich Observatory, Herstmonceaux.

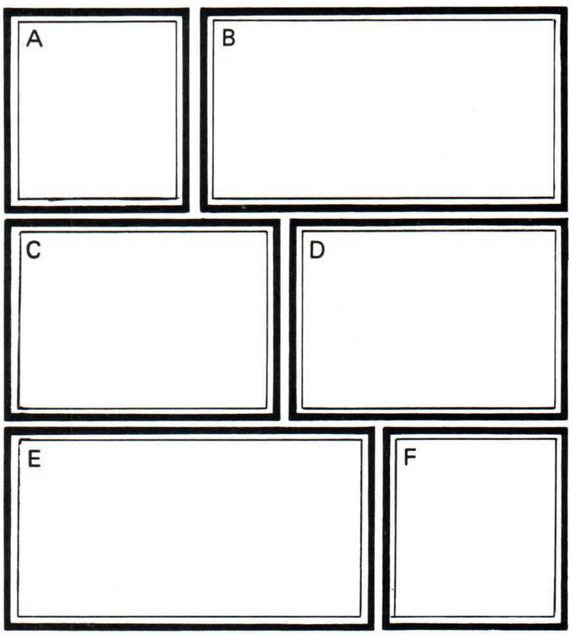


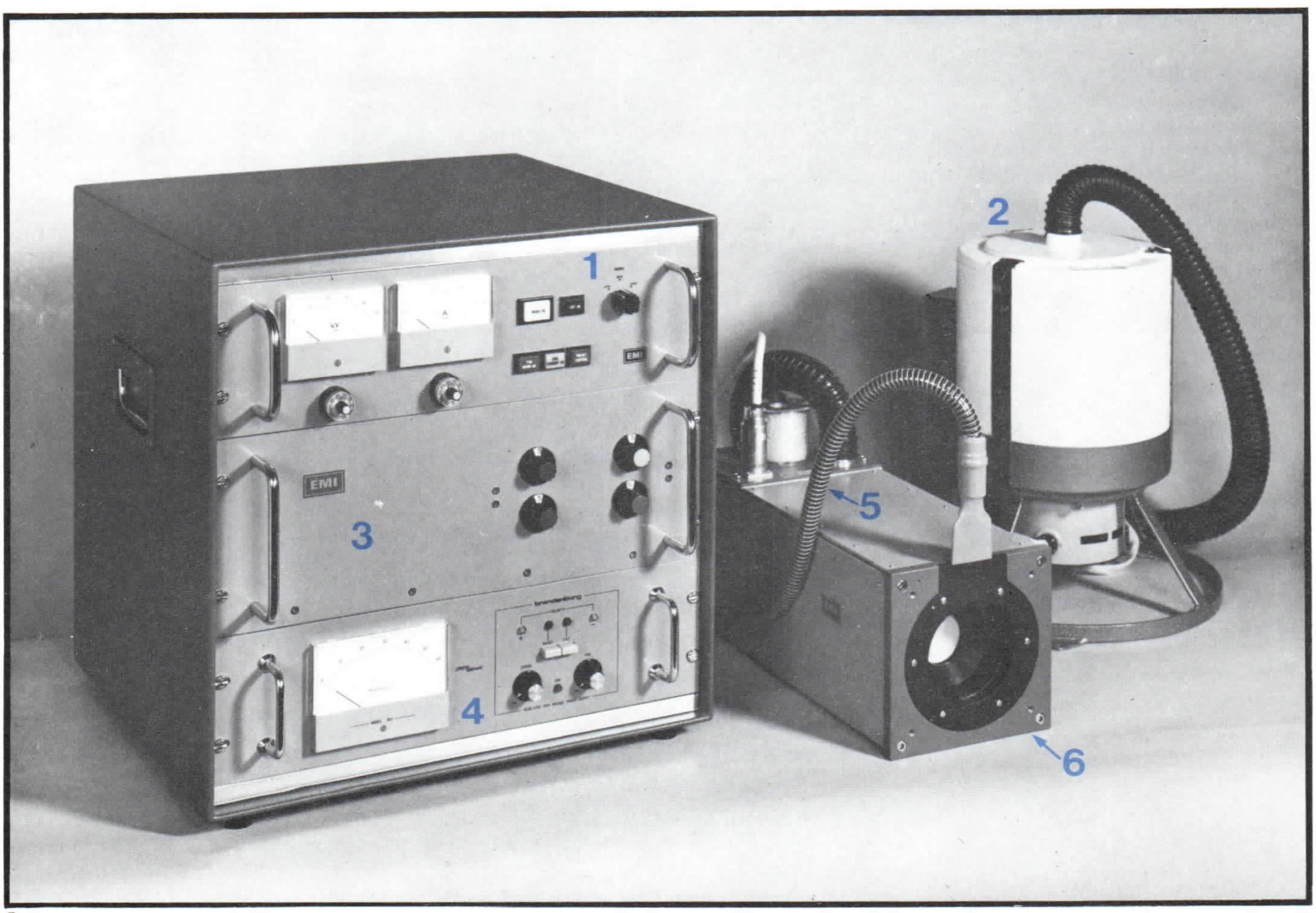
Image intensifier systems

Contents

T2001 system

Key to photograph

1 Control unit C192
2 Cooling blower
3 Combined EHT divider chain and coil power supply.
4 EHT power supply
5 Sheathed EHT connection to tube
6 Forced air cooled coil



Introduction to EMI image intensifier tubes and systems

The 9910 series of image intensifier tubes comprises 2, 3 and 4 stage magnetically focused tubes having 48mm input/45mm output useful diameters. They provide exceptional resolution, gain and low dark current, and their use with the T2001 series of image intensifier systems ensures that the high quality, low distortion imaging characteristic of the magnetically focused image intensifier is readily available to the user.

Developed from our previous type 9694, the principal features of the 9910 tube series are:

- Re-designed electron optics, giving improved image geometry with reduced magnetic field. The lower magnetic field and smaller tube diameter have led to the design of a compact air cooled focus coil.
- New phosphor screening methods used in making phosphor/photocathode sandwich layers have resulted in substantially grain free images, higher resolution and lower operating voltages.
- A novel approach to encapsulation, totally containing all tube voltages, provides excellent image stability, lowest dark current and safe high altitude operation (up to 4000 m).
- Versatility, e.g. 3 methods of gating and choice of photocathodes, phosphors and input windows.
- Extra high quality tubes to individual specification.

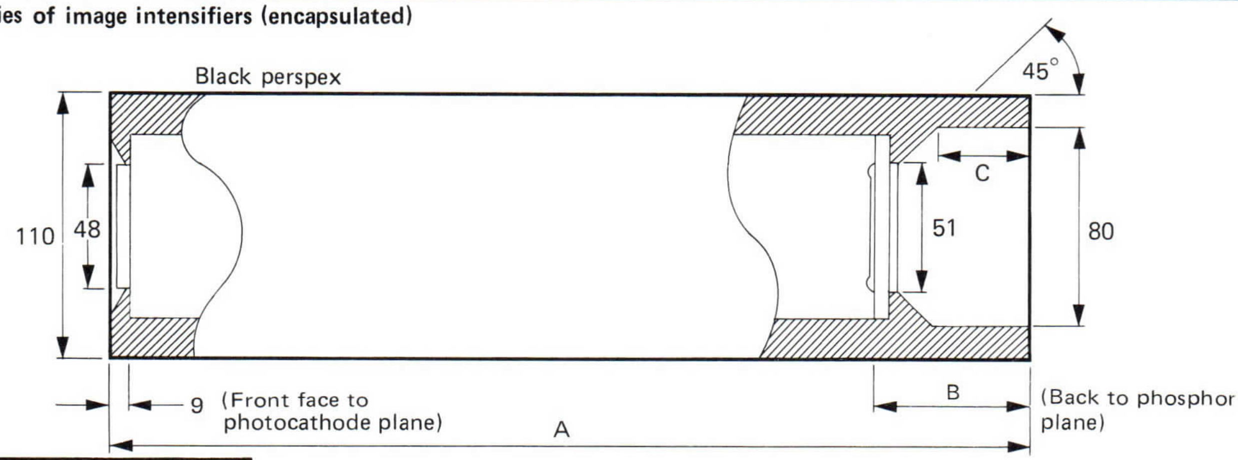
The T2001 image intensifier system allows the 9910 tube series to be installed, set up and operated with the minimum of skill and effort. Specifically designed to match the excellent qualities of these tubes, each model in the T2001 range provides the following facilities:

- All electrical operation, by virtue of the forced air cooled focus coil.
- High stability electrical supplies to the image intensifier.
- Manual or 3 position pre-set gain adjustment.
- Remote operation.
- Safety interlocks in the event of incorrect operating procedures:
  - (a) Protection from overloading on EHT
  - (b) Protection from optical overloading (under development).

9910 series of magnetically focused image intensifiers: general information

Type number	Replaces type	Number of stages	Used with: T2001 system	Used with: Focus coil	Used with: Divider chain
9912	9694	4	T2001/4	C142	C152B
9914	9794	3	T2001/3	C141	C151B
9916	9723	2	T2001/2	C141	C154B

9910 series of image intensifiers (encapsulated)



APPROXIMATE DIMENSIONS mm			
Type No.	A	B	C
9912	373	69	39
9914	302	69	39
9916	302	44	16

All dimensions are in millimetres, and subject to working tolerances.

