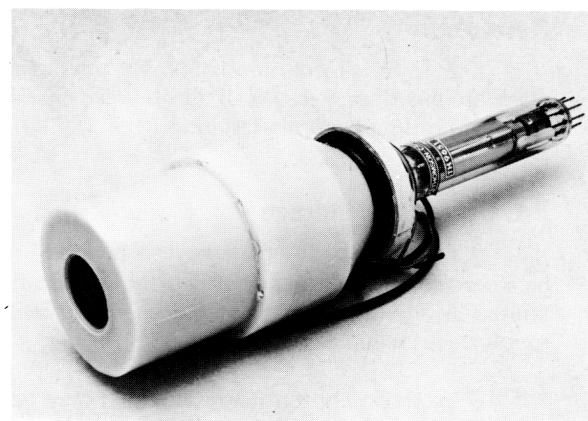
TH9651 SUPER-ESICON*

CAMERA TUBE FOR LOW LIGHT LEVEL T.V.

- S 20ER PHOTOCATHODE (25 mm useful diameter)
- INTENSIFIER AND IMAGE SECTION : diodes - electrostatic focus
- SCANNING SECTION : electromagnetic focus and deflection
- VERY HIGH SENSITIVITY (700 mA/lm)
- LOW LAG
- INTEGRATION AND STORAGE CAPABILITY
- INDUSTRIAL - SCIENTIFIC-NUCLEAR APPLICATIONS

The TH 9651 Super-Esicon is a very high sensitivity camera tube composed of an Esicon (TH 9650) mechanically coupled by fiber optics with an electrostatic focus image intensifier (TH 9473).



The useful diameter of the flat input faceplate is 25 mm and the photocathode is of the S 20ER type with a spectral response in visible spectrum extended to the near infrared.

The high gain secondary emission target allows the tube to operate over a wide range of illumintation and specially at low light level where the low image persistence makes easier the viewing of moving scenes. Furthermore, regions of a scene which is sufficiently bright to cause saturation do not produce halation altering the surrounding information.

The very low dark current of the target enables excellent storage characteristics and permits the integration of low light level images for extended period of time. The TH 9651 also performs well at slow scanning rate as used with narrow bandwidth transmission chanel.

The high voltages required for the intensifier and the image section of the Esicon can be obtained from a small size modular power supply. The requirements for the scanning section electrodes and the scanning power supply are similar to those of a standard 1" magnetically focused and deflected Vidicon.

PERFORMANCE DATA

Spectral response

The spectral response is that of a S 20ER type photocathode which is deposited on the fiber optics input window. The maximum quantum efficiency is 15 % and corresponding wavelength is 450 nm.

Typical sensitivities are 12 mA/W at 800 nm and 6 mA/W at 850 nm.

The photocathode has a white light sensitivity (2854 °K) in the order of 200 μA/lumen.

Overall sensitivity

High efficiency of the input photocathode combined with the gain of the intensifier and the gain of the target permit a typical overall sensitivity of 0.2 mA/lux (2 mA/fc). With illuminated area of 15 mm x 20 mm, equivalent sensitivity is near to 700 mA/lumen.

* Registered Trade Mark.

Light transfer characteristics

The TH 9651 can be used for photocathode illumination from 5.10^{-6} to 2.10^{-3} lux (5.10^{-7} to 2.10^{-4} fc). The gamma varies from 1 at very low light level to 0.6 at 10^{-3} lux (10^{-4} fc). At higher light levels the target saturates at a potential near to that of the suppressor grid which provides a knee in the transfer curve. It is advisable not to exceed the indicated values because excessive illumination may cause temporary or permanent "burn-in". However, the tube can be safely operated at higher light levels by reducing the voltages applied to the intensifier and the Esicon. By combining these two parameters it is possible to cover a dynamic illumination range in the order of $5.\ 10^3$.

Persistence

The signal generating mechanism of the target is essentially lagless due to the target design.
Typical residual signal at third frame is 5 % for a signal current of 100 nA.

Resolution

The limiting resolution is 500 TV lines at center of image for stationary scenes and 10^{-3} lux (10^{-4} fc) faceplate illumination. Because of the low lag characteristics, good dynamic resolution can be obtained : a typical value of limiting dynamic resolution is 400 TV lines for an object moving across the picture width in 10 seconds.

