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TOSHIBA IMAGE ORTHICON CAMERA TUBE

TYPE 5820

Toshiba

TOKYO SHIBAURA ELECTRIC CO., LTD.

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TOSHIBA IMAGE ORTHICON CAMERA TUBE
TYPE 5820

The Toshiba tube type 5820 is a television camera tube suitable for both studio and outdoor pickups. It is interchangeable with the RCA tube type 5820.

The Toshiba 5820 has several merits as follows:

(1) Toshiba 5820 can be used at higher temperatures, because it has special target glass made by Toshiba.

(2) Less tendency for "Burning" contributes to longer service hours.

(3) Higher resolution capability

INTRODUCTION

The Toshiba 5820 is a television camera tube suitable both for outdoor pickups at low level of illumination as well as for studio pickups because of its exceptionally high sensitivity and particular storage capacity.
A light flux of only 0.25 milli-lumen to the photocathode is sufficient to make full use of the transfer characteristic of the tube. In spite of this high sensitivity the 5820 shows no sign of instability.

The spectral sensitivity of the photocathode used in the 5820 is high for blue and green, very good for yellow and good for red; in the infrared region there is practically no sensitivity, thus preventing a colour-masking by this part of this spectrum.

The secondary electron multiplier incorporated in the 5820 has an average gain of 500 to 1000, giving signal currents of several micro-amperes; these high output currents eliminate the need for a special low noise amplifier in the camera and allow the use of a relatively low number of stages.

Under proper operating conditions, the 5820 has light transfer characteristics which do not require the use of gamma-correction circuits to provide normal tone rendition in black-and-white pictures on the picture tube screen.

OPERATING PRINCIPLES

The 5820 has three sections — an image section, a scanning section, and a multiplier section

1. Image Section

The image section contains a semitransparent photocathodes on the inside of faceplate, a grid to provide an electrostatic accelerating field, and a target which contains of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene to be televised is focused by an optical lens system onto the photocathode from which photo-electrons are emitted proportionally to the intensity of the optical image at any particular point. These photo-electrons are focused onto the target by the compined action of the electrostatic and longitudinal magnetic field, the latter being produced by an external coil. Secondary electrons produced by the incident photo-electrons are collected by the fine mesh screen which is held at a definite small positive potential with respect to the target. The potential excursion of the target is thus limited, ensuring complete stability at all light levels. The secondary emission at the target produces a pattern of positive charges corresponding point to point with the light distribution of the original scene. The thinness of the target allows this charge pattern to be reproduced on its reverse side, i.e. the scanned side.

2. Scanning Section

The reverse side of the target is scanned by an electron beam emanating from the electron gun in the scanning section. This gun comprises a thermionic cathode, a control grid (Grid #1) and an accelerating grid (Grid #2). The beam is focused at the target by magnetic field of the external focusing coil and the electrostatic field of Grid #4.

The beam is aligned with the focusing magnetic field by means of a small transverse magnetic field produced by an external coil located at the gun and of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflection coils.

The relative potential of the gun and associated electrodes are such that the beam approaches the target with substantially zero velocity. In areas of the target corresponding to the dark areas of the image, the beam is unable to land and the beam is reflected towards the gun. In areas corresponding to the illuminated regions of the image, the target will be positively charged and electrons will be deposited until the traget potential is restored to its original value. That fraction of the beam not required for neutralisation of the target charge pattern will return towards the gun. The return beam is thus amplitude modulated, its intensity being inversely proportional to the brightness of the original image.

3. Multiplier Section

The electrons which fail to land on the target constitute the return beam and are directed to the first dynode of a five stage electrostatically focused multiplier. This utilizes the phenomenon of the secondary emission to amplify signals composed of electron beam. The electrons in the beam impinging on the first dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid # 3 facilitates a more complete correction by dynode #2 of the secondaries from dynode #1. The multiplier process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode #5 are corrected by the anode and constitute the current utilized in the output circuit.

The multiplier section amplifies the modulated beam about 500 to 1000 times. The gain of the multiplier is sufficiently high so that the random noise of the electron beam is brought above that of the input stage of the video amplifier. It thus becomes the limiting noise in the use of the tube. The presence of the multiplier also permits the use of an amplifier of fewer stages.

It can be seen that when the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resister changes in the positive direction. Hence for highlight in the scene, the grid of the first video amplifier stages swings in the positive direction.

DATA

1. General Ratings

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 volts ± 10 %
Current	0.6 ampere
Direct Interelectrode Capacitance:	
Anode to all other electrodes	12 pF
Photocathode, Semitransparent:	
Response	See Fig. 2
Rectangular Image (4x3 aspect ratio):	
Useful size of	1.8" max. diagonal

Note: The size of the optical image focused on the photocathode should be adjusted so that its maximum diagonal does not exceed the specified value. The corresponding electron image on the target should have a size such that the corners of the rectangle just touch the target ring.

Orientation of — Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through center of faceplate and pin #7 of the shoulder base.

Focusing Method	Magnetic
Deflection Method	Magnetic
Overall length	15.20" ± 0.25
Greatest Diameter of Bulb	3.00" ±0.06
Shoulder Base	Keyed Jumbo Annular 7-pin
End Base	Small-Shell Diheptal 14-pin (JETEC #B14-45)
Operating Position	Undermentioned
Weight (approx.)	1lb 6oz
Minimum Deflecting-Coil Inside Diameter	2-3/8"
Deflection-Coil Length	5"
Focusing-Coil Length	10"
Alignment-Coil Length	15/16"
Photocathode Distance Inside End of Focusing Coil	1/2"

2. Maximum Ratings (Absolute values)

Photocathode:	
Voltage	-550 max. volts
Illumination	50 max. ft-c
Operating Temperature:	
~~Of any part of bulb~~	~~55 max. °C~~ sup.6
Of bulb at large end of tube (Target section)	40 min. °C
Temperature Difference:	
Between target section and any part of bulb hotter than target section.	5 max. °C
Grid-No.6 Voltage	-550 max. volts
Traget Voltage:	
Positive value	10 max. volts
Negative value	10 max. volts
Grid-No.5 Voltage	150 max. volts
Grid-No.4 Voltage	300 max. volts

Grid No. 3 Voltage	400 max. volts
Grid-No. 2 & Dynode-No. 1 Voltage	350 max. volts
Grid-No. 1 Voltage:	
Negative bias value	125 max. volts
Positive bias value	0 max. volts
Peak Heater-Cathode Voltage:	
Heater negative with respect to cathode	125 max. volts
Heater positive with respect to cathode	10 max. volts
Anode-Supply Voltage	1350 max. volts
Voltage Per Multiplier Stage	350 max. volts

