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MANUFACTURE OF AN

RCA DEVELOPMENTAL

THREE-GUN TRI-COLOR KINESCOPE

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION
INDUSTRY SERVICE LABORATORY

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Approved

Stuart Wm. Seeley.

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Introduction

The characteristics and operation and the internal geometry of the RCA Tri-Color Kinescope C73293 are described in LB-808 *Characteristics and Operation of an RCA Developmental Three-Gun Tri-Color Kinescope* and LB-809 *Geometrical Considerations of an RCA Tri-Color Kinescope*. The present bulletin describes the techniques used in producing the engineering models of this tube. Many of the operations employed in the making of a tri-color kinescope are identical with those used in conventional kinescope manufacture and are omitted from this bulletin, whereas those procedures and component parts which are peculiar to the C73293 are given.

General Discussion

The manufacture of the tri-color kinescope can be divided into two parts: (1) fabrication of the aperture mask--phosphor-dot plate assembly and (2) the building of this assembly, together with electron guns, into a metal envelope to form a finished tube. For brevity, the aperture mask--phosphor-dot plate assembly is referred to as the "screen assembly".

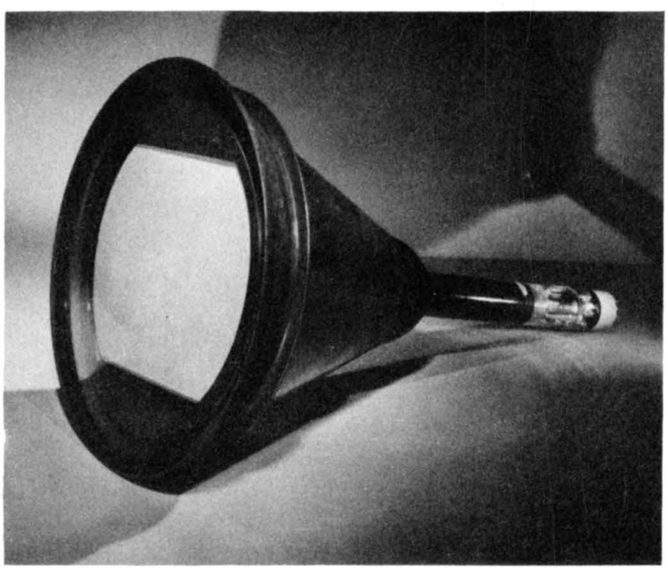

Fig. 1 - Photograph of an RCA three-gun tri-color kinescope.

Though this bulletin describes the manufacture of the three-gun tri-color kinescope, it should be noted that the screen assembly can be the same whether a single-gun or three-gun tube is to be made. The metal cone could also be the same but the design of the glass neck for the cone would differ. Tools and jigs for positioning the guns would also be different for the single and triple-gun tubes. A photograph of the complete three-gun tube ready to be placed in operation is seen in Fig. 1.

Screen-Assembly Fabrication

Description

The screen assembly consists of an aperture mask, spacer frame, and tri-color phosphor-dot plate. The phosphor-dot plate, which acts as the direct-view color screen, is a flat glass plate on which has been deposited an orderly array of small, closely spaced phosphor dots arranged in triangular groups. Each group comprises a green-emitting dot, a red-emitting dot, and a blue-emitting dot. The aperture mask, which is located between the electron-gun structure and the phosphor-dot plate, is made of metal and contains an array of holes. For each dot group on the phosphor-dot plate there is a corresponding opening in the aperture mask.

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It is the function of the spacer frame to maintain the correct spacing between the aperture mask and phosphor-dot plate. Exact aligment of the three units is assured by two pins, one of which goes through close-fitting holes in the three pieces at one edge, and the second pin which passes through close-fitting slots in the mask-frame subassembly and a close-fitting hole in the phosphor-dot plate at the oposite edge. An exploded view of the various components incorporated in the screen assembly is shown in Fig. 2.

