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P. C. BAILEY, B.Sc, Ph.D, English Electric Valve Company Limited

NEW LEAD-OXIDE TUBES

INTRODUCTION

Lead-oxide camera tubes have for some time been accepted as the outstanding pick-up tube for colour television. However, although their performance is of a very high standard they do possess certain limitations. English Electric Valve Company is developing two new Leddicon tubes types P8008, P8009 to overcome these limitations. The main features of these new tubes are described.

Both types are of separate mesh construction employing magnetic focussing and deflexion with dimensions identical with those of existing 30mm lead-oxide tubes. The P8009 differs from the P8008 in that it has a spectral response extended slightly from 6400Å to 7000Å to provide a more accurate colour reproduction from the red channel. Modifications which are common to both types, are:

1) Light biasing.
2) A highlight overload protection gun.
3) An anti-reflection coating on the faceplate stud.

Figure 1 is a diagrammatic representation of the new tubes, showing constructional details, and illustrating the various modifications which are described in more detail.

LIGHT BIASING

Light biasing is a method of further reducing the already very low lag of lead-oxide camera tubes. By augmenting the extremely low natural dark current of the lead-oxide target with a fixed amount of photo-induced 'dark current', the scanning beam is able to establish a new equilibrium target potential more quickly when the illumination level changes.

The type of lag which light biasing will reduce is known usually as beam discharge lag and arises as a consequence of the finite spread of energies of the electrons in the scanning beam. It is particularly troublesome at low illumination levels, where the increase in potential of the target surface during the charge integration period is very small. In the absence of illumination, only the high energy electrons in the exponential tail of the beam energy distribution contribute to the target discharging process. When the equilibrium light level increases slightly the target potential will increase but there will be insufficient high energy electrons to discharge the target. The target potential will therefore rise gradually on successive scans until sufficient of the lower energy electrons are able to land and establish a new equilibrium state. This will give rise to build-up lag. Similarly, if the illumination level is removed, several scans will be necessary to re-establish the original dark equilibrium potential, giving rise to decay lag.

The higher the dark current of the target, the more positive will be the equilibrium potential of the target in the absence of illumination, and the larger the proportion of electrons from the beam which will be able to contribute to the target discharging process. In deciding the optimum amount of bias current to introduce, a compromise has to be made between the desired improvement in lag, and that of dark current shading problems. Figures 2a, b, c, d show measurements of build-up and decay lag as a function of bias current at various signal current and beam current settings on a standard P8001 Leddicon tube. The measurements were made by the BBC Research Laboratories, (Kingswood Warren). From these results, it was decided that a bias current in the range 5 to 10nA gave a good compromise.

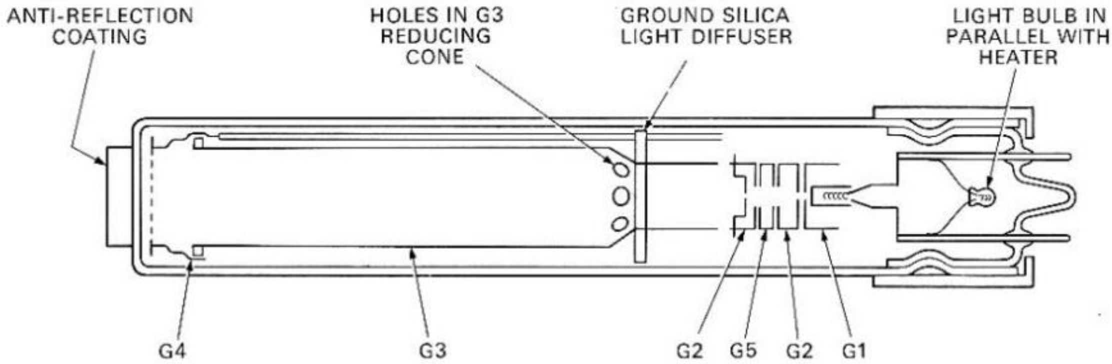

Fig.1 Constructional details of P8008 and P8009.

