TH 9840

1" PYRICON

INFRA-RED PICK-UP TUBE FOR THERMAL TV

- OPERATING AT AMBIENT TEMPERATURE
- PYROELECTRIC TARGET SENSITIVE TO VERY LOW TEMPERATURE DIFFERENCE
- EXTENDED SPECTRAL SENSITIVITY
- GENERAL CONSTRUCTION SIMILAR TO 1" VIDICON
- ELECTROMAGNETIC FOCUS AND DEFLECTION

MAIN CHARACTERISTICS

- Infra-red sensitive pick-up tube utilizing the thermal radiant energy of bodies.
- Wide spectral sensitivity in the infra-red range ; the sensitivity is in practice limited by the input window transparency. For the TH 9840, it is optimized in the 8000 to 14000 nm band which corresponds to the maximum radiant energy of objects at ambient temperature.
- Minimum resolvable temperature lower than 0.5 °C in the case of a black body at 300 °K (27 °C).
- Electronic scan - Ease of operation.
- Motion retrieval.

TYPICAL APPLICATIONS

Thermal TV gives an additional "dimension" to the daylight or night TV operating in the visible range of the spectrum. It shows information that would not be provided by a conventional camera. Operating at European TV standard (625 lines/50 Hz) or American TV standard (525 lines/60 Hz) the thermal TV is suited to all existing CCTV equipment (or even broadcast TV equipment). It is easy to superimpose or to add thermal to visible information in the displayed image.

Thermal TV permits the observation of objects through light diffusing media such as flames, fog... ; the direct and passive viewing of variation or difference of temperature or emissivity.

In the **industrial field**, thermal TV permits technical inspection of materials, welds, engine components , electric lines, electronic circuits, heat exchangers.

In the **security field**, it permits the detection of fire, fluid leakage, the surveillance of technical installations, intruder detection, camouflage detection.

In the **environment protection field**, it can be used to detect effluents.

In the **medical field**, it is a diagnostic instrument for circulation troubles, burns, healing and diverse lesions.

DESCRIPTION

The TH 9840 Pyricon is an infra-red sensitive pick-up tube which includes a pyroelectric retina one side of which faces the scanning electron beam while the other side is backed by a metal electrode used as the signal electrode.

The general configuration of the tube is similar to a vidicon but it mainly differs by the input window, transparent to infra-red radiation and by the target made out of a thin wafer of pyroelectric material.

In the direction normal to its surface, the target presents a spontaneous polarization which varies as a function of its temperature (pyroelectric effect). When an image is projected through the input window, the incident energy is absorbed in the target and produces local variations of temperature which induce a surface distribution of charges. These charges are compensated by the scanning beam which gives rise to the video signal through capacitive coupling with the signal electrode.

At any point of the target, the reading beam permits the detection of temperature variation between two successive scans. Consequently, a still object at a constant temperature cannot be detected when the target has reached its thermal equilibrium. In this case, it is necessary to chop the infra-red flux by means of a chopper or to permanently displace the image on the target either by modifying the angle of view (panning) or by using an optical device (orbiter).

Temperature variations induce either positive or negative charges in the target depending on the direction of variation (increase or decrease of temperature). In the C.P.S. mode (Cathode Potential Stabilization), the electron beam stabilizes the target face at cathode potential ; so the negative charges cannot be compensated by the electron beam. To neutralize these charges, the retina face is raised to a positive potential between two scans by positive ions. These positive ions are provided by the electron beam which ionizes the molecules of a gas maintained at a certain pressure inside the tube by means of a reservoir. This polarization produces, in the absence of incident radiation, a dark current called pedestal current.

GENERAL CHARACTERISTICS

Electrical

Cathode	unipotential, indirectly heated, oxide coated	
Heater :		
- voltage	6. 3	V
- current at 6. 3 V	0. 15 ± 10 %	A
Gas reservoir :		
- voltage	1 to 4	V
- current, max.	0. 5	A
Minimum preheating time	5	mn
Output capacitance (signal electrode to all other electrodes)	< 6	pF
Focusing method	electromagnetic	
Deflection method	electromagnetic	

Optical

Target :		
- minimum useful target diameter	16	mm
- minimum scanning format	18 mm x 24	mm
Orientation of quality rectangle :		
Horizontal scan parallel to the plane passing through the tube axis and short index pin.		
Spectral response	Note 1 and Figure 1	

