

TUBE DATA SHEET

Tentative Data

**7389**  
**IMAGE**  
**ORTHICON**

For Studio Use

Magnetic Focus  
Magnetic Deflection

4½" Diameter Bulb  
19⅜" Length

The CMC 7389 is a 4½" Image Orthicon interchangeable with the 7295. This type has a higher target capacitance than the 7295 and is particularly suited for studio applications.

The 7389 retains all the outstanding features of the 7295, including complete stability at all light levels. The photocathode has a spectral response approaching that of the eye. The absence of infra-red sensitivity prevents colour masking by the infra-red and permits the portrayal of colours in nearly their true tonal gradations.

**PRINCIPLES OF OPERATION**

For descriptive purposes, the 7389 may be divided into three sections, the image section, the scanning section and the multiplier section.

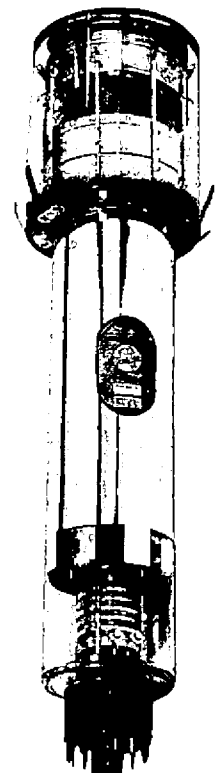
**A. Image Section**

The Image Section contains a semi-transparent photocathode on the inside of the face-plate, and electrodes to accelerate the photo electrons towards the target. This consists of a very thin sheet of glass, with a fine mesh screen mounted very closely to it on the photocathode side.

An image of the scene being televised is focussed on the photocathode by means of an optical lens. Electrons are emitted from the photocathode, proportionately to the brightness of the original scene, at any point. Under the combined influence of the electrostatic field and the magnetic field due to an external coil, the electrons are focussed at the target. The magnetic field is so graded that the image formed at the target covers approximately three times the area of the image at the photocathode.

The impact of the photo electrons upon the target causes the release of secondary electrons which are collected by the mesh screen held at a definite small positive potential.

The loss of the secondary electrons leaves on the target a positive charge pattern which corresponds point by point with the light pattern in the original scene. Owing to the thinness of the target this charge pattern is transferred immediately to the other face of the target.



Please send inquiries to:

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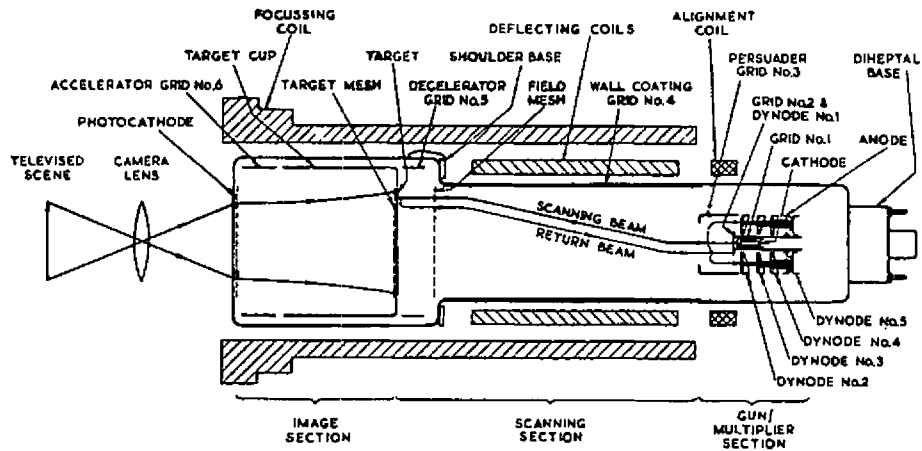


Fig. 1—Schematic Arrangement

### B. Scanning Section

The face of the target remote from the photocathode is scanned by an electron beam emanating from a triode electron gun, the potentials applied to the gun being so adjusted that the beam approaches the target with a substantially zero velocity. In those regions of the target corresponding to the light areas of the original scene, the target is positively charged.

In those regions of the target corresponding to the dark areas of the original scene, the target is not charged and the beam electrons are repelled. The beam electrons not landing on the target constitute the modulated return beam, the signal current being inversely proportioned to the light intensity in the original scene. All beam electrons can be prevented from landing on the target, whatever the photo cathode illumination, if the target mesh is made more negative than a certain potential termed "the target cut-off potential." For normal operation the target mesh potential is set 2-3 volts above this value.