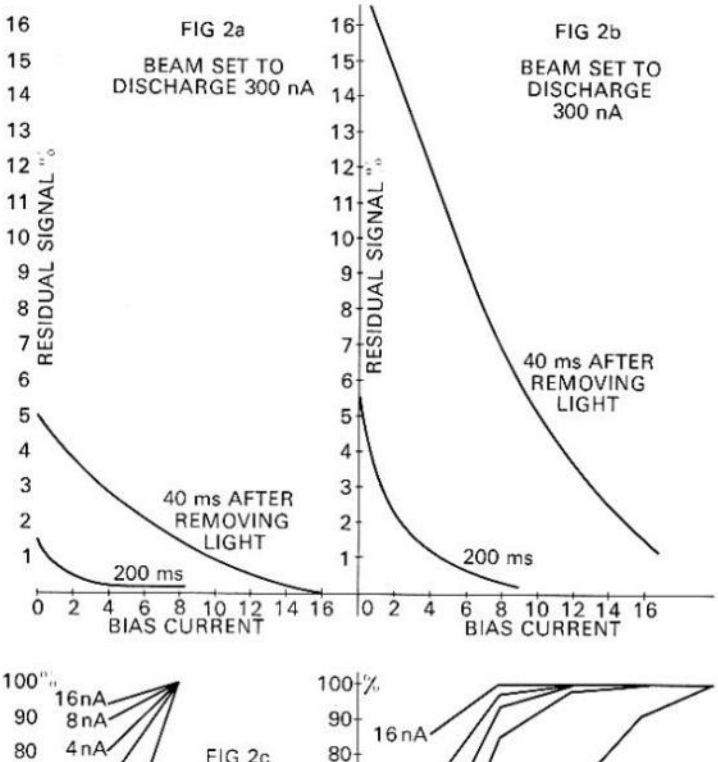

Fig.2 Effect of bias light on P8001 Leddicon. (2a) Decay lag, signal current 100nA (2b) Decay lag, signal current 30nA (2c) Build-up lag, signal current 100nA (2d) Build-up lag, signal current 30nA.

In the Leddicon tubes described the bias light is produced by a small light bulb inside the tube (Fig. 1), and connected in parallel with the heater. No additional controls or power supplies are therefore necessary. A ground silica disc at the base of the G_3 reducing cone diffuses the light before it enters the G_3 cylinder through an array of holes in the reducing cone. By painting part of the outside surface of the tube, the amount of light channelled toward the target can be controlled. By this means it is possible to compensate for variations in target sensitivity from tube to tube, and control the bias current at 8nA. The bias current shading is slightly parabolic, being about 15% up in the centre.

HIGHLIGHT OVER LOAD PROTECTION GUN

The Highlight Overload Protection (HOP) gun is a method of overcoming blooming and comet-tailing effects arising from excessive highlight areas which cannot be discharged by the scanning beam. This type of gun is sometimes referred to as a Roosmalen gun, since the principle involved and a description of a suitable gun design was first discussed by van Roosmalen.[1]

During the normal 'read' process, the target is scanned, as in a standard tube with a beam current of 1 or 2μA, but during the line flyback period the next line to be scanned is prescanned with a high intensity beam (100–200μA). During this flyback period the cathode is pulsed a few volts positive so that those target elements which have been exposed to very high illumination levels are restored to a potential which the normal scanning beam can subsequently handle. This introduces a 'knee' into the light transfer characteristic, the position of the knee being controlled by the size of the cathode pulse. A typical light transfer characteristic is shown in figure 3. It shows that the tube with the HOP gun can handle over-exposures of up to five stops without the problems associated with overloading and with the resolution capability of the tube unimpaired. Above the knee the light transfer characteristic has a small finite slope so that the tube is also capable of providing information from the highlight areas.

The gun design requires an additional electrode (G_5) which is situated in the middle of a split G_2 anode (Fig. 1). During the normal scan period G_5 is electrically connected to G_2 at 300V, but during the line flyback period it is pulsed down to +25V and, at the same time, G_1 is pulsed from its normal negative operating potential up to cathode potential. The effect of this is to increase the beam entering G_2, and to focus it through the G_2 limiting aperture. Compared with a standard tube the gun therefore requires an additional pin connection for G_5, and use is made of the registration pin for this purpose. The new pin arrangement is shown diagramatically in figure 4.

ANTI-REFLECTION COATINGS

The front surface of the faceplate stud of lead-oxide tubes reflects approximately 4·5% of the incident light. This reduces the contrast ratio and can give rise to ghosting. It also results in a small loss of tube sensitivity. Anti-reflection coatings have therefore been applied to the faceplate studs of the tubes to be used in the red, green and blue channels. The spectral reflectances of the coated studs, and of an uncoated stud, are shown in figure 5.

ACKNOWLEDGEMENTS

Several persons at the English Electric Valve Company were involved in the development of the Leddicon tubes described, but in particular the contributions of Dr. L. H. Horton, Mr. H. Scholz and Mr. M. Simmonds should be mentioned.

Thanks are also expressed to The BBC Research Laboratories (Kingswood Warren) and The Marconi Company (Broadcasting Division) for their co-operation and assistance in the evaluation of these tubes.

