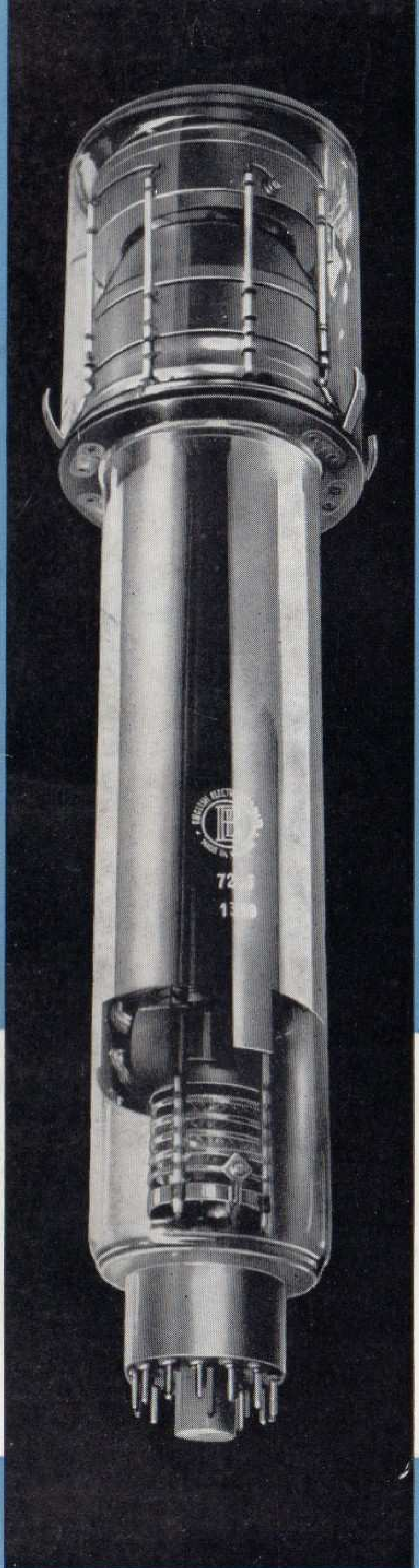


ENGLISH ELECTRIC

IMAGE ORTHICONS

4½ inch

4½-INCH IMAGE ORTHICONS

ENGLISH ELECTRIC VALVE COMPANY LIMITED, CHELMSFORD, ENGLAND
TELEPHONE: CHELMSFORD 3491 TELEGRAMS: ENELECTICO, CHELMSFORD

CONTENTS

INTRODUCTION

The 7295, 7389 and P812 are $4\frac{1}{2}$-inch image orthicons forming part of the range of image orthicon and vidicon television camera tubes produced by the English Electric Valve Company Limited. Although electrically and mechanically interchangeable, the three types differ slightly in the capacitance of the storage target, these differences producing slight changes in their performances and intended applications.

In the $4\frac{1}{2}$-inch image orthicon the target area is three times that of the standard 3-inch tube. The increase in target capacitance which results from this increase in area gives substantial improvements in signal to noise ratio, resolution and contrast handling ability relative to the 3-inch tube while retaining all the virtues of the smaller tube, such as high sensitivity, complete stability and good colour response. Arranged in order of ascending target capacitance, the types of image orthicon available, and their intended applications, are:—

7295 (*alternatively known as P*811). Completely satisfactory for studio use and its sensitivity is adequate for outside broadcasts under normal conditions.

7389 (*alternatively known as P*822). More suited to studio productions where some measure of control over scene illumination is possible, so enabling its full performance to be realised. Its sensitivity is somewhat less than that of the 7295 but is adequate for outside broadcasts under normal conditions.

P812 Recommended for use in systems conversion equipment only. This tube tends to exhibit lag when used for live pick-up.

PRINCIPLES OF OPERATION OF THE IMAGE ORTHICON

For descriptive purposes, the tube may be divided into three sections, the image section, the scanning section and the multiplier section, as shown in Fig. 1.

IMAGE SECTION

The image section contains a semi-transparent photocathode on the inside of the faceplate, and electrodes to provide an accelerating electrostatic field to the target. The latter consists of a thin glass disc with a fine mesh screen mounted very closely to it on the photocathode side.

An image of the scene to be televised is focused by an optical lens system on to the photocathode and causes photo-electrons to be emitted. This photo-electron emission is proportional to the intensity of the optical image at any particular point. The photo-electrons are focused on to the target by the combined action of the electrostatic field and a longitudinal magnetic field, the latter being produced by an external coil. 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.

Secondary electrons are produced by the impact of the photo-electrons on the target and these are collected by the fine mesh screen which is held at a definite small positive potential with respect to the target. The screen potential limits the excursion of the target and ensures complete stability at all light levels. The secondary emission at the target produces a pattern of positive charges corresponding point by point with the light distribution of the original scene and the thinness of the target allows this charge pattern to be reproduced immediately on its reverse side, i.e. the scanned side.

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 being so adjusted that the beam approaches the target with a substantially zero velocity and is, therefore, unable to produce unwanted secondary electrons.

In areas of the target corresponding to the dark areas of the image, the beam electrons are unable to land and are 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 target 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 will thus be amplitude modulated, its intensity being inversely proportional to the brightness of the original image.

All beam electrons can be prevented from landing on the target, whatever the photocathode 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 a few volts above this value.

