The RCA Developmental Three-Gun Tri-Color Kinescope

by

H. R. Seelen

Manager, Lancaster Engineering

RCA Tube Department

Several fundamental differences distinguish the tri-color kinescope from black-and-white kinescopes. Although these differences require additional engineering and manufacturing techniques, they are of such a nature that if adequate manufacturing care and diligence are pursued, production of the tri-color kinescope will impose no more serious problems than those which were experienced in the early days of black-and-white kinescope production. The most obviously different feature of the color tube is, of course, its phosphor viewing screen. In contrast to the uniformly coated phosphor mixture used in black-and-white kinescopes, the color tube screen is composed of three sets or arrays of dots, accurately deposited in interlaced positions on a supporting glass surface. Each set of dots emits a different color light upon bombardment by electrons; one set gives out deep blue; one, green; and one, red. The phosphor dots emitting these colors must be kept separate without waste of space and yet without overlapping. It is important, for example, that the electron beam intended to strike the red-emitting set of dots will not accidentally strike some green-emitting crystals in adjacent dots.

A second difference in the color tube is the aperture mask. From the position of the tube viewer, the mask is located parallel to and just back of the phosphor-dot plate. The mask provides color separation by shadowing certain phosphor dots from the electron beam, while exposing others to bombardment. Thus, the beam which is to produce red portions of the picture, for instance, is so directed toward the mask that, upon passing through the apertures in the mask, it can strike only the red-emitting phosphor dots. For the production of pure colors, it is essential that the holes in the mask be properly aligned with the phosphor dots composing the screen. In order that proper alignment can be obtained, the mask and the phosphor-dot plate are made flat, contrary to the conventional practice for black-and-white tubes, which use a curved viewing screen on the inner surface of the tube face. Likewise for accuracy, mask and phosphor-dot plate are mounted together in an assembly which holds these elements in proper alignment. This assembly is then placed in the tube by an accurate jigging method to be subsequently described.

A third distinguishing feature of the color tube is its three-gun assembly. Three parallel, closely spaced, electron guns, built into a

unit, provide separate beams for excitation of the three different phosphors. Thus, it is possible to control the brightness of each of the three colors independently of the other two. As compared with the single guns used in black-and-white kinescopes, this three-gun assembly has a larger number of parts and requires careful alignment of each gun and of the gun assembly. The gun assembly is sealed into the tube neck in good alignment with the neck and the viewing-screen assembly.

In a black-and-white kinescope, the angle at which the beam strikes the viewing screen is immaterial, whereas in the color tube the approach angle is important because it determines the color of light output. Because stray magnetic fields may affect the approach angle and, hence, affect the color output, an inner shell of soft magnetic material is provided for the color tube.

The envelope of the color tube differs from that of a black-and-white metal tube in two respects:

1. A welded flange located a short distance back of the rim of the tube constitutes the final envelope seal, and is used, rather than a face-plate seal, to avoid possible heat damage to the viewing-screen assembly.

2. The neck has a 2-inch diameter in place of the usual 1-7/16-inch diameter to provide space for the three electron guns.

Fig. 1 - Three-Gun Tri-Color Kinescope
RCA Developmental No. C-73293-C.

The Envelope Assembly

For the developmental tri-color tube shown in Fig. 1, the 16-inch round metal shell, used for the 16AP4, was selected because of its size and the desirability of having a strong metallic support for the viewing-screen assembly. The shell assembly for the tri-color tube actually consists of two pieces (an upper and a lower section), made of spun chrome-iron and flanged at adjacent ends which are subsequently welded together.

Fig. 2 shows diagrammatically a cross section of the major tube parts and their relative positions. Screen-assembly support posts of steel are bolted and welded to the lower shell section, after which the free ends of the posts are machined down to a plane perpendicular to the long axis of the envelope. The posts are then drilled and tapped. The plane of their free ends is used as a reference during further steps in tube assembly. The glass neck-and-funnel assembly consists of two