REFERENCE

1 J. H. T. van Roosmalen: Advances in Electronics and Electron Physics; Vol. 28A, pp 281-288, 1969.

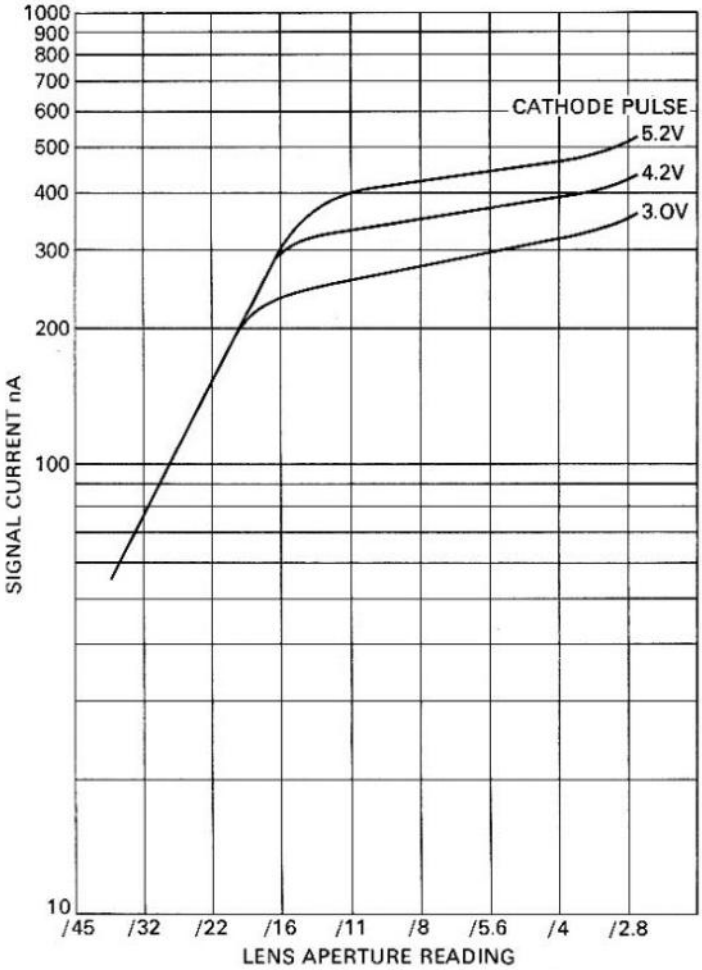

Fig.3 Light transfer characteristic for a H O P tube.

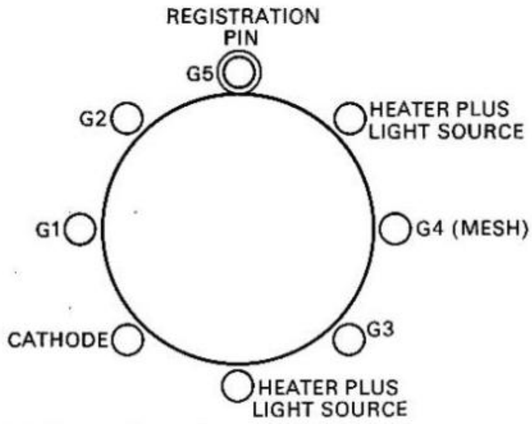

Fig.4 Basing diagram, bottom view.

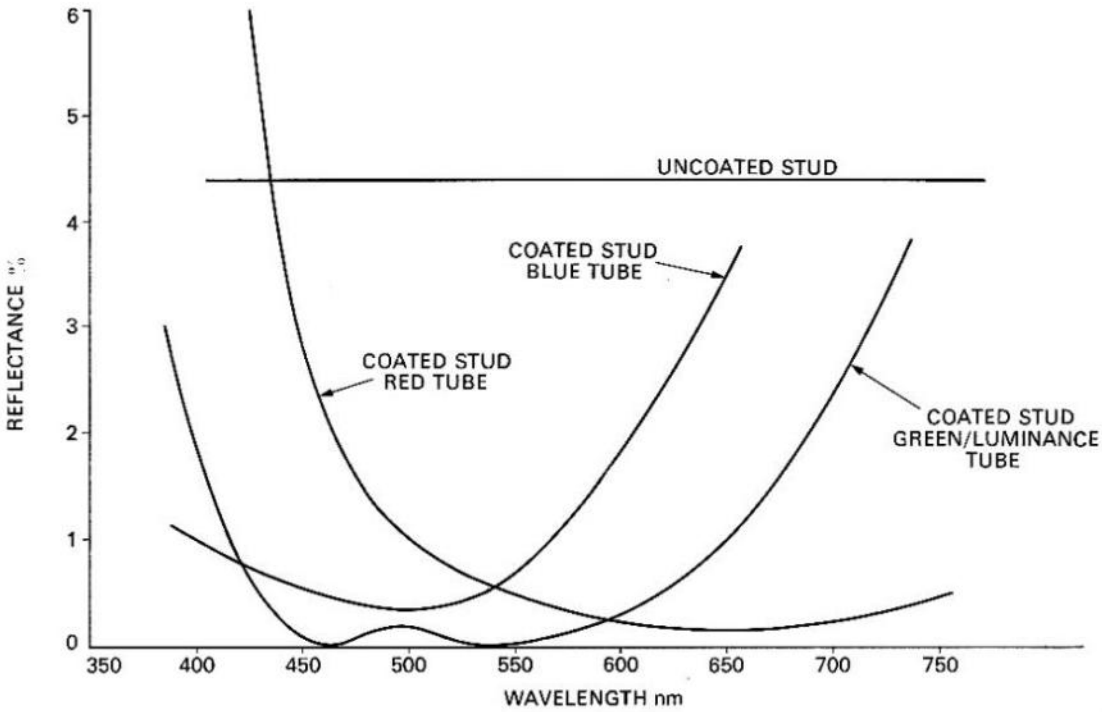

Fig.5 Reflectances of faceplate studs.