Integration and storage

A signal can be integrated over a period of several minutes without degradation due to target leakage. It can be stored for many hours provided the photocathode voltage is turned off. The maximum integration period is limited by the dark current of the intensifier and the transfer section of the Esicon and the low illumination due to the electron gun cathode.

If excessive photon noise occurs, it may be found advantageous to reduce the gain of the tube by reducing the high voltage and to operate the tube with longer integration periods.

OPERATING CONSIDERATIONS

Supplies and circuits

When using a basic Vidicon camera three additional voltage supplies are required :

- 25 kV to be applied to the intensifier photocathode
- 12 kV to be applied to the Esicon photocathode

and 30 V to be applied to the suppressor grid.

In order to maximize the signal to noise ratio, it is necessary to keep the input noise current as low as possible. For a shunt capacity of 25 pF and a bandwidth of 7 MHz, a 4 nA R.M.S. noise current can be obtained with a preamplifier using D3 tube or FET 2N 4416 transistor.

Environmental characteristics and life

1 - The Super-Esicon is designed to offer good resistance to shock and vibration. However, care should be taken in the design of the camera head so to avoid microphonics. The tube can be provided encapsulated in a silicone rubber compound which protects the intensifier and the image section from humidity and break-down.

2 - The tube can be operated between $-30\ ^\circ C$ and $+50\ ^\circ C$ without any appreciable effect upon its performances. However, it is advisable to operate at room temperature.

3 - The average life time is in excess of 500 hours.

GENERAL CHARACTERISTICS

Mechanical

Overall length	289	mm
Maximum diameter :		
- non potted type	71	mm
- potted type	80	mm
Diameter of scanning section	26	mm
Base (Ditetrar 8 pins)	UTE 9 C 15 (JEDEC E8 - 11)	
Socket (note 1)	METOX N° 30 520	
Deflecting yoke - Focus coil - Assembly (note 2)	GERHARD BV 200 - 1 k 1 or equivalent	
Alignment coil (note 2)	GERHARD BV 80/3 or equivalent	
or Deflecting yoke - Focusing and alignment coils - Assembly - (note 2)	CLEVELAND VYFA - 355.2 or equivalent	
Weight, approximate :		
- non potted type	450	g
- potted type	700	g
Operating position	any	

Electrical

– INTENSIFIER SECTION :

Focus	electrostatic	
Type	diode	

– IMAGE SECTION :

Focus	electrostatic	
Type	diode	

– SCANNING SECTION :

Cathode	unipotential indirectly heated oxide coated	
Heater :		
- voltage	6. 3	V
- current at 6. 3 V	150 ± 10 %	mA
Minimum preheating time	60	s
Output capacitance (target to all other electrodes)	25	pF
Focus	electromagnetic	
Deflection	electromagnetic	

Optical

– INTENSIFIER SECTION :

Photocathode	S 20 ER	
Input window (note 9) :		
- shape	circular - flat (1 μ flatness)	
- nature	fiber optics (6 μ elementary fibers)	
Useful diameter	25	mm
Useful area	4. 9	cm^2
Useful size	20 mm x 15 mm	

– IMAGE SECTION :

Photocathode	S 20	

– SCANNING SECTION :

Photoconductive layer :		
- normal dimension of image on target	12. 7 mm x 9. 5 mm	
- maximum useful diameter (4 x 3 aspect ratio)	17	mm

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OPERATING CONDITIONS

Unless otherwise stated, voltages are given with respect to ground, the anode of the image section and the cathode of the scanning section being grounded.