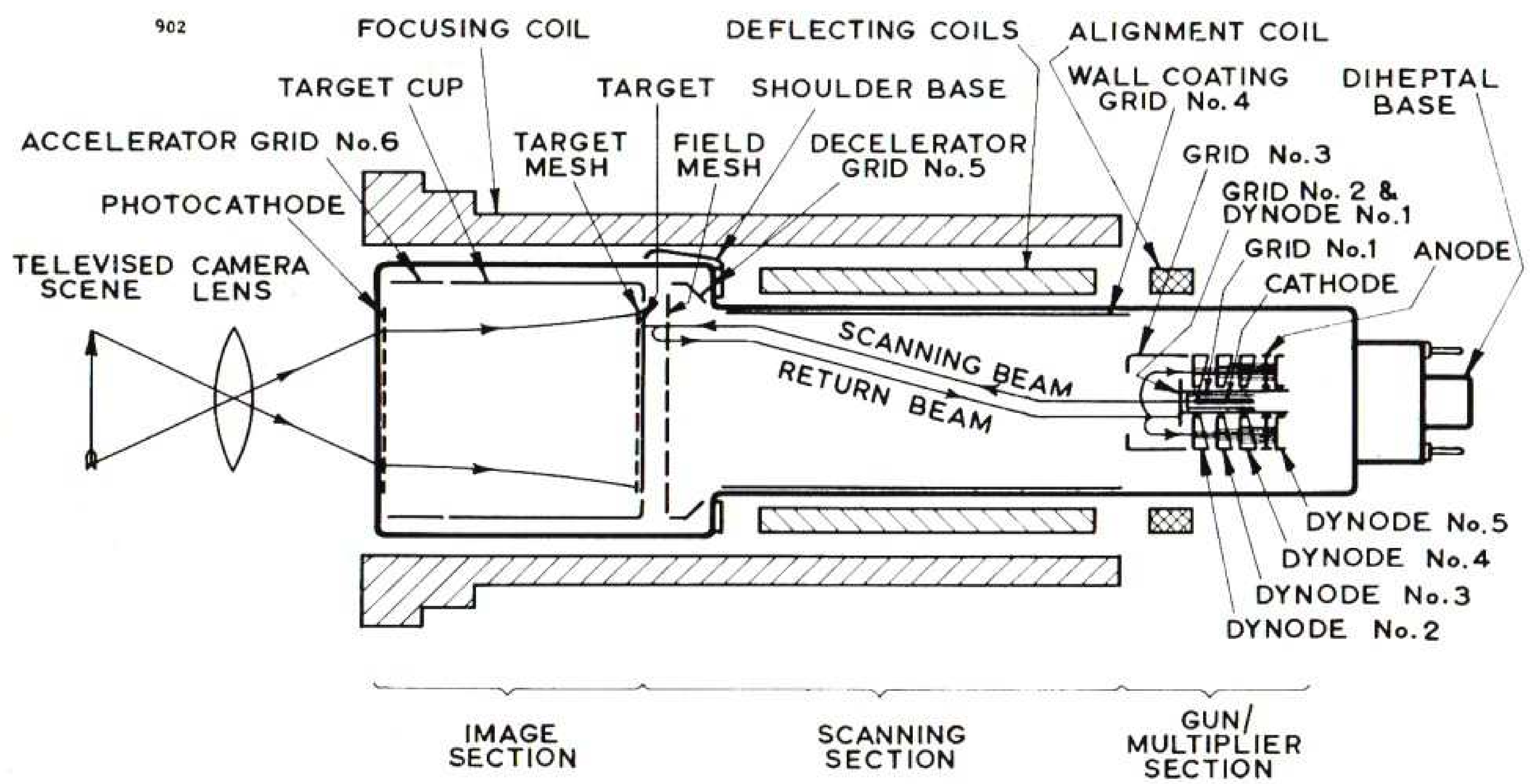


Fig. 1.—Schematic arrangement of the $4\frac{1}{2}$-inch image orthicon.

The beam is focused at the target by the magnetic field of the external focusing coil and the electrostatic field of the wall coating (grid No. 4), and deflection is accomplished by transverse magnetic fields produced by external deflection coils. The beam is aligned with the focusing magnetic field by means of a small transverse magnetic field produced by external coils located at the gun end of the focusing coil.

The target end of the wall coating (grid No. 4) is closed by a fine mesh screen called the field correcting mesh. This is maintained at a potential a few volts positive with respect to the wall coating. In addition to improving the landing characteristics of the beam at the target, the presence of the field correcting mesh reduces the intensity of the white edging typical of pictures produced by earlier versions of the image orthicon.

The edge field at the end of the beam focusing electrode is controlled by adjusting the potential of the decelerator (grid No. 5) which is situated between grid No. 4 and the field mesh. This adjustment helps to improve the landing characteristics of the beam.

As a precaution against light leakage, which has been shown to cause spurious results, the gun end of the tube is coated with an opaque enamel.

MULTIPLIER SECTION

The return beam, comprising electrons which are not required for neutralising the charge on the target, travels back along approximately the same path as the outgoing electron beam and is directed into a five-stage electron multiplier where it is amplified to become the output video signal. In order to reduce the intensity of the image of the first dynode which will be superimposed on the transmitted picture, the whole of the multiplier section assembly is mounted off centre.

The multiplier gives an overall multiplication from the five stages of between 500 and 2000. This is sufficiently high to bring the random noise of the electron beam well above that of the input stage of the camera head amplifier and is, therefore, the limiting noise factor in the use of the tube. The multiplier also permits the use of an external amplifier of lower gain.

It will be appreciated that when the beam moves from a less positive portion of 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 valve swings in the positive direction.

DATA FOR THE 4½-INCH IMAGE ORTHICON

GENERAL

OVERALL LENGTH	$19\frac{3}{8} \pm \frac{5}{16}$ INCHES
DIAMETER OF IMAGE SECTION	$4\frac{1}{2} \pm \frac{3}{32}$ INCHES
DIAMETER OF SCANNING SECTION	$3\frac{1}{8} \pm \frac{1}{16}$ INCHES
DEFLECTING COIL LENGTH	7 INCHES
FOCUSING COIL LENGTH	15 INCHES
ALIGNMENT COIL POSITION	Centre line of magnetic field should be 15 inches from the faceplate of the tube and coils should be arranged to produce horizontal or vertical movement of the picture
OPERATING POSITION	Any except with diheptal base up and tube axis at an angle of less than 20° from vertical
NET WEIGHT	$2\frac{1}{4}$ POUNDS (1·1 kg)

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 AND 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