Mechanical

Input window thickness (germanium)	2. 1 ± 0. 1	mm
Distance from target to window inner face	1. 2 to 1. 5	mm
Overall length, max.	165	mm
Outer diameter, max.	29	mm
Bulk diameter, max.	26. 7	mm
Base (Ditetrar 8 pins)	UTE 9 C 15 - JEDEC E 8 - 11	
Socket	METOX No. 30520	
Focus and deflection coils	GERHARD No. 200 - 1K1 or equivalent	
Alignment coil	GERHARD No. BV 80/3 or equivalent	
Focus - deflection - alignment coil assembly	THOMSON-CSF No. TH 7200 or equivalent	
Weight, approx.	60 g	
Operating position	any	

OPERATING CONDITIONS

All potentials referred to cathode

Maximum ratings

Heater voltage	max.	7	V
	min.	6.3	V
Peak heater cathode voltage :			
- heater negative with respect to cathode		125	V
- heater positive with respect to cathode		10	V
Grid g1 voltage :			
- negative bias value		125	V
- positive bias value		0	V
Grid g2 voltage		200	V
Grid g3 voltage		400	V
Grid g4 voltage		500	V
Target voltage (signal electrode)	min.	0	V
	max.	– 10	V
Pedestal current (Note 2)		100	nA
Grid g4 current (Note 2)		15	μA
Gas reservoir voltage (Note 2)	max.	5	V
Maximum irradiance faceplate for continuous operating in the 8000 to 14 000 nm range (Note 3)		40	$W.m^{-2}$
Faceplate temperature (Note 4)	max.	40	°C

Typical operation

Faceplate temperature : 30 °C
Scanning standard : 625 lines interlaced - 25 images/second
Preamplifier bandwidth : 2. 5 MHz at 3 dB
Scanned image format : 18 mm x 24 mm ; scanned area A = 4. 3 cm^2 (Note 5)
Target poling (Note 6 and Fig. 2)

Target voltage		0 to – 5	V
Grid g4 voltage (Note 7)		225 to 275	V
Grid g3 voltage (Note 7)		160 to 200	V
Grid g2 voltage		160	V
Grid g1 voltage : to be adjusted for I_{g4} = 5 μA		– 10 to – 30	V
Picture cut-off	max.	– 20	V
	min.	– 60	V
Minimum blanking peak to peak voltage :			
- applied to g1		– 75	V
- applied to cathode		+ 20	V
Grid g4 current		5	μA
Pedestal current		50	nA

Electro-optical

Under conditions given in Typical Operation

• Average gamma	1	
• Average intrinsic responsivity in the 8000 - 14 000 nm range (Note 8)	⩾ 3. 5	$\mu A.W^{-1}$
• Responsivity uniformity referred to the retina center, measured on centered circles of :		
8 mm diameter (Note 9)	± 12. 5	%
13 mm diameter (Note 9)	± 17. 5	%
• Resolution (Note 10) :		
- limiting, in panning mode ($v \sim 0.4\ cm.s^{-1}$)	6	lp/mm
- at 50 % modulation :		
in panning mode ($v \sim 0.4\ cm.s^{-1}$) (Figure 3)	> 2	lp/mm
in transient mode at the first frame	> 2	lp/mm
• Minimum difference of temperature resolved	see Figure 4	

• Signal current :

A tube having an intrinsic responsivity of S = 4 $\mu A.W^{-1}$ submitted to a differential irradiance $\Delta E_e = 1\ W.m^{-2}$ in the 8000 to 14 000 nm range delivers a signal current of I_s = 1. 7 nA .

With a lens matching the 8000 - 14 000 nm range at F/1 aperture, the signal current is 1 nA for $\Delta\theta$ = 1 °C (in the case of a black body at temperature close to 300 °K).

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NOTES

1 - The spectral response of the tube is determined by the transmittance of the input window. For the TH 9840, the transmittance τ is higher than 90 % in the 8000 to 14 000 nm range.

2 - The pedestal current is the difference between the currents in signal electrode when the electron beam scans the mask which borders the retina and the retina itself respectively.

Its value increases when the I_{g4} current and the reservoir voltage increase. It must be sufficient to permit the reading of negative charges which are generated when the target temperature decreases after irradiation is removed.

The value of the pedestal current can be calculated, assuming that the preamplifier characteristics are known, from the preamplifier output voltage by line measurement on an oscilloscope.

In normal operating conditions, I_{g4} is 5 μA and pedestal current 50 nA. The voltage to be applied to the reservoir is given in Test Report accompanying the tube.

