The Bivicon† Camera Tube—A New Double Vidicon

R. L. Spalding, S. A. Ochs, and E. Luedicke*

RCA Electronic Components, Lancaster, Pennsylvania

Abstract—The RCA Bivicon television camera tube, a 1½ inch vidicon with two separate guns and targets, was developed for use in two-frame color systems. Its special features include a non-parallel twin-gun structure, a novel mesh-support design, and a faceplate with a double target structure and embedded signal contact buttons. The Bivicon produces excellent color signals with the Holotape† system. It can also be used in film chains, live pickup television cameras, and in a variety of other schemes based on a two-frame television system.

Introduction

Several methods have been developed for generating color-television signals by means of two separate camera tubes. In the RCA Holotape video playback system, for instance, two optical frames are imaged onto the two vidicon targets for each single television frame of the output color signal. The two input frames are in monochrome, one

* RCA Laboratories, Princeton, N.J.

† Registered trade name of RCA.

containing the luminance portion of the television signal, while the other frame contains all the information necessary for generating the chrominance portion.[1] Such a system requires excellent registry, i.e., spatial alignment, between the two scanned rasters so that the two simultaneous signals will be accurately in phase with each other. This requirement suggests that several advantages can be gained from combining the two tubes within a single enevelope:

(1) The relative position of the two sets of components of a double tube is established within its structure. If the tube has been properly designed as to rigidity and thermal stability, only the initial mechanical adjustment is needed for obtaining the required superposition of the output signals.

(2) A smaller and lower-cost camera results because the double tube can be operated in a single focus coil and deflection yoke.

(3) With the two camera-tube targets located on the same faceplate, the two optical images can be positioned close together, which can lead to considerable simplification of the camera optics. For instance, it would be possible to operate with a single lens.

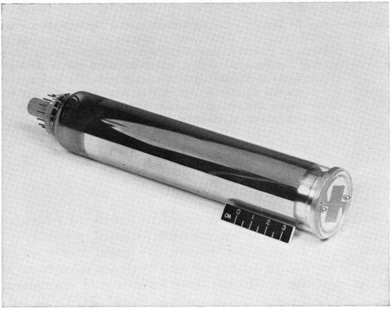

Fig. 1—Bivicon camera tube.

A double vidicon, of course, is only useful if it yields a satisfactory degree of coincidence of the two output signals and if it is economically practical. These conditions are satisfied by the Bivicon camera tube[2] (developmental type C23244), which is described in this paper. Its external appearance is shown in Fig. 1. The following sections discuss the special design features and the performance of this tube.

Design

One of the design goals was to produce a tube that can achieve a color signal comparable to that obtained from two one-inch vidicons. This goal suggested that each of the two rasters have the same dimensions as that used with the one-inch tube, i.e., 0.50 × 0.375 inch. With a small separation between the scanned regions, the total area required for the two rasters then became 0.50 × 0.875 inch, requiring a diagonal of slightly more than one inch. An outside diameter of 1.5 inch therefore was chosen for the tube. In order to achieve satisfactory resolution performance, it was decided to base the electro-optical system on that of the 8521 vidicon, a 1.5-inch-diameter vidicon of high resolution capability. This decision implied the use of magnetic focus and deflection and the inclusion of a separately connected mesh electrode near the two signal plates.

Because the two electron optical systems should yield identical scanned rasters, they were placed in symmetrical locations relative to the tube axis. For proper performance, as well as in the interest of economy, the tube has several unusual features which are described below.

Envelope

In order to minimize parts costs, it was decided to use soft (potash soda lead) glass for the envelope of the tube instead of the usual hard (borosilicate) glass. Use of soft glass not only reduces the envelope cost, but also permits the use of an inexpensive stem (the lower end of the envelope, which contains the contact pins and the exhaust tubulation) used in large quantities in the manufacture of picture tubes. Since the faceplate is attached to the envelope by an indium seal, as used in other vidicons, the decision to make the envelope of soft glass did not affect the choice of glass for the faceplate.

