A High-resolution Ruggedized Half-inch Vidicon

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Introduction

A demand arose for a small, high resolution camera tube capable of operating under severe environmental conditions. Several successful ruggedized 1-in. vidicons have been developed such as the RCA 6263, and it was decided to develop a similar $\frac{1}{2}$-in. tube. Half-inch tubes have previously been made such as Types PTW 135 and RCA 4427, but these have relatively poor resolution.[1,2] To meet the resolution requirement it was necessary to incorporate a separate field mesh, which has proved so successful in the 1-in. vidicons.[3]

Tube Construction

Preliminary experiments with a hybrid tube having a conventional 1-in. gun and a short $\frac{1}{2}$-in. diameter scanning section incorporating a separate mesh structure, as seen in Fig. 1, gave very promising results. One of the major problems, therefore, was to develop a rugged electron gun to fit into a bore of less than 10 mm. Related experience in similar problems for small klystrons led to the use of a brazed ceramic and metal construction. The gun consists of the various electrodes fabricated from sheet titanium and separated by precision-ground sintered aluminium oxide ceramic collars. The various parts are assembled on a locating jig with thin copper shims between the alumina and the titanium electrodes. By heating the whole assembly in a vacuum to 950°C, the electrodes are brazed to the ceramic collars, and a very strong structure results. The various gun parts and a completed gun are seen in Fig. 2. The gun is held firmly in the tube by its base mounting seal and a stiff molybdenum spring member at the top. It was found possible to employ the low heater-power cathode assembly, previously used in the larger vidicon, which requires only 0·6 W.

The wall anode G_3 is an evaporated hard chromium layer on the inner wall of the precision-bore glass envelope. With the envelope wall forming the G_3 cylinder, it is not possible to bring a separate high potential mesh connexion to the tube base pins inside this without severe electron-optical distortion, and therefore the mesh G_4 is mounted

FIG. 1. Hybrid ½-in. vidicon.

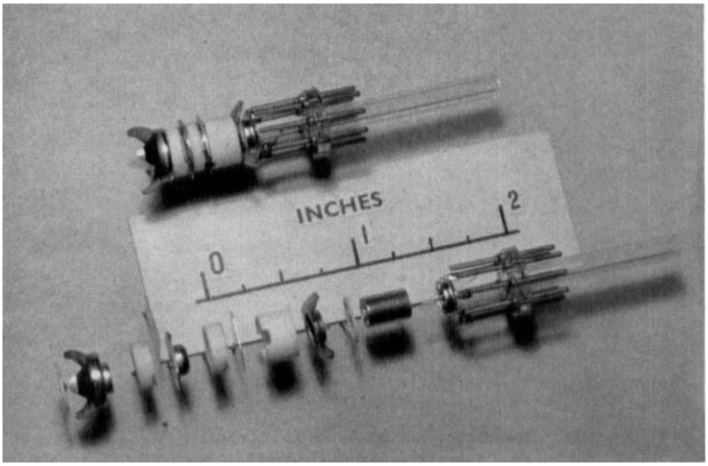

FIG. 2. Electron gun parts and completed gun for ½-in. vidicon.

on a ring for external connexion at the window end of the tube. The optical face plate window has a prefabricated photoconductive target previously prepared in a demountable processing system. The window is sealed to the envelope by means of a cold press indium seal, and connection to the transparent signal plate is by means of a second ring. As this sealing technique is quite reliable, the separate mesh frame is also rigidly held in a similar indium seal and separated from the target by means of a glass collar. A high transparency copper

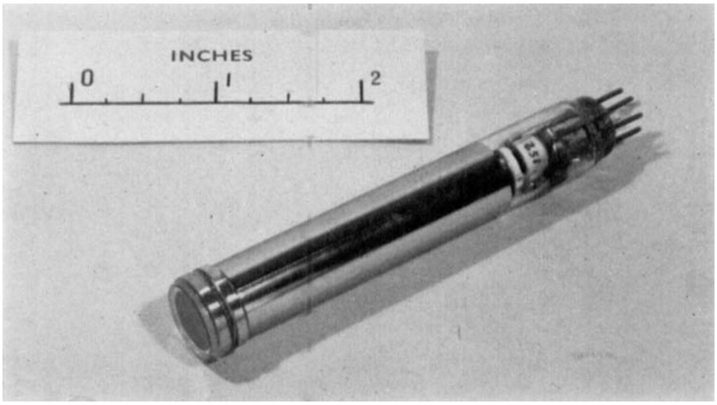

FIG. 3. Completed ½-in. vidicon.

mesh of 1500 meshes/in. is used and, by careful stretching techniques, it can be made sufficiently taut to avoid any microphony at the vibration levels required. The tube is pumped through the glass base tubulation, and the high vacuum processing is quite conventional. A completed tube is shown in Fig. 3.