3. Typical Operation and Characteristics

Image Focus (Photocathode) Voltage	-400 to -540 volts
Accelerator (Grid-No. 6) Voltage Approx. 75% of photocathode voltage	-300 to -405 volts
Target-Cutoff Voltage	-3 to +1 volts
Decelerator (Grid-No. 5) Voltage	0 to 125 volts
Beam Focus (Grid-No. 4) Voltage	140 to 180 volts
Multiplier Focus (Grid-No. 3) Voltage	225 to 330 volts
Grid-No. 2 & Dynode-No. 1 Voltage	300 volts
Grid-No. 1 Voltage for Picture Cutoff	-45 to -115 volts
Dynode-No. 2 Voltage	600 volts
Dynode-No. 3 Voltage	800 volts
Dynode-No. 4 Voltage	1000 volts
Dynode-No. 5 Voltage	1200 volts
Anode Voltage	1250 volts
Anode Current (DC)	30 μamp
Signal-Output Current (Peak to peak)	3 to 24 μamp
Target Temperature Range (See Text)	40 to 50 °C
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	35
Minimum Peak-to-Peak Blanking Voltage	5 volts
Field Strength at Center of Focusing Coil	75 gausses
Field Strength of Alignment Coil (Approx.)	0 to 3 gausses

OPERATION

Sequence of Adjustment

1. Insert tube camera and apply voltages as indicated under Typical Operation. Uncap the lens momentarily while adjusting the Grid #1 voltage to give a small amount of beam current. This procedure will prevent the mesh from being electrostatically pulled into contact with the glass disc. Make certain that the deflection circuits are functioning properly to cause the electron beams to scan the target.
2. Set scan amplitude control at maximum.
3. Leave to warm up for 1/4 to 1/2 hour with the camera lens capped.
4. With the lens still capped and the target voltage set at approximately 2 volts negative, adjust the Grid #1 voltage until noise or a rough-textured picture of Dynode #1 appears on the monitor. Then adjust the alignment coil current so that the small white dynode spot does not move when the beam-focus control (Grid #4) is varied, but simply goes in and out of focus.
5. Uncap camera lens.

6. Increase target voltage until information appears. Set voltage of target approximately 2 volts above cutoff and adjust beam current to the lowest value consistent with a satisfactory picture.
7. Decrease the scanning amplitude until the edge of the target ring just disappear at the corner of the picture.
8. Adjust the lens to produce the best optical-focus, and the voltage on the photocathode as well as the voltage on Grid # 4 to produce the sharpest picture.
9. Adjust the Grid #5 voltage control to produce the picture that has the most uniform shading from center to edge.
10. Adjust the Grid #3 voltage control to produce the maximum signal output.
11. Adjust image accelerator (Grid #6) for minimum S distortion.
12. Adjust gain for signal of correct amplitude.
13. Readjust beam, beam focus and image focus for the best picture.

SPECTRAL RESPONSE

The spectral response of the 5820 is not subject to appreciable variation from tube to tube.

The spectral response of the 5820 without correcting filter is shown by curve A in Fig. 2. Curve B in the same figure, shows the spectral response when a Wratten #6 filter is used with the 5820. This curve very closely approaches that of the eye shown by the dotted curve C.

TRANSFER CHARACTERISTICS

The basic light transfer characteristic of the 5820 is shown in Fig. 3. This curve is representative only for small area highlights. For larger area highlights, the bend or "knee" is not quite as abrupt as shown in Fig. 3.

The knee of the curve is explained by the fact that the charge accumulated by the target can not exceed the charge which raises the voltage of the target to the collector-mesh potential. As the result, when the 5820 is operated with highlights above the knee, not all of the secondary electrons emitted by the target glass disc are collected by the adjacent mesh, because it no longer maintains a positive accelerating field between itself and the charged areas. These secondary electrons not collected fall back on their original location or are randomly distributed over adjacent picture areas. Since they land on these areas at a low velocity, they tend to discharge the positive areas and limit their charge buildup.

Operation with the highlights above the knee allows the image orthicon to develop an electrial signal that, in conjunction with the light-output characteristics of the TV receiver kinescope, presents a picture having normal tone rendition.

In general, when operated with the camera lens stop opened one position beyond point where the highlights of the scene reach the knee of the curve, the 5820 will produce a picture having very normal and pleasing tone rendition, especially for studio pickup where light levels and contrast range can be controlled.

For outdoor pickup where extreme scene brightness ranges are encountered, it will be necessary to operate the 5820 with the lens stop opened so that highlights fall further than one stop above the knee. This setting is necessary in order that the extreme scene contrast can be compressed into the rather narrow contrast range reproducing capabilities of a television system without loosing the informations contained in the low light areas of the scene. Operating the lens stop two positions above the point where the highlights of the scene reach the knee will normally suffice in outdoor pickup operation. If the lens stop is opened further, excessive black flare around bright object will occur and random distribution effects will produce a distorted picture.

OPERATING POSITION

The operating position of the 5820 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical.

OPERATING TEMPERATURE

Aiming at higher resolution, the Toshiba 5820 has special target glass made by Toshiba. therefore this range is 5°C higher than conventional tube types

The operating temperature of any part of the glass bulb should never exceed 55°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 40°C during operation.

The temperature of the target is essentially the same that of the adjacent glass bulb and can, therefore be determined by measuring the temperature of the glass bulb adjacent to the target.

For best results, it is recommended that the temperature of the entire bulb be held between 40°C and 50°C.

Operation at too low temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved.

Operation at too high temperature will cause loss of resolution and possibly permanent damage to the tube. Resolution is regained by waiting for the temperature to drop below 50°C.

No part of the bulb should run more than 5°C hotter than the target section to prevent cesium migration to the target. Such migration will result in loss of resolution and in probable parmanent damage to the tube.

Like other photosensitive devices employing cesium, the 5820 may show fluctuation in performance from time to time. Strict observance of the above recommendations with respect to operation temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

RESOLUTION

The resolution of the 5820 is primarily limited by magnetic stray fields from the scanning coils reaching as far as the image section of the tube; under the influence of these fields the points of impact of the photoelectrons on the glass membrane perform minute scanning motions. This effect, mostly referred to as "cross talk", can be minimized by an efficient magnetic shielding of the scanning coils.

A Second factor limiting the resolution is excessive conductivity of the glass membrane: here one has to distinguish between a surface conductivity and the volume conductivity of the glass. A surface conductivity may be caused by condensation of cesium on the glass membrane whenever the tube is operated under conditions where parts of the glass envelope become more than 5°C hotter than the bulb in the vicinity of the target. The volume conductivity of the glass membrane depends very strongly on the temperature, increasing by about 6% for every degree rise in temperature, thus leading to a lateral charge spread at excessive temperatures.