In order to make the adjustment easier and to obtain better stability in operation, I_{g4} current can be regulated (by action on V_{g1}) and reservoir voltage slaved to the chosen pedestal current (THOMSON-CSF patent).

3 - An irradiance $\Delta E = 40$ W.m^{-2} corresponds, for a F/1 lens aperture and $\tau = 0.8$ transmittance, to an exitance of 470 W.m^{-2} i.e. to source temperature of about 85 °C in the case of a black body ($\Delta\theta = 58$ °C).

The tube even out of use and without lens must be protected against intensive infra-red irradiance which could abruptly raise the retina temperature (sun for example).

With its lens, too hot point sources of radiation can also damage the target.

4 - The optimal operating temperature is from 20 °C to 30 °C. For temperatures lower than 20 °C, the tube sensitivity progressively decreases. For temperatures higher than 30 °C, the capacitance of the retina increases which results in excessive lag hence degradation of tube performance. At temperature near to the Curie point (49 °C) of retina material, the sensitivity to radiation (i.e. pyroelectric effect) disappears.

5 - In order to obtain stable operation, the target must be entirely scanned. The format 18 mm x 24 mm is recommended.

The signal current is proportional to scanned area, However increasing this area is not advantageous because lag and increase of video band are the limiting factors.

6 - Before a normal operation, the polarization of the target must be made uniform over its whole surface and oriented in such a way that a temperature increase gives rise to positive charges on the inner face of the retina. This is done by raising the potential of the retina surface to a value of about 150 V higher than that of the backplate during 20 to 30 seconds. The field between the two faces of the retina is then suppressed before returning to the normal operating conditions.

This sequence (poling) can be realized by negatively biasing the cathode-control grid assembly while maintaining the signal electrode at 0 V in order to raise the surface of the retina to a potential near to that of grid g4 through secondary emission ratio $\delta > 1$.

The polarization field must be maintained for 20 to 30 seconds and then suppressed by shifting V_{g4} down to 0 V. After 10 to 20 seconds, the beam current is switched-off and the cathode-control grid assembly potential returns to its normal value. The beam is then switched on and the tube is operative.

7 - The grids g3 and g4 voltages must be adjusted in order to obtain a good image uniformity ; V_{g4} must be higher than V_{g3} so as to avoid a brilliant zone at the center of image.

8 - The intrinsic responsivity is determined by measuring the signal current delivered by the tube 60 ms after irradiance setting ; the zone to be irradiated is limited to a circle of 2 mm diameter centered on the faceplate.

The infra-red flux is in the 8000 to 14 000 nm range and the irradiance $\Delta E = 7$ to 10 W.m^{-2}.

The intrinsic responsivity is defined by :

$$S = \frac{Is}{\Delta E . A}$$

with
- Is = signal current in amperes
- ΔE = irradiance on input window in W.m^{-2}
- A = scanned area in m^2
- S = responsivity in A.W^{-1}

9 - The measurement of the responsivity uniformity is made at 8 points of 2 mm diameter located at the crossing points of the two circles of 8 mm and 13 mm diameter and two perpendicular axes, one of this axis being parallel to image scanning line.

10 - The resolution is measured as follows :

- in **panning mode** : the image of an infra-red test chart is displaced on the retina at a rate of 0.4 cm.s^{-2} ; two resolutions are determined : the limiting resolution corresponding to the limit of discernibility and the resolution corresponding to 50 % modulation by using a storage oscilloscope at the preamplifier output.
- in **transient mode** : the still image of an infra-red test chart is projected on the retina through an electronic chopper synchronized to frame scan.
  The modulation of the resulting signal, after 20 ms irradiance, is measured at the preamplifier output by a storage oscilloscope.