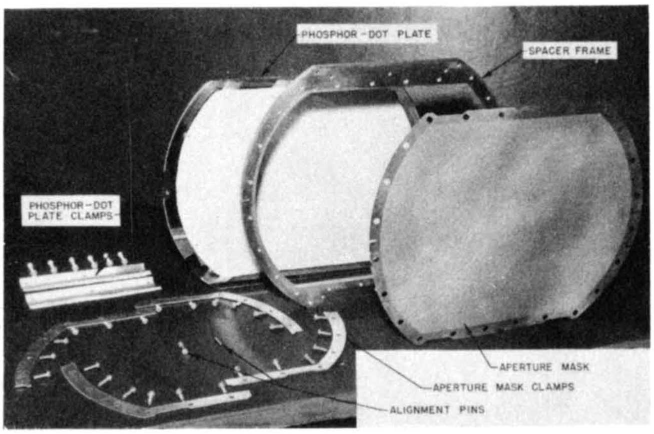

Fig. 2 - Exploded view of screen assembly.

Aperture Mask

The thin metal sheet in which the array of holes is etched to form the aperture mask is made from 0.004-inch thick copper-nickel alloy, ASTM B122-48T alloy No. 5. A photograph of the aperture mask with an enlarged sketch of the apertures is shown in Fig. 3. Photoengraving techniques are used to etch the proper holes in the metal.

Spacer Frame

The spacer frame is shown in Fig. 4. It will be noted that it is wider at the top and bottom to provide room for screw holes to fasten the phosphor-dot plate to the spacer frame and for screw holes to fasten the screen assembly to the metal cone. The thickness of the spacer frame is uniform and is determined for a particular design by the position of the electron guns with respect to the aperture mask and the spacing between holes in the aperture mask.

Mounting of Aperture Mask on the Spacer Frame

The aperture mask is mounted on the spacer frame by means of clamps and screws. In order