RECOMMENDATIONS AND WARNINGS

1. Recommendations
    1. Allow the 5820 to warm up prior to operating.
    2. Hold temperatures within the operating range.
    3. Cap lens during standby operation.
    4. Keep beam current as low as possible to secure higher signal-to-noise ratio.
    5. Make sure the beam is properly aligned.
    6. Adjust target voltage exactly 2 volts above cutoff.
    7. Adjust illumination correctly.
    8. Condition spare tubes by operating several hours once a month.
2. Warnings
    1. Do not force the tube into the shoulder socket.
    2. Do not operate the tube without scanning.
    3. Do not underscan the target.
    4. Do not focus the tube on a stationary bright scene.
    5. Do not carry a tube with the image section downwards.
    6. Do not leave camera unattended without capping lens.

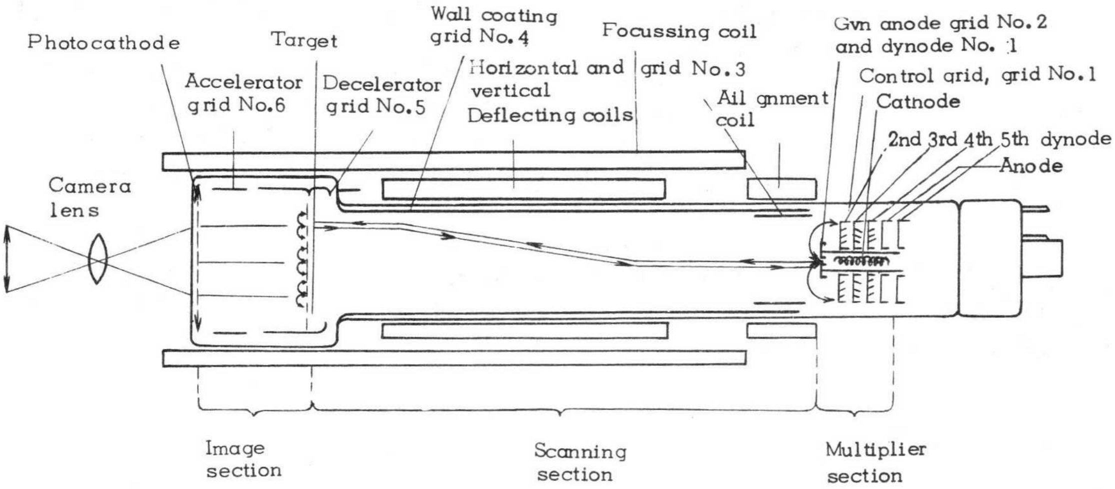


Fig. 1 Construction

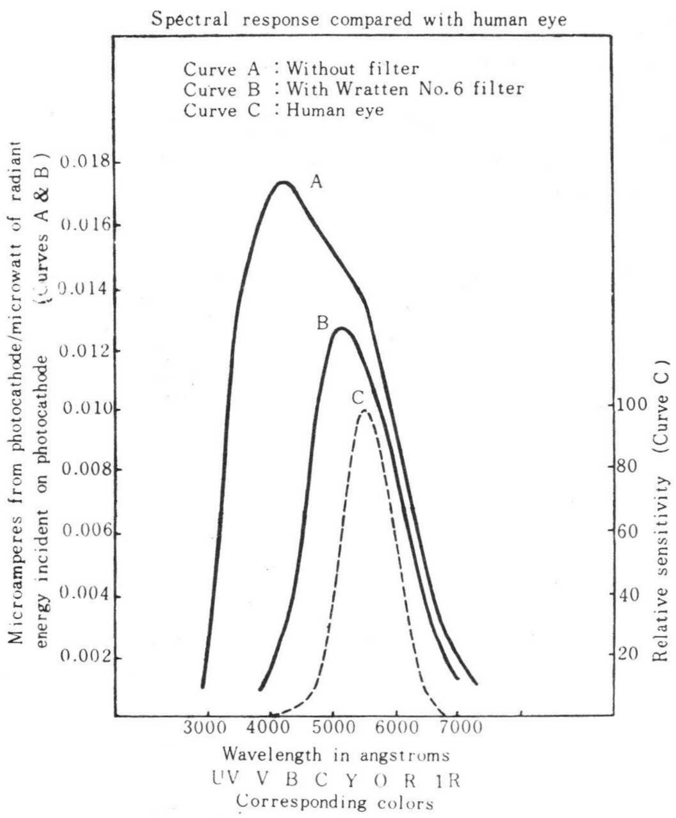


Fig. 2 Spectral response compared with human eye

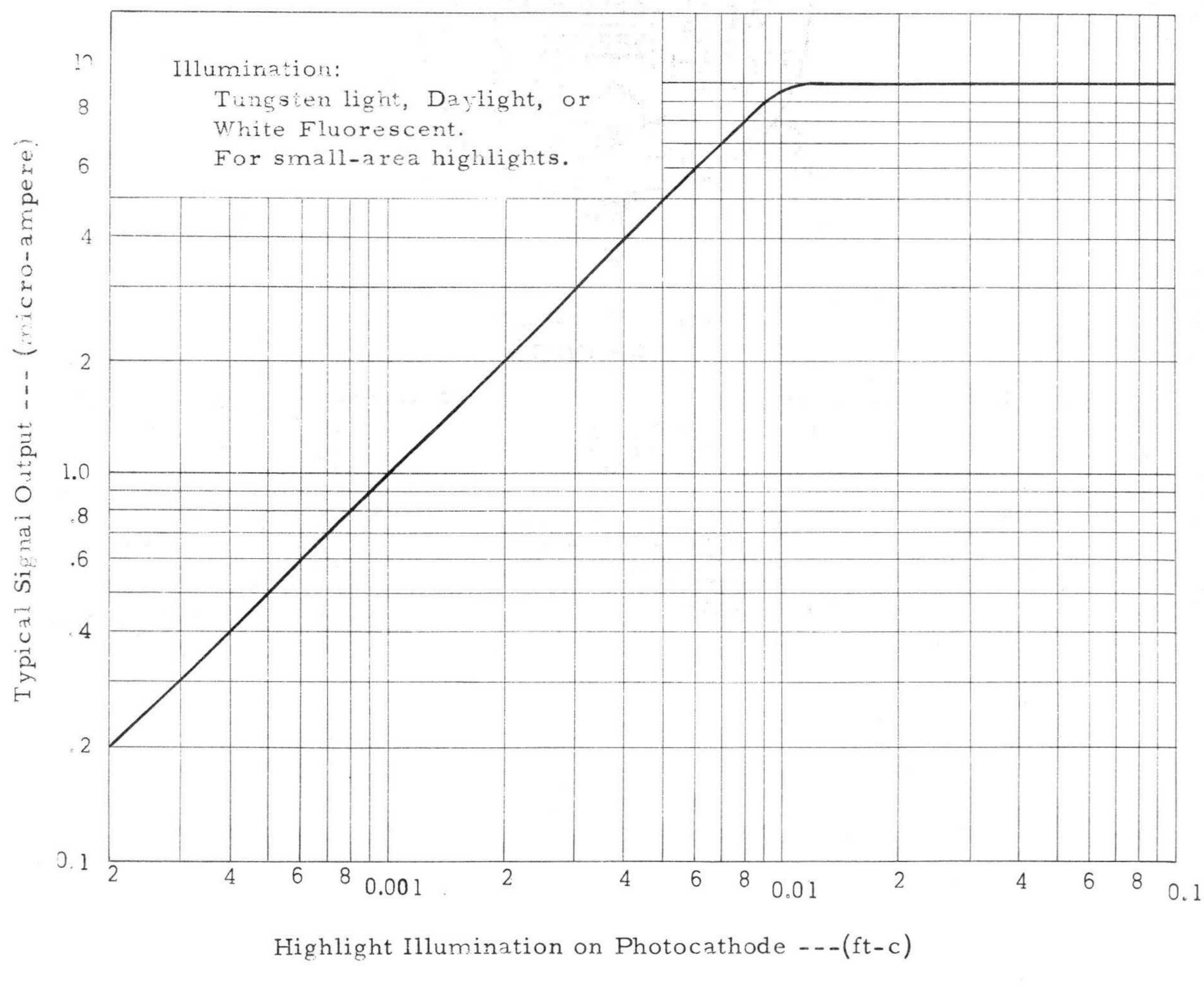
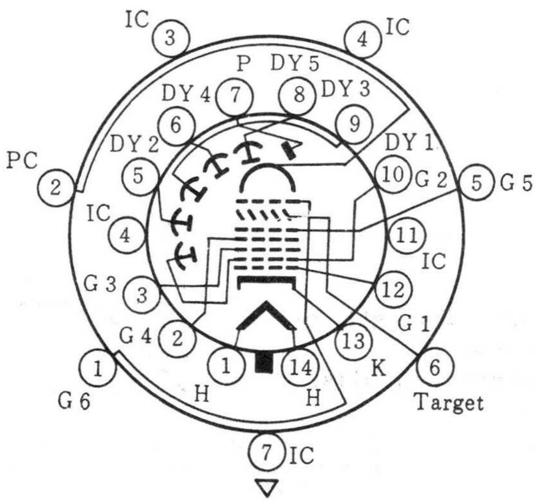


Fig. 3 Basic light transfer characteristics

SOCKET CONNECTIONS
Bottom View



WHITE INDEX LINE
ON FACE

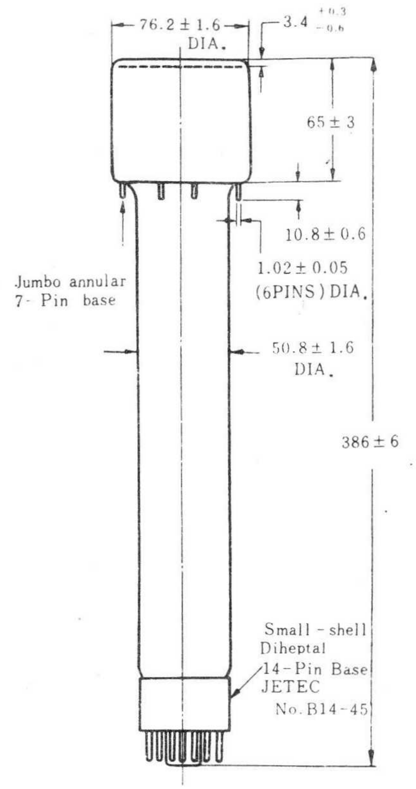
SMALL-SHELL DIHEPTAL 14-PIN BASE

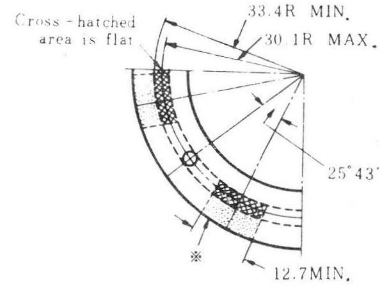
PIN 1: HEATER
PIN 2: GRID NO. 4
PIN 3: GRID NO. 3
PIN 4: INTERNAL CONNECTION--DO NOT USE
PIN 5: DYNODE NO. 2
PIN 6: DYNODE NO. 4