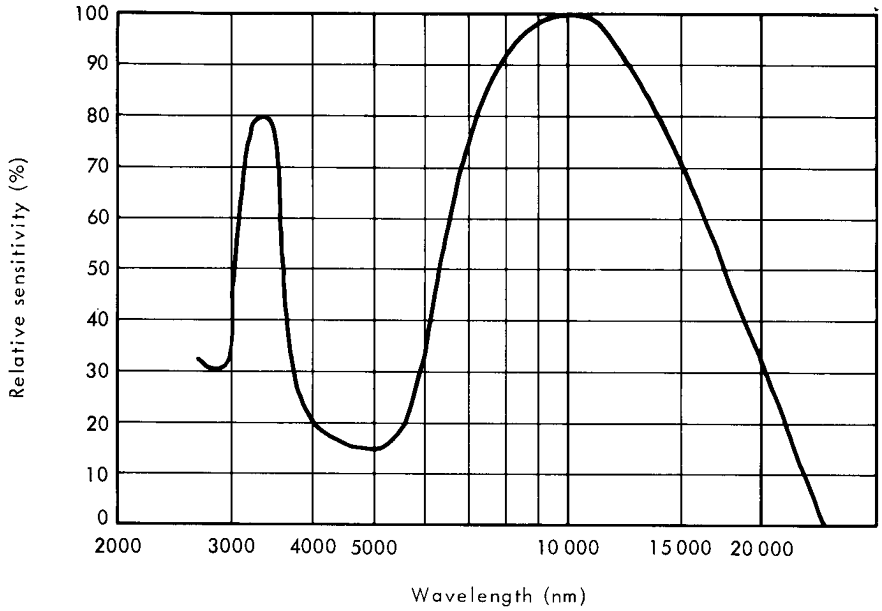


Figure 1 - Spectrale response.

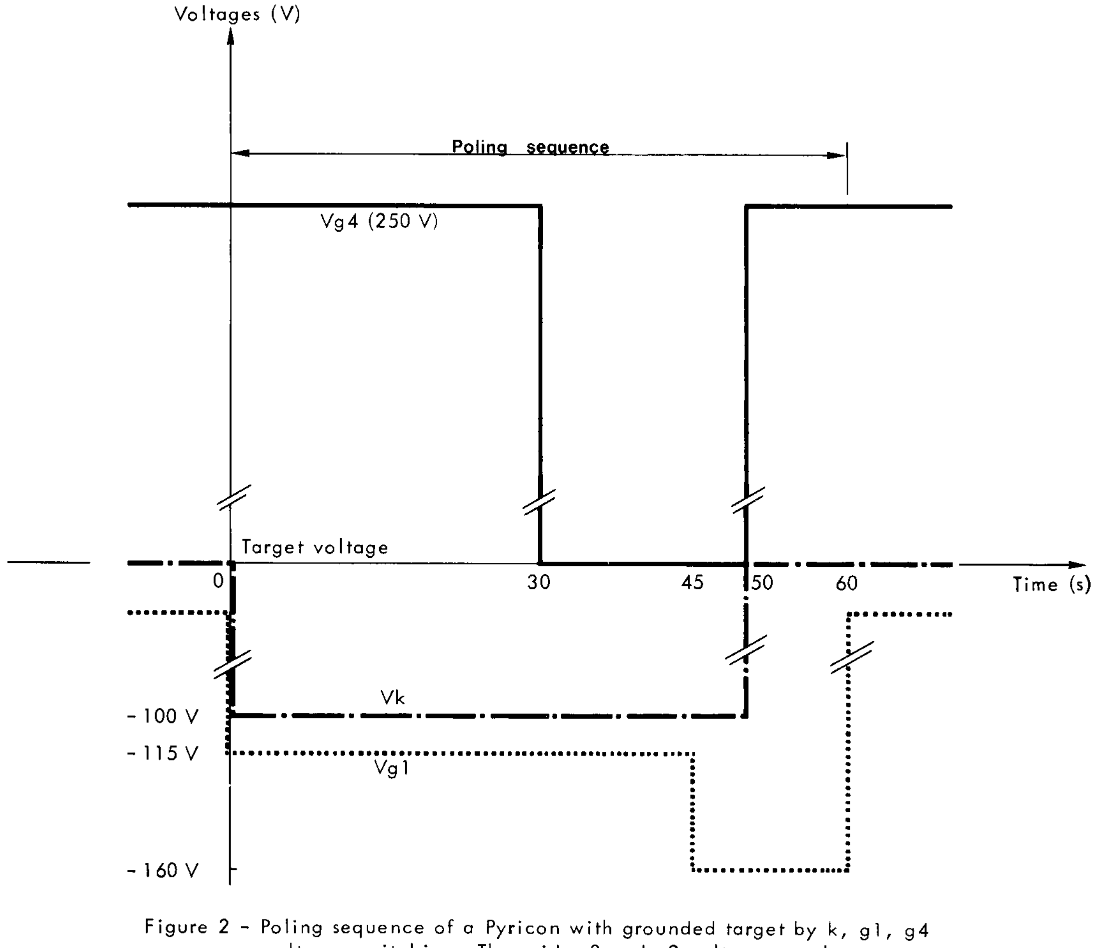


Figure 2 - Poling sequence of a Pyricon with grounded target by k, g1, g4 voltages switching. The grids g3 and g2 voltages are kept constant (Vg3 = 180 V; Vg2 = 160 V).

