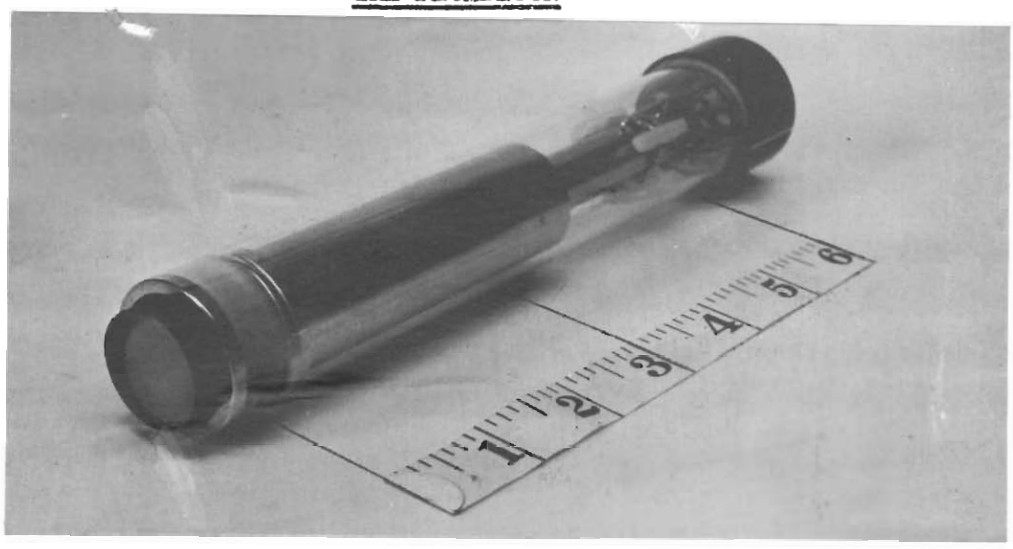
THE BRITISH BROADCASTING CORPORATION ENGINEERING TRAINING DEPARTMENT

INFORMATION SHEET

THE PLUMBICON



The plumbicon is a photo-conductive orthicon developed in the early 1960's, it is the result of many years of research to find a target material and construction that does not exhibit appreciable photo-conductive lag and dark current, the main limitations in the performance of the vidicon. This has been achieved but unfortunately, at present, the red sensitivity of the layer is very low. This deficiency gives serious tonal gradation errors in monochrome but in a colour camera the colour errors are not serious.

The small size, high sensitivity and linear characteristics of the tube make it particularly suited for use in colour cameras but its poor red response has so far limited its introduction into the monochrome field.

Target Construction

The target material is lead monoxide (PbO) deposited on a transparent signal plate of tin oxide (SnO_2). The layer on the beam face is transformed, by doping, into a p-type semi-conductor and on the signal plate face, by combination with tin oxide, into an n-type semi-conductor both doped areas are very thin by comparison to the total layer thickness. Thus the doped layers sandwich the intrinsic layer of PbO and so form a p-i-n diode which in normal operation is reverse biased. The size of the target is limited to a scanned rectangle 0·64" x 0·48" (2 cm. diagonal) to avoid high target capacitance and so reduce beam lag.