Application & specification

Application notes

The 4 stage tube type 9912: Provides very high gain (up to 10^7) and is intended for broad application where a wide range of gain levels is required. At peak gain, detection of single photoelectrons from the input photocathode by photography or television techniques is readily achieved. Thus the tube provides ultimate detection sensitivity to extremely low light level events, as can be experienced in Raman spectroscopy, X-ray and electron diffraction, scintillography, high speed photography and photon position counting.

The 3 stage tube type 9914: Has been specifically developed for astronomical photography, providing the highest quality gain/resolution product. The tube is therefore ideally suited to applications where image detection requires not only fast recording speed, but high resolution.

The 2 stage tube type 9916: Is designed to yield optimum detection efficiency. The gain of this tube is high enough for the effective quantum efficiency of a photographic system to be principally limited by the input photocathode characteristics, and the very high resolution of this tube ensures that there will be minimal information loss.

Input photocathodes: All photocathodes provided in these tubes are based on the S 20 trialkali type (SbNaKCs). The bialkali (SbNaK) gives exceptionally low dark current, the characteristics of the full range of photocathodes available being illustrated in Figs 1 and 2.

Windows: Standard: zinc crown
Variants: extended U.V. transmitting zinc crown (selected for astronomical applications), sapphire, fibre optics (input or output). Due to the manufacturing technique employed in producing these special window types, tube specifications may be limited by the paricular characteristics of these materials. Every effort is made by the Company to use components which will enable tubes to be produced to the specifications published herein.

It should be noted however that bialkali photocathode tubes with sapphire faceplates will in general have a typical dark current of twice the specified maximum for a bialkali tube, because of scintillations occurring in the window due to cosmic rays and natural radioactivity.

The structured nature of fibre optic plates will modify resolution limits attainable. 9912 types are not affected; 9914 types will be within minimum specified limits; 9916 types will have a minimum limit of 50 lp/mm.

In general, blemish specifications will be achieved but additional blemishes of low contrast may be present.

Phosphors: Standard output: P11. P20 or special fast phosphors can be employed on individual stages or throughout the tube for fast storage or response characteristics.

Pulsing:

(a) Input gating. Gating pulse is applied to the input photocathode. Normal maximum pulse voltage is −4 k V, normal pulse duration, less than 1 μs.

(b) 1st/2nd stage gating. This method allows stored information on phosphor of 1st dynode to be selected for intensification in response to external stimulator. Normal maximum pulse voltage -4 kV. Storage times, either 200 μs or 5 μs dependent upon phosphor type.

(c) Last stage gating. Provides similar facility to (b) and 'total black' output conditions prevent film fogging in 'open shutter' photography when long intervals between events are experienced. Normal maximum pulse voltage, 10 kV. Normal storage time, 200 μs.

Specification 9910 series of image intensifiers

General data:

Spectral response		see figs 1 and 2
Minimum useful input photocathode diameter		47mm
Minimum useful output phosphor diameter		42mm
Standard input/output window material		Zinc crown glass
	thickness	4mm± 0.1 mm
	refractive index	1.5079
	shape	Flat, circular
Image magnification	2 loop focus	0.95
	1 loop focus	0.75
Weight (encapsulated)		2 kg. max.
Operating position		Any

Absolute ratings:

Cathode to anode voltage *		40 kV max.
Average anode current:		1μA max.
Ambient temperature:	Non-operating	50°C. max.
	Operating	35°C. max. −20°C. min.
Highlight screen brightness:		For input exposures of less than 1 ms the highlight screen brightness must not exceed 1000 cd/m^2, for exposure periods of greater than 1 ms the product of highlight screen brightness and exposure time must not exceed 10 cd/m^2.

* It is usual to supply recommended maximum operating voltage on the test ticket supplied with each tube. If not so stated, this rating applies.

Typical output characteristics

These characteristics are obtained when the tubes are used with the recommended condition of 2 loop focus.

Image distortion: (all tube types)

	at edge of 40mm diameter zone	at edge of 25mm diameter zone
Radial displacement of image from true position, as percentage of full field diameter.	2%	1%
Tangential displacement of image from true positon, as percentage of full field diameter.	1%	¼%
Visual limiting resolution, as percentage of centre resolutions: Radial:	75%	90%
Tangential:	50%	85%

Image rotation: Less than 3° for all tubes.

Note: Care is taken to avoid gain variation over small areas within the specified limit.

Non-uniformity of gain over tube diameter: ± 25% maximum
± 15% typical

Blemishes: Maximum permissible spot diameter: .... 1 mm
Maximum number of spots between 0·25mm and 1·0mm diameter outside this zone: 2
Maximum number of spots between 0·25mm and 1·0mm diameter in 20mm central zone:..... 5

Image drift: Selected tubes having guaranteed minimum image drift can be supplied to customer specification subject to a surcharge. This test condition, measured at 2 loop focus in the 30 mm central zone, is nominally 5 microns per hour after one hour warm up.

Background: Tubes are virtually free of fine grain phosphor brightness variations within the limits of maximum resolutions, see fig. 3.

Signal induced background: The general background signal, induced by areas of signal of random brightness and disposed at random over the tube output, is 0·5% of mean signal level for each 1 cm^2 area of signal. See fig. 4 for general illustration of this effect.

Notes: See tables below

1. Data for standardized types.
2. Tubes supplied for lower dark current and less than standard S20 red response will have sensitivities in the range 70 - 110μA/lumen. Tubes can be selected having cathode sensitivities greater than 150μA/lumen.
3. Measured at wavelength of maximum photocathode response.
4. Tubes which are subject of orders specifying all or most of the parameters as typical (or better) may represent a selected tube at special pricing.
5. Visual limiting resolution determined from an input image of a bar pattern at 100% contrast.
6. It is recommended that tubes are used under 2 loop focus conditions to obtain ultimate performance. The use of the T2001 system ensures this.

Typical operating characteristics

	9912		9914		9916	
	S 20	Bialkali	S 20	Bialkali	S 20	Bialkali
Gain at 35 kV	4×10^6	2×10^6	5×10^5	$2{\cdot}5\times10^5$	10^4	5×10^3
Minimum gain at maximum voltage	10^6	10^6	$2{\cdot}5\times10^5$	$2{\cdot}5\times10^5$	3×10^3	3×10^3
Resolution centre (5) (lp/mm) –						
2 loop focus (6) Typical	35	40	50	55	70	75
Minimum	30	30	45	45	60	60
1 loop focus Typical	30	35	45	50	60	65
Minimum	25	25	40	40	55	55

Photocathode characteristics

Photocathode type (1) (4)	S20			Bialkali			Units
	Min	Typical	Max	Min	Typical	Max	
Sensitivity (2)	100	140	-	30	50	-	uA/1m
Quantum efficiency at 420 nm	15	20	-	15	20	-	%
Electron dark current	-	200	1000	-	2	10	counts/cm^2/s
Ion dark current	-	1	10	-	0·1	2	counts/cm^2/s
Dark current - equivalent irradiance (3)	-	5×10^{-16}	3×10^{-15}	-	5×10^{-18}	3×10^{-17}	W/cm^2
Dark current - equivalent light input	-	2×10^{-9}	10^{-8}	-	5×10^{-11}	2×10^{-10}	lux

Image intensifier system T2001

General description: Each system comprises, (as shown in photograph on page 2), (1) EHT supply, (2) Focus coil power supply, (3) EHT divider chain, (4) Control panel, (5) Focus coil, (6) Focus coil exhaust fan. Tubes for use in the systems are quoted for separately owing to their special and varied characteristics. The system is available as three models to suit 2, 3 or 4 stage tubes:

	T2001/4	T2001/3	T2001/2
Tube Type	9912	9914	9916
Focus coil	C142	C141	C141
EHT Divider Chain/ coil power supply	C202	C201	C203
Common components:	Control panel C192, EHT supply C205, fan C171 or C172, cabinet and interconnections.		

The electrical supply and controls can be provided either for mounting in customers 19" rack, or built into a cabinet, 20" x 20" x 18". The systems are provided for 50 Hz or 60 Hz operation. Standard lead length between coil unit and supplies is 2 metres. Longer lengths can be provided on special request. The principal advantage to the user in employing the T2001 system is its 'ready to use' concept, factory tested with the customer's tube (where possible). Details of the components of the T2001 system are given in the appropriate sections of the catalogue. Where indicated, these component units can be purchased separately so that customers with already available equipment, such as EHT supplies, can assemble a simplified system themselves. Variations and extensions to the basic T2001 system for special applications can be considered on request.

Remote operation of the T2001 system can be achieved by removing the control panel C192 and operating this unit at the required distance from the rest of the system. A set of extension leads is available to special order.

Power requirements: The total power requirement for the T2001 system is 1525 VA.
Supplies for the forced air fan, EHT unit and coil power supply are taken from the control unit. Systems can be supplied for operation at 240/220 V 50 Hz or 110 V 60 Hz.

Control units C192

C192 control unit incorporates:

a) Control and metering for coil power supply incorporated in T2001 systems.
b) Coil protection circuitry in event of blower failure.
c) Mains distribution centre for EHT supply and coil power supply, including safety interlocks.
d) Timing circuit ensuring that blower is kept running for pre-set period after coil power switched off.
e) Remote control and metering of EHT supply.
f) Pre-set controls for EHT and focus coil current providing 3 settings of the image tube giving high, medium and low gain.