TUBE CHARACTERISTICS

The tube was developed to be used in conjunction with commercially available magnetic focus and deflexion coils.† It was found that, with the tube positioned in the coils for optimum geometry, the minimum beam landing error on the target was given when the mesh potential was approximately 1·6 times that of the wall anode. It was found that 500 V was the maximum potential that could be utilized without risk of electrical breakdown. Accordingly, all subsequent characteristics were measured with potentials of 500 V on the mesh and 290 V on the wall anode and with an axial magnetic focusing field of 60 G. Under these conditions, it was found possible to increase the size of

† Cleveland Electronics Inc., Cleveland, Ohio, U.S.A., Focus Coil 5VF-225. Deflexion Yoke 5VY-216.

the scanned raster from that in previously developed tubes to a scanned area 0·260 in. × 0·195 in. while still maintaining good picture geometry.

Tubes have been made with various photoconductive targets having differing spectral responses. These included Sb_2Se_3, Sb_2S_3 and AsSe, to give infra-red, panchromatic and ultra-violet responses, respectively. The majority have the now widely used porous/solid Sb_2S_3 target. The layer is made thinner than that of the 1-in. tube in order to increase the capacitance of the smaller target employed and thereby increase the maximum signal current available. All the subsequent measurements were made on tubes of this type.

The variation of signal with target potential is given in Fig. 4. The

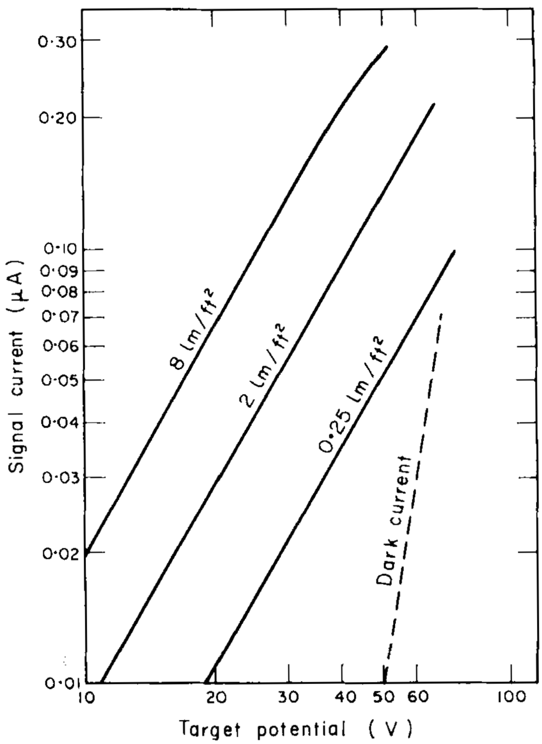

FIG. 4. Signal current as a function of target potential for various levels of illumination.

signal current i varies with target potential V as approximately $i = KV^{1\cdot7}$ where K is a constant. The dark current varies approximately as the sixth power of the target potential. In practice one cannot go much above 0·05 μA dark current because of the increasingly grainy appearance of the target. For equal target illumination and

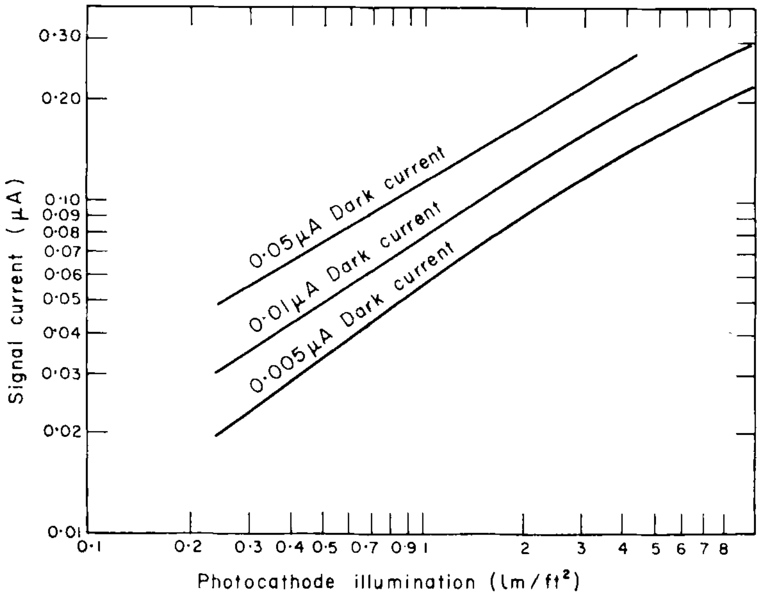

FIG. 5. Signal current as a function of illumination for various dark currents.