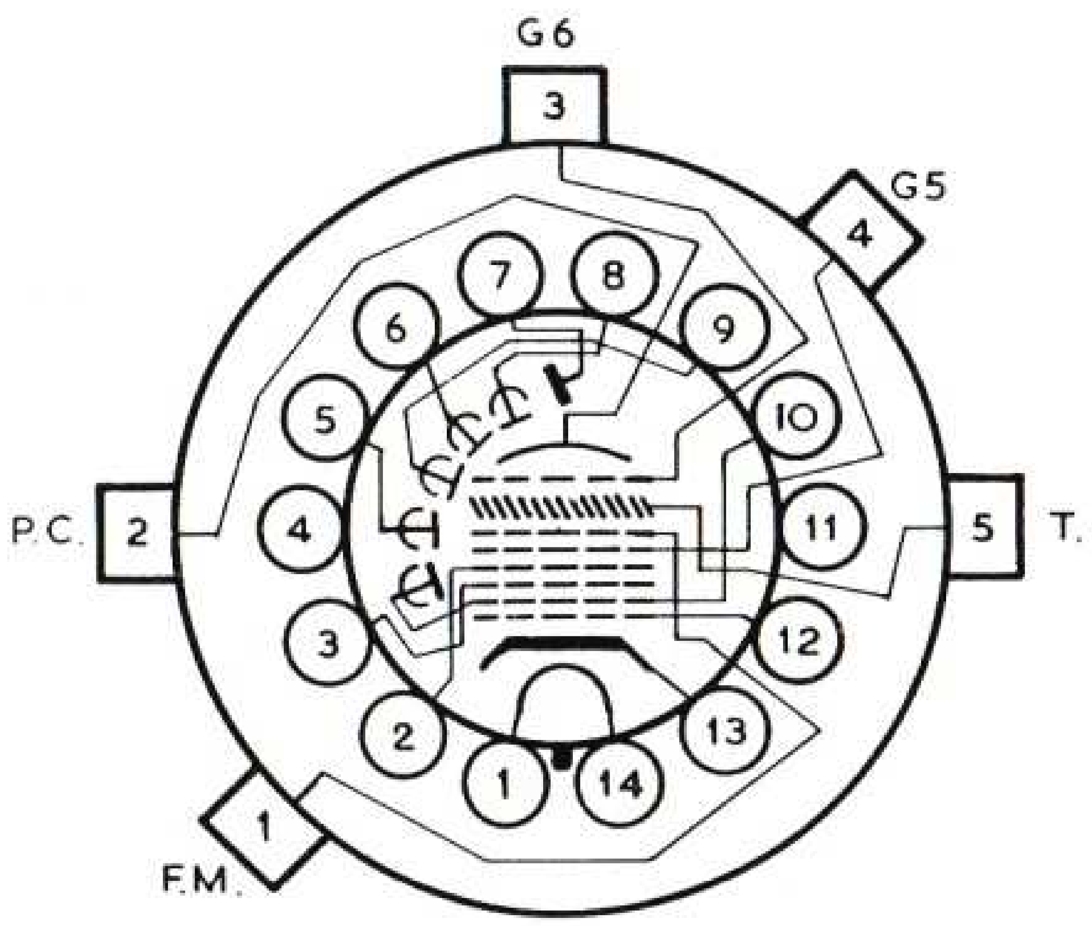
CONTACT 2 — PHOTOCATHODE

CONTACT 3 — GRID No. 6

CONTACT 4 — GRID No. 5

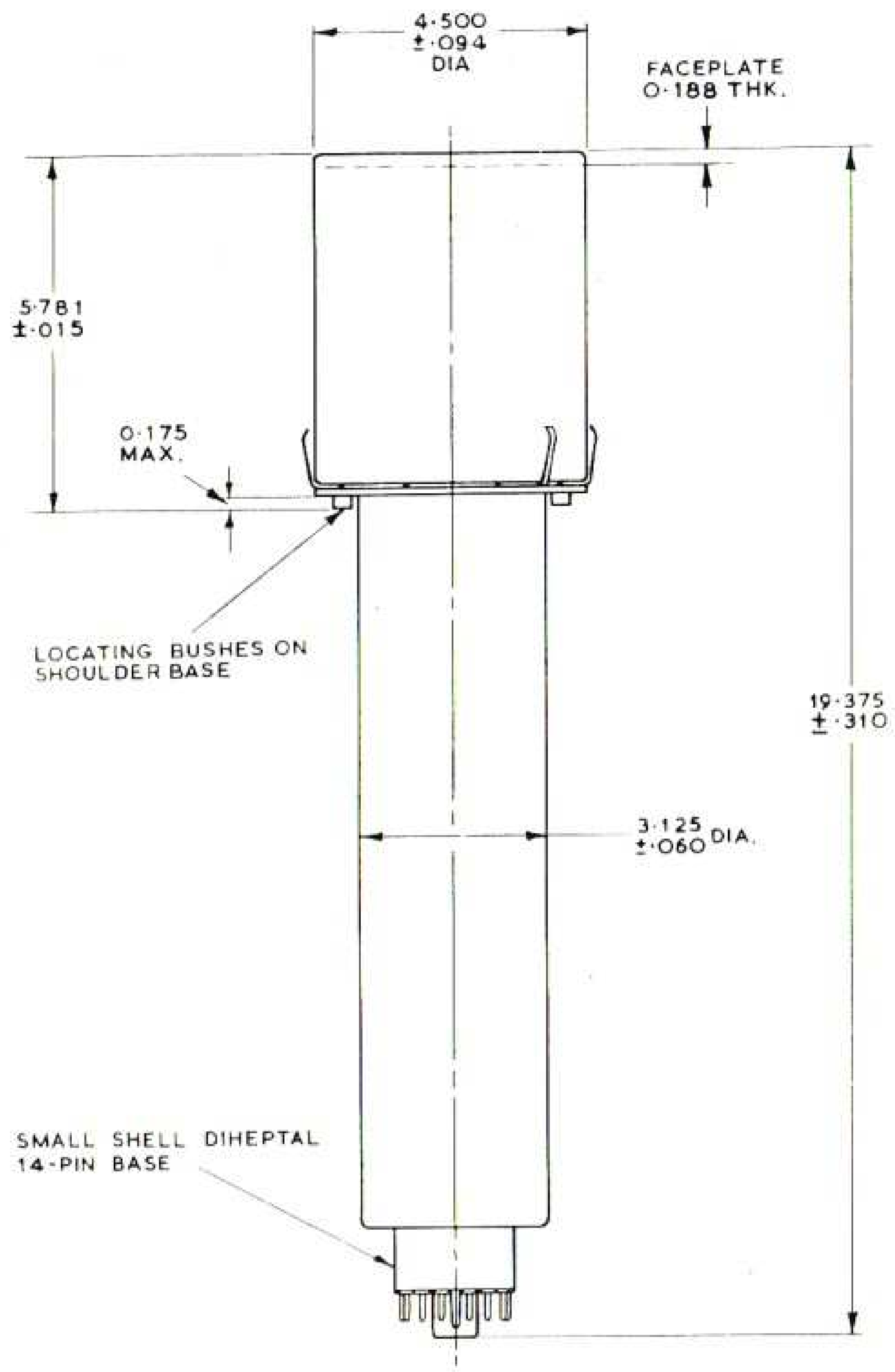
CONTACT 5 — TARGET

SOCKET CONNECTIONS



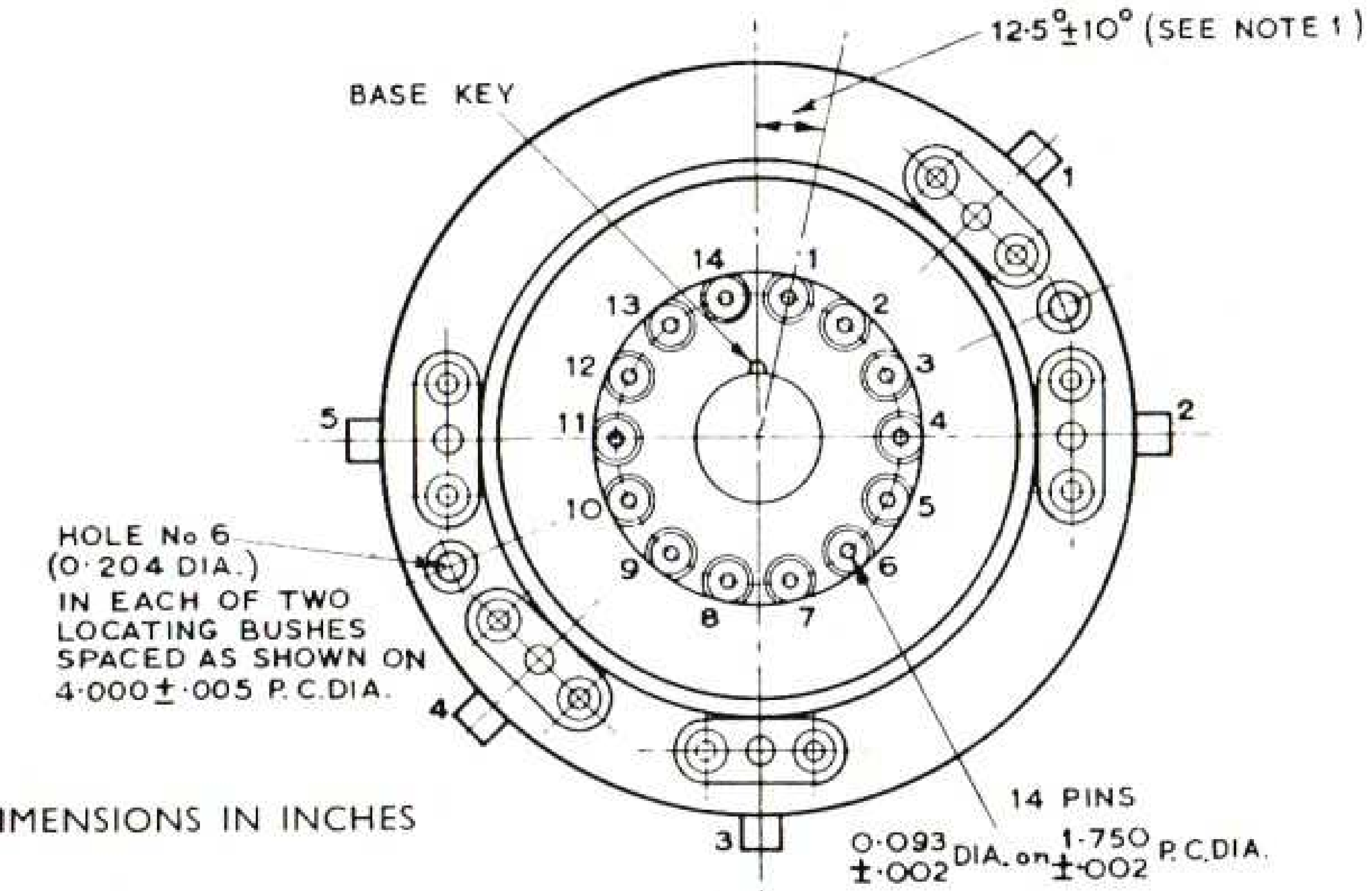
(VIEW FROM BASE END)

OUTLINE



ALL DIMENSIONS IN INCHES

VIEW OF BASE END OF TUBE



ALL DIMENSIONS IN INCHES

Note 1.—*The plane through the axis of the tube and the base key is coincident with the plane through shoulder base contact No. 3 and the axis of the tube to within 10°.*

PHOTOCATHODE

SPECTRAL RESPONSE	See Curve, Fig. 2. Maximum response at 4500 ± 300Å. Approx. JEDEC S.10 response
MAX. USEFUL SIZE OF RECTANGULAR IMAGE	1·8 inches max. diagonal at photocathode. Electron image magnified electron optically to diagonal of approximately 2·4 inches at the target, where it should be of such size that the corners of the rectangle just touch the target ring.
ORIENTATION OF RECTANGULAR IMAGE	Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through the centre of the faceplate and contact No. 3 of the shoulder base.

OPERATING TEMPERATURE

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

CATHODE	Indirectly heated, oxide coated
HEATER VOLTAGE (AC OR DC)	6·3 ± 10% V
HEATER CURRENT	0·6A
PEAK HEATER-CATHODE VOLTAGE:	
HEATER NEGATIVE WITH RESPECT TO CATHODE	125V MAX.
HEATER POSITIVE WITH RESPECT TO CATHODE	10V MAX.
INTER-ELECTRODE CAPACITANCE:	
ANODE TO ALL OTHER ELECTRODES	12 pF MAX.