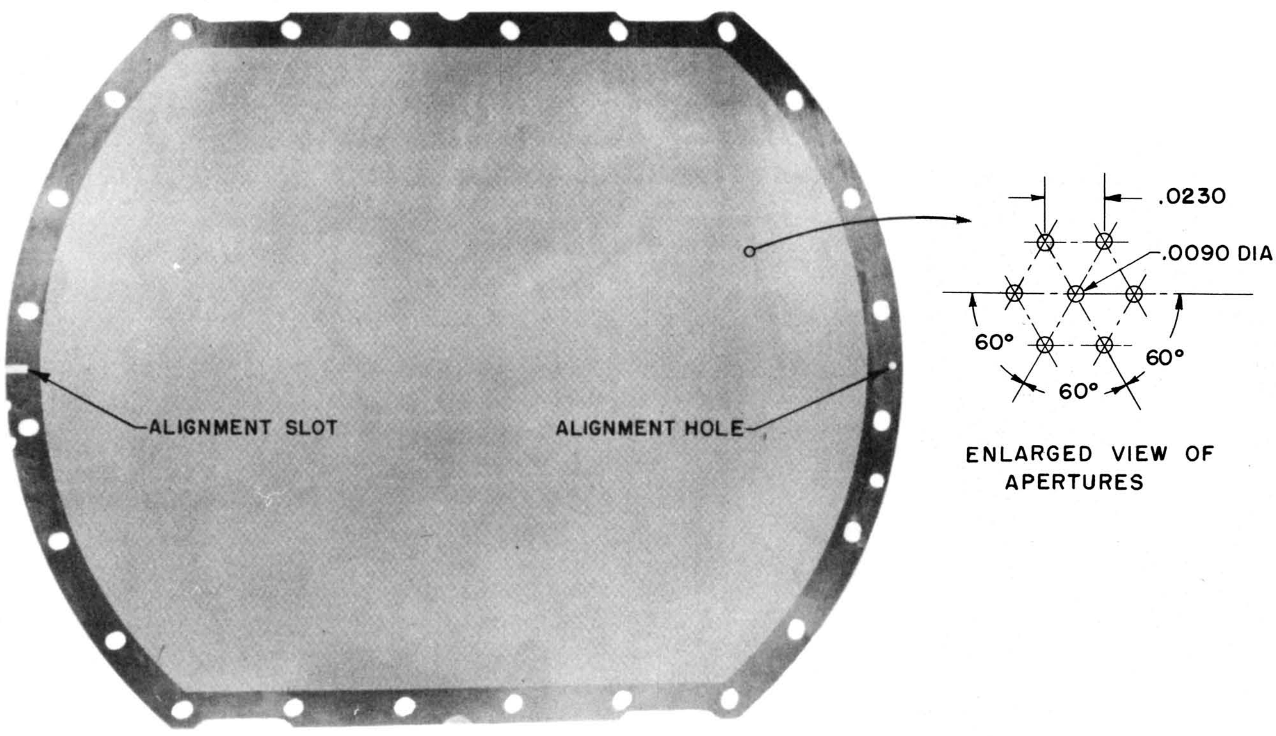

Fig. 3 - Aperture mask with enlarged sketch of the apertures.

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to mount the mask in a taut condition, a technique known as "hot blocking" is used. The mask is placed between the clamps and the spacer frame. The screws that are to clamp the mask to the spacer frame are started but are not tightened. The holes in the aperture mask are oversize for the screws, but the pins are arranged so that at one end a pin fits through the alignment hole in the mask and the corresponding hole in the spacer frame; while at the other end, the pin is placed in the alignment slot in the mask and the matching slot in the spacer frame. This arrangement permits differential expansion and contraction of the parts.

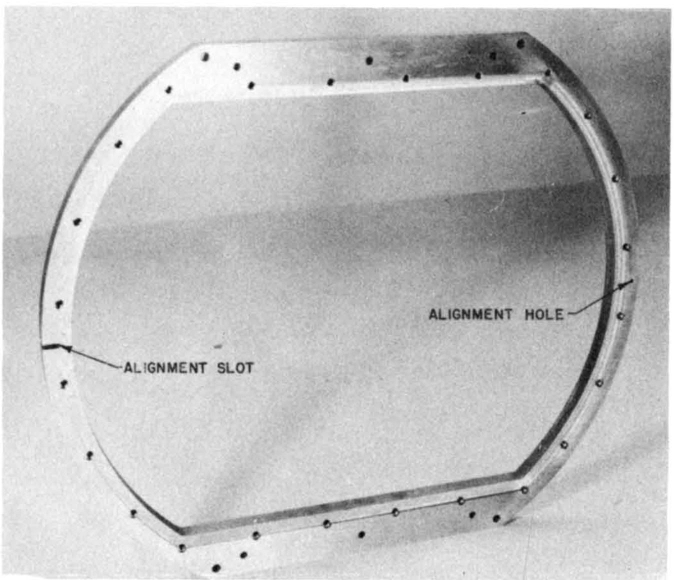

Fig. 4 – Photograph of spacer frame.

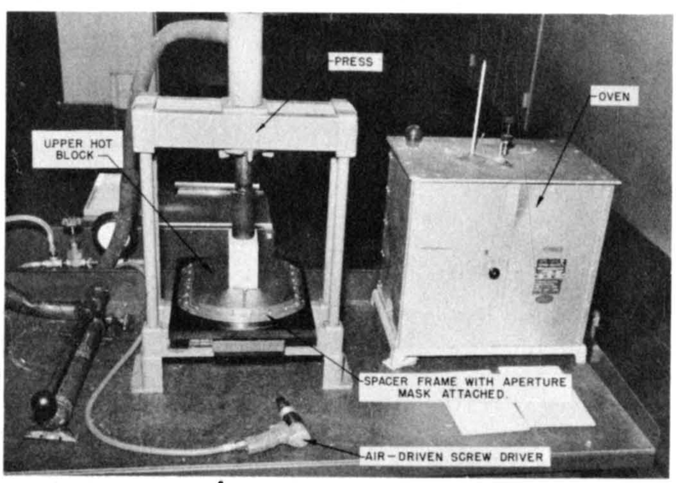

Fig. 5 – Press and oven for "hot blocking" of aperture mask to spacer frame, showing sub-assembly in position on the press.