Mechanical specification: The control unit is mounted on a panel suitable for 19" rack mounting.

Overall height	133 mm
Overall depth	265 mm ....behind panel
Overall width	482 mm
Weight	53 kg

This unit is normally supplied only as part of T2001 systems.

Control unit C192

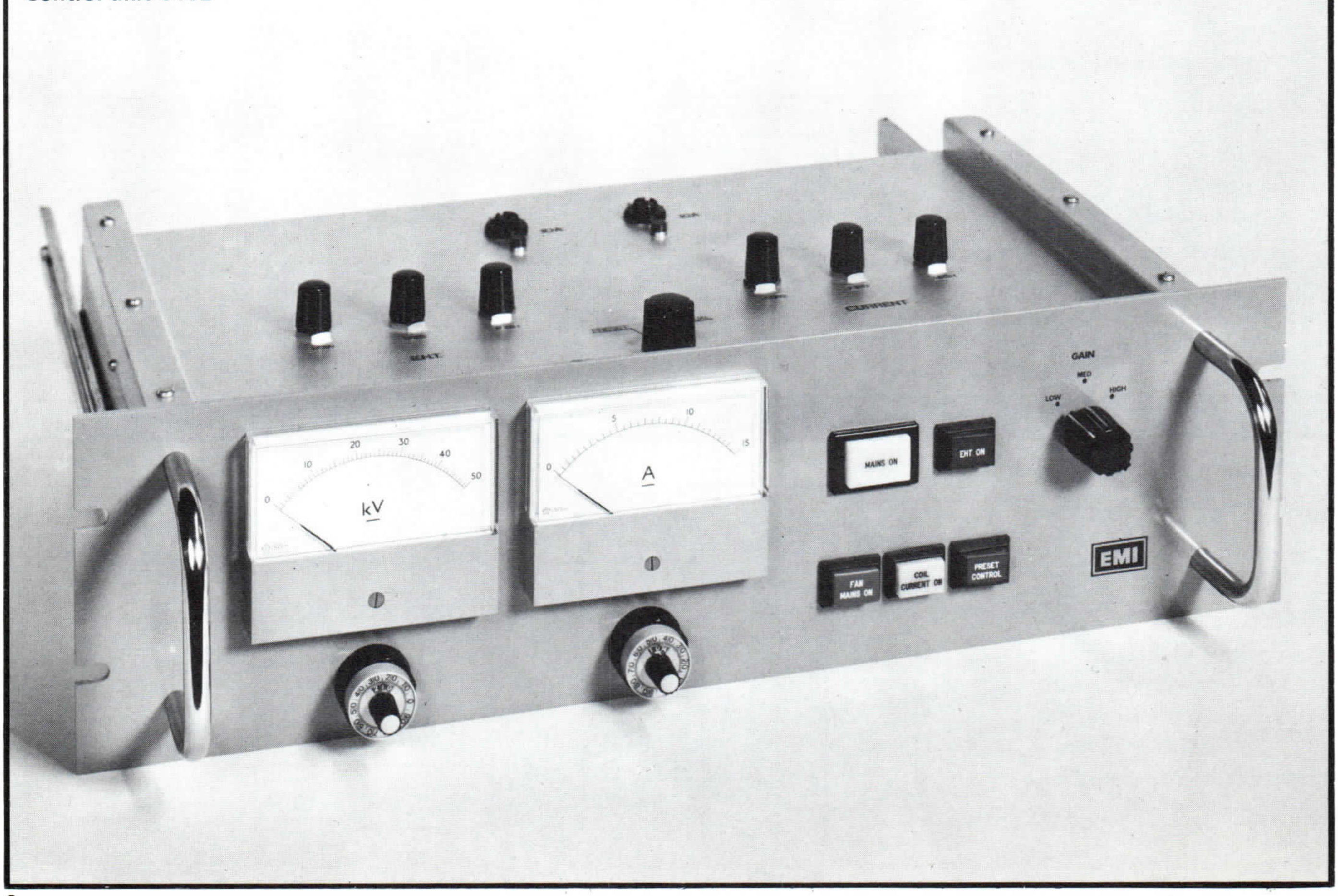


Image intensifier system T2001

Coils and blower units

Tube type	Focus coil	Blower unit *
9912	C142	C171 or C172
9914	C141	C171 or C172
9916	C141	C171 or C172

* Blower unit type dependent upon supply voltage and frequency.

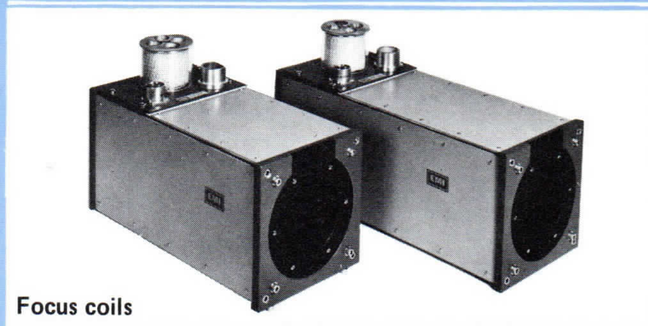
Forced air cooled focus coils types C141 and C142: The coils have been designed to be fully compatible with the 9910 series of image tubes. These tubes are maintained precisely in their correct operating position irrespective of the orientation of the coil itself. The use of air cooling and 2 loop focus operation has resulted in a relatively compact unit. The coils must be used in conjunction with blowers type C171 or C172.

Warning: Care must be taken to ensure that the air blower is operating at all times when the focus coil is energised and for a period of at least 20 minutes after the coil current is removed. Failure to do this could result in serious tube damage. If the control panel C192 is used, protection circuitry is provided, including pre-set delays.

Electrical specifications: Typical operating conditions (referred to tube type used).

Blower units:C171 (220-240 V 50 Hz) and C172 (120 V 60 Hz)
The blower units are supplied complete with hose, normally 3m long, or to suit customer's requirement.

Mechanical specification	C172	C171
Overall height	385 mm	430 mm
Blower diameter	242 mm	242 mm
Base diameter	356 mm	356 mm
Weight	13.4 kg	15 kg

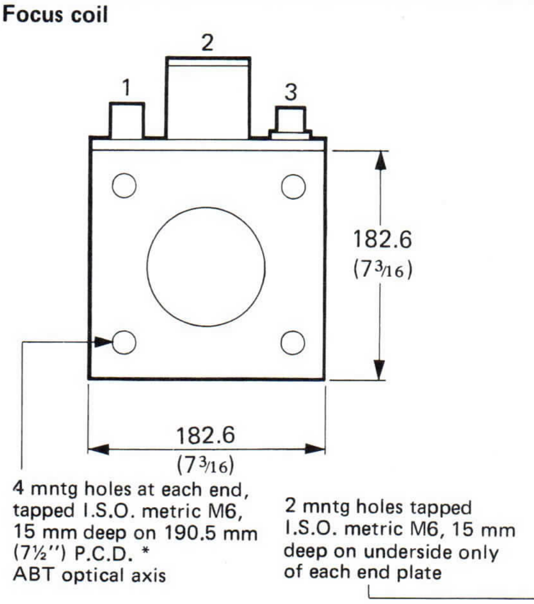

Focus coils

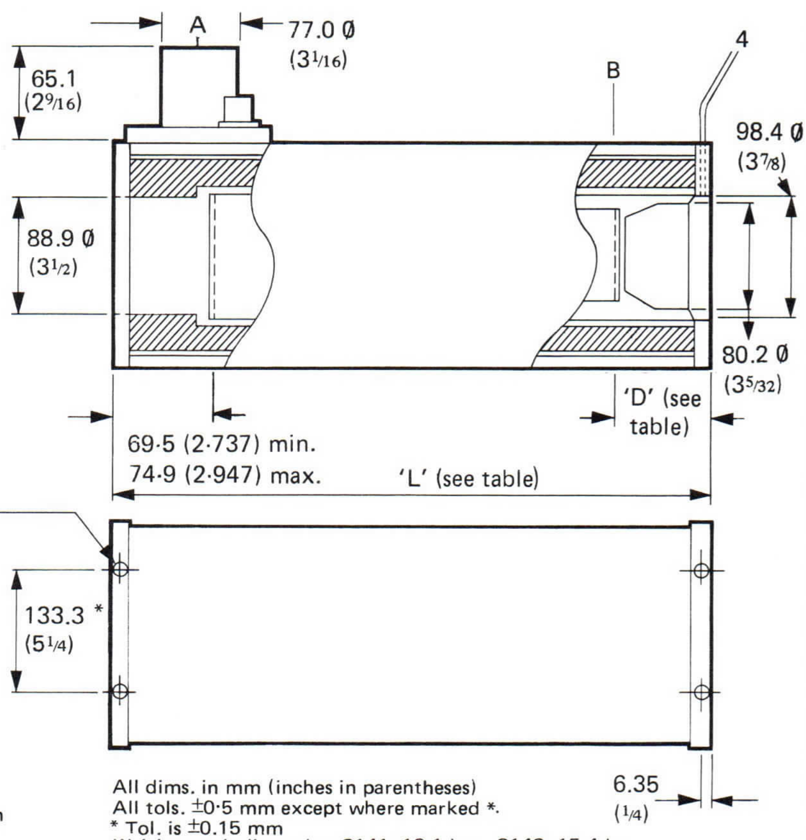
	9912 tube	9914 tube	9916 tube
Current for 2 loop focus at 20 kV tube voltage	8.0A	9.0A	6.5A
Maximum current for 2 loop focus at nominal maximum tube voltage	12.0 A (40 kV)	12.0 A (35 kV)	9.0 A (35 kV)
Maximum voltage at 30°C * ambient temperature	28.0 V	23.0 V	16.5 V

* At high ambient temperatures the voltage will rise due to the increase in resistance of the windings.