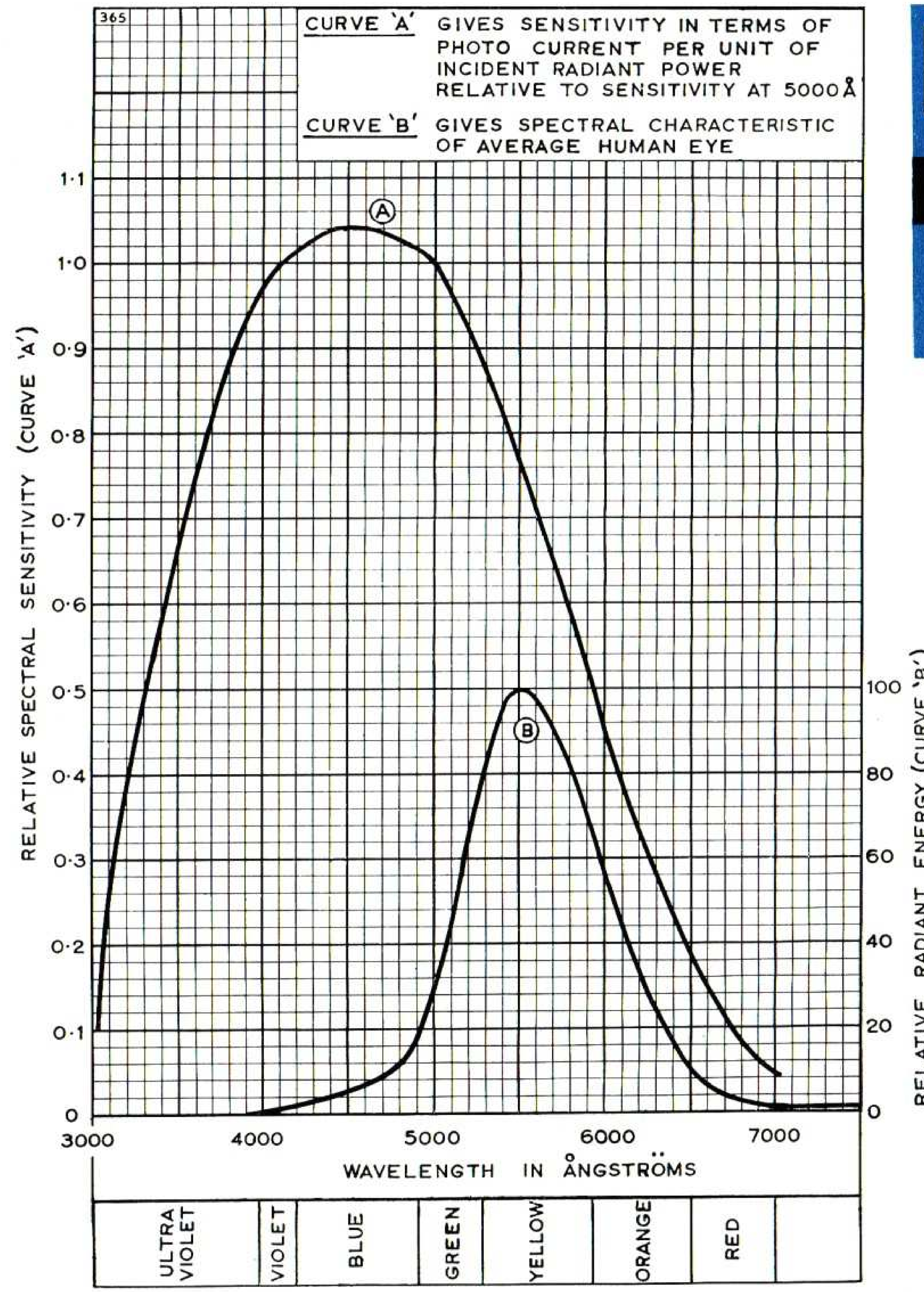


Fig. 2.—Spectral sensitivity characteristic of typical 7295 and 7389 tubes (approximates closely to JEDEC S.10)

MAGNETIC FIELDS:

IMAGE SECTION FIELD, IN PLANE OF PHOTOCATHODE	120 GAUSS APPROX *
SCANNING SECTION FIELD, IN PLANE OF TARGET	65 GAUSS APPROX *
ALIGNMENT FIELD, ADJUSTABLE	0–3 GAUSS †

The direction of the focusing current should be such that a north-seeking pole is attracted to the image end of the focusing coil which is, therefore, a north pole.

* *The relation between these two fields must be such that correct image magnification is ensured.*

† *The alignment coil should be located on the tube so that its centre is at a distance of 15 inches (381mm) from the faceplate of the tube and so positioned that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil. The orientation of the coils should be such that variation of the alignment current in one coil produces approximately horizontal movement of the picture. Variation of current in the other coil should produce movement at right-angles to that produced by the first.*

RATINGS AND OPERATING CONDITIONS FOR 4½-INCH IMAGE ORTHICONS

	MIN	MAX	TYPICAL	
HEATER VOLTAGE	5·7	6·9	6·3	V
PHOTOCATHODE VOLTAGE (IMAGE FOCUS): NEGATIVE VALUE (see Note 1)	—	700	200 to 600	V
GRID No. 6 VOLTAGE (IMAGE ACCELERATOR): NEGATIVE VALUE (see Note 2)	—	700	40 to 80% of photo-cathode voltage	V
TARGET VOLTAGE (see Note 3)	—	±10	2 to 4 above cut-off	V
TARGET BLANKING VOLTAGE (PEAK TO PEAK)	—	—	5	V
GRID No. 5 VOLTAGE (DECELERATOR) (see Note 4)	—	300	−100 to +250	V
FIELD MESH WITH RESPECT TO GRID No. 4 VOLTAGE (see Note 5)	+5	+25	10 to 15	V

	MIN	MAX	TYPICAL	
GRID No. 4 VOLTAGE (BEAM FOCUS) (see Note 6)	—	350	80 to 200	V
GRID No. 3 VOLTAGE (MULTIPLIER FOCUS) (see Note 7)	—	350	215 to 300	V
GRID No. 2 AND DYNODE No. 1 VOLTAGE	—	350	300	V
GRID No. 1 VOLTAGE (NEGATIVE VALUE, NEVER POSITIVE) (see Note 8)	0	125	4 to 115	V
ANODE SUPPLY VOLTAGE (see Note 9)	—	1650	1300	V
VOLTAGE PER MULTIPLIER STAGE	—	350	—	V
VOLTAGE BETWEEN ANODE AND DYNODE No. 5 WHEN ANODE CURRENTS UP TO 100μA ARE DRAWN	40	—	—	V
DYNODE No. 2 VOLTAGE	—	—	600	V
DYNODE No. 3 VOLTAGE	—	—	800	V
DYNODE No. 4 VOLTAGE	—	—	1050	V
DYNODE No. 5 VOLTAGE	—	—	1250	V

PERFORMANCE

Performance figures for P812 are available on application.

	7295	**7389**	
SCENE ILLUMINATION AT f/5·6 FOR OPTIMUM PICTURE QUALITY	50	75	ft-lamberts
SIGNAL CURRENT (see Note 10):			
MINIMUM	4	4	μA
MAXIMUM	40	80	μA
DROP IN AMPLITUDE RESPONSE AT 400 LINES PER PICTURE HEIGHT, WITHOUT APERTURE CORRECTION, WITH RESPECT TO BLACK/WHITE SIGNAL:			
AT CENTRE: MINIMUM	7	7	db
AVERAGE	5	5	db
IN ANY CORNER: MINIMUM	11	11	db
AVERAGE	9	9	db
SIGNAL TO NOISE RATIO (see Note 11):			
CREST FACTOR 6:			
MINIMUM	32	34	db
TYPICAL	35	37	db
CREST FACTOR 7:			
MINIMUM	34	36	db
TYPICAL	37	39	db

NOTES

1. Adjusted for best focus. Image focus may be obtained at several values of photocathode voltage. The most negative value should be used, as under these conditions the resolution and the life of the tube will be improved.
2. Adjusted for minimum 'S' distortion with photocathode and grid No. 5 at correct values.
3. Supply adjustable from -3 to $+5$V with the blanking voltage off.
4. Adjusted for minimum corner shading and best corner geometry.
5. The supply for this electrode should be derived from that for grid No. 4. Individual adjustment of the voltage is not necessary.
6. Beam focus may be obtained at several values of grid No. 4 potential but, for one particular type of camera, best results will be obtained at a consistent figure. The grid No. 4 potential at which optimum performance is obtained is a function of the magnetic field distribution in the focusing coil and the range of potentials available for grid No. 5. For example, in the case of the Marconi Mk. III Camera, 135 volts appears to be the optimum grid No. 4 voltage. The camera manufacturer's advice must be obtained on this point.
7. Adjusted to give the most uniformly shaded picture near maximum signal.
8. Adjusted for best picture.
9. The anode voltage must not drop more than 10V (with reference to dynode No. 5) when anode currents up to 100μA are drawn.
10. With the gain adjusted to give 0·7V output from the channel, remove the tube signal from the head amplifier by biasing off the beam and inject a line frequency test signal (amplitude during active line period 0·7V) to the head amplifier via an attenuator.