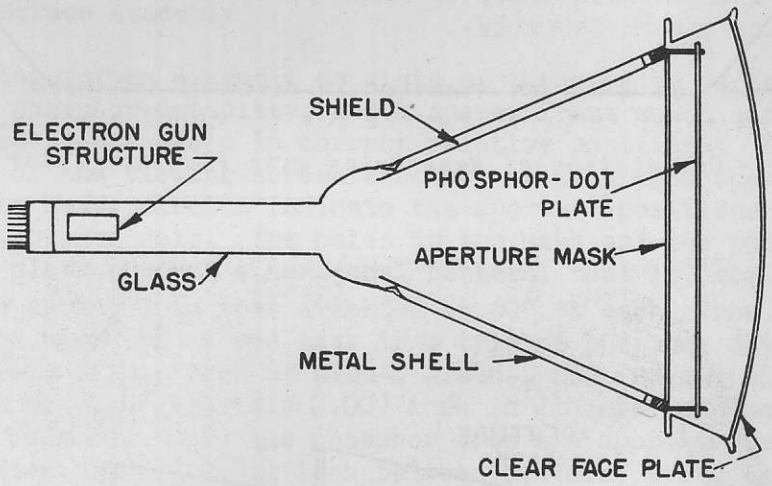

Fig. 2 - Cross-Sectional Diagram of Tri-Color Kinescope Showing Major Parts and Their Relative Positions.

sections. The first of these is a piece of tubing 2 inches in diameter, shrunk on a mandrel for accuracy of inside diameter and then flared at one end. The second is a section of a blown-glass bulb. The flared end of the tubing and the bulb when joined give a contour which provides maximum clearance for the deflected electron beams when the tube is in operation. The glass funnel is sealed to the lower metal section by means of a jig bolted to the screen-assembly support posts. This jig has a shaft, centered between the support posts and perpendicular to the reference plane, which fits closely in the shrunk neck tubing and thus insures that the projected neck axis will strike the reference plane at a 90° angle and midway between the screen-support posts.

A conductive coating is applied to the inner wall of the glass funnel and the upper neck. Next, the shield of soft magnetic material (50%

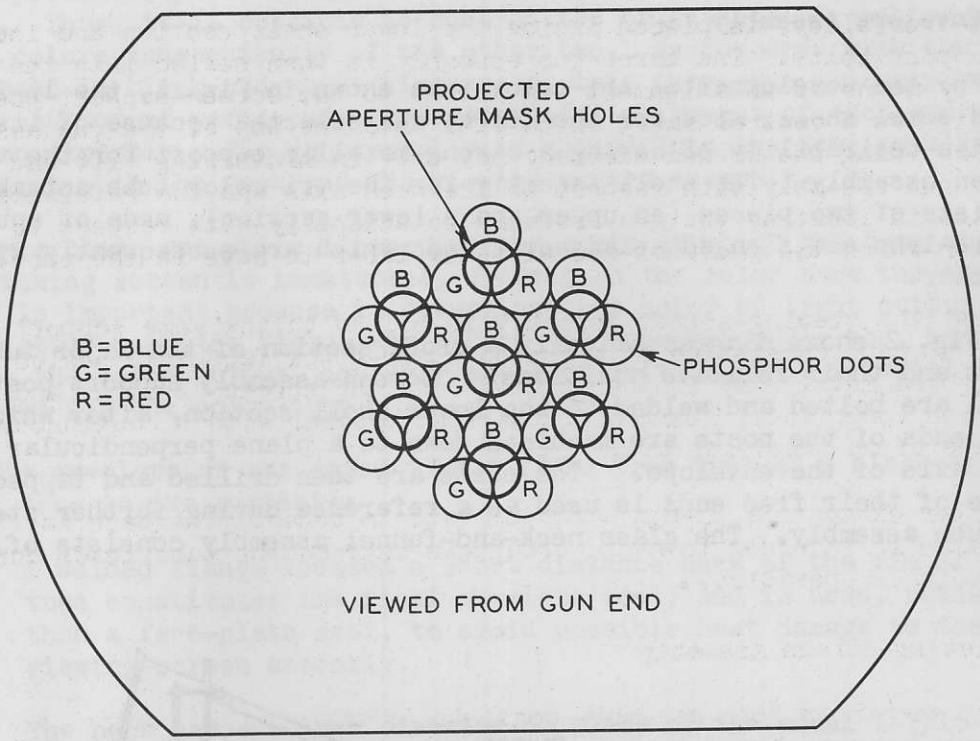

Fig. 3 - Orientation of Mask Holes with Phosphor Color Dots.