Maximum ratings (absolute values) :

Ambient temperature :			
- storage	max.	+ 70	°C
	min.	− 55	°C
- operation	max.	+ 50	°C
	min.	− 30	°C
− INTENSIFIER SECTION :			
Photocathode voltage (with respect to cathode K) :			
- negative value	max.	25	kV
- positive value	max.	0	V
Photocathode voltage (with respect to Esicon photocathode) :			
- negative value	max.	15	kV
- positive value	min.	0	V
− IMAGE SECTION :			
Photocathode voltage (with respect to cathode K) :			
- negative value	max.	12	kV
- positive value	min.	0	V
Anode voltage		0	V
− SCANNING SECTION :			
Target voltage	max.	40	V
Grid g5 voltage (suppressor)	max.	30	V
Cathode K voltage		0	V
Grid g1 voltage (image cut-off) :			
- negative bias value	max.	150	V
- positive bias value	max.	0	V
Grid g2 voltage (accelerator)	max.	400	V
Grid g3 voltage (wall electrode)	max.	400	V
Grid g4 voltage (field electrode)	max.	600	V
Heater voltage	max.	6. 9	V
	min.	5. 7	V
Peak heater - cathode voltage :			
- heater negative with respect to cathode	max.	125	V
- heater positive with respect to cathode	max.	10	V
Signal current	max.	300	nA

Typical operation

Temperature (note 3)		+ 25	°C
− INTENSIFIER SECTION :			
Photocathode voltage (with respect to cathode K)		− 23	kV
− IMAGE SECTION :			
Photocathode voltage (with respect to cathode)		− 8	kV
Anode voltage		0	V
− SCANNING SECTION :			
Target voltage		5 to 30	V
Grid g5 voltage		15	V
Cathode K voltage		0	V
Grid g1 voltage (note 4)		− 80	V
Grid g2 voltage		300	V
Grid g3 voltage		320	V
Grid g4 voltage		360	V

Minimum blanking peak to peak voltage :		
- applied to cathode	+ 30	V
- applied to g1	− 80	V
Focus magnetic field	40	Gauss
Alignment magnetic field	0 to 4	Gauss

Electro-optical performances

Light sensitivity	700	mA/lumen
Operating sensitivity	200	µA/lux
Image size on the photocathode	20 mm x 15 mm	
Photocathode illumination (2854 °K) (note 5)	1	mlux
Signal current	200	n A
Limiting resolution (note 6) :		
- at center of image	500	TV lines
- at periphery of image	350	TV lines
M.T.F. for 400 T.V. lines at center of image (note 7)	10	%
Persistence (note 8) :		
- 3rd frame after illumination is removed	< 5	%
- 10th frame after illumination is removed	< 1	%

NOTES

1 - METOX - 86, rue de Villiers de l'Isle Adam - 75020 PARIS - France.

2 - GERHARD KG - Reichelsheim/ODW - Germany.
CLEVELAND ELECTRONICS Inc. - 2000 Highland Road - TWINSBURG - OHIO - 44. 087

3 - All the data are given for a temperature of the tube in the proximity of the target of 25 °C, the recommended temperature range for a good operation being 25 °C to 30 °C.

4 - Without blanking pulses applied to grid g1.

5 - All the above mentioned illuminations assume 2854 °K incandescent tungsten source.

6 - Practically the limiting resolution corresponds to the resolution measured with twin bar test card with a modulation ratio of 7 %.

7 - For the C.C.I.R. Standard - 625 lines, line duration being 52 µs (line suppression period not included), 400 T.V. lines correspond to a 5 MHz bandwidth.

8 - The persistence is defined as the ratio of the residual signal current measured at the n^{th} frame after excitation is removed to the initial signal current (100 nA) ; these values assume 50 fields/second scanning rate.

9 - One clear glass disc is bonded in front of optical fibers with conducting back face glass connected to the intensifier photocathode. This device permits to avoid flicker phenomena because fluctuating potential optical fibers face generated by electroctatic charges. On request, the Super-Esicon may be provided with quartz disc which is non-browning in nuclear environments.

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OPERATING RECOMMENDATIONS

The Super-Esicon is a rugged tube easy to use. However care must be taken so to avoid all risk of damage to the tube.

Important recommendations

1 - A protecting device is supplied to limit the potential difference between the target and the suppressor. This should not be disconnected.

2 - The scanning voltages should be applied before electrode voltages applications. For shutdown, deflection power should be switched off only after the electron beam has been removed.

3 - When operating the tube, apply the high voltage in the last sequence. For shutdown, switch off the high voltage before the other voltages.