PIN 7: ANODE
PIN 8: DYNODE NO. 5
PIN 9: DYNODE NO. 3
PIN 10: DYNODE NO. 1
GRID NO. 2
PIN 11: INTERNAL CONNECTION--DO NOT USE
PIN 12: GRID NO. 1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

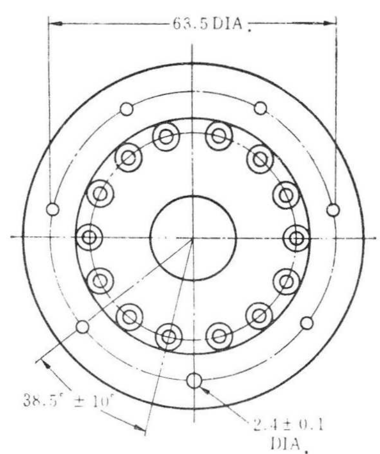
PIN 1: GRID NO. 8
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION--DO NOT USE
PIN 4: INTERNAL CONNECTION DO NOT USE
PIN 5: GRID NO. 5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION--DO NOT USE

DIMENSIONAL OUTLINE (ALL DIMENSIONS, IN mm)





※ : Dotted area is flat or extends toward Diheptal - base end of tube by 1.5 mm MAX.



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see p. 5 for reference to "Experimental anti-black-border 5820"

Rec'd March 1961

TOSHIBA IMAGE ORTHICON 5820
for
TV CAMERA

TOKYO SHIBAURA ELECTRIC CO., LTD.

TOSHIBA Image Orthicon 5820 For TV Camera

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Matsuda Research Laboratory,

Tokyo Shibaura Electric Co., Ltd.

TOSHIBA has conducted various studies and investigations into tubes for photo devices that translate light energy into electrical energy, and produced television pickup tubes (iconoscopes, tecoscopes, etc.) and is now manufacturing photo tubes, photomultipliers, image-converter tubes and image intensifiers. Backed by these studies, researches have been conducted with success on image orthicon 5820 which is the best television pickup tube at present.