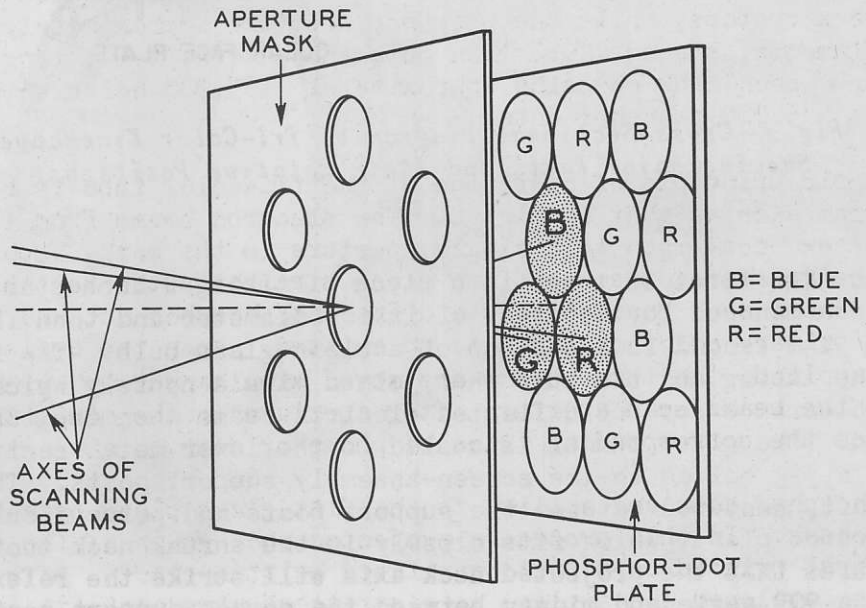

Fig. 4 - Diagram Illustrating Principle of Operation of Tri-Color Kinescope.

nickel-iron alloy) is placed inside the lower shell section and fastened to the post bolts. The three-gun assembly is then sealed into the neck, again by means of an alignment jig bolted to the screen-support posts. This jig has a central shaft which fits into the top of the gun assembly, thus providing the needed accuracy not only in minimizing tilt and offset of the gun assembly with respect to the neck axis and the reference plane, but also in locating the gun assembly rotationally with respect to the position which the phosphor-dot plate is later to have in the tube.

Next the viewing-screen assembly is bolted to the same support posts. The front cap, consisting of a curved clear-glass faceplate sealed into the flanged metal rim, is then placed over the screen assembly and the upper and lower shell flanges are sealed together with a continuous weld by means of an inert-gas arc.

After exhaust, a 14-pin diheptal base is added. The base is filled with plastic in order to avoid breakdown between the tube leads during high-voltage operation.

The Viewing-Screen Assembly

The viewing-screen assembly consists of three major parts: an aperture mask, a phosphor-dot plate, and a spacer frame which serves to hold mask and phosphor-dot plate in correct relative positions. Fig. 3 shows a projection of the viewing-screen assembly as seen from the gun end of the tube. The heavy circles indicate the aperture positions with respect to the phosphor dots. The holes in the mask and the phosphor dots on the glass plate present a hexagonal pattern; that is, the holes and dots are both arranged in rows oriented at 60° to each other. In alignment with each aperture of the mask is a trio of phosphor dots. A trio of dots consists of one each of blue-, green-, and red-emitting phosphors. The apertures are approximately 0.009 inch in diameter, spaced 0.023 inch between centers, while the phosphor dots are approximately 0.014 inch in diameter, spaced 0.014 inch between centers, i.e., tangent to each other. Each mask contains approximately 195,000 holes which correspond to 585,000 phosphor dots.

The basic principle of operation of the tri-color tube is best shown by a diagram such as that of Fig. 4. The electron beams from the three guns are shown converged to a single aperture in the mask. Upon passing through the aperture, they continue along straight paths to the phosphor-dot plate where each beam strikes a different phosphor dot and causes a different primary color of light to be emitted. When the deflecting field is applied, the three beams are moved simultaneously across the mask. As the beams scan aperture after aperture in the mask, they excite in sequence the corresponding trios of phosphor dots.

The phosphor dots are applied to the flat glass plate by a "silk" screen process. In this process a projected photograph of the aperture mask is first printed on a photosensitized gelatin sheet. After the gelatin is developed and applied to a stretched wire mesh, it is used as a stencil through which phosphor paste is squeegeed onto the glass plate. An exploded view of the viewing-screen assembly appears in Fig. 5, showing not only the major components (mask, frame, and phosphor-

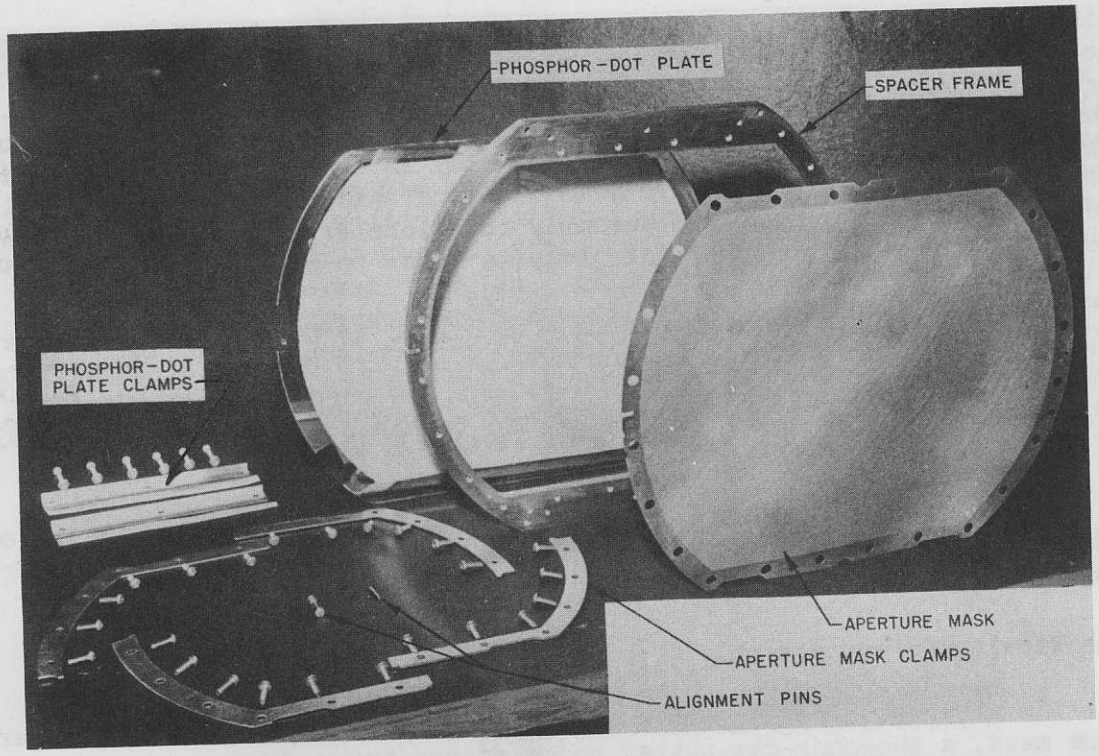

Fig. 5 - Exploded View of Viewing-Screen Assembly.

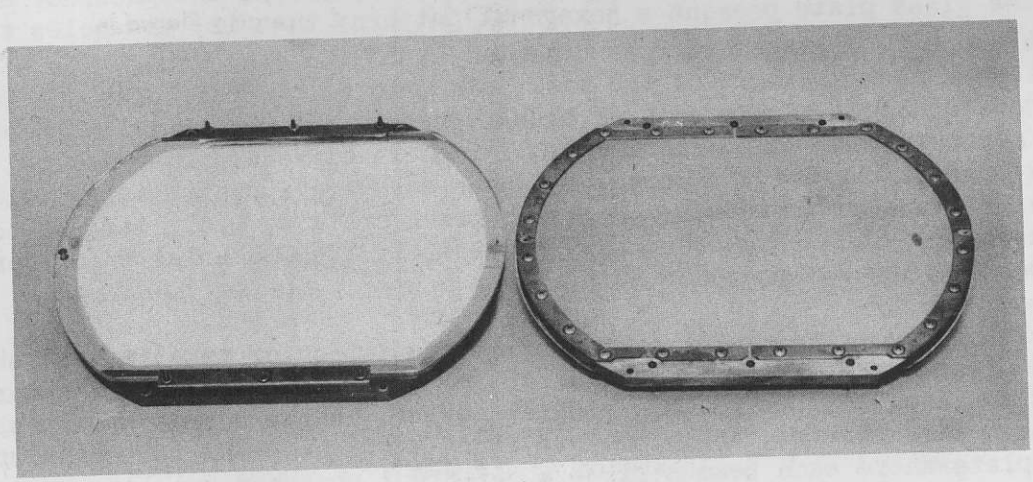

Fig. 6 - Front and Rear View of Viewing-Screen Assembly.

dot plate) but also the clamps and screws. After the phosphor-dot plate is processed and aluminized, it is assembled to the metallic spacer frame upon which the mask was stretched before photographing. Accuracy is required in all the steps of screen-making in order to produce an assembly having the mask holes and the phosphor dots correctly aligned.

Fig. 6 shows two views of the finished viewing-screen assembly ready for mounting in the envelope shell.