(Note : The value of Vg1 as compared to Vk is such that the Ig4 current is between 5 and 10 μA).

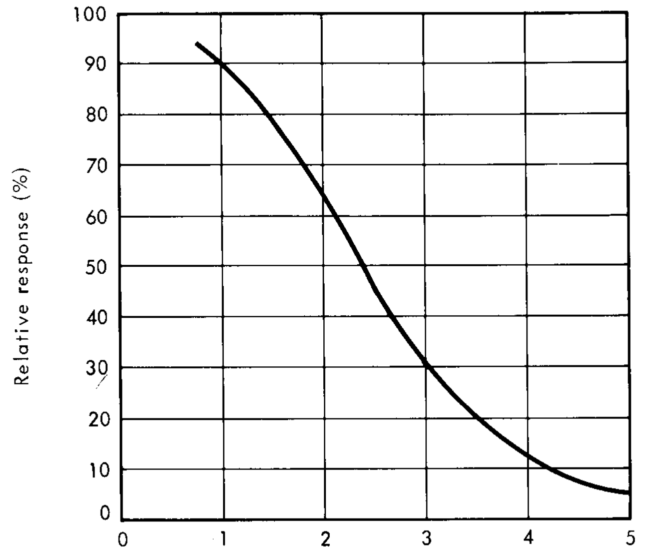


Figure 3 - M.T.F. measured in panning mode v = 0.4 cm.s^{-1}
Scanning standard : 625 lines/25 Hz
Bandwidth : 2.5 MHz

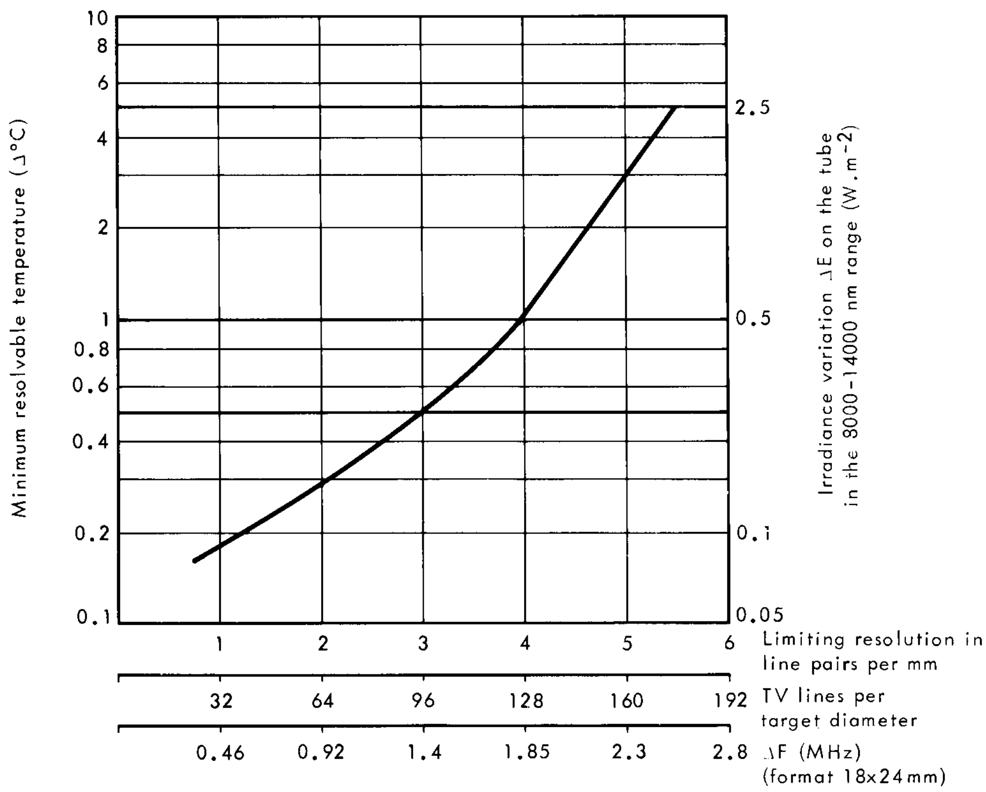
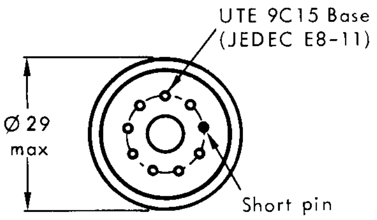
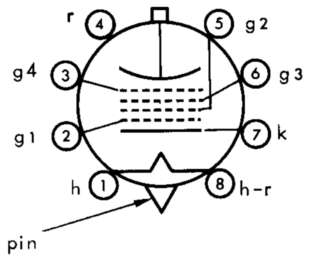