Structure

The structure of the image orthicon consists of three sections, i.e., the image, scanning and multiplier sections as shown in Fig. 1.

The image section comprises the semitransparent photocathode, accelerating electrode and target assembly. The photocathode is made of Ag-Bi-O-Cs and its spectral characteristic nearly equals that of the human eye as shown in Fig. 2. The accelerating electrode provides an accelerating electrostatic field and focuses a distortionless image on the target. The target assembly consists of a fine mesh of 750 lines per inch and an extremely thin glass plate. This target assembly makes the whole system a highly sensitive pickup tube through its charge-multiplying and storage action. The rise of an after image in the target glass is at present generally considered to be the terminating factor of the life of the image orthicon. In other countries, the life of the image orthicon is said to be 1,000 hr., whereas in Japan it has been considered to be about 500 hr. This is due largely to the temperament of the people who are very critical about picture quality—not only the spurious signal but also the after image.

As a result of various researches on the material of the target glass, a material, having a proper resistance value twice as high as any known heretofore, has been successfully developed. Used at 40 to 50°C, it is free from sticking. Its resolving power is high, and its life has been increased by as much as 30 to 80%. It is believed that the after image, as a whole, occupies less than a few per cent of all factors considered to cause the termination of the life. The main factors are believed to be the excess of the target cut-off voltage over the limit of the image orthicon camera control circuit as well as the black suppression of the tone.

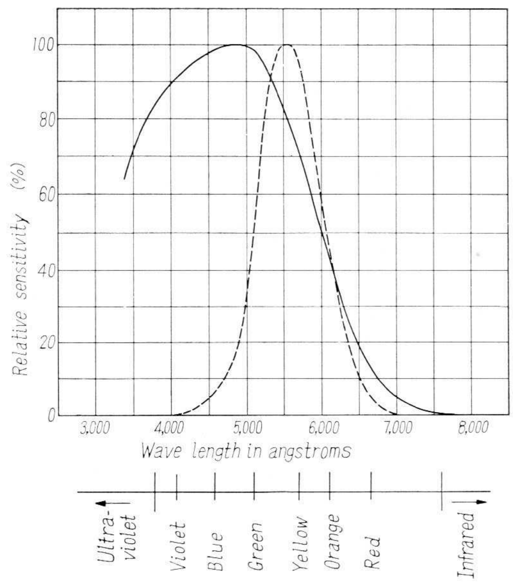

Fig. 2 Spectral sensitivity characteristics of TOSHIBA image orthicon 5820 for equal values of radiant flux at all wave lengths
Dashed curve shows spectral characteristic of average human eye.

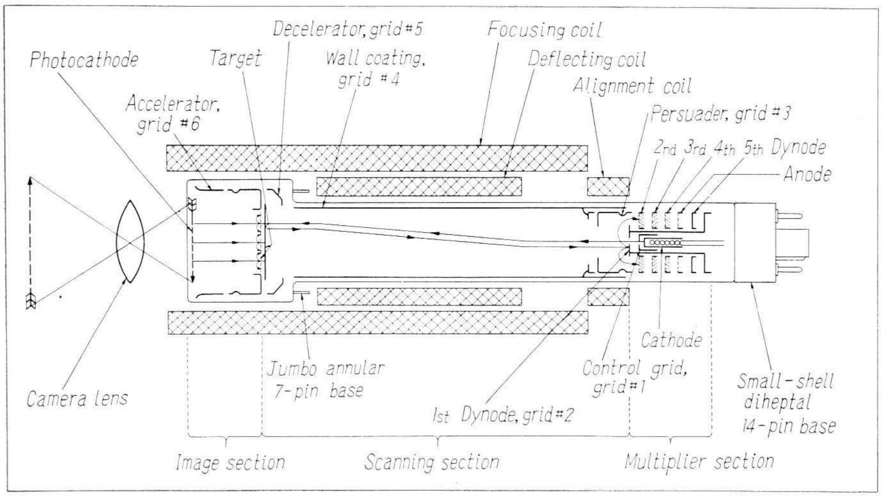

Fig. 1 Schematic arrangement of TOSHIBA image orthicon 5820

In the scanning section, an electron beam is focused and deflected by the magnetic field, slowed down to a low velocity by the decelerating electrode, and scans the whole surface of the target. This scanning beam neutralizes the positive signal charges on the target, is modulated and driven back to the multiplier. In order to improve the signal-to-noise ratio, researches have been made on the landing of the beam onto the target, the velocity distribution of the electron beam, etc.

The multiplier section amplifies the modulated return beam by about 1,000 times. Since the image is likely to be marred by the crude texture of the first dynode surface, a super dynode of fine structure is adopted to improve the image quality. As to a dynode of pinwheel type, researches on the modes of potential-giving and the surface condition of the Ag-Mg secondary emitter have been conducted with satisfactory results.

The formation of ghosts or halos has also been studied. To minimize the black border, the investigation of an image orthicon of anti-black-border type was attempted, and it has been clarified that it can reduce to a great extent the black border which is very unpleasant to the eye.

Since all parts and their materials such as the face plate, target glass, Ag-Mg alloy, etc. have been made and assembled by Toshiba itself under careful control Toshiba image orthicon is assured of high and uniform quality.

Resolution and Sticking Picture[1]

The resolution of the image orthicon is mainly determined by the lateral electric leakage of the target glass. To reduce the lateral leakage, it is necessary to reduce the thickness of the target glass and increase the specific electric resistance within permissible limits. The thickness of the target glass is reduced as much as the mechanical strength can withstand, namely, no more than a few microns.

If the electric resistance of the target glass becomes too high, the electric charges at both sides of the glass plate do not neutralize in a short time. Under this condition, focusing on a stationary bright figure brings a gradual decrease in the output signal current, and the panning of the image orthicon camera brings forth a rapidly disappearing "sticking picture" of opposite polarity. This picture appears when the target glass of the image orthicon is used while it is still cold, and can be prevented by increasing the temperature. This sticking picture differs from the after image which appears and stays for a considerable length of time upon the termination of the life of the tube.

Therefore, it is advisable to keep the electric resistance as high as possible within permissible limits.

The ratio of the sticking signal current of opposite polarity (I_{st}) to the initial value of the image signal current (I_{in}) can be expressed approximately by the following equation (see Fig. 3):

$$I_{st}/I_{in} = \frac{\frac{C_m}{C_g} e^{-T/\tau_g}}{1+\frac{C_m}{C_g} - e^{-T/\tau_g}}$$

where

C_m = the capacitance between the target glass and the mesh of one picture element

C_g = the capacitance between both sides of the target glass of one picture element

T = the time of one frame

$$\tau_g = R_g C_g = \frac{1.1}{4\pi} \rho K \times 10^{-12} \text{sec}$$

ρ indicates the specific electric resistance, K, the dielectric constant of the target glass.