Focus coil

Pin No. connection	1	2	3	4
	case	positive	negative	no connection





		C141 (Tube Type 9914)	C141 (Tube Type 9916)	C142 (Tube Type 9912)
'D'	min.	73.2 (2.883)	43.8 (1.725)	70.3 (2.768)
	max.	85.8 (3.378)	56.3 (2.217)	82.8 (3.261)
'L'	min.	374.6 (14¾)		447.7 (17⅝)
	max.	377.8 (14⅞)		450.8 (17¾)

1. Air exhaust nozzle.
2. Air inlet/filter.
3. Power supply socket.
4. EHT leads from tube.

A-A[1] Photocathode position
B-B[1] Phosphor position

All dims. in mm (inches in parentheses)
All tols. ±0·5 mm except where marked *.
* Tol. is ±0.15 mm
Weights excluding tube: C141–13·1 kg; C142–15·4 kg.

Image intensifier system T2001

Combined EHT divider chains and focus coil power supplies

These units comprise a focus coil power supply and a series C150 divider chain. Controls are provided on the front panel giving fine control of the inter-stage voltages for focusing. The focus coil power supply is controlled from the control panel C192, which also contains the metering of focus coil current. Three models are available, type numbers as below:

Tube type	System type	Combined coil power supply/divider chain
9912	T2001/4	C202
9914	T2001/3	C201
9916	T2001/2	C203

Mechanical specifications:

Overall height	178 mm
Overall depth	405 mm •••••behind panel
Overall width	482 mm
Weight	24.7 kg

These units are not available other than as part of T2001 systems.

Warning:
Other power supplies can be used in conjunction with the focus coils but care must be taken to ensure that they do not become unstable when operated into an inductive load. Alternative supplies should be current stabilized to better than 0.5% long term.

EHT divider chains C150 series

This series of divider chains is based upon a cylindrical construction with a single multiway lockable EHT plug thus enabling all connections to the image tube to be made easily and simultaneously. C150 divider chains normally form an integral part of the combined focus coil power supply/divider chain units but can be supplied separately on a panel suitable for 19" rack mounting to special order, type nos. being as follows:

Tube type	EHT divider chain
9912	C152B
9914	C151B
9916	C154B

Mechanical specifications:

Overall height	178 mm
Overall depth	254 mm•••••behind panel
Overall width	482 mm
Weight	3.3 kg

Fine focus controls are provided on the front panel and input and output sockets are at the rear of the unit.

Combined EHT divider chain and focus coil power supply

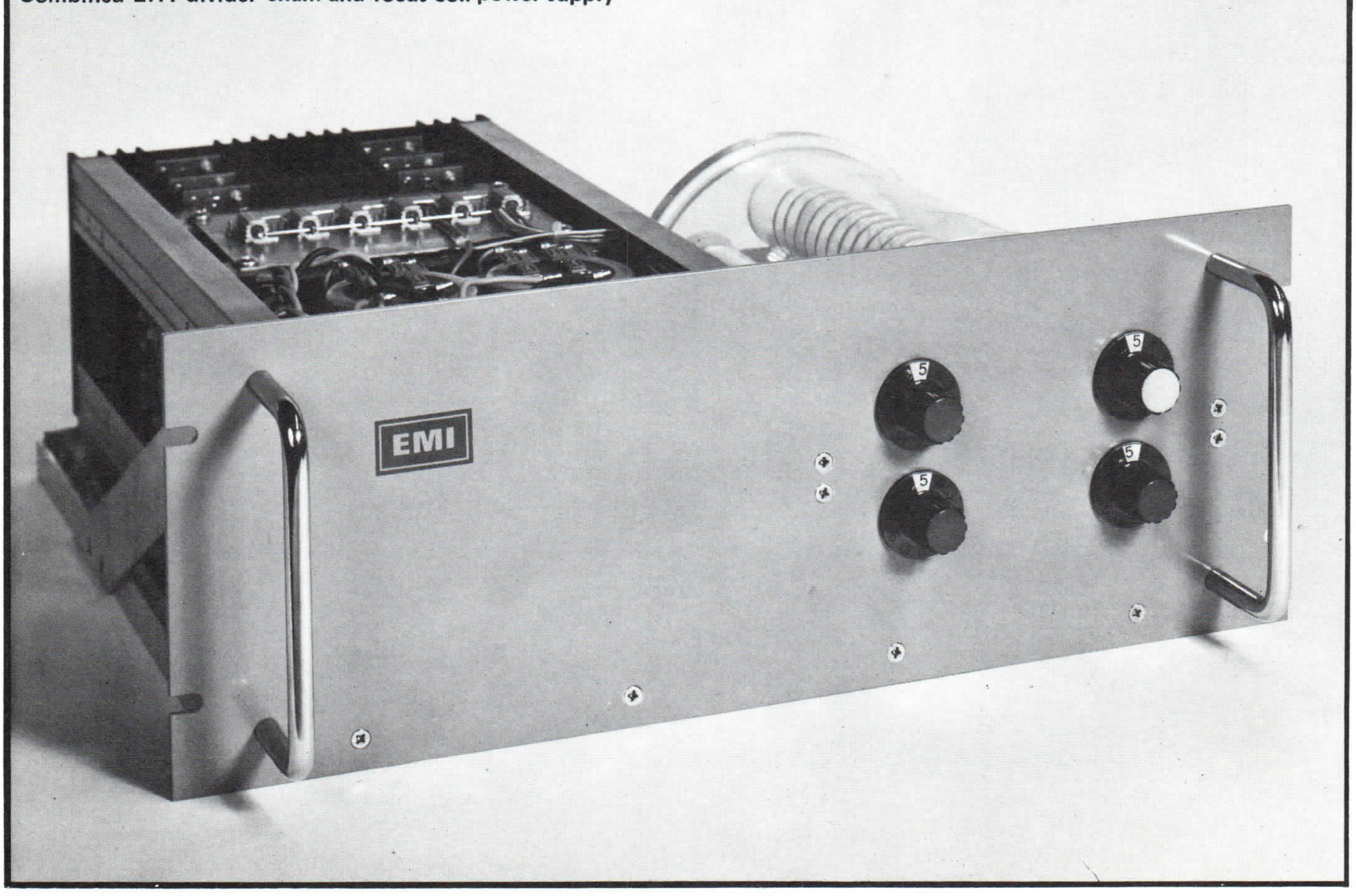


Image intensifier system T2001

EHT power supplies

Two supplies are available both of which are based upon the 'Brandenburg 907P' unit.

C204 — basic 907P but with a modified output lead for connection to EMI C150 divider chains.

C205 — basic 907P modified as the C204 and with additional changes allowing for remote control and metering from the EMI C192 control unit.

Note:
The C204 is available to special order ONLY
The C205 is normally supplied as an integral part of the T2001 system.

In addition to the changes mentioned above both C204 and C205 units include the following:

- maximum programmed voltage limited to 42 kV.
- time constant of the programmed controls increased.

Mechanical specification: (C204 and C205)

Overall height	133 mm
Overall depth	305 mm·····behind panel
Overall width	482 mm
Weight	14.0 kg

Electrical specification: (C204 and C205)
The electrical specifications of these units are the same as those for the 'Brandenburg 907P', except where modifications listed above have been made.

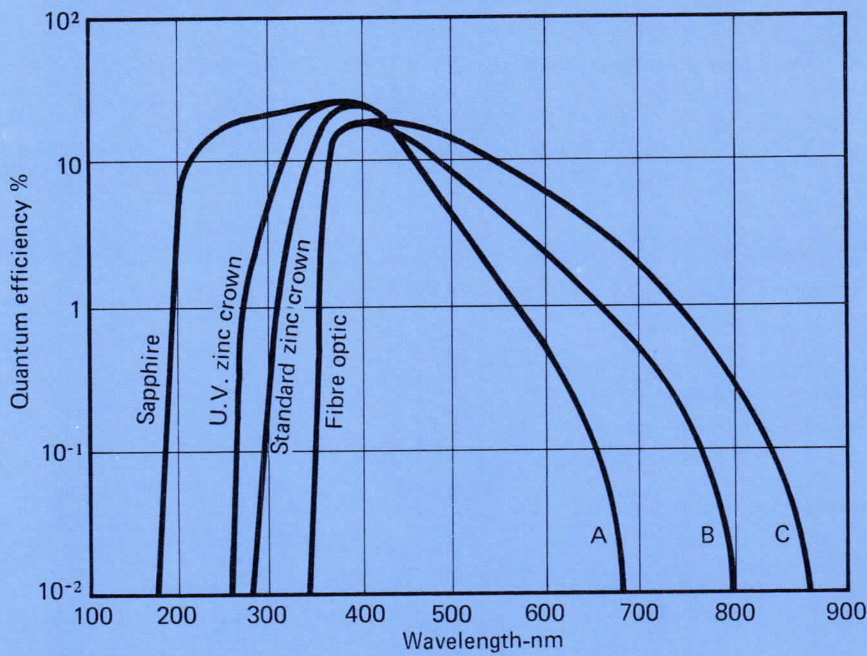
Output voltage control:	Continuously variable by coarse and fine controls on front panel.
Output ripple:	0.01%
Stability against 7% mains change:	0.01% or better.
Drift:	40 PPM per 15 minutes.
Temperature co-efficient:	40 PPM/ °C

EHT power supply

Typical characteristics

Spectral response curves

Figure 1



Key

Curve	Photocathode Type	Nominal Sensitivity
A	SbKNa	50µA/lm
B	SbKNaCs	80µA/lm
C	SbKNaCs	120µA/lm

Note
There is an appreciable spread about these curves, particularly at long wavelengths, and any specific response required at a particular wavelength should be stated by the customer. Where possible such requirements will be met by selection.