The beam is focussed at the target by varying the voltage of the wall cylinder (G.4). The target end of the wall cylinder is closed by means of a mesh screen of high transparency. This screen which is termed the field mesh is maintained at a potential a few volts positive with respect to that of the wall coating (G.4). In addition to improving the landing characteristics of the beam at the target this screen reduces the intensity of the white edging which was noticeable on pictures produced by earlier versions of the Image Orthicon.

The electric field in the immediate vicinity of the target is varied by adjusting the potential of the ring decelerator (G.5) which is situated between the target and the field mesh. This adjustment also effects correction of bad landing on the beam.

### C. Multiplier Section

The return beam travels along approximately the same path as the outgoing electron beam and is directed into a five stage electron multiplier mounted coaxially with the electron gun. This multiplier amplifies the modulated beam about 1,000 times, with very little increase in the noise level. The gain is sufficiently high so that the random noise of the electron beam is brought above the input noise of the first stage of the video amplifier. The

limiting noise in the use of the tube is thus that due to the electron beam.

When the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resistor changes in the positive direction. Hence for highlights in the scene, the grid of the first video amplifier stage swings in the positive direction.

## CAMERA EQUIPMENT

### 1. Focussing and Scanning Coils

The focussing coil should be so designed as to provide the correct relation between the magnetic field at the photocathode and that at the target. The electron lens so formed magnifies the electron image from a diagonal of 1.6" at the photocathode to a diagonal of 2.4" at the target. The field in the scanning section should be substantially uniform.

The image section of the coil should be well shielded to prevent cross talk from the scanning coils. If this is not done the electron image will oscillate at scanning frequency with a consequent loss in resolution.

If the heat generated by the focussing and scanning coils is sufficient to elevate the temperature of the tube above the maximum permitted 65°C, provision must be made for forced air cooling. For this purpose a small blower is satisfactory, but care must be taken to prevent vibration of the image orthicon and its amplifier.

In the event of there being insufficient heat generated to maintain the temperature within the recommended range, a heater surrounding the image section should be provided. This should preferably be controlled by means of a thermostat.

The image orthicon has two guides for inserting the tube correctly in the focussing coil; they are the location contact No. 3 on the shoulder base and the short radial line in the corresponding position on the faceplate.

The focussing and deflection coil assembly should be so positioned that the key way for the location contact is at the bottom of the image coil. The orientation of the scanning coils should be such that the vertical scan is essentially parallel to the plane passing through the location contact and the centre of the faceplate. Provision

(CONT'D ON PAGE 5)

## APPROXIMATE DATA

### GENERAL

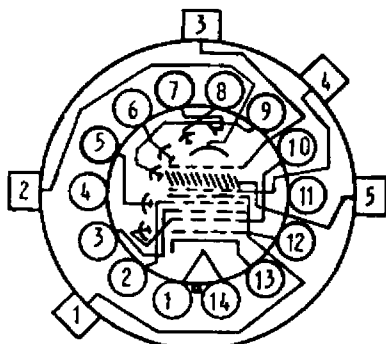
Overall length:	19 $\frac{3}{8}$ " $\pm$ $\frac{1}{16}$ "
Diameter of Image Section:	4 $\frac{1}{2}$ " $\pm$ $\frac{1}{32}$ "
Diameter of Scanning Section:	3 $\frac{1}{8}$ " $\pm$ $\frac{1}{16}$ "
Focussing Coil Length:	15"
Deflecting Coil Length:	7"
Operating Position:	Any except with diheptal base up and tube axis at angle of less than 20° from vertical.

### End Base—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

### Shoulder Base

Contact 1—Field Mesh
Contact 2—Photocathode
Contact 3—Grid No. 6
Contact 4—Grid No. 5
Contact 5—Target



SOCKET CONNECTIONS  
BOTTOM VIEW

### PHOTOCATHODE

Spectral Response:	See curve, Fig. 4.
Useful size of rectangular image for standard operation:	1.6" max. diagonal at photocathode. Electron image magnified electron optically to diagonal of approximately 2.4" at the target.
Orientation of rectangular image:	Proper orientation is obtained when vertical scan is essentially parallel to the plane passing through the centre of the faceplate and contact 3 of the shoulder base.

### OPERATING TEMPERATURES

Maximum operating temperature of any part of bulb	..... 65°C.
Operating temperature of bulb at image section	..... 35° to 60°C.
Maximum temperature excess of any part of the bulb over that of the image section	..... 5°C.

### ELECTRICAL DATA

#### Heater for unipotential cathode

Voltage	..... 6.3V $\pm$ 10% a.c. or d.c.
Current	..... 0.6 amp.