4 - The tube should not be operated at exposure levels greater than those given in figure 1*.

5 - It is recommended not to exceed the given values for target and suppressor voltages**. If destabilization occurs resulting in loss of gain and sometimes in negative image, reduce exposure level and set the suppressor grid to 5 Volts. Check eventually the beam current to make sure that it is sufficient to discharge the target. When the stabilization voltage becomes normal, the tube recovers its characteristics.

6 - The horizontal and vertical deflection power should be adjusted to assure that the target is either normally scanned or over scanned. Avoid underscanning.

7 - As high voltage is applied to the input faceplate a good design of the camera and particularly of lens fixture is necessary in order to prevent arcing and breakdown which would impair the fiber optics faceplate or cause a high dark current equivalent illumination.

* *However, damage due to unduly high light exposure disappears in a few minutes if over exposure time is not too long.*

** *See Data Sheet accompanying the tube.*

Set up procedure

1 - Install the tube in the camera head using focusing, deflection and alignment coils locations shown in figure page10. If the tube is operated in horizontal position, the short index pin should be positioned in the horizontal plane parallel to the traces of line scannings. A mask of 15 mm x 20 mm dimensions can be used to prevent light reaching the unscanned zones of the photocathode.

2 - Connect all electrodes.

3 - Apply heater, focusing, deflection and alignment voltages.

4 - Apply −120 V to g1. Then apply voltages to g2, g3, g4 electrodes.

5 - Increase the grid g1 voltage up to − 50 V and adjust g5 and target voltage to obtain recommended values.

6 - Apply about 0. 01 mfc illumination to the faceplate.

7 - Apply progressively the high voltage and adjust the g1 voltage until the beam current is sufficient to discharge the target.

8 - Focus and center a pattern on the faceplate. The illumination level should be 0. 1 mfc.

9 - Adjust the deflection amplitude such that the target ring is visible at the corners of image. Decrease the deflection power so to obtain the normal scanning area.

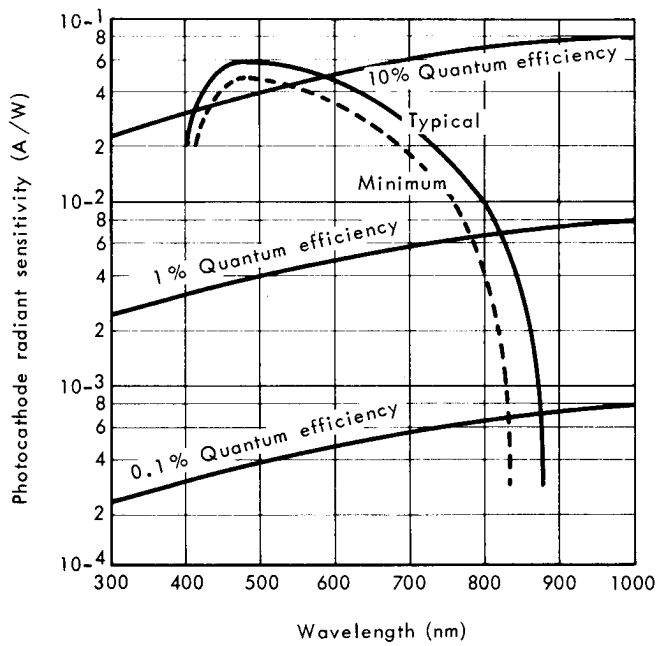
10- Adjust the focusing by varying g3 voltage and optimize the optical focus. The electrode g4 voltage should be maintained above that of electrode g3 by about 30 to 40 Volts.

11- Adjust alignment currents in the following manner :

- reduce g5 voltage to a value just above the threshold for beam landing ;
- adjust the alignment current to center the area over which the beam can land ;
- if more than 2 V on g5 is necessary for beam to land over the entire area, check the positions of focusing and deflection coils.

12- Shift g5 voltage to normal value, check g3 voltage and optical focus.