Typical characteristics of dark current vs photocathode red sensitivity

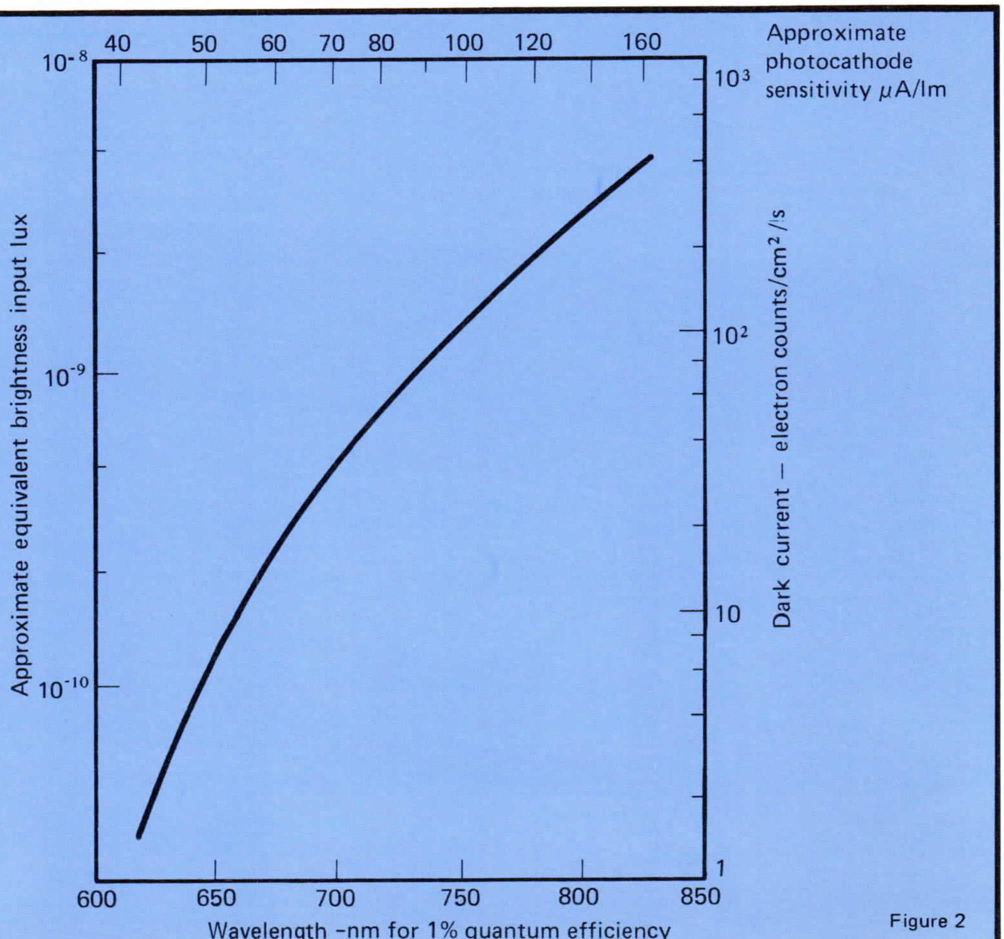
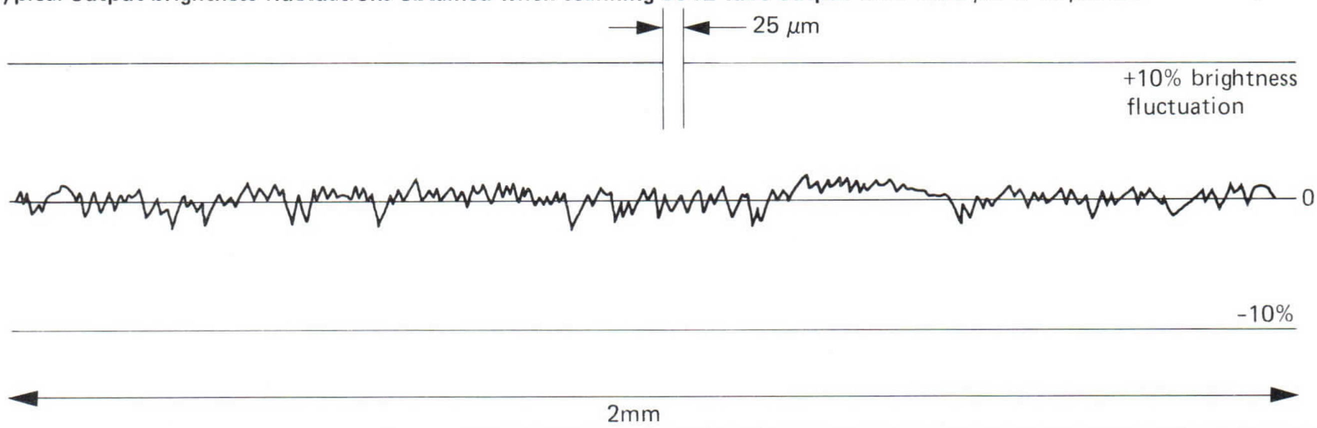


Figure 2

Typical characteristics

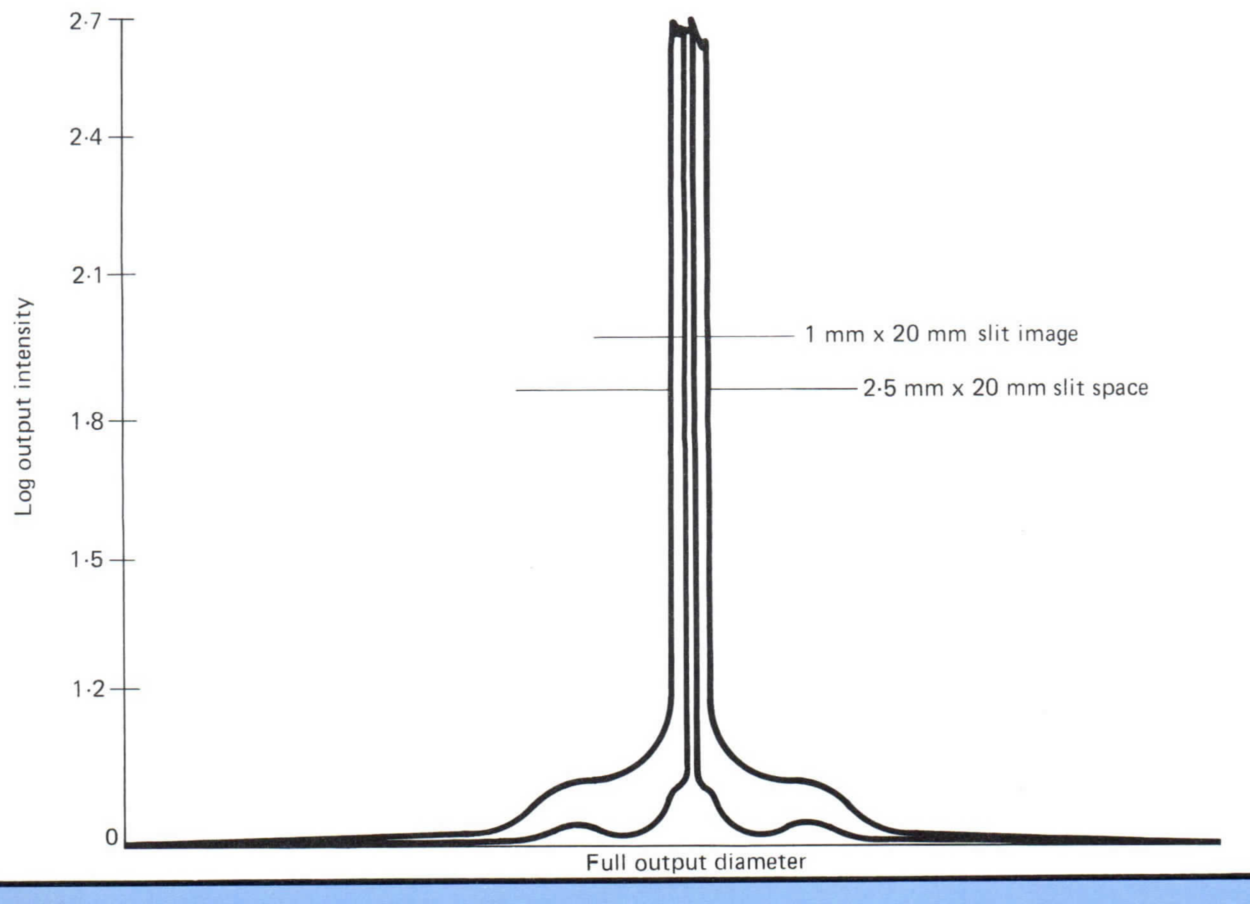
Typical output brightness fluctuations obtained when scanning 9912 tube output with 1000 μm x 10 μm slit