#### Peak heater-cathode voltage

Heater negative with respect to cathode	..... 125 max. volts.
Heater positive with respect to cathode	..... 10 max. volts.

Direct inter - electrode capacitance anode to all other electrode	..... 12 uuf max.
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#### Strength of magnetic fields:—

Image section in plane of photocathode	..... 120 gauss.
Scanning section	..... 70 gauss.
Alignment	..... 0 to 3 gauss.

**APPROXIMATE DATA FOR 7389 (CONTINUED)**

	<b>Max. Rating</b>	<b>Typical Operating Condition</b>	<b>Notes</b>
Photocathode voltage (Image Focus)	—700 V	—200 to —600 V	
Grid No. 6 Voltage (Accelerator) ....	—700 V	40% to 80% of photocathode voltage	Adjust for minimum 'S' distortion
Target voltage	±10 V	2 volts above cut-off.	Adjustable from —3 to +5 volts with blanking voltage off.
Target blanking voltage (minimum)		5 volts peak to peak	
Field Mesh	15 V positive with respect to G4	10 to 15 V positive with respect to G4	
Grid No. 5 voltage (Decelerator) ....	300 V	—100 to 250 V	Adjust for minimum corner shading and best corner geometry.
Grid No. 4, voltage (Beam Focus) ....	350 V	100 to 160 V	
Grid No. 3 voltage (Multiplier Focus)	400 V	215 to 350 V	Adjust to give the most uniformly shaded picture near maximum signal.
Grid No. 2, Dynode No. 1 voltage ...	350 V	300 V	
Grid No. 1 voltage (Beam)			
Positive value	0 V	—4 to —115 V	
Negative value	125 V		For picture cut-off.
Anode supply voltage	1650 V	1300 V	§ See below.
Voltage per Multiplier Stage	350 V	See below	
Dynode No. 2 Voltage		600 V	
Dynode No. 3 Voltage		800 V	
Dynode No. 4 Voltage		1050 V	
Dynode No. 5 Voltage		1250 V	
Signal Current		4 to 20 $\mu$ A	

§ The anode voltage must not drop more than 10 V (with reference to Dynode No. 5) when anode currents up to 100 micro-amps are drawn.

**Performance**

Scene illumination at F.5.6	Operational sensitivity is in the region of f/5.6 at 25 foot Lamberts.	Limiting resolution	Better than 600 lines per picture height.
		Contrast range	Large areas 10 : 1. Small areas 40/50 : 1.
Ratio peak to peak signal to RMS noise.	Minimum 37 db. (Average 39 db.)		N.B. Much larger ranges may be accommodated if the presence of small spurious effects is accepted.
[Amplifier flat to 5.1 Mc]			
Amplitude response at 400 TV lines per picture height, with respect to black/white signal.	Min. —8 db. Average —5 db.		

should be made to allow a slight rotation of the shoulder socket and deflection coils to permit correction of any image rotation introduced between the photocathode and target.

The image orthicon is installed by inserting the diheptal base end of the tube through the coil, the orientation of the tube being such as to ensure registration of the shoulder contacts with their correct slots in the yolk. The radial line should thus be at the bottom of the faceplate.

## 2. Power Supplies

The d.c. voltages required are stated in the electrical data on page 4.

The field mesh should be maintained at a potential 10-15 volts above that of the wall coating. It is convenient to derive both supplies from a common source. Independent adjustment of the field mesh potential is not necessary.

In designing a voltage divider for the multiplier section of the tube, it should be recognized that the d.c. output of individual tubes may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a tube with a d.c. output at the upper end of the range. As a result there will be an abrupt drop in the a.c. output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened.

Even with satisfactory bleeder resistor values, it is possible to overload the tube itself. For tubes having high d.c. outputs, a current reversal can occur at the 5th dynode stage of the multiplier as the beam current is increased. This current reversal will also produce a sharp drop in the a.c. output of the tube. To prevent such a current reversal, it is recommended that provision be made to reduce the overall multiplier voltage for tubes with d.c. outputs at the upper end of the range. A reduction to 1,000 volts should be adequate for most tubes.

## 3. Video Amplifier

The video amplifier should be designed to cover a range of a.c. signal voltages corresponding to signal output currents of 4 to 20 microamperes in the load resistor.

To utilize the resolution capability of the tube in the horizontal direction, it is necessary to use a video amplifier with an adequate bandwidth. For 405 lines a bandwidth of at least 4 megacycles is necessary; 525 and 625 lines require 6 megacycles.

## 4. Shading Correction

The provision of shading correction signals is recommended. A sawtooth signal with a frequency equal to the line frequency and an amplitude approximately twice that of the video signal should be provided. Provision should be made for varying the amplitude and polarity of the signal. Field shading correction should also be provided.