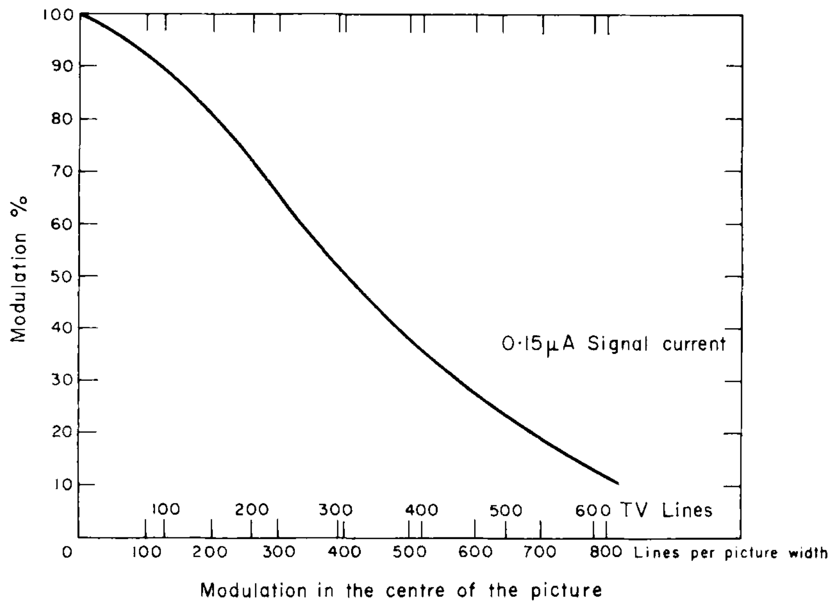

FIG. 6. Resolution of ½-in. vidicon with 0·15 μA signal current output.

dark current, the small tube gives about half the signal current output compared with a similar 1-in. vidicon. Because of the higher specific loading that can be applied to the small target, the loss is rather less than would be expected from the smaller area of target employed. In a camera, for similar angles of view and equal focal depths, the smaller tube is actually slightly more sensitive.

The variation of signal with incident illumination is given in Fig. 5. The signal i varies with illumination I as $i = kI^{\gamma}$, where the value of γ ranges between 0·6 and 0·75.

The variation of modulation with frequency for this tube is shown in Fig. 6. It was measured for a 0·15 μA signal current using a series of precision square-wave optical grids in conjunction with a light box and a high-quality Vidital lens working at $f/4$. The resolution is seen to be remarkably good, and even better than in the older 1-in. vidicon without a separate mesh.

The tube will withstand considerable mechanical shock without damage, and it has been operated in a severe vibration environment. It will give a picture without noticeable degradation when subjected to random vibration at a spectral density level of 0·04 g^2 per c/s over the frequency range 30–2000 c/s.

Conclusion

A high resolution, miniature vidicon has been described suitable for operation in a severe vibration environment and where a very small camera is necessary. A camera has been developed with an overall diameter less than 43 mm for use in internal pipe-inspection as in Fig. 7. The tube can be used to observe aircraft and rocket components in actual flight operation.

Fig. 7. Miniaturized camera employing ½-in. vidicon for internal examination of pipes.

Acknowledgments

The author would like to thank the Directors of Electric & Musical Industries Ltd. for permission to publish and Dr. H. G. Lubszynski under whose direction the development was done. Thanks are also due to colleagues, R. D. K. Gilden, H. Jepson, F. W. Jackson, M. J. King, B. Robinson and S. Taylor for assistance during the work.

References

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2. Cope, A. D., *RCA Rev.* **17**, 460 (1956).
3. Lubszynski, H. G. and Wardley, J., *Instn. Elect. Engrs Conf. Rep. Ser.* **5**, 59 (1963).

Discussion

Y. NOZAWA: Have you tested the tube under combined conditions of low temperature and vacuum?

J. WARDLEY: No.

W. HEIMANN: The tube you have reported has magnetic focusing and deflexion. Do you have any idea how much the resolution will decrease when you use an electrostatic lens for focusing? Can you give this as a percentage?

J. WARDLEY: Electrostatic focusing systems have not yet given as good a performance as magnetic focusing in 1-in. vidicons. An electrostatic system for a $\frac{1}{2}$-in. tube would be quite difficult to develop and its performance difficult to predict.

J. D. McGEE: Is it not a fact that further reduction in the size of the vidicon would reduce sensitivity because the f-number remains the same and the area decreases?

J. WARDLEY: With the smaller tubes, one is already limited by the availability of suitable lenses. For equal focal depths, a greater aperture is possible thus regaining the sensitivity loss due to the smaller photoconductive target used. However the lenses with large apertures must be corrected for the effect of the vidicon window thickness for optimum performance and one cannot easily obtain lens apertures greater than $f/1$.

W. P. WEYLAND: What is the resonance frequency of the mesh in your ruggedized tube?

J. WARDLEY: The resonance frequency of a well stretched mesh appears to be between 2 and 3 kc/s.