Figure 3



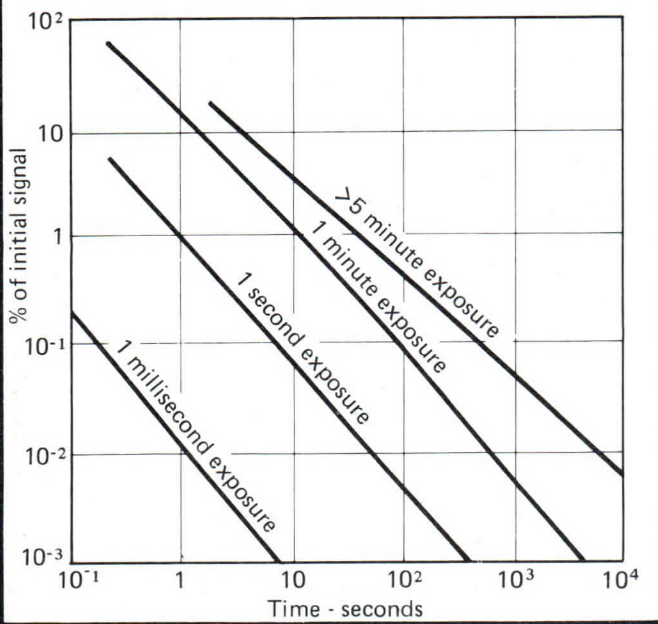
Signal induced noise characteristics - 9912 image intensifier

Figure 4

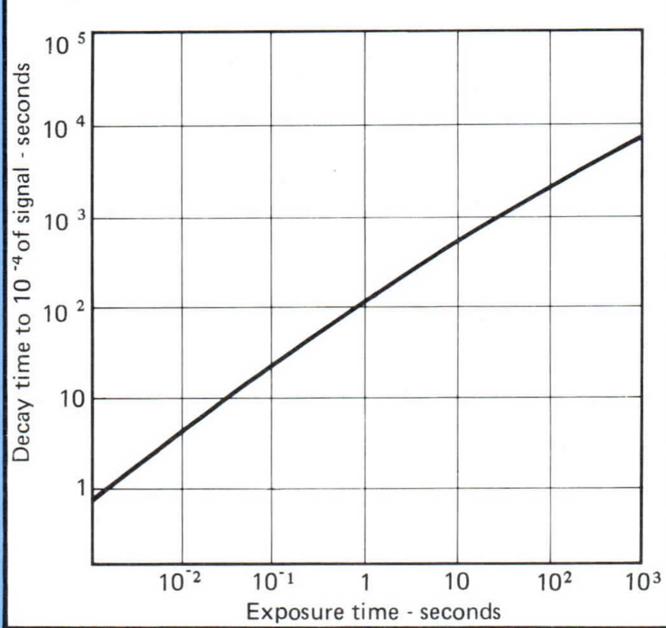


Typical characteristics

Decay characteristics (1) Figure 5



Decay characteristics(2) Figure 6



Ordering information

We recommend that the Electron Tube Division of EMI Electronics or your nearest distributor should be contacted at an early stage in tube selection to ensure that the best tube for specific applications is chosen.

At the time of ordering the following information should be clearly stated:

a) The photocathode required, with reference to Figure 1.
b) Any particular phosphor requirements other than the standard P11 type.
c) Particular window requirements, i.e. fibre optic input and/ or output, sapphire input, etc.
d) The pulsing method to be used, if any, so that the tube may be checked in that way, where possible.
e) Application.

When a T2001 system is being purchased, the operating supply voltage and frequency must be given together with any special requirements concerning lead lengths or hose lengths.

Some reprints of articles are available giving further information concerning the performance and application of the EMI range of Image Intensifiers and these will be provided, free of charge, on request.

The manufacture of custom built systems employing the 9910 series of tubes can be undertaken and specific requests are welcome.

Product range

Photomultiplier Tubes
For astronomy, spectrophotometry, scintillation counting, spectrometry, broadcast television and environmental monitoring.

Photomultiplier Tube Housings
For optimum photomultiplier tube operation.
RF shielded housings have been introduced for wide band photon counting applications.

Photomulitiplier Power Supply
A new highly stable, compact power supply specifically designed for use with photomultiplier tubes and for other stringent applications is now available. The output voltage is continuously variable from 100 volts to 2,500 volts with an output current capability of 5mA.

Photomultiplier Magnetic Focusing Assemblies
Designed to reduce the effective cathode area and thereby the dark current in 50 mm diameter photomultiplier tubes.

Photomultiplier Calibration Service
A monochromator spectral calibration service for photomultiplier tubes is now offered. Readings of quantum efficiency in per cent and radiant sensitivity in mA/W at wavelength intervals of 20 nm are provided so that the spectral response curve for a particular tube can be plotted in either unit.

Camera Tubes
A wide range of both magnetic and electrostatic vidicons in various grades from television broadcast to general surveillance. Of particular interest are the high quality tubes used in conjunction with medical X-ray intensifiers. Tubes with specialised faceplates and/or target layers are available. For low light level work, an intensifier vidicon, the Ebitron, operates down to part moonlight conditions.

Camera Scanning Coils
A range of high performance printed circuit scanning coils for use with vidicon type tubes.

Cathode Ray Tubes
For radar and TV flying spot scanning systems, where major improvements have been achieved by the use of EMI phosphor developments. Enquires for developmental tubes are welcomed.

Precision Micromesh
For use in microscopy, mass spectrometry, biology, filtering and optics.

Image Intensifiers and Associated Equipment
A range of high quality 2, 3 and 4 stage magnetically focused image intensifiers for a wide variety of scientific applications. The comprehensive range of associated equipment includes air cooled coils designed to be operated with a rack mounted control system. This provides manual and pre-set gain controls, various protection circuits and remote control facilites.

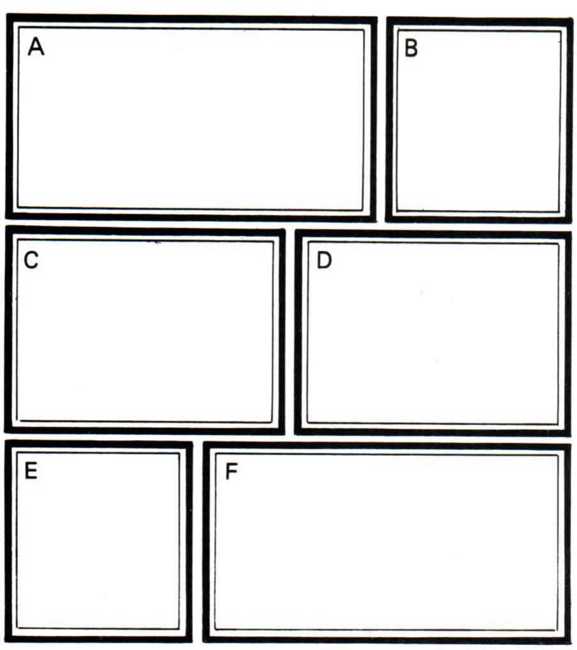
Hollow Cathode Lamps
For use in all atomic absorption spectrophotometers.

Electrodeless Discharge Tubes and Associated Equipment
7mm and 10mm diameter tubes, complete with cavity and a highly stable microwave generator for use in atomic fluorescence analysis.

Solid State Photodiodes
Avalanche silicon photodiodes including separate photodetector packages.

Special Products
The Electron Tube Division has wide experience in the development of light sensing and light emitting devices and is always pleased to consider requirements for Special Tubes outside the normal range. A variety of tube components and /or services is available to assist educational and research establishments.

Key to back cover photographs



A

Primarily intended as a direct replacement in existing compact TV cameras, this EMI 18mm ($\frac{2}{3}$in) vidicon has a low wattage heater, separate mesh construction and a high quality target layer.

B

An EMI broadcast television flying spot film scanner tube suitable for colour and monochrome film television transmission.

C

The T2001 image intensifier system which has been designed by EMI to enable research workers to operate EMI magnetically focused cascade image intensifiers with maximum efficiency.

D

Two versions of EMI s low noise, 50 MHz bandwidth photodector unit which utilises the Company's avalanche photodiodes for laser range finding and fibre optic line communications.

E

A section of EMI's camera tube test facility showing measurements being taken on the Ebitron low light level intensifier vidicon.