And the number of frames n_0, which pass before the sticking image becomes $1/e$, can be represented approximately as

$$n_0 = \frac{1}{\frac{T}{\tau_g} + \log\left(1 + \frac{C_m}{C_g}\right)} + 1$$

From the above equations we can learn the relation between the magnitude of sticking and the electric resistance as well as that between the decrement and the electric resistance. These relations are given in Fig. 4. Based on these calculations, Toshiba 5820 employs a target glass of high resistivity whose value is about ten times larger than that calculated by H. B. De Vore. It has excellent resolution characteristics as shown in Figs. 5 and 6.

The photograph given in Fig. 6 was taken by using the master monitor ST-1763B which employs 10SP4A and also the Toshiba image orthicon camera DO-1330C. And for the coil assembly, the Toshiba stock number FF-45884 was used.

Toshiba image orthicon 5820 enjoys not only excellent resolution as stated above, but also a superb characteristic regarding to the after image that appears at the end of the life, thus making the life longer.

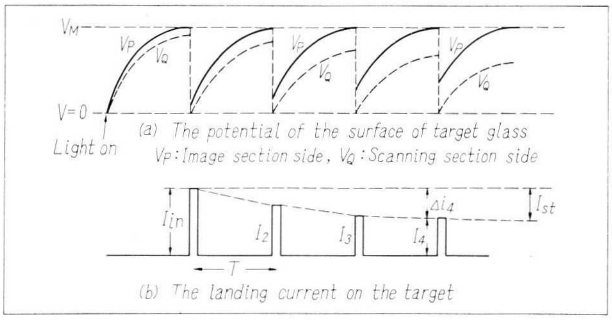

Fig. 3 The potential transition and the landing current on the target glass

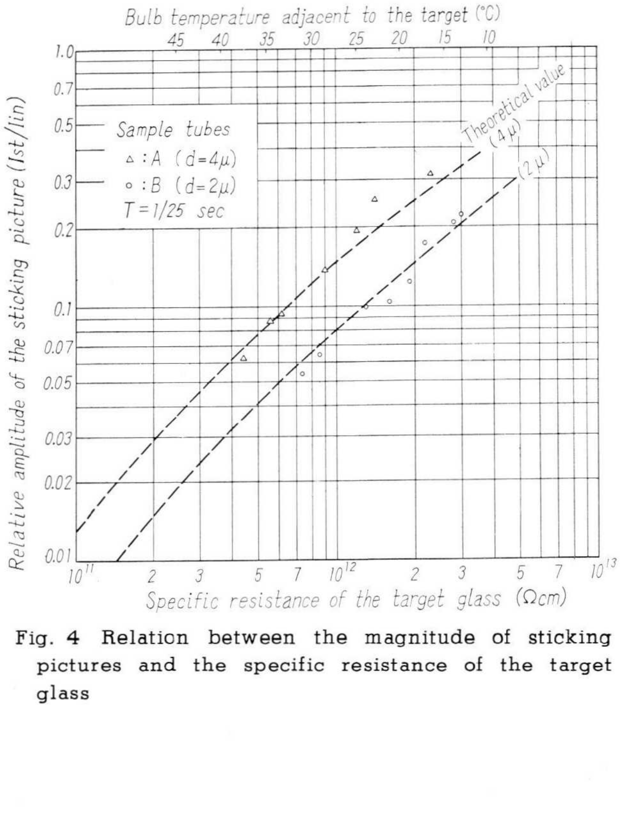

Fig. 4 Relation between the magnitude of sticking pictures and the specific resistance of the target glass

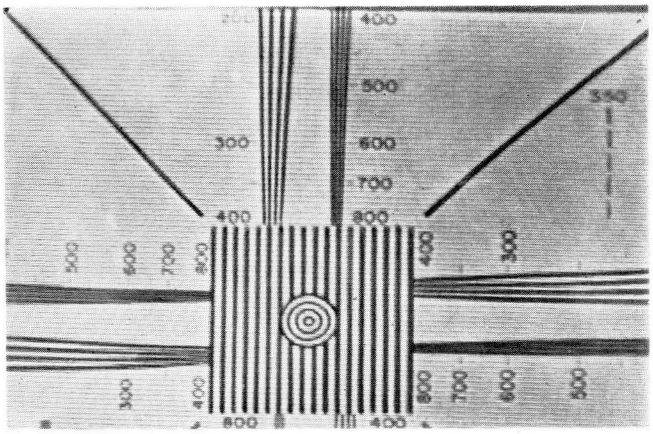

Fig. 5 The picture of the center of the master monitor—
The resolving power of 700 TV lines is observed at 45°C of the target glass temperature.
(Test pattern : RETMA resolution test chart)

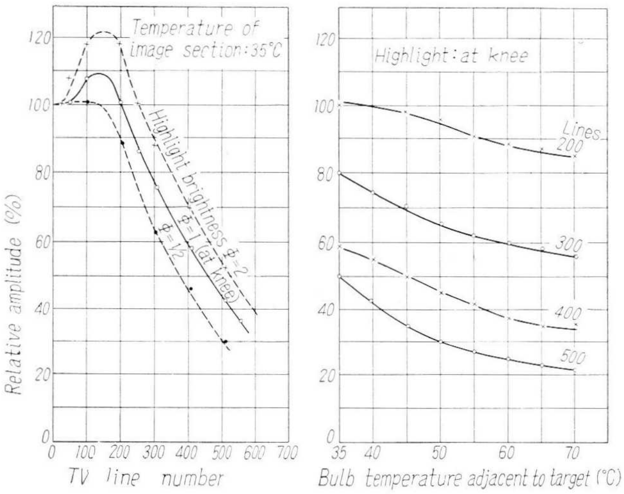

Fig. 6 Amplitude response and effect of temperature of the TOSHIBA 5820 (Test pattern : RETMA resolution test chart)

Signal-to-Noise Ratio[2]

Since the image orthicon contains a high-gain multiplier in itself, it is capable of supplying larger output signal current than the pre-amplifier noise of the camera. Therefore, it is necessary for the image orthicon itself to have a better signal-to-noise ratio. This noise is due mainly to the shot noise in the beam, and so to improve the signal-to-noise ratio, it is of utmost importance to increase the modulation of the signal in the return beam. Consequently, the scanning beam should be so adjusted as to give just enough current to discharge the target positive charge corresponding to the highlight of the picture.