S20ER PHOTOCATHODE SPECTRAL RESPONSE
(with extended red sensitivity)



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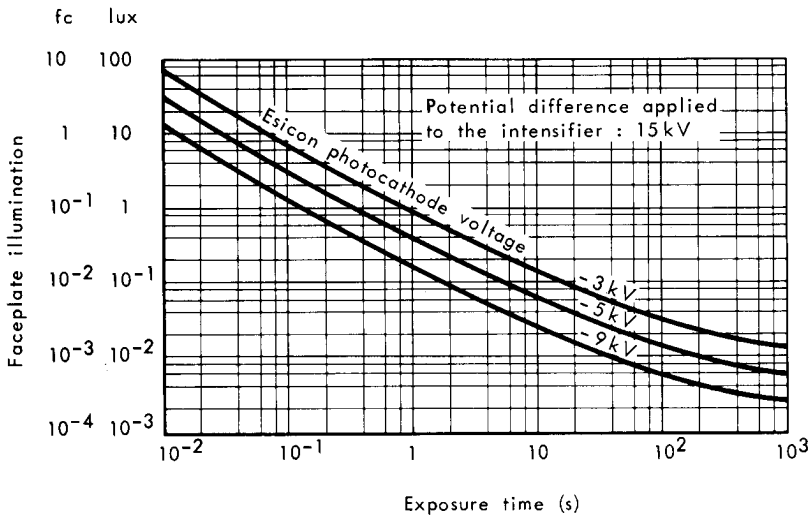

Fig. 1 - Maximum exposure levels.

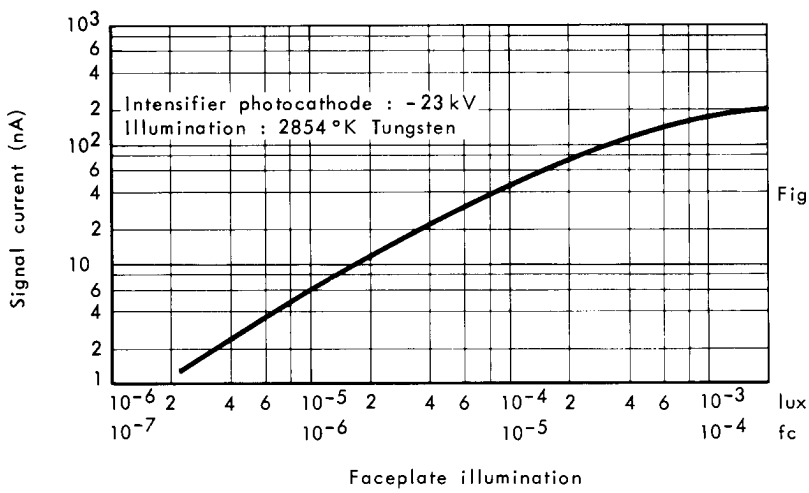

Fig. 2 - Light transfer characteristic.

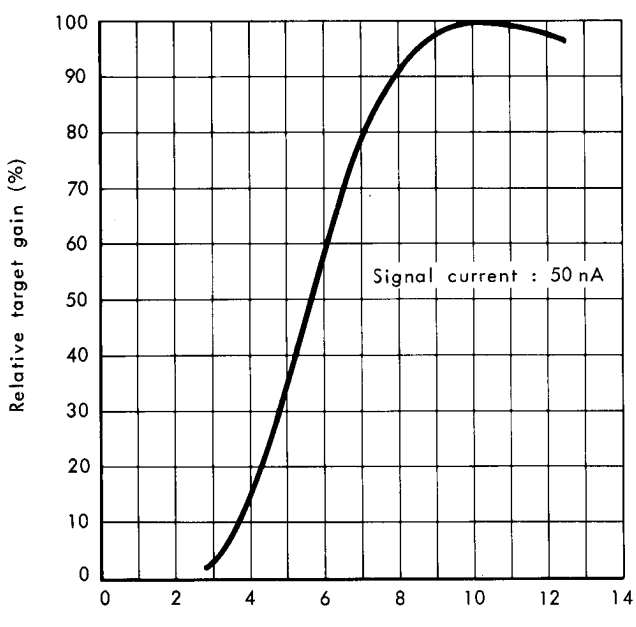

Fig. 3 - Relative gain vs. Esicon photocathode voltage.