    Adjust the attenuator to give 0·7V amplitude signal output from the channel. Read the attenuator setting and calculate the input signal voltage to the amplifier.

    From the values for the amplifier input signal voltage and the image orthicon load resistor, calculate the signal current.
11. The signal to noise ratio is measured on a channel having a flat frequency response $\pm$0·25db to 5·1Mc/s, this bandwidth limitation being made by a suitable filter. Using a line strobe waveform monitor, select a line containing peak white information and measure the amplitude of the peak white signal with respect to the black level as determined with the lens capped.

    The peak to peak noise amplitude is then measured with the lens capped.

    The signal to noise ratio is expressed in decibels as given by:

$$20 \log_{10} C \left[\frac{\text{Signal amplitude}}{\text{Noise amplitude}}\right]$$

    where C is the conversion factor from peak-to-peak to r.m.s. If a flat amplifier of restricted bandwidth is not available, the measurement should be made on a standard channel and the result corrected for:

    (*a*) Aperture correction present in the amplifier,
    (*b*) Increased bandwidth.

CAMERA EQUIPMENT

1. FOCUSING, SCANNING AND ALIGNMENT COILS

The focusing coil for the tube 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 inches at the photocathode to a diagonal of 2·4 inches 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.

The alignment coils are usually a pair of mutually perpendicular saddle coils arranged with their magnetic centre about $\frac{1}{4}$ inch in front of the first dynode of the gun and the magnetic axes vertical and horizontal. The resultant field should be not less than 3 gauss.

If the heat generated by the focusing and scanning coils is sufficient to elevate the temperature of the tube above the maximum permitted level of 60°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 tube 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 tube has two guides for inserting it correctly in the focusing 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 focusing 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 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.

Installation in the camera is effected 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 two locating bushes on the shoulder where fitted, and also the shoulder contacts with their correct slots in the yoke. The radial line should thus be at the bottom of the faceplate.

2. POWER SUPPLIES

The d.c. voltages required by the tube are stated in the electrical data on pages 10 and 11.

The field mesh should be maintained at a potential 15 to 25 volts above that of the wall coating forming grid No. 4.

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 recognised that the d.c. output of individual tubes of any one type 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 fifth 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 1000 volts should be adequate for most tubes, provided that the anode voltage relative to dynode No. 5 is maintained. A preferable alternative is to adjust the potential of dynode No. 3 relative to dynode No. 2 and No. 4.

3. VIDEO AMPLIFIER

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

To utilise fully 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 6 megacycles is necessary; 525 and 625 lines require 10 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 must be applied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflection 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 resistor.

6. SCAN FAILURE PROTECTION CIRCUITS

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

7. OPTICAL LENS

The lens system used with the tube 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 matt black, and a lens hood employed whenever possible.

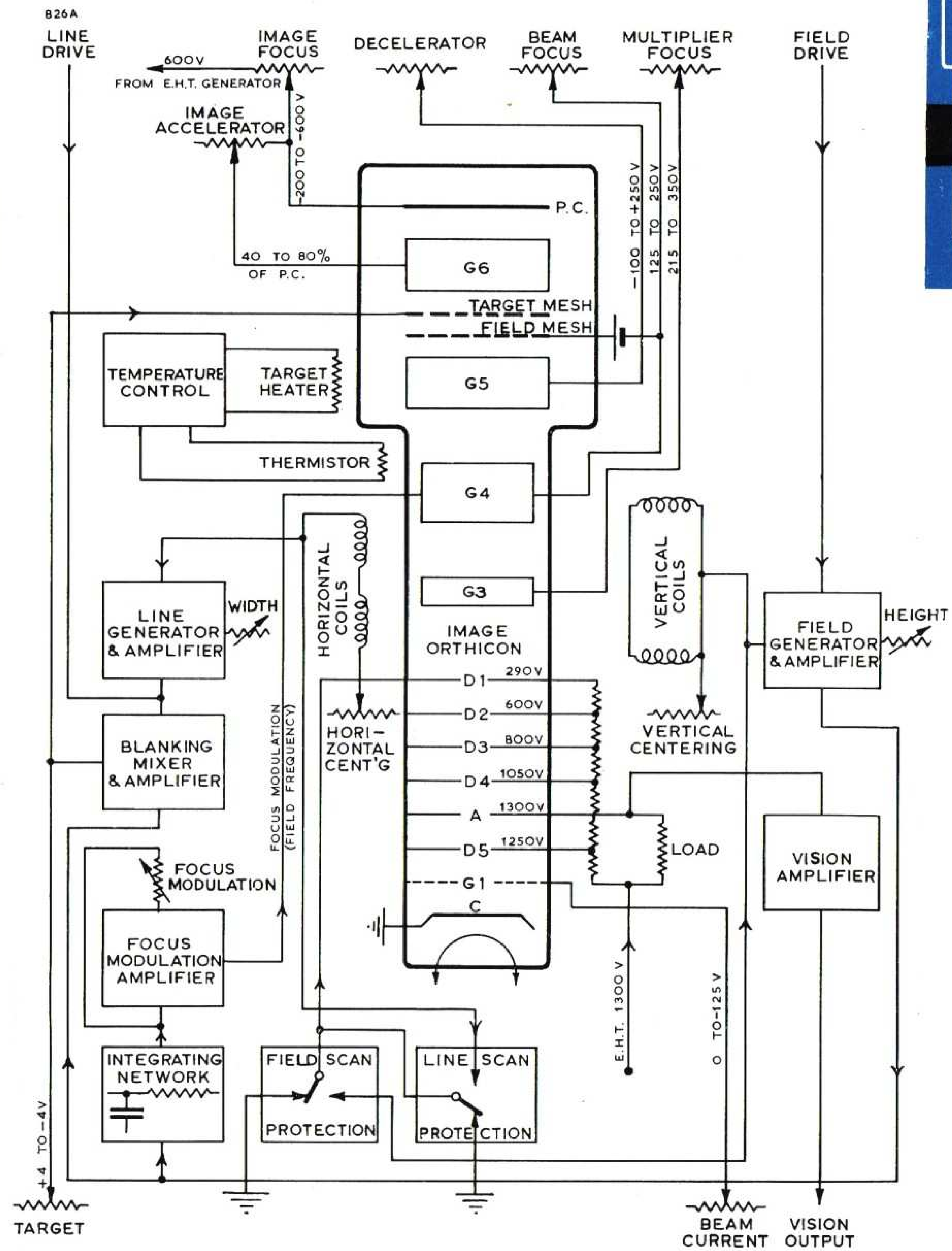


Fig. 3.—Block diagram of image orthicon and associated control units.