Sensitivity and transfer characteristics

Fig. 1. Graph showing variation of signal current with target bias

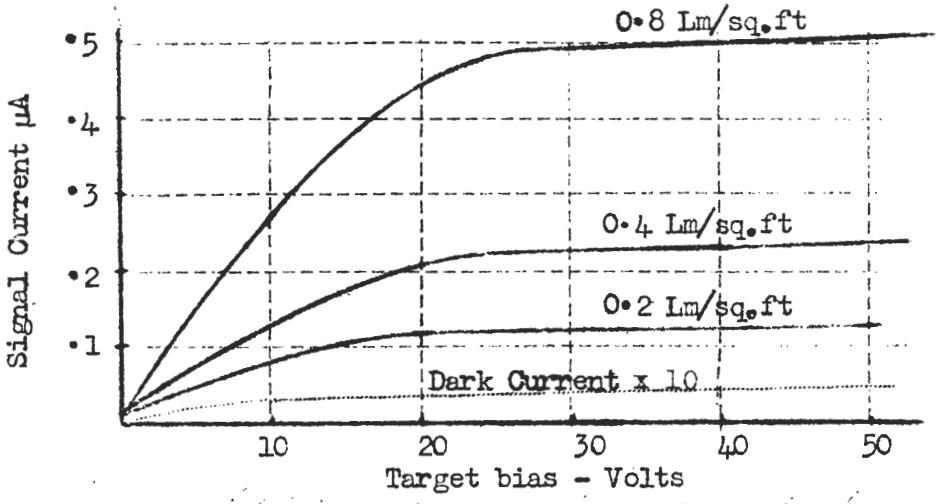


Fig. 2. Graph showing variation of signal current with target illumination

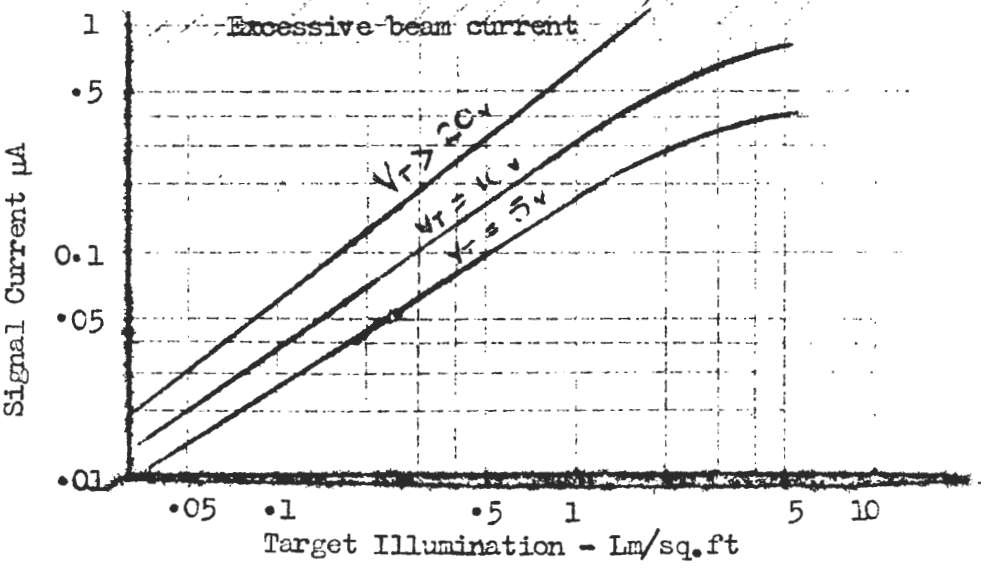


Fig. 2 shows that with normal target bias (>20v) the tube has a constant gamma characteristic with a gamma between 0·8 and 1·0.

Fig. 1 shows that the reverse biased characteristics of the layer result in a small and almost constant dark current thus permitting the use of sufficient bias to operate in the photo-saturated mode and so fully utilise the high sensitivity of the photo-conductive layer.

A typical figure of sensitivity is 300µA/Lumen. Thus with scanned area of 0·31 sq.ins. a target illumination of approx. 0·5 lumen/sq.ft. will be required to give a signal current of 0·3µA.

Lag

The lead monoxide layer exhibits very little photo-conductive lag particularly when operated with high target potentials (30 - 50v).