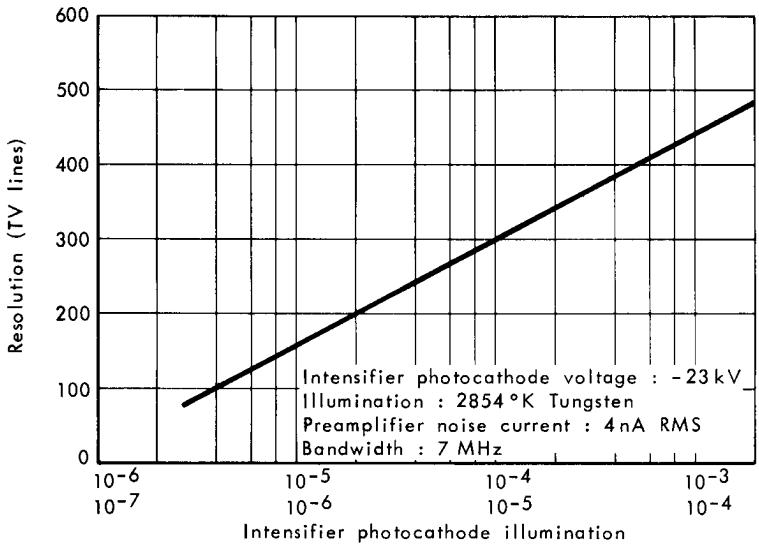

Fig. 4 - Resolution vs. photocathode illumination.

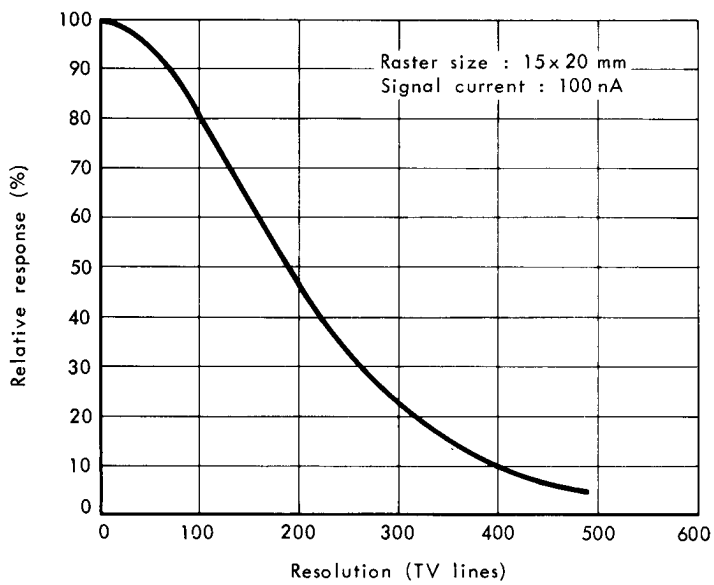

Fig. 5 - Modulation transfer function.

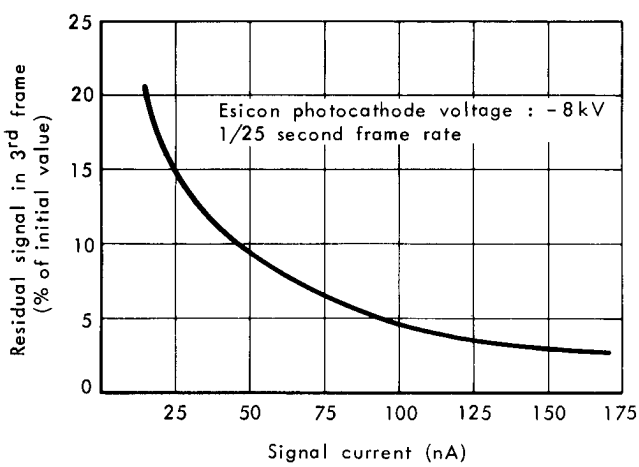

Fig. 6 - Residual vs. signal current.