OPERATION IN CAMERA

SEQUENCE OF ADJUSTMENTS

1. Verify that the tube and camera are functional. Bias off the target, cap the lens, and adjust grid No. 1 voltage to give a small amount of beam current.
2. Set the scan amplitude controls at maximum.
3. Leave to warm up for 30 minutes or a shorter period if experience has shown that this is sufficient.
4. Uncap the camera lens.
5. Increase target voltage until information appears.
6. Adjust beam focus, image focus and optical focus until details 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 " (grid No. 4) voltage is varied.
8. Set voltage of target approximately 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 are inscribed two concentric circles of diameter 0·96 inches and 1·28 inches, 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 centring 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 the scanned area is centrally located with respect to the target ring.

†*Alternatively a diascope and mask may be used.*

10. Adjust the lens stop for correct exposure.
11. Adjust decelerator (grid No. 5) for minimum shading consistent with best geometry.
12. Adjust image accelerator (grid No. 6) for minimum 'S' distortion when camera is panned horizontally.
13. Cap lens and adjust multiplier focus (grid No. 3) 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.

STANDBY PROCEDURE

During programme and rehearsal breaks of short duration, the camera should be optically capped. 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 at least +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 circumstances should the heater voltage be switched off without removing the high-voltage supplies to the tube.

TARGET VOLTAGE

The target voltage should be set at 2 to 3 volts above cut-off.

Operation at high target voltages improves the signal to noise ratio and grey scale, but reduces tube life and may encourage the onset of microphony.

As grey scale rendition is dependent on target voltage, it is desirable that cameras to be matched should be operated at the same target potential.

Operation at voltages below 2 volts should be avoided as the signal to noise ratio is reduced and the contrast range 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 " of the transfer characteristic, depending on the tube type. 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 or adjusting the variable light attenuator, such as a filter wheel, so that the light input is increased by the requisite

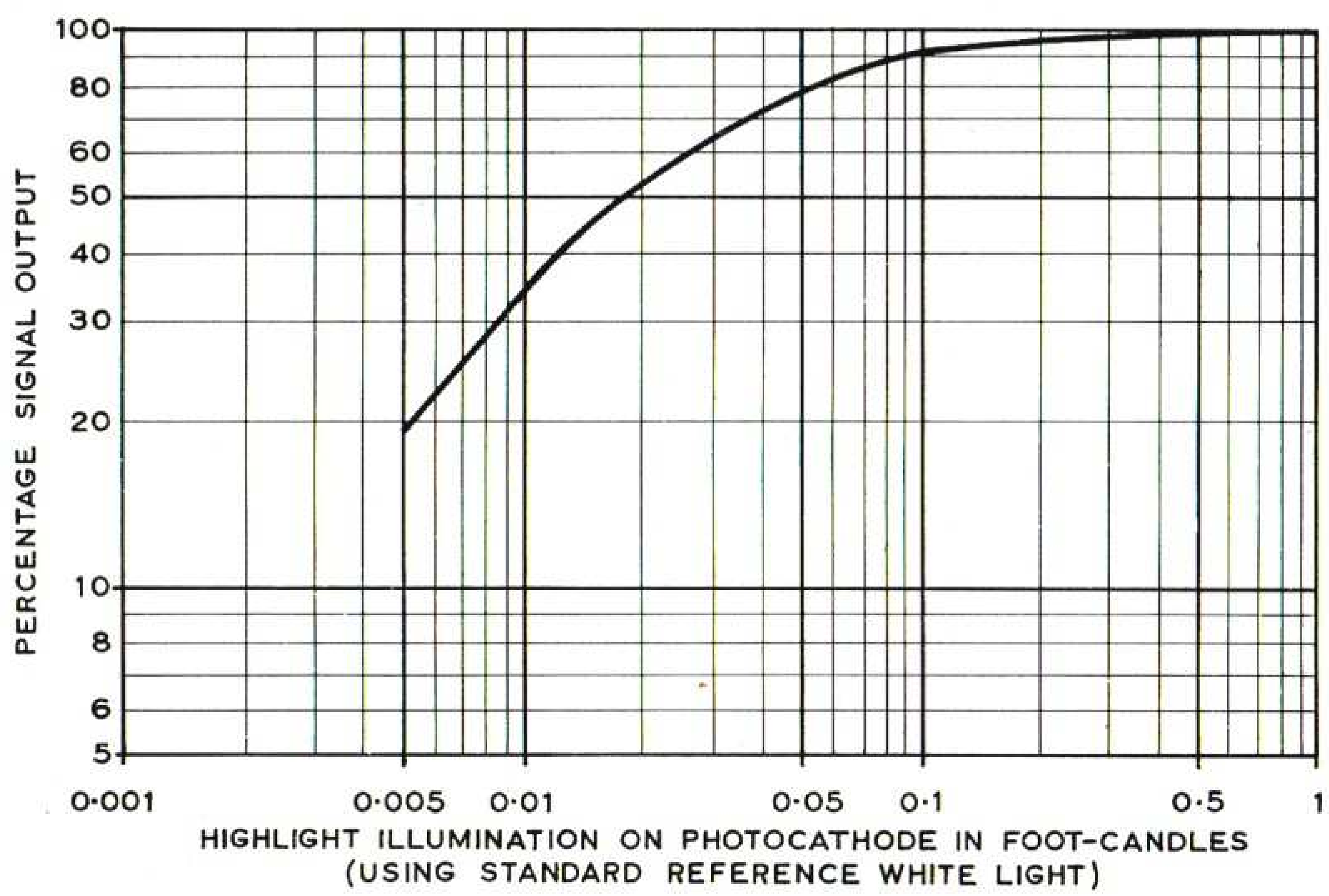


Fig. 4 (a).—Typical 7295 transfer characteristic.