## 5. Target Blanking

A blanking signal should be applied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done the camera tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video signal modulation is returned to the multiplier and its multiplied output flows through the load resistance.

## 6. Scan Failure Protection Circuits

To avoid damage to the target, provision should be made to bias off the electron beam in the event of failure of the deflection circuits.

## 7. Optical Lens

The lens system used should be designed in accordance with standard optical practice. An iris or other mechanism must be incorporated to control the amount of light falling on the photocathode. To prevent the entrance of any stray light, all the internal surfaces of the lens holder should be finished in matte black, and a lens hood employed whenever possible.

## OPERATION

### Sequence of Adjustments

1. Insert tube in camera, verify that the tube and camera are functional. Bias off target, cap lens, and adjust Gric' No. 1 voltage to give small amount of beam current.
2. Set scan amplitude controls at maximum.
3. Leave to warm up for 30 minutes.
4. Uncap camera lens.
5. Increase target voltage until information appears.
6. Adjust beam focus, image focus and optical focus until detail can be discerned.
7. Adjust alignment current controls until picture response is a maximum. If the picture appears in negative contrast increase the beam current. The tube is correctly aligned when the centre of the picture does not rotate but goes in and out of focus, when "beam focus" (G4) is varied.
8. Set voltage of target approx. 2 volts above cut off and adjust beam current to lowest value consistent with a satisfactory picture.
9. Decrease the scanning amplitude until the edge of the target ring just disappears at the corners of the picture. The adjustment of the scanning raster to the correct size and aspect is facilitated by use of a ring mask consisting of a perspex disc on which is inscribed two concentric circles of diameter .96", and 1.28", placed in contact and concentric with the photocathode of the tube.† Light is allowed to fall on the photocathode and an image of the rings is obtained on the monitor. No lens is necessary. The scan amplitude and centering controls on the camera are adjusted until the diameter of the large circle is equal to the width of the raster and the diameter of the smaller circle is equal to the height. Verify that scanned circle area is centrally located with respect to the target ring.
10. Adjust lens stop for correct exposure.
11. Adjust Decelerator G5 for minimum shading consistent with best geometry.
12. Adjust image accelerator G6 for minimum S distortion when camera is panned horizontally.