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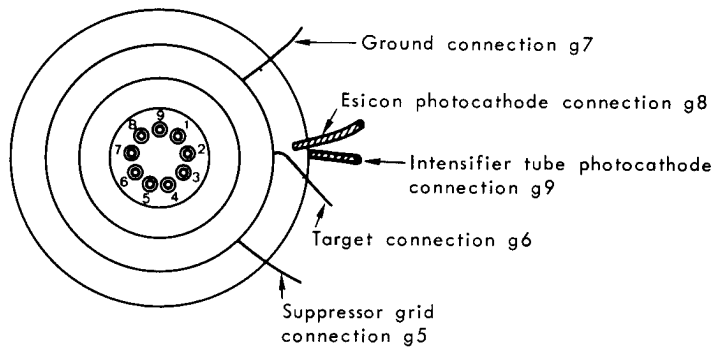
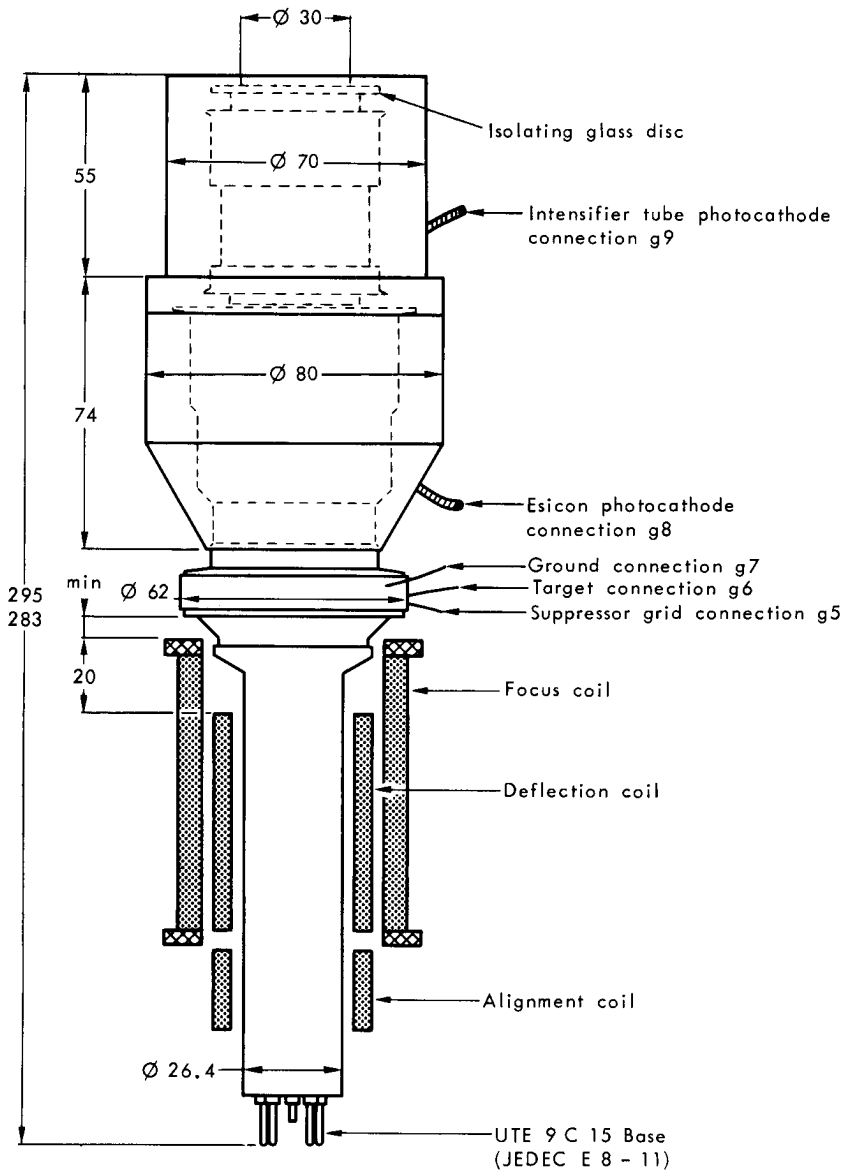
OUTLINE DRAWING

BASING DIAGRAM

1 - h
2 - g1
3 - g4
4 - g1
5 - g2
6 - g3
7 - k
8 - h
9 - Index pin





Dimensions in mm.

Potted tube