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Next, two blocks of metal of proper shape to fit inside the spacer and clamps are heated in an oven to about 85 degrees C. They are then placed on either side of the mask, causing the mask temperature to rise and expansion to take place. The screws are tightened quickly with an air-driven screw driver and the hot blocks removed. When cool, the mask is taut and properly located on the spacer frame. The press and oven used for this "hot blocking" operation are shown in Fig. 5. In this illustration the mask-frame subassembly is shown in position with the metal blocks. In the foreground is seen the air-driven screw driver.

Method for Locating Phosphor Dots

Following assembly of the aperture mask on the spacer frame, this subassembly is positioned, open end up, at the top of a unit which is referred to as the "lighthouse". A point source of light equivalent to a Western Union concentrated-arc lamp is placed in the lighthouse at a position below the mask-frame subassembly corresponding to the position where the electron beam, which excites the blue phosphor, will cross the deflection plane in the assembled tube. A Kodalith photographic plate is placed on top of the spacer frame so that its position corresponds to the location of the phosphor-dot plate in the final assembly. An exposure is then made through the mask. After development of the photographic plate there is recorded on it an opaque spot corresponding to each mask opening. These spots correspond to the locations where the blue phosphor should be placed on the phosphor-dot plate to be struck by the electrons from the blue-exciting electron gun.

The principle of using a light source to locate the position of the phosphor dots is shown diagrammatically in Fig. 6. In Fig. 7, the actual lighthouse with the mask-frame subassembly and the photographic plate in position for exposure are shown. In Fig. 8, the light shield has been removed from the lighthouse to show the adjustments for positioning of the light source.

For this portion of the process, the two alignment pins previously used for accurately positioning the mask and frame are removed. At the time of the exposure, the positions of the alignment hole and the alignment slot are recorded on the plate by means of two small

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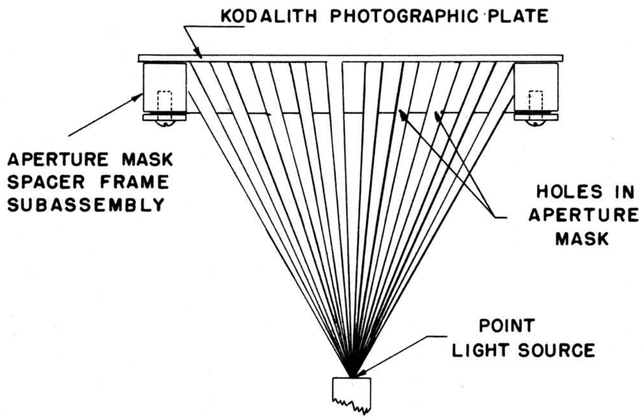
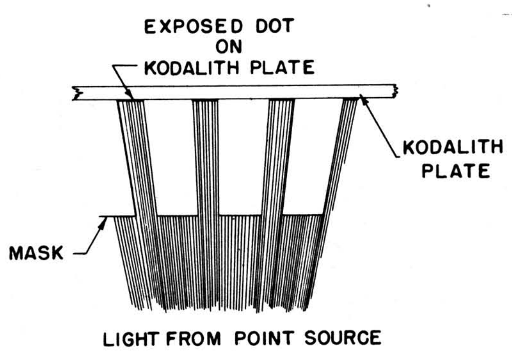


Sketch showing lighthouse operation.



Enlarged view of section of aperture mask spacer frame, subassembly.

Fig. 6 - Sketch demonstrating principle of lighthouse.