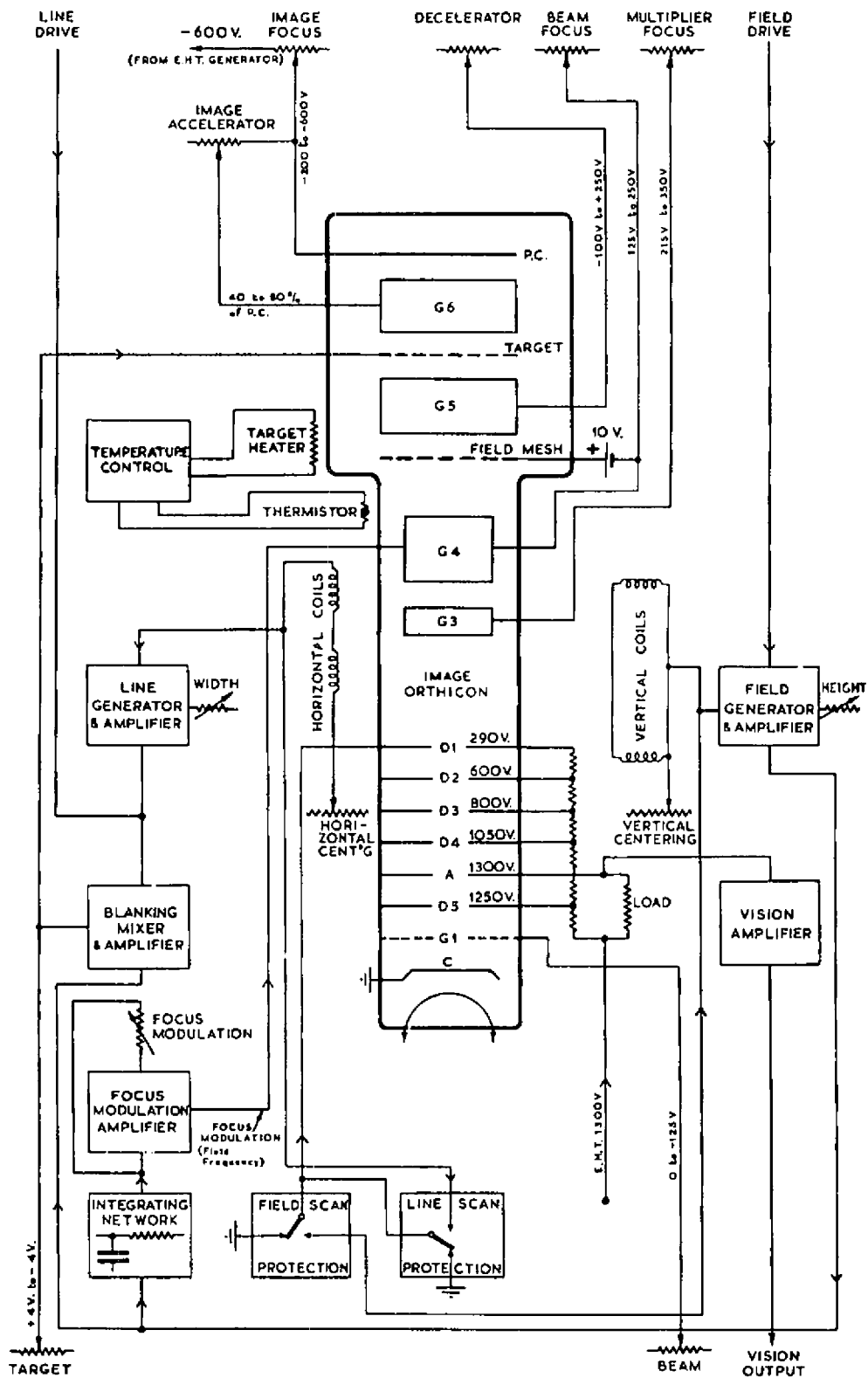


FIG. 2. BLOCK DIAGRAM AND ASSOCIATED CONTROL UNITS

Fig. 2

13. Cap lens and adjust multiplier focus G3 for most uniform black signal near maximum output. Residual frame and line tilt should be corrected by insertion of shading correction.
14. Adjust gain for signal of correct amplitude.
15. Readjust beam focus and image focus for sharpest picture.

†Alternatively the Marconi diascope and mask as designed for the Marconi Mark III camera may be used.

### Standby Procedure

During programme and rehearsal breaks of short duration, the camera should be capped up. It is unnecessary and undesirable to bias off the beam, which should be left at the picture setting. This ensures that the potential of the target glass remains stable and that high potential differences between the target glass and mesh, which may cause contact of the two elements, do not develop.

In addition it improves the stability of the beam and multiplier, with an accompanying improvement in the signal to noise ratio.

If an "electronic cap" is required, this should be done by switching the photocathode potential to about +20v. during standby. Although no signal is transmitted by the tube under these conditions, damage to the photocathode can occur if the camera is left pointing at bright lights.

Under no conditions should the filament voltage be switched off without removing the high tension supplies to the tube.

### Target Voltage

The target voltage should be set at 2 volts.

Operation at a higher target voltage is undesirable for the following reasons:—

- (i) Tube life is reduced.
- (ii) Inter field flicker effects are more pronounced.
- (iii) Onset of microphony is encouraged.

Conversely operation at target voltages lower than 2 volts should be avoided, as under these conditions the signal to noise ratio is poor due to the deterioration in beam modulation, and the contrast range of the tube is limited.

### Adjustment of Exposure

As a general instruction the lens aperture should be opened until the highlights are between ½ and 1 stop above the knee. However, the quality of the pictures obtained under this condition is very dependent upon the contrast range of the scene being reproduced.

The position of the "knee" can be determined by observing the wave form monitor whilst the lens aperture is opened. The highlight signal will increase steadily to a certain value and then saturate. At this point the highlights are at the knee of the transfer characteristic. The preferred operating point can then be determined by opening the lens aperture one stop number, or adjusting the filter wheel by the equivalent amount.

Ideally the lens aperture required for each shot should be determined and noted during the lighting rehearsal. However, this is often not possible, the adjustment being made immediately before the camera is taken on a new shot. In this case the lens or filter wheel should be adjusted until highlight saturation occurs and expansion of

the grey tones takes place. Correct operation is facilitated if the highlight levels in the various sets are adjusted so that, with a given acceptable aperture setting, differences from set to set may be accommodated on the filter wheel.

The scene brightness and photocathode illumination are related by the following formula.

$$B = \frac{4 \text{ lpc } f^2 (m + 1)^2}{T}$$

B = Highlight brightness of subject in foot lamberts.

lpc = Photocathode illumination in foot candles.

T = Total transmission of lens.

f = f number of lens.

m = Linear magnification from scene to target.  
(This can be ignored except for close shots.)