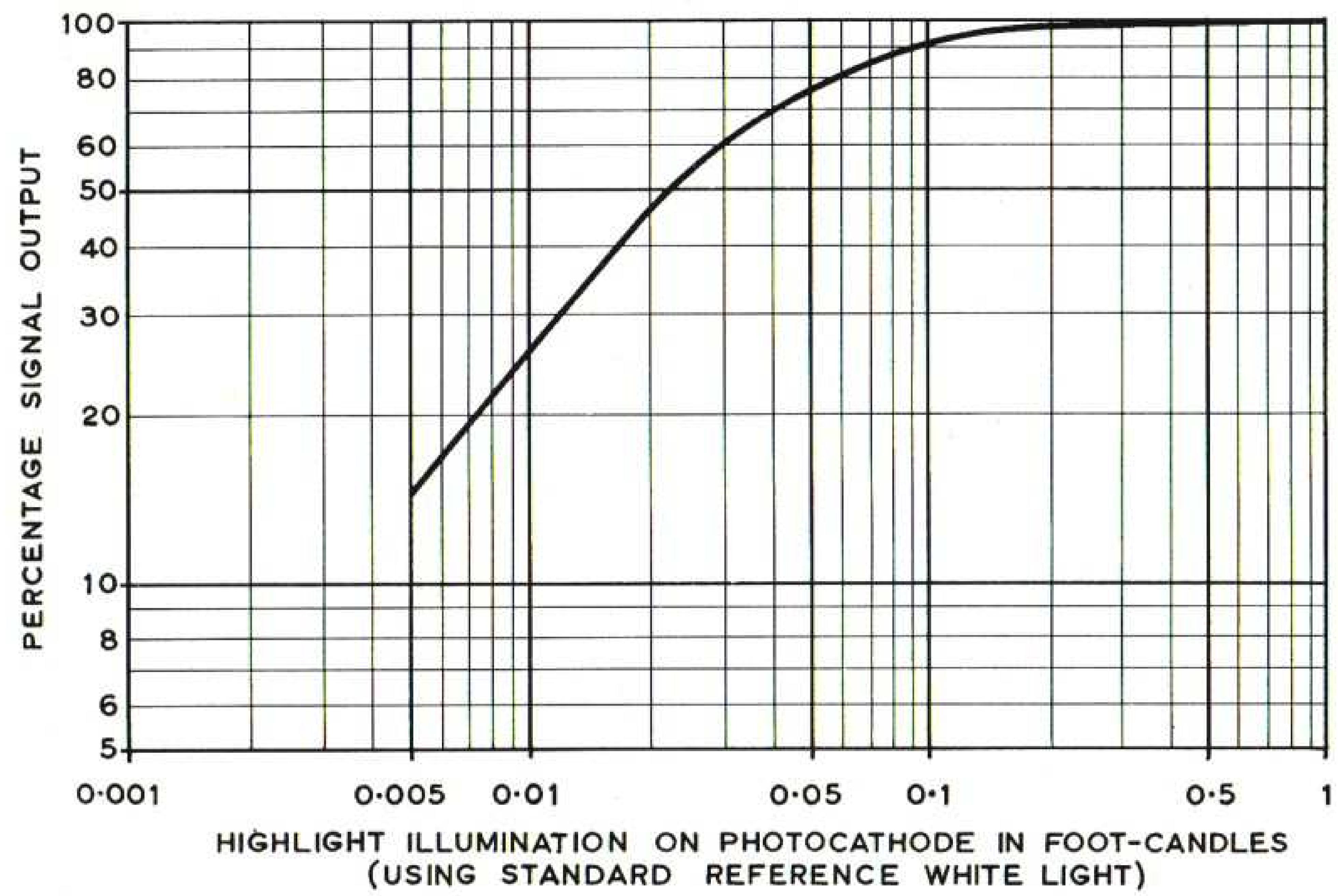


Fig. 4 (b). — Typical 7389 transfer characteristic.

amount. The recommended operating points are:

7295—Highlights 1 to 2 stops over the knee.

7389—Highlights ½ stop over the knee.

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

$$B = \frac{4\, I_{pc}\, f^2\, (m + 1)^2}{T}$$

where B = Highlight brightness of subject in foot lamberts.

I_{pc} = 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 7295 the "knee" will occur at a value of the photocathode illumination of approximately 0·1 foot candles. This corresponds to a scene highlight brightness of 50 foot lamberts at f/11.

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

50 foot lamberts at f/5·6 for 7295
75 foot lamberts at f/5·6 for 7389

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% transmission and the other 10% will give sufficient choice.

GAMMA CORRECTION

The reproduction of scenes containing information in the darker greys by the 7389 is often improved by the use of a non-linear amplifier producing increased gain at signal levels below 30% peak white.

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

"Black stretch" is not normally required with the 7295 and, in general, need only be used if its introduction leads to an improvement in the final picture.

OPERATIONAL NOTES

1. LIGHTING AND STAGING

It is impracticable 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 tube 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 department exists, and the technical limitations of the tube and system are appreciated.

It is important to realise 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 mid-point, and an acceptable aperture setting.

(ii) The contrast range of the set is best restricted to the following values:

Small areas (less than 10% picture area) 40: 1
Large areas (more than 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. OPERATION OF CAMERA CONTROL UNIT

(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 characteristics for the tubes are 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 wave-form monitor when the exposure is correct. It is malpractice to artificially stretch the wave-form trace by 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.

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 reintroduced. Under-scanning 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.

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.

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

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

Image Retention

If the tube is operated before it has reached the correct temperature, i.e. between 35°C and 60°C, images may be 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 tube towards a clear white screen and allowing it to operate with an illumination of about 1 foot candle on the photocathode.

Images may be retained if the tube 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.

RECOMMENDATIONS AND WARNINGS

IN THE USE OF IMAGE ORTHICONS

RECOMMENDATIONS:

1. Allow the tube to warm up prior to operation.
2. Hold temperature of the tube within operating range.
3. Condition spare tubes by operating them for at least 5 hours each month.

WARNINGS:

1. Do not force the tube into its 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.

The significance of each of the above points for obtaining optimum performance from image orthicons is explained in the preceding pages of this booklet.

BIBLIOGRAPHY

Zworykin and Morton: "Television"—John Wiley & Sons.

Amos and Birkinshaw: "Television Engineering"—Iliffe & Sons.

Rose, Weimer and Law: "The Image Orthicon—A Sensitive Television Pick-up Tube"—*P.I.R.E.*, July 1946.

Janes, Johnson and Moore: "Design and Performance of Television Camera Tubes"—*R.C.A. Review*, June 1949.

Janes, Johnson and Handel: "A New Image Orthicon"—*R.C.A. Review*, December 1949.

Janes and Rotow: "Light Transfer Characteristics of Image Orthicons"—*R.C.A. Review*, September 1950.

Banks, Frank and Hendry: "Image Orthicon Camera Tubes"—*Journal of the Television Society*, September 1953.

Turk and Hendry: "An Improved Image Orthicon"—*J.S.M.P.T.E.*, February 1960.

McGee: "A Review of Some Television Pick-up Tubes"—*Proc. I.E.E.*, 97: 391.

Theile: "Recent Investigations into the Operation of Image Orthicon Camera Tubes"—*Journal of the Television Society*.

Rotow: "Image Orthicon for Low Light Levels"—*R.C.A. Review*, 17: 432, 1956.

Partington: "The Design of a $4\frac{1}{2}$-inch Image Orthicon Camera Channel"—*J.S.M.P.T.E.*, 69: 92–98, February 1960.

Brothers: "The Testing and Operation of a $4\frac{1}{2}$-inch Image Orthicon Tube"—British Institution of Radio Engineers' Television Convention, Cambridge, July 1959, published in *Brit. I.R.E.*, 19: 777–805, December 1959.

Mayer and Partington: "A Survey of Simplified Image Orthicon Operation"—*Sound and Vision*, Vol. 2, No. 1.

Poole: "The Marconi Mark IV Camera"—*Sound and Vision*, Vol. 1, No. 1.

P7247.Feb.1964

Printed in England