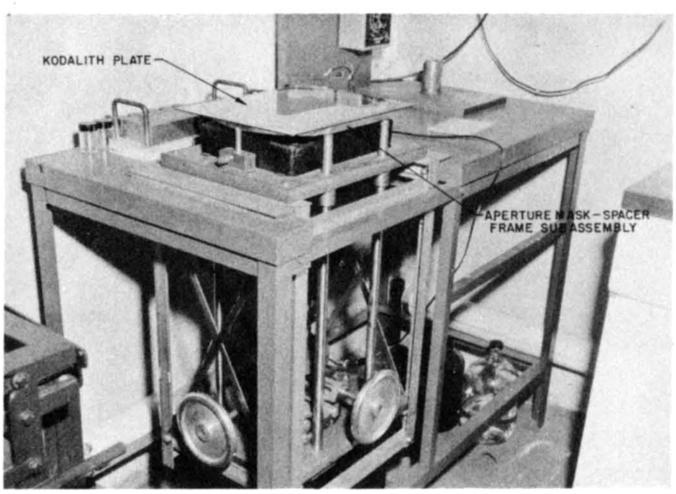


Fig. 7 - Lighthouse with mask-frame subassembly and photographic plate in position.

supplementary lights so that the position of the phosphor-dot pattern with respect to the mask is determined. These supplementary light sources are so constructed that their light is confined only to the alignment hole and slot, respectively. Only the blue phosphor color position is recorded on the plate, since the the two other color patterns are identical but shifted so that the three arrays nest together.

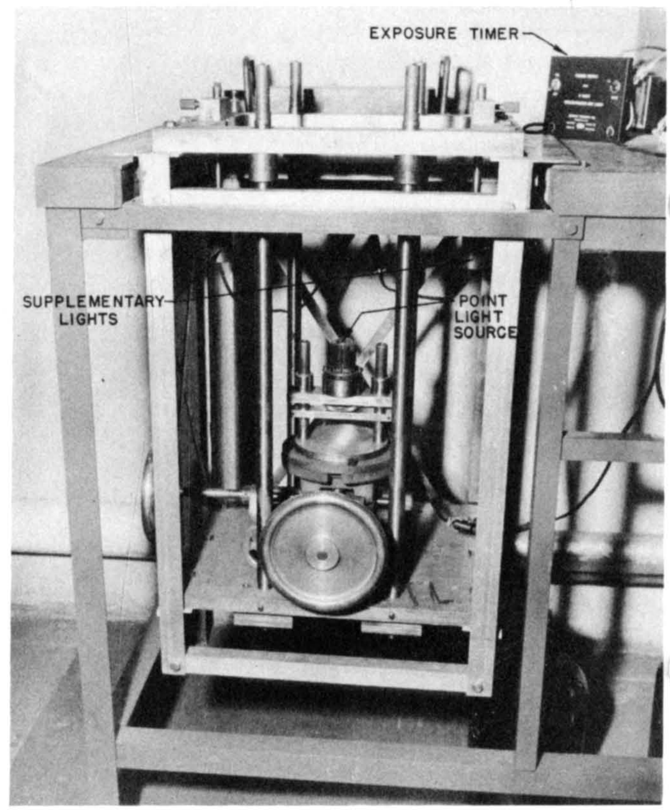


Fig. 8 - View of lighthouse with light shield removed.

Phosphor Dot Printing Stencil

The Kodalith plate mentioned above is used to make a gelatin-stencil printing pattern. The procedure employs novel techniques in printing the phosphor-dot plate. For best accuracy it has been found desirable to use metal mesh for the printing screen. The process is as follows: Commercial paper-backed pigmented gelatin is sensitized in dichromate solution. A sheet of 0.005-inch thick Vinylite is then placed over the gelatin and excess sensitizer is squeezed off. While the Vinylite-gelatin-paper sandwich is still damp, a contact exposure is made of the Kodalith plate, the Vinylite being placed in contact with the Kodalith emulsion. Figs. 9 and 10 show the equipment used to make the gelatin contact print.