The photocathode illumination required at the knee will vary from tube to tube depending on the sensitivity of the photocathode. For an average tube the knee will occur at a value of the photocathode illumination of approx. 0.1 ft. candles. This corresponds to a scene highlight brightness of 50 ft. Lamberts at F.11.

In practice the operating point is one stop above the knee and if allowance is made for the absorption of the filter wheel, the operational sensitivity of the average tube will be:—

25 ft. Lamberts at F.5.6.

On very bright days, it may not be possible to stop the lens down far enough to reduce the highlight illumination on the photocathode to a value near the knee of the signal output curve. When such a condition is encountered the use of a neutral density filter, selected to give the required reduction in illumination is recommended. Usually two filters—one having 1 per cent. transmission and the other 10 per cent., will give sufficient choice.

### Gamma Correction

The reproduction of scenes containing information in the darker greys can be improved by the use of a non-linear amplifier providing increased gain at signal levels below 30% peak white. A suitable circuit modification for the Marconi Mark III camera is described in the Marconi Unit Modification Notice No. 71/BA.

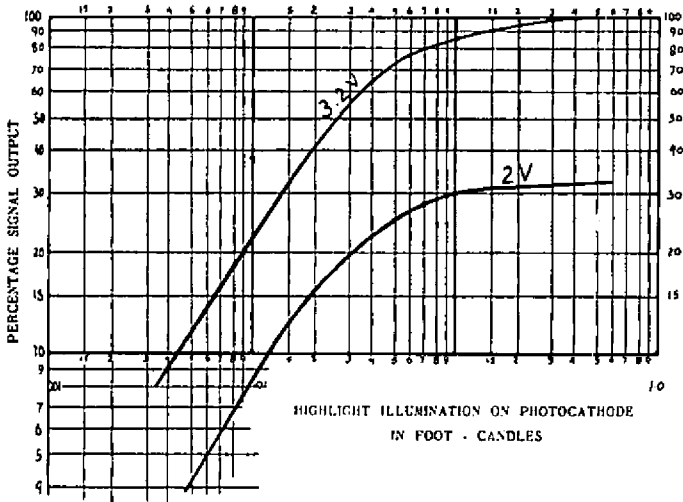
The overall effect of the "black stretch" circuit is to increase the contrast range of the tube by a small factor.

Black stretch should only be used if its introduction leads to an improvement in the reproduced picture.

### Scanning of Target

It is essential that the correct area of the target should be scanned. The continual transference of charge through the target causes a gradual change in the contact potential of the target with respect to the thermionic cathode of the gun. As a result the scanned area slowly darkens giving rise to what is termed "raster burn". This is not apparent if the same area of the target is always employed, but if at some time the target has been under-scanned, this effect will be apparent when correct scanning is re-introduced. Underscanning the target produces a picture of larger magnification on the monitor.

In a similar manner failure of either of the scanning circuits during operation will cause permanent damage to the target. This will appear as a dark line or spot when normal scanning is resumed.



#### METHOD OF OBTAINING 7389 TRANSFER CHARACTERISTIC

The camera was accurately set up on a normal picture and then moved to view a scene comprising a step tone wedge of a similar range of brightness, surrounded by black.

The characteristic was obtained by measuring the brightness of the wedge and the resulting signal, the latter being displayed on an oscilloscope. The range of the wedge was increased by varying the overall illumination, i.e. by adjusting the lens aperture.

The voltage indicated on the curves is the potential of the target above cut-off.