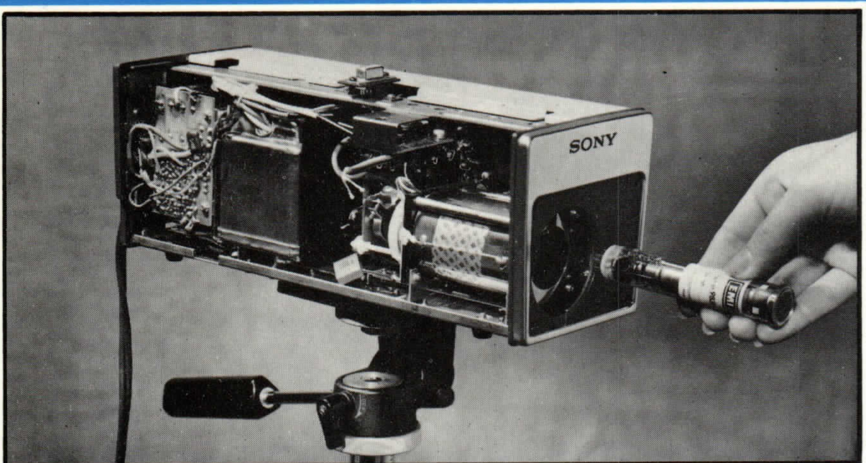
F

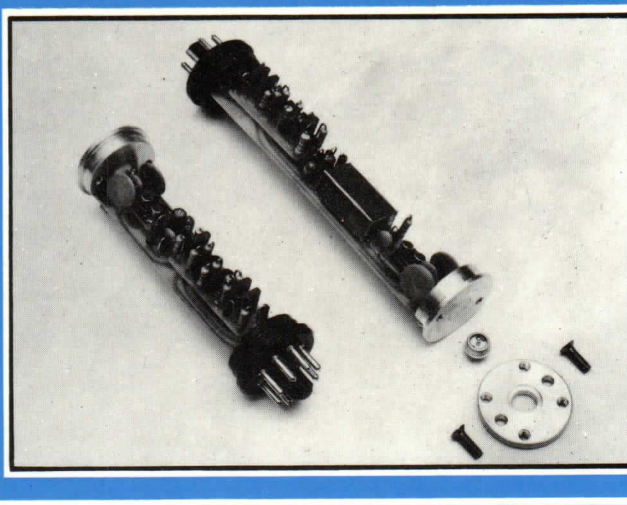
A high grade EMI photomultiplier tube being tested with computer-aided equipment.

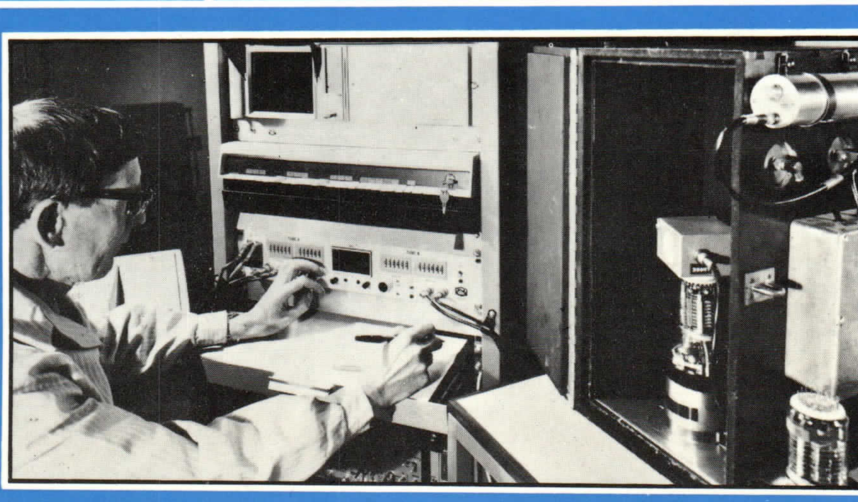
EMI

Electron Tube Division

EMI Electronics Limited,
243 Blyth Road, Hayes,
Middlesex, England, UB3 1HJ.
Telephone: 01-573 3888
Telex: 935261
Cables: Emitube, Hayes.







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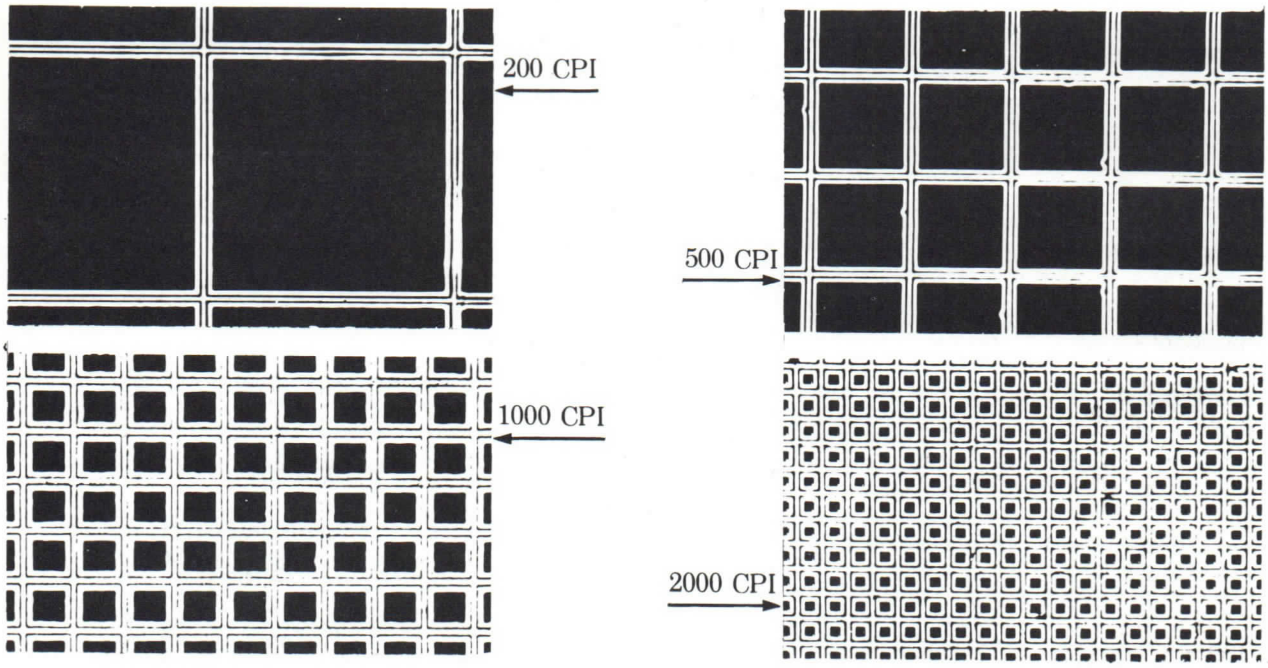
EMI MICROMESH



Unretouched X260 photographs

One component of EMI special vacuum tubes is a very fine metallic mesh. This is used to present an equipotential plane to an electron beam approaching it perpendicularly while at the same time allowing the beam to penetrate the mesh without distortions due to fringe effects and non-linearity.

Mesh for this purpose must be extremely uniform in geometry, without blocked apertures or missing web, and must have maximum transparency compatible with mechanical strength.

EMI micromesh, manufactured by a special technique of electro-plating from a ruled glass master, is a product so unusual that it has found applications in many branches of science and industry quite unconnected with electronics.

In its standard form, in grades and materials listed on page 2, this micromesh is fragile and care must be taken while handling it to prevent wrinkling and other damage. For special applications it can be supplied mounted on rings and stretched and strengthened by heat treatment.

Additional electro-plating may be deposited in order to reduce the size of the apertures and the transparency, but beyond certain limits the uniformity of aperture size and thickness will not be maintained.

The reinforced micromesh, described on page 4, consists of standard micromesh mounted between two coarser support grids and finally electro-plated. This will be suitable for sifting and other applications requiring greater mechanical strength.

In addition to the normal range described in this leaflet, special micromesh can be manufactured to suit individual needs. For example, it is possible to supply micromesh with rectangular instead of square cells having, say, 100 cells to the inch in direction 'X' and 1000 in direction 'Y'. Micromesh with overlaid concentric rings or rectangles can be made. Enquiries for custom-engineered meshes will be welcomed.

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DS.1036

APPLICATIONS

The following uses are intended to serve as examples and have been selected from known applications:

Microscopy

In both optical and electron microscopes the wide variety of micromesh sizes make them extremely versatile specimen supports and stage micrometers.

Mass Spectrometry

Micromesh presents an accurate equi-potential plane surface while at the same time allowing the passage of particles.

Biology

Micromesh sieves are used to grade cells by size or to filter particles from liquid suspension. The web approaches a triangular cross-section and this is a considerable advantage as cleansing may be performed by reversing the direction of flow of clean carrier fluid.

Filtering

Apart from the special biological case, many industries handling fine powders or filtering liquids use the reinforced micromesh sieves.

Optics

As neutral density filters, micromeshes remove all doubt of possible colour presence. Simple classroom experiments may be devised employing the effect of interference patterns and the diffraction of lights may be immediately demonstrated.

UNMOUNTED MICROMESH

This is available in copper and nickel and both types can be plated with gold or silver. Solid gold and silver micromesh can also be made to special order.

QUALITY

Micromesh is made to a very high quality specification and is perfectly suitable for use in the manufacture of electron tubes and optical applications.

It is also equally suitable for filtration and sieving purposes; when ordering please state applications.