Figure 4 - Minimum resolvable temperature in panning mode (v = 0.4 cm.s^{-1})
Black body near to ambient temperature - F/1 aperture number.

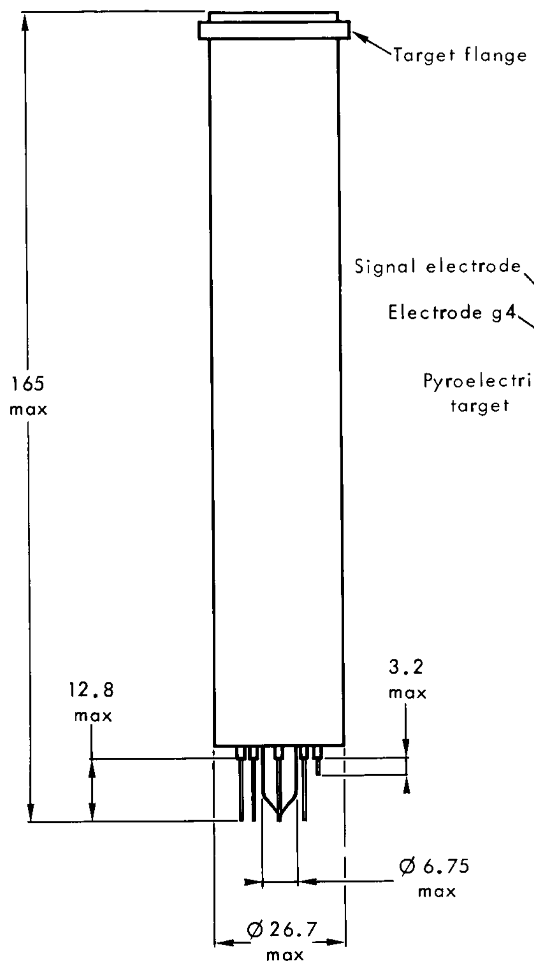
OUTLINE DRAWING

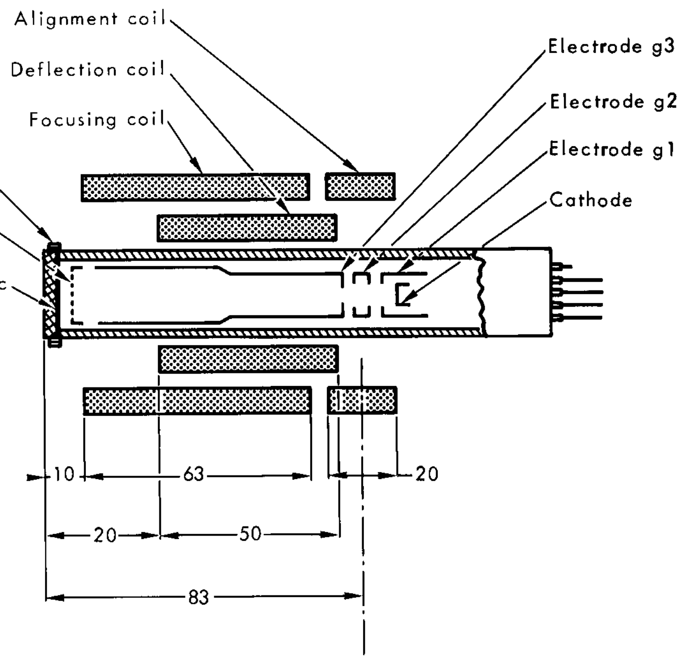


BASING



1 - Heater	5 - Electrode g2
2 - Electrode g1	6 - Electrode g3
3 - Electrode g4	7 - Cathode
4 - Reservoir	8 - Heater-Reservoir





Optimum location of the tube inside the deflection-focus-alignment coils.

Dimensions in mm.

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