Guns

The guns developed for the Bivicon, shown in Fig. 2, have a "triode" arrangement, similar in concept to that of most vidicons, but their actual construction is based on that of the gun used in the RCA small-neck 110°-deflection-angle color picture tubes. This design was chosen because of its adaptability to large-quantity production. Fig. 3 is a sketch of one of the two (identical) guns developed for the Bivicon tube. Each gun consists of a cathode structure, a control (G_1) grid, an accelerator (G_2) assembly, and a focus (G_3) cylinder. These electrodes are held in place by two glass beads. This arrangement avoids the need for a brazed cathode–G_1 assembly, as is used in most other camera-tube and picture-tube guns.

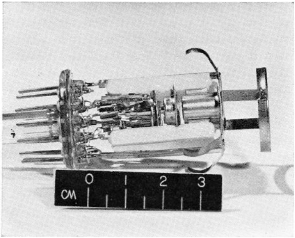

Fig. 2—Double-gun for Bivicon tube.

A special feature of the electron gun is the method by which the limiting aperture (indicated in Fig. 3) is mounted within the G_2 electrode. When the gun is in operation, a cone-shaped stream of electrons issues from this aperture and is then focused, through the action of the electro-optical system of the tube and magnetic focus field, into a minute spot that scans the photoconductive target. If the aperture, whose diameter is 0.0015 inch, is off the gun axis by more than 0.0001 or 0.0002 inch, there will be an appreciable loss of resolving power of the beam and of its ability to properly discharge the charge pattern stored on the photoconductor. A technique was therefore developed that results in accurate centering of the limiting aperture and is well suited to the mass production of tubes.

The two electron guns are mounted on either side of, and symmetrically with respect to, the tube axis. However, they are not parallel to the axis or to each other. To understand the actual location and orientation chosen for the guns, consider the path followed by an electron that starts from a source at a distance from the tube axis with an initial velocity parallel to this axis. An analysis of the motion of this electron shows that, with no deflection field applied, the electron arrives at the target (1) closer to the tube axis than the radial distance of its starting point, (2) in a different axial plane (i.e., at a different azimuthal angle) than that of its source, and (3) at an oblique angle of incidence.

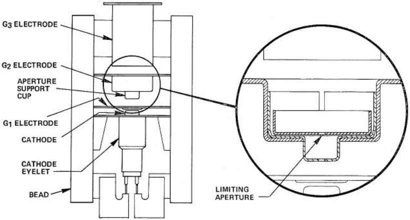

Fig. 3—Sketch of one of two Bivicon guns.

The first of these three items can be accommodated readily by determining the proper distance of the electron source (i.e., of the limiting aperture of the gun) from the tube axis, so as to yield the desired separation of the two electron spots on the target. Similarly, the second item results in an angle of rotation between the line joining the two limiting apertures and the common center line of the two scanned rasters that can be computed and measured. It is then taken into account by a suitable angular rotation of the electrode pattern on the tube faceplate relative to the position of the guns.

Item (3), however, cannot be dealt with quite so easily. It is complicated by the fact that when deflection fields are applied, the particular electrons considered above (those leaving the limiting apertures parallel to the tube axis) arrive at different angles of incidence depending on the amplitude and direction of the deflection fields at any given moment. In practice, this difference in the angle of incidence means that the tube would show objectionable shading if no correction were applied. This problem was solved by so aiming the two guns that the undeflected beams leave in such directions that they arrive at their respective targets parallel to the tube axis. When deflection fields are now applied so that the two electron spots scan their individual rasters, the angles of incidence will still vary slightly from the value at raster center, causing a certain amount of shading towards the corners of the scanned regions. However, the magnitude of this effect is no greater than it is in standard camera tubes, where it generally is found to be acceptable.