Mesh Size		Trans-parency %	Absolute Filtration. Sphere dia. μ	Typical Data						
Cells per in	Cells per mm			Based on a transparency %	Aperture size In x 10^{-3}	μ	Web size In x 10^{-3}	μ	Thickness In x 10^{-3}	μ
20	0.79	over 94	1300	96	49	1250	1.0	25	0.6	14
80	3.15	88 – 95	320	91	11.9	290	0.6	16	0.4	10
100	3.94	85 – 93	260	88.5	9.4	240	0.6	15	0.4	9
200	7.88	75 – 85	130	80	4.5	114	0.5	13	0.3	8
250	9.8	72 – 82	100	75	3.5	89	0.5	12	0.3	7
375	14.8	65 – 75	65	70	2.2	56	0.4	11	0.2	6
500	19.7	60 – 70	50	65	1.6	41	0.4	10	0.2	5
600	23.6	57 – 67	40	60	1.3	33	0.4	10	0.2	5
750	29.5	53 – 63	30	55	1.0	25	0.33	8	0.2	5
1000	39.4	48 – 58	25	50	0.71	18	0.29	7	0.2	5
1500	59.1	40 – 50	15	45	0.45	11	0.22	5.5	0.15	4
2000	78.8	28 – 38	10	30	0.28	7	0.22	5.5	0.15	4
3000	118.1	below 20%								

NOTES

(i) 3000 CPI is at present only available in squares 1 in x 1 in (25 mm x 25 mm) other types 3 in x 3 in (75 mm x 75 mm).

(ii) Mesh size is precise (the metric figures are derived from original inch figures).

(iii) Aperture size, web size and thickness may vary slightly but will remain within the limits quoted for transparency.

(iv) Transparency over any one sheet of Grade I material will not vary by more than a few per cent. Transparency can be measured both geometrically and by optical transmission. Using the latter method, care should be taken to avoid inaccuracies due to scatter, diffraction and other aberrations.

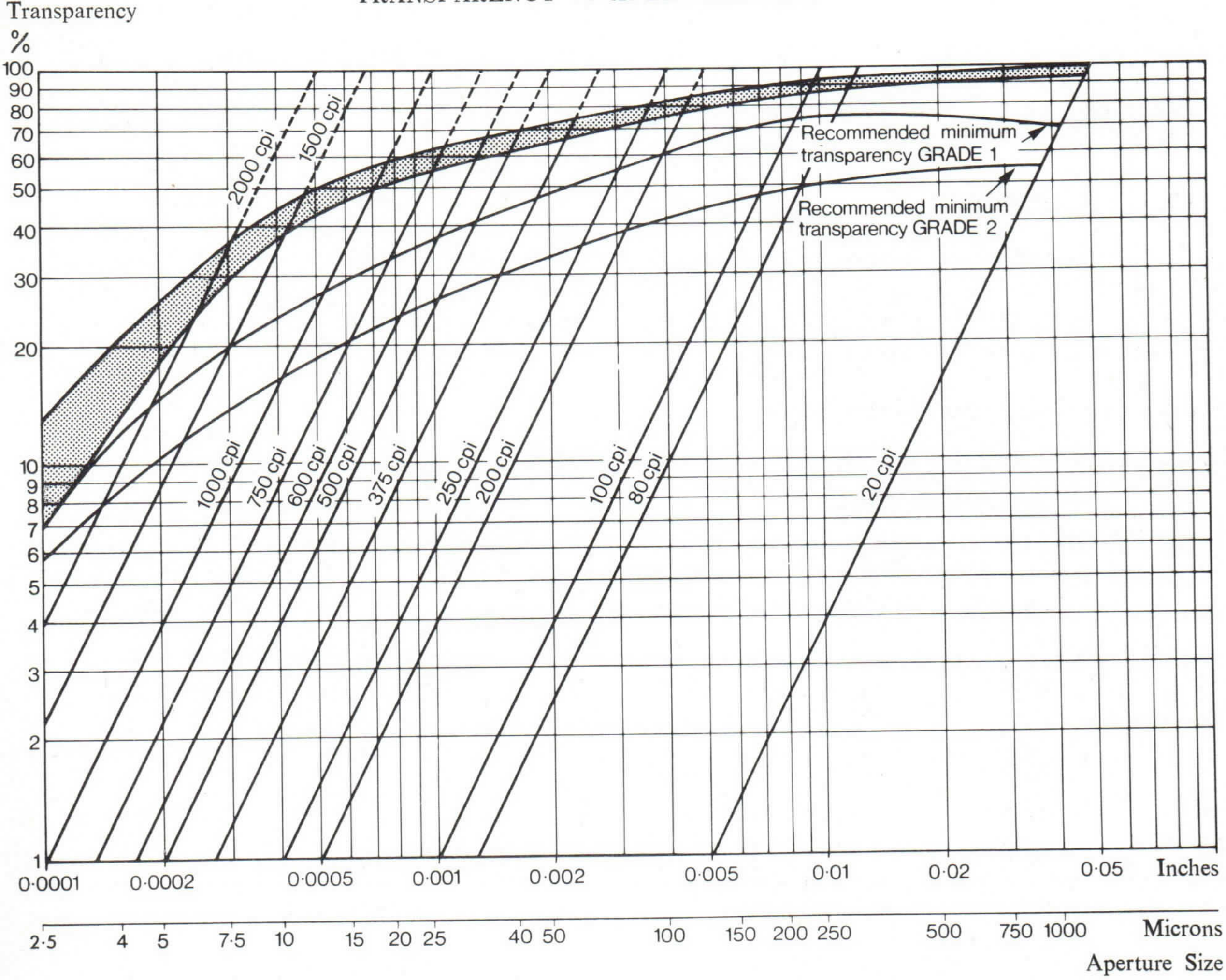
(v) Absolute filtration: The mesh will not pass a sphere of diameter greater than that shown in the above table.

(vi) Copper micromesh should not be left exposed to atmospheric conditions for any period of time, as this will result in oxidisation.

PLATED MICROMESH

Micromesh can be plated to a specified transparency, subject to the limits shown on the graph. Further electroplating beyond these limits will result in degradation of the aperture shape, and loss of uniformity over the area of the sheet. Unless otherwise ordered, plating will be of the same material as the basic mesh.

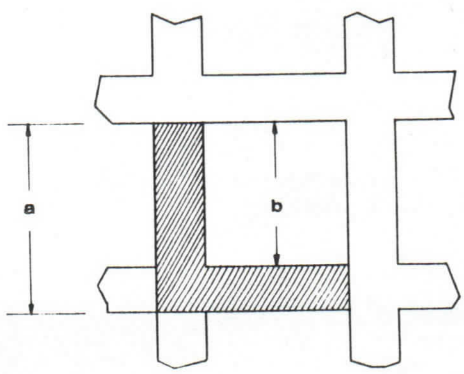
TRANSPARENCY vs APERTURE SIZE



The above graph represents, for various mesh sizes, the formula:

$T = \frac{b^2}{a^2} \times 100)$ % (for area >> aperture size)

where T = per cent transparency
a = cell size
b = aperture size



When ordering please state:

1. Mesh size (cells per inch or mm)
2. Material (copper, nickel, etc.)
3. Grade
4. Proposed application of mesh

MOUNTED MICROMESH

Micromesh can be supplied mounted on the following standard copper nickel rings:–

Nominal	Inside Diameter		Outside Diameter	
½ in ring	0.33 in	8.4 mm	0.45 in	11.4 mm
1 in ring	0.705 in	17.9 mm	0.92 in	23.0 mm
1½ in ring	1.50 in	38.1 mm	1.72 in	43.7 mm

Mounting can also be carried out on certain non-standard frames to customer's requirements.

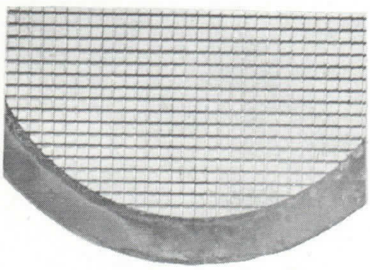
Mounted copper mesh is subsequently stretched by heat treatment.

REINFORCED MICROMESH

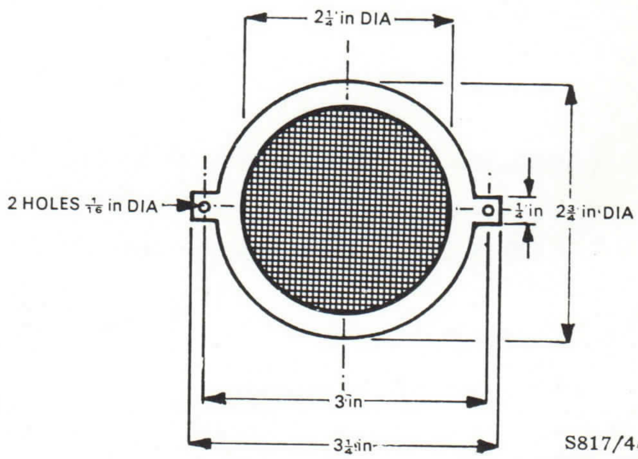
In order to give additional strength, mainly for filtering and sieving applications, nickel micromesh can be sandwiched between two 15 c.p.i. nickel support grids, and subsequently plated overall. Unless otherwise ordered, the final plating is also in nickel. Any aperture size, from 4 μ to 100 μ can be supplied. Examples of standard sizes are given below.

When ordering please state aperture size in μ.

Fine Mesh					Overall Transparency %	Absolute Filtration. Sphere dia. μ
Aperture Size		Mesh Size		Transparency %		
μ	In x 10^{-3}	cells per in	cells per mm			
4	0.16	2000	78.8	10	7	6
8	0.32	1500	59.1	22	15	10
15	0.59	1000	39.4	35	25	18
30	1.08	600	23.6	50	35	34
50	1.97	375	14.8	55	39	55



This is a full size photograph of a 1500 c.p.i. reinforced micromesh and is not retouched.



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