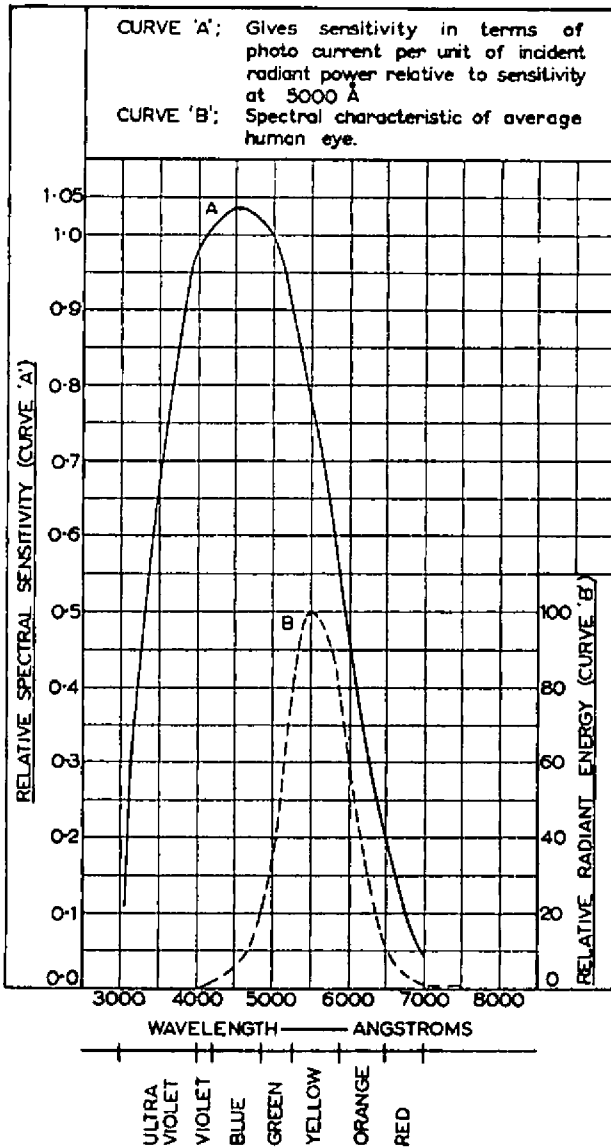


Fig. 4—Spectral Sensitivity Characteristic of Typical Type 7389

To avoid damage to the target, provision should be made for automatically biasing the beam off in the event of failure of either of the deflection circuits.

Overscanning the target is permissible during rehearsals, but the scanning amplitudes should be reduced to their correct values before transmission.

Overscanning the target produces a picture of lower magnification at the monitor, and limits the resolution of the system.

#### Sticking Picture

If the tube is operated before the tube has reached the correct temperature, i.e. between 35°C. and 60°C., a "sticking picture" will be observed. Images are retained for several seconds, gradually fading away. The magnitude of the effect depends upon the age of the tube, and in the case of an old tube, the image will be retained for a considerable period. The erasing of the sticking picture can be accelerated by directing the 7389 towards a clear white screen and allowing the tube to operate with an illumination of about 1 foot candle on the photocathode.

A "sticking picture" will also be observed if the 7389 is left stationary on a bright scene for more than a few minutes. The risk may be reduced by using the lowest illumination consistent with a satisfactory picture and limiting the time of exposure.

#### OPERATIONAL NOTES

##### 1. Lighting and Staging

It is impractical to lay down a set of rules which will be acceptable to all users under all conditions of staging and lighting. However, the following notes on the application of the 7389 may be of assistance in ensuring that best possible performance is obtained.

In deriving the rules, it is assumed that full co-operation between the technical and production departments exists, and the technical limitations of the tube and system are appreciated.

It is important to realize that unsatisfactory pictures are more often the result of bad staging, which the CCU operator is powerless to correct.

##### Set Design

- (i) The highlight brightness in each set should be adjusted to permit the least sensitive tube of the studio complement to operate at the preferred point with the filter wheel in the midpoint, and an acceptable aperture setting.
- (ii) The contrast range of the set is best restricted to the following values:—  
 Small areas (<10% picture area) 40 : 1  
 Large areas (>10% picture area) 10 : 1  
 Scenes of excessive contrast can only be accommodated at the expense of crushed lower greys or over exposure of the highlight areas, both conditions being aesthetically unacceptable.  
 The restriction of scene brightness to a range of 10 : 1 requires that the incident light levels be limited to a range of 5 : 1, to allow for the variation in scene reflectance values.
- (iii) Large matt areas, particularly in the darker greys should be avoided due to the sensitivity of the eye to noise within these areas. If possible, large areas



should be broken up with patterning, etc., of lower modulation. If such "a.c." backgrounds are provided, the aperture settings and camera shots should be adjusted to provide sufficient depth of focus.

- (iv) Scenes of very low overall contrast should be avoided.

The application of the above rules is exceedingly difficult unless a satisfactory method of determining the light content of scenes is adopted. It is recommended that lighting engineers work in brightness values rather than incident light levels. The light input to the camera is a function both of the incident light level and the reflectivity of the illuminated surface, and unless both quantities are measured no useful control can be maintained.