Upper G_3 Electrode and Mesh

In the interest of minimizing tube costs, a large portion of the G_3 electrode consists of a metallic coating on the inside wall of the glass envelope. This coating replaces the metal cylinder used in most other camera tubes that is connected to the beaded gun assembly by a funnel-shaped connecting piece. A considerable saving is achieved by eliminating the latter part, which would have a complicated shape to fit the double-gun structure, and the metal tubing connected to it. Also, due to the higher sheet resistance of the wall coating as compared to the resistance of a reasonably rigid metal cylinder, there is less loading of the deflection yoke (smaller eddy currents are induced). Several leaf springs are used to make contact to the wall coating at both ends, i.e., near the gun and near the mesh.

At the upper end of the tube is a structure, shown in Figs. 4(a) and 4(b), that contains two electrically isolated sections. One part is the upper end of the G_3 electrode and is connected to the conducting wall coating on the envelope. The other section consists of the mesh assembly. The tightly stretched nickel mesh contains 1000 lines per inch and is mounted parallel to the plane of the two targets. This arrangement, which basically is similar to that used in most camera tubes, provides an electrostatic lens (between G_3 electrode and mesh) followed by a region of uniform electric decelerating field (between mesh and faceplate). Its function is to bend the path of the electrons leaving the deflection region so as to cause them to approach the target

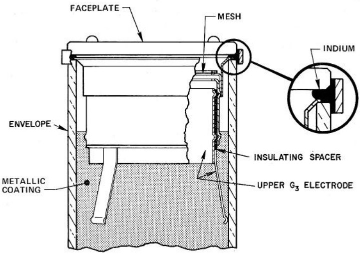

Fig. 4(a)—Sketch of mesh structure.

as nearly perpendicular to the target plane as possible. In other tubes that have continuous G_3 cylinders, as described above, the upper portion of the gun mount, including the mesh, is supported by the beaded lower gun assembly. The mesh electrode is then connected to one of the stem pins by a wire running the length of the tube next to the envelope wall. In the novel arrangement developed for the Bivicon tube, the mechanical support for the upper structure of the gun and

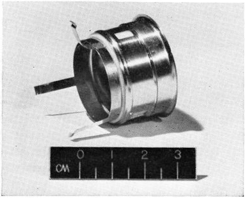

Fig. 4(b)—Photograph of mesh structure.

the electrical connection to the mesh are provided by a funnel-shaped ring that rests on the target end of the glass envelope and is rigidly secured in place by the indium faceplate-to-envelope seal. The external contact to the mesh is then made via the metal ring that surrounds the indium seal.

Faceplate

Fig. 5 is a view of a Bivicon faceplate as seen from the outside of the tube. Two conducting plugs set in the faceplate provide the external signal connections. On the inner surface of the faceplate are two separate transparent signal electrodes covered by a common layer of antimony trisulfide photoconductor. Each scanned raster area is surrounded, on three sides, by a "frame" of evaporated aluminum to

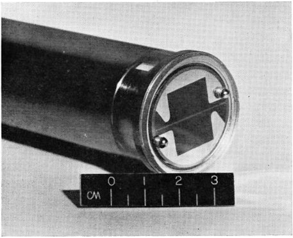

Fig. 5—Faceplate.

minimize variations in resistance from different regions of each raster to the corresponding conducting plug. (In conventional camera tubes this requirement is taken care of by the indium seal material that contacts the circular signal plate along its periphery.) Each conducting plug contacts one of the aluminum regions on the inner faceplate surface. On the other end of each plug, a convex metal button is provided for ease of making the signal connection.

Tube Assembly

The stem of the tube was chosen as the basic reference for precisely aligning the guns, envelope, and faceplate. Thus, in mounting the two-gun assembly on the stem, a fixture is used that ensures accurate positioning of the guns relative to the tube pins. The glass envelope is subsequently sealed to the stem, again lined up with reference to the pins such that the central axis of the gun assembly coincides with the center line of the envelope. Finally, when the faceplate is attached by an indium seal to the other end of the envelope, the pins in the tube stem again are used to provide the reference needed for proper alignment of the faceplate.