Calculations have made it clear that the reflection coefficient of the scanning beam on the target glass surface and the velocity distribution of the beam largely affect the beam modulation. When the low velocity electrons of the scanning beam impinge on the scanning side of the target glass, a relatively large number of electrons undergo elastic reflection. This reflection can be reduced to a great extent by the evaporation coating of some metal on the scanning side of the target. The reflection coefficient was measured by the use of the image orthicon. If, by feeding sufficient light, the scanning beam current is reduced to 1/30 of the ordinary current (i.e. approximately 1×10^{-9}A), it is possible to keep the surface potential almost constant even at the time the electrons land on the target. Under this condition, the relation between the reflection coefficient and the velocity of landing electrons can be determined by measuring the ratio of the beam current to the magnitude of the landing beam current on the target by varying the potential of the target mesh. Fig. 7 gives the results of measurements taken when metal (i.e. Ag, Au, Pt, Cu, Ge, etc.) was deposited on the scanning side of the target glass. The reflection coefficient stands at 0.7 to 0.9 with the glass alone, while it is reduced to 0.3 to 0.5 when a metal is deposited on the glass. And the figure clearly shows that among other metals Ag is most suitable to reduce the reflection coefficient without loss of resolution.

Fig. 8 shows the velocity distribution of the electrons in the scanning beam along the axis of the tube. Here the measurement was made by the use of a metal plate instead of the glass target. The result coincides approximately with Maxwell's theoretical value calculated from the cathode temperature. It stands at about 0.1eV. It shows clearly that the characteristic of the electron gun is good enough for the beam landing.

The return beam produces impact on the first dynode of fine and uniform texture forming a rectangular raster whose diagonal measures approximately 8 mm. The secondary electrons produced there are directed to the second dynode by the persuader electrode G_3. The observation of the electron trajectories, which have been rendered visible by coating phosphor on

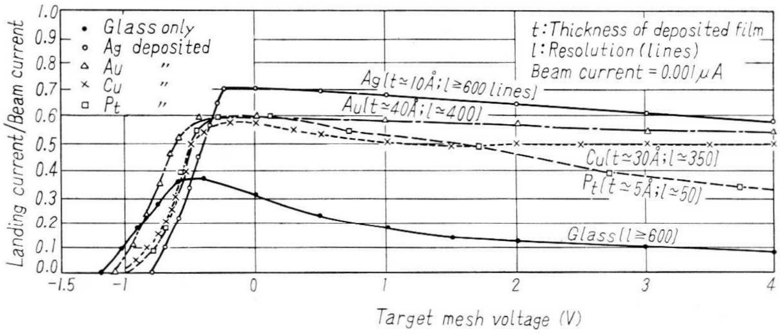

Fig. 7 Reflection of slow electrons on the glasses on which various metals are deposited

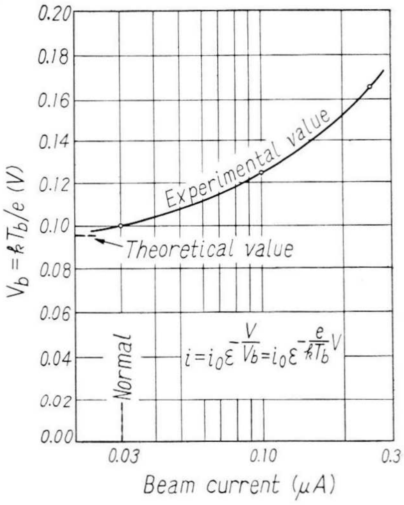

Fig. 8 Velocity distribution of scanning beam electrons

each dynode, is shown in Fig. 9. When the potential of G_3 is about 280 volts, the electrons reach the final dynode without much lateral deflection, resulting in the maximum gain and the minimum multiplier shading.

The multiplier dynode is made of an alloy of Ag-Mg, which, before being placed into the tube, is treated by heat in rarefied oxygen or water vapor to form an MgO film of several hundred A. over the surface. It has been found that, during this activation process, the selective oxidization proceeds according to the parabolic rate law in the low pressure atmosphere of oxidizing agent, and that the diffusion rate of Mg through the oxide layer is determined.

Also concerning the characteristic of the Ag-Mg emitter, various basic research data have been obtained on the problem of the gain decay due to carbon contamination induced by the electron bombardment(3) as well as on the effects of cesium vapor, various gases, heat treatment, light exposure, etc. on the gain.

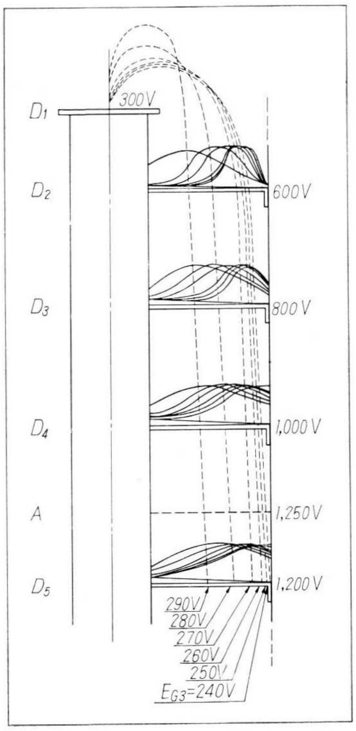

Fig. 9 Electron trajectory in the multiplier

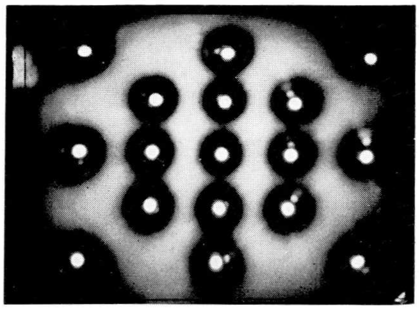

Fig. 10 An image picked up by 5820 image orthicon in spurious signal experiment

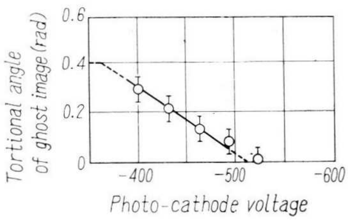

Fig. 11 Tortional angle of ghost image in 5820—
The angle with which the center of picture subtends the arc between ghost and real image

Spurious Signals

Although the spurious signals of the image orthicon include the problems of defects and shading, these will not be discussed in this article since various detailed reports have already been made on them. The writers will report here on newly-obtained information concerning such spurious signals as ghosts, haloes, black-border effects, etc.