## 2. CCU Operation

- (i) The adjustment of the camera should be checked, using an illuminated test chart or diascope, immediately before transmission.
- (ii) During transmission only the minimum of adjustments should be made. Under favourable conditions, when the sets have been carefully lighted, it is unnecessary to make any adjustment other than that to the filter wheel. The transfer characteristic of the tube is relatively stable and continual adjustment of the black level is unnecessary and undesirable.
- (iii) Since the adjustment of the exposure of the tube is the prime consideration of the CCU operator it is essential that the operator is familiar with the appearance of the picture under various conditions of exposure:
  - (a) Characteristics of over-exposed picture.
    - (i) Black halo around highlight areas.
    - (ii) White edges at high contrast, horizontal transitions.
  - (b) Characteristics of under-exposed pictures:
    - (i) Compression of lower greys.
    - (ii) Excessive contrast in higher greys.
    - (iii) Poor resolution.
- (iv) When adjusting the filter wheel small area highlights such as specular reflections should be ignored.
- (v) If the camera is viewing a set of low contrast the trace will not necessarily fill the waveform monitor when the exposure is correct. It is malpractice to artificially stretch the waveform trace by the manipulation of gain and black level controls. Such a procedure leads to excessive contrast and noise in the reproduced picture, and necessitates further adjustments when the camera reverts to a high contrast scene.

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## DO'S AND DON'TS

Here are the "do's"—

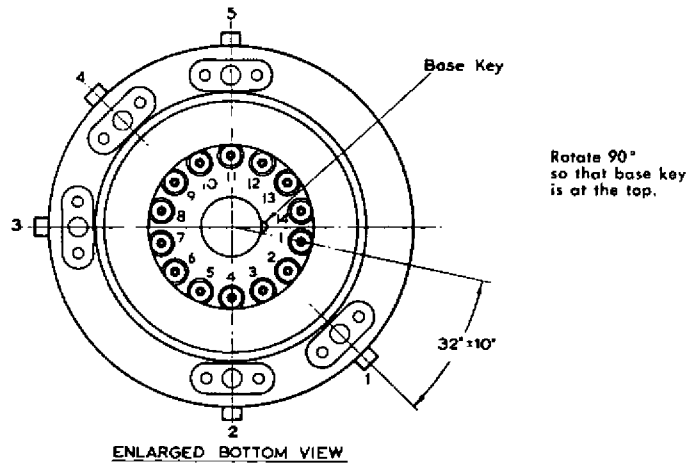
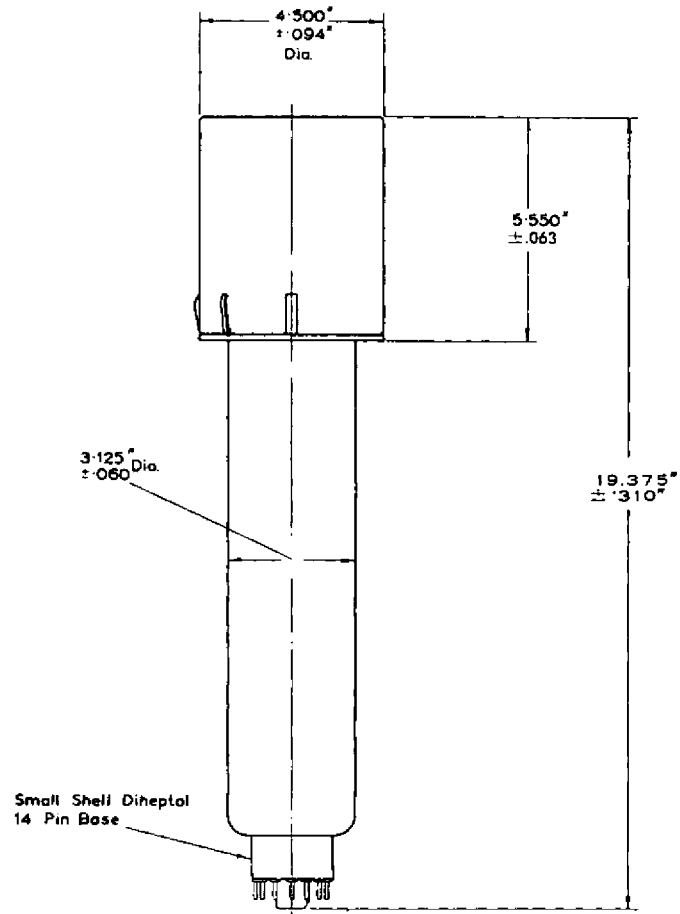
1. Allow to warm up prior to operation.
2. Hold temperature within operating range.
3. Condition spare tubes by operating them for several hours each month.

Here are the "don'ts"—

1. Don't force into its shoulder socket.
2. Don't operate without scanning.
3. Don't underscan the target.
4. Don't focus on a stationary bright scene.
5. Don't carry with the image section downwards.
6. Don't leave camera unattended without capping lens.

**The significance of each of the above "do's" and "don'ts" in obtaining optimum performance is explained in the preceding pages of this bulletin.**

# DIMENSIONAL OUTLINE



Devices and arrangements shown or described herein may use patents. Information contained herein is furnished without responsibility for its use and without prejudice to patent rights.