In this fashion the critical parts of the tube, such as the two guns, the G_3-mesh section, and the signal electrodes, are accurately positioned in relation to each other, and the user of the tube has a ready reference—the pin structure—for mounting the tube properly in the focus coil and deflection yoke of the television camera.

This method of tube assembly, in contrast to that used for other camera tubes, does not depend on optical alignment using human judgment. Also, it permits the use of relatively economical glass envelopes with reasonable wide dimensional tolerances because the inner envelope surface is not used for aligning the gun mount with the tube axis. However, the method described above requires that the structure that holds the gun mount to the stem pins be sufficiently stiff to ensure that it will not deform when it is handled or when it is inserted into the envelope. Therefore, several of the rather flexible stem leads that support the gun assembly were replaced with stiff support beams made by metal ribbons longitudinally bent so as to give them an L-shaped cross section.

Performance

In typical operation, the voltage of the signal electrodes (relative to the cathode) is adjusted so that the current for each target in the dark is 20 nA with a raster size 0.50×0.37 inch, an accelerating electrode voltage (E_{c2}) of 300 V, a focus electrode voltage (E_{c3}) of 900 V, and mesh voltage (E_{c4}) of 1400 V. Typical target voltage is 20 to 40 V. The required field strength then is about 46 gauss at the center of the focusing coil.

Because the photoconductor material used for the Bivicon tube is the same as that used for commercial vidicons such as the 8507A, 7735B, and 8521, the tube has essentially the same photoconductor-dependent performance characteristics (e.g., spectral response and sensitivity).

The resolution capability of the Bivicon is shown in Fig. 6 as a plot of the amplitude-response characteristic for each of its two outputs. The horizontal peak-to-peak response, without aperture correction, is given for a square-wave test pattern at the center of each 0.50×0.37 inch raster. The illumination is such that the high-light signal current is 300 nA. The abscissas are given in terms of television line number (total number of black-and-white lines per raster height) as well as in line-pairs per millimeter. Although not shown in Fig. 6, the limiting resolution in the center exceeds 1000 television lines, while near the corners it ranges from 500 to 700 television lines.

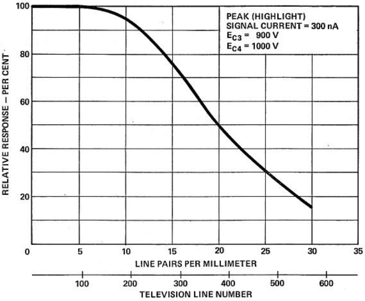

Fig. 6—Horizontal square-wave response.

When a Bivicon tube is first operated in a standard 1½ inch focus-coil/deflection-yoke, the output signals from its two signal plates overlap, but are not registered perfectly. To obtain scan registry, several parameters can now be adjusted such as the electrode voltages and rotation of the tube in the yoke. Without much difficulty the two output signals can be registered to a high degree of perfection. In a typical case, with the two raster center points conicident, the greatest discrepancy in any region of the raster will be no more than 1% of the raster width.[1]

Conclusion

The RCA Bivicon television camera tube was designed to perform a quite demanding task and yet be suitable for use in low-cost systems. As a result of several innovations in construction methods, materials, and design concepts, these goals have been attained. The initial application of the tube was its use in two-frame color systems, and it has been demonstrated to perform its function in this application exceedingly well. Among the other applications in which such a "two-eyed" camera tube might be usefully employed are stereoscopic television, comparators, motion detection, surveillance with periodic switching between objects, and simultaneous pickup using wide and narrow-angle lenses with fast switching between the two.

Acknowledgment

The authors gratefully acknowledge the contributions made by J. D. Herrington and P. W. Rothweiler in the development work on various aspects of the tube and by J. F. Otto in making prototype tubes and valuable suggestions.

References:

[1] R. E. Flory, "Applications of the Bivicon Tube," **RCA Review**, Vol. 34, No. 1, p. 132, March 1973.

[2] R. L. Spalding et al, "Bivicon—A New Double Vidicon," **Proc. IEEE**, Vol. 60, p. 1236, Oct. 1972.