Part of the secondary electrons emitted from the target cause spurious signals which are unique to the image orthicon. Although a brief explanation has been made about these phenomena, the writers have learnt that this explanation would not be sufficient. Fig. 10 shows the televised picture of a sheet of black paper with small holes illuminated from the back. A strong contrast ghost image of the hole appears by the side of each real image, being distributed in a counterclockwise direction. These are the same ghost images as those found in an ordinary broadcast picture. By varying the photocathode potential, the ghost image can be made to move toward the true image as seen in Fig. 11. Finally it unites with the real image and disappears. It has also been found that by varying the voltage of the photocathode or the accelerator, the ghost image can be made to fade into a faint round halo. We may call these ghosts and haloes "primary." Furthermore, at the outskirt of the photograph, faint ghosts of a different type can be observed. These "secondary" ghosts almost never change their positions even when the electrode voltage is varied. In Fig. 10, the region other than the black-border appears whitish because of a fogging effect, although the region is dark in the original scene. This kind of halo is called "secondary." On the basis of these factors, it may be reasonable to conclude that the high-velocity electron group gives rise to the relatively inconspicuous "secondary" ghost, whereas, of the medium-velocity electron group those electrons with a velocity that just satisfies the focus condition causes the "primary" ghost as well as the "primary" or round haloes, and the "secondary" halo is caused by the remaining part of the medium-velocity electron group.

The black-border effect is caused by part of the low-velocity secondary electrons emitted from the target, and renders the image scene unpleasant to the eye as illustrated in Figs. 10 and 12. Shown in Fig. 13 is the black-border width as it varies according to the brightness ϕ_S of the bright spot and the brightness ϕ_B of the background. It is to be noted that at $\phi_B < 1/4$, the black-border is extraordinarily enlarged by the halo effect. It has also been learned that the black-border width is quickly saturated when the size of the bright body is increased.

In order to minimize the black-border, the writers have made experimental tubes(4), whose underlying principle consists in the prevention of the electron redistribution on the target glass by inserting into the photocathode side of the target screen another mesh screen with positive potential to collect the excess secondary electrons. It has been found that there exist optimum points of the potential and position of the collector mesh as a result of theoretical considerations supported by numerous experiments. Fig. 14 and the chain line in Fig. 13 represent the remarkable results obtained with one of the experimental tubes. Such improvement in image quality is highly desirable for picking up a scene of a wide contrast range and for the color TV camera.

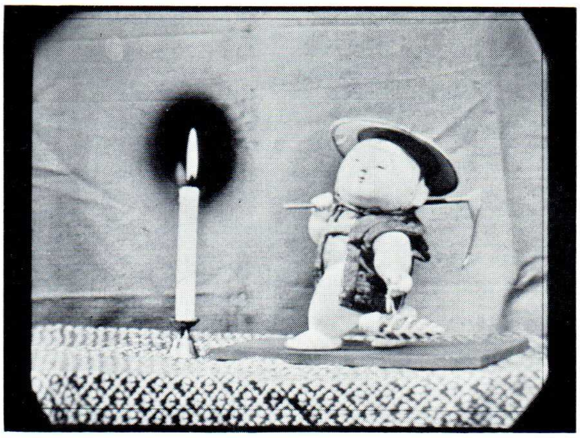

Fig. 12 Example of black-border effect in 5820 image orthicon

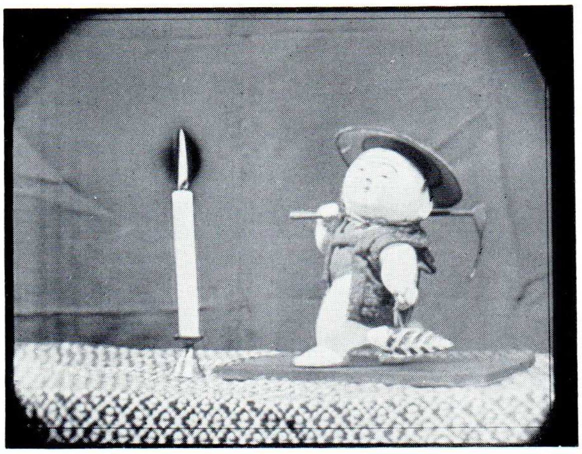

Fig. 14 An example of picture taken by the experimental anti-black-border image orthicon 5820

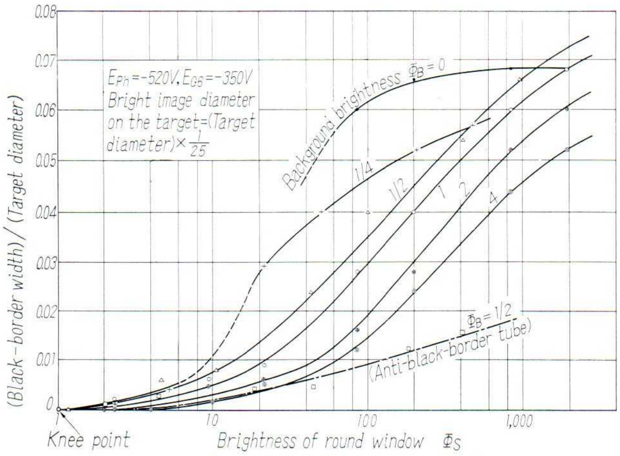

Fig. 13 Magnitude of black border in the image orthicon 5820

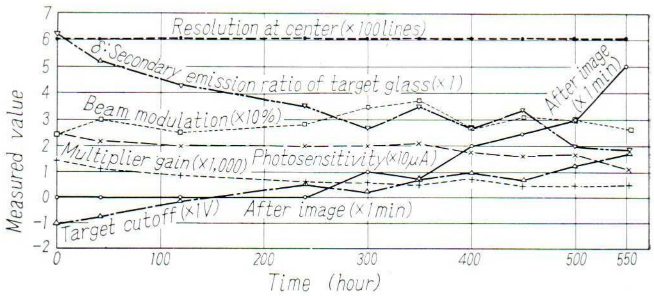

Fig. 15 Results of life tests of TOSHIBA image orthicon 5820

Summary

The characteristics of the tube are very satisfactory, and may be summed up as follows:

(1) The electric resistance of the target glass in use is twice as high as that of a conventional one, and the tube is superior in resolution, sticking and longevity. These are supported by serious theoretical and experimental studies. Fig. 15 shows one of the results of life tests.

(2) The signal-to-noise ratio is high. The beam landing and the velocity distribution of the scanning beam were measured by special methods.

(3) Regarding to the multiplier, various researches were made into the process of forming an MgO film of some hundred Å on the Ag-Mg alloy surface. The electron path was also visually observed to ascertain the potential on the dynode.

(4) Research was done into spurious signals caused by the "secondary" electrons emitted from the target. They were closely observed and carefully studied. Experimental anti-black-border image orthicons have been devised, and the black-border effect considerably reduced, though with some loss of sensitivity.

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