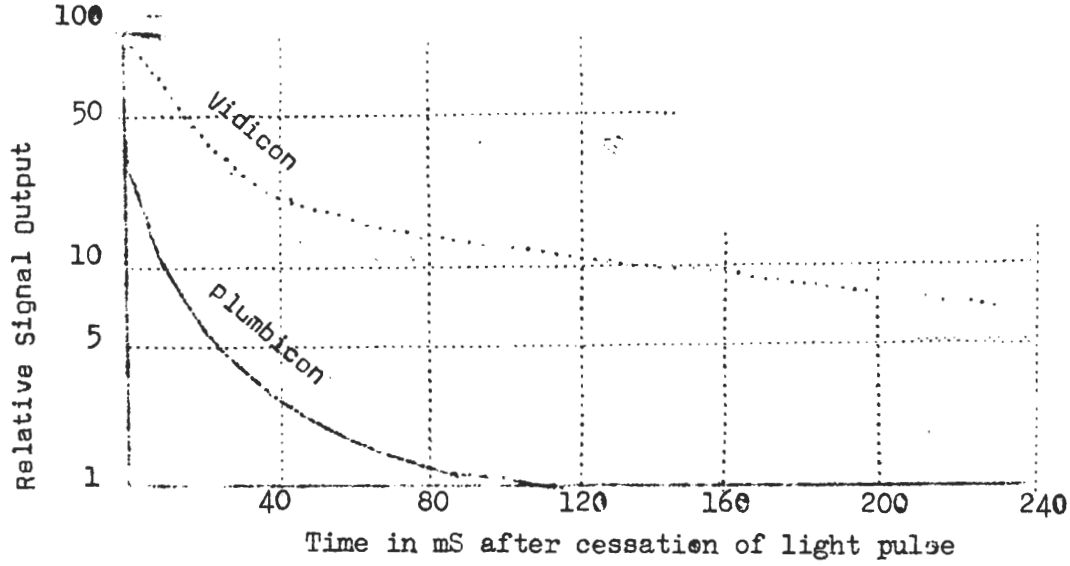


Fig. 3. Lag in Plumbicon (Vidicon lag shown dotted for comparison).

Typical lag characteristics under normal working conditions are shown in Fig. 3. The major part of this lag is beam lag. As with all low velocity tubes this beam lag will increase if the tube is operated with either very low or very high scanned face potentials. The former occurs in areas of prolonged low illumination and may be minimised by the use of bias lighting; the latter occurs when highlights produce beam starvation and can be minimised by over beaming, operating with low target bias (just sufficient to give photo-saturation) or by redesigning the electron gun to provide fly-back charge erasure (ACT gun).

Resolution

The resolution appears to be mainly limited by light scatter within the target layer. A typical figure is 45% modulation at 400 lines/picture height (5MHz - 625 line system).

Separation of the field mesh from the wall anode does not give any significant improvement in resolution but a slight improvement can be achieved by operating with a high focus field.

Spectral response

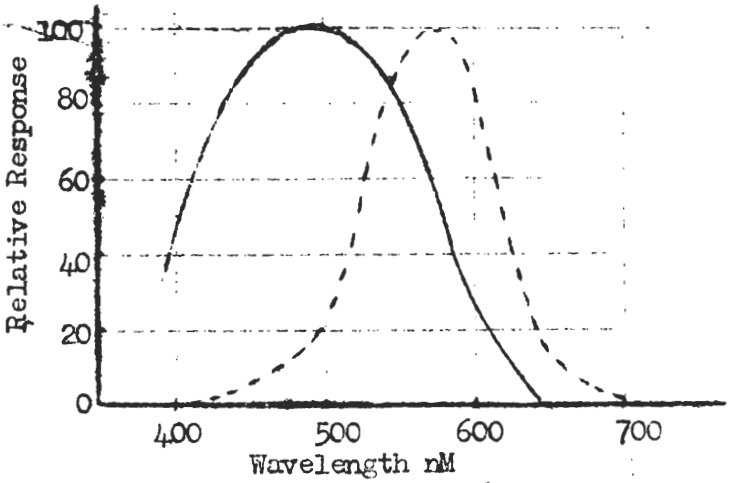


Fig. 4. Equal energy spectral response of plumbicon (Photopic curve is shown dotted as reference)

Fig. 4 shows that there is no response above 640nM so that even with filters it is not possible to obtain a response satisfactory for monochrome television, the gradation errors are produced in the face tones where they are least acceptable. In colour television this lack of red response produces colour errors in the reproduction of deep reds and magentas which are not wholly unacceptable.

Experiments with lead sulphide - lead oxide mixtures have shown that is is possible to overcome this deficiency in the red response.

Operating notes

To obtain a satisfactory signal-noise-ratio the tube must be operated with a peak signal current of between 0.1 and 0.5μA (this depends on the design of the head amplifier). When operated in a photo saturated mode i.e. target bias > 20v this can be obtained from a scene luminance of 15 Ft-L at T/No 2.8.

The signal requires full gamma correction in a corrector with gamma 0.5 and approximately 6dB of aperture correction, both these deteriorate the signal/noise ratio and to maintain the signal/noise ratio > 40dB after correction a peak scene luminance of 20 to 30 Ft-L is required. Target bias should be set to give photo saturation, approximately 20v, higher values than this reduce lag slightly but increase the tendency to beam starvation and beam pulling on scene speculars. The bias cannot be used as a signal current control, as with the vidicon, unless the tube is operated below photo saturation level.

The tube should be over-beamed to the point where resolution is slightly impaired to minimise the chances of beam starvation.

J. Fraser/MH
19th December 1967