The Three-Gun Assembly

The gun assembly used in the tri-color kinescope is shown in Fig. 7. The assembly, in which the major parts are of non-magnetic stainless steel, consists of three single parallel guns spaced equidistant from, and at angles of 120° about the axis of the assembly. Each of the three guns includes an indirectly heated cathode and grids No. 1, 2, 3, and 4 Grids No. 4 open into a common cup, to which they are connected. When the tube is in operation, there exists between this cup and the conductive neck coating an electrostatic lens which serves to converge the beams at the aperture mask. Although this converging lens also tends to focus the individual beams, additional beam-focusing is needed and is provided by three separate lenses between grids No. 3 and 4. Although the three beams must ultimately be made to converge at the mask, there are two major reasons for using a parallel-gun structure. First, the

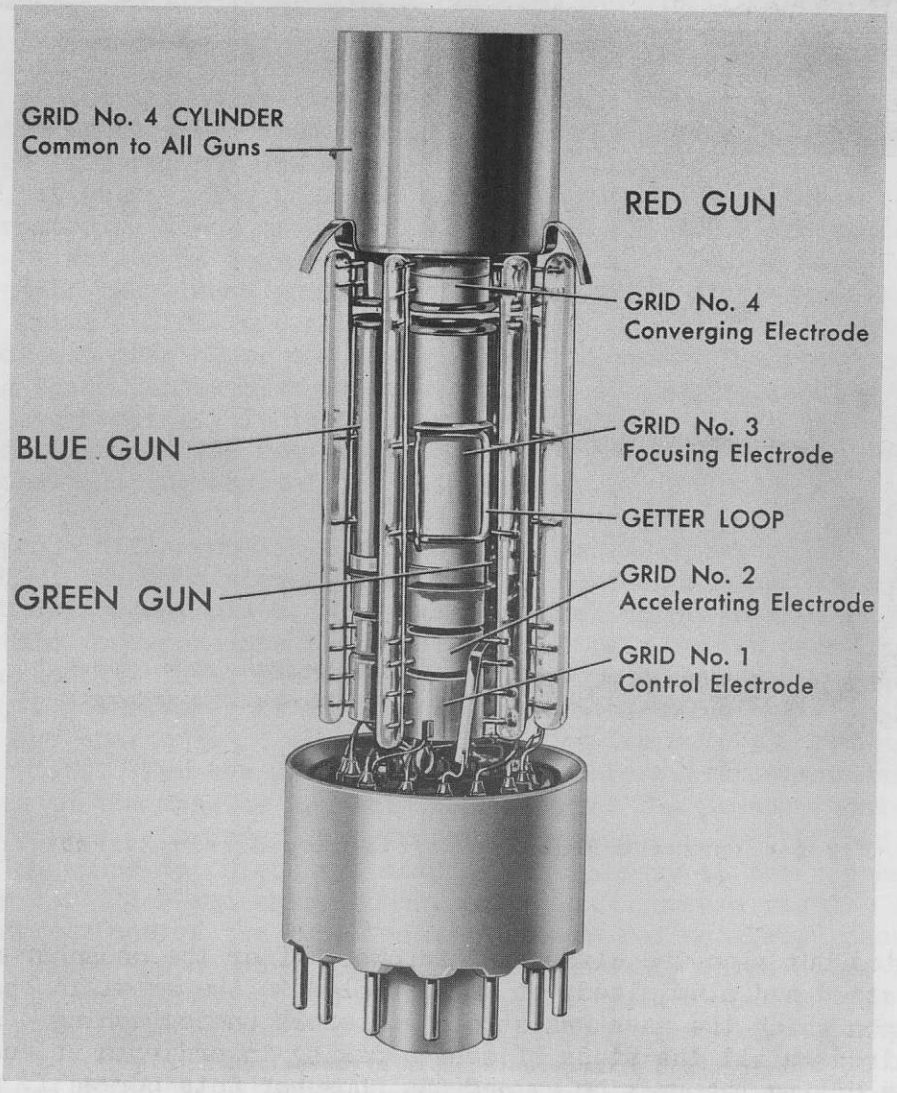

Fig. 7 - Structure of Three-Gun Assembly.

parallel arrangement is compact and therefore permits use of a neck of minimum diameter; and second, it allows the use of a parallel-membered jig, which may readily be kept in good alignment, both for mount assembly and for mount sealing.

Separate leads are brought out through the base from the three cathodes, the three grids No. 1, and the three grids No. 2 to permit adjustment of individual drive characteristics. There is a common base pin for the three grids No. 3. The three heaters are connected in parallel to two base pins.

Mr. Seelen concluded his talk with a summary of some of the more significant operation considerations covered in the tube bulletin on the RCA Developmental Kinescope C-73293-C.

Photolithographed in U.S.A.