The gelatin is then developed by removing its paper backing and rinsing it in warm water

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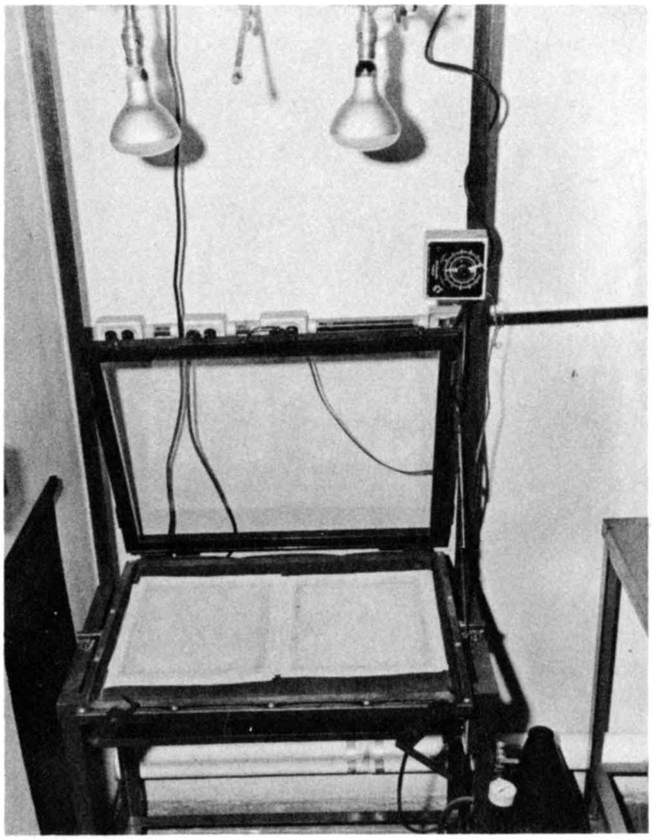

Fig. 9 - Vacuum frame and light for making gelatin stencil. Frame open.

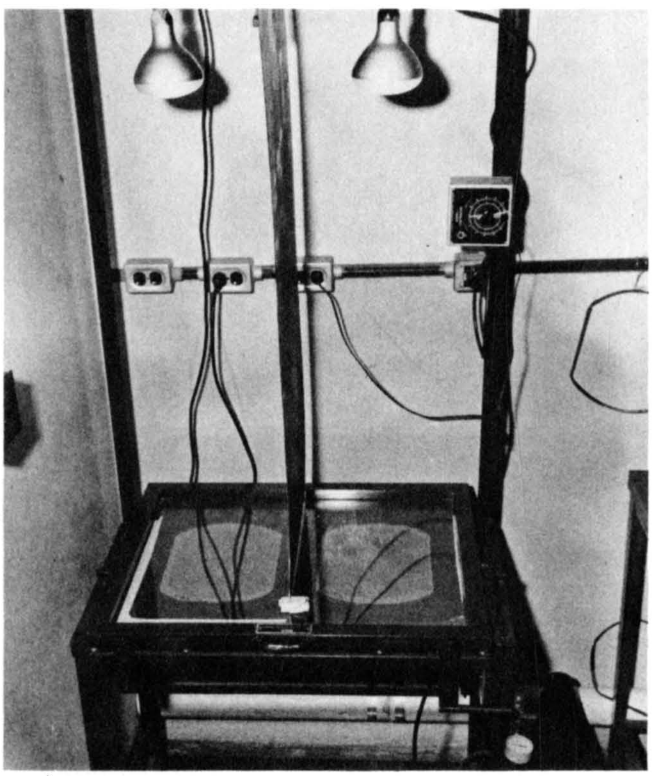

Fig. 10- Making gelatin stencil from Kodalith plate. Frame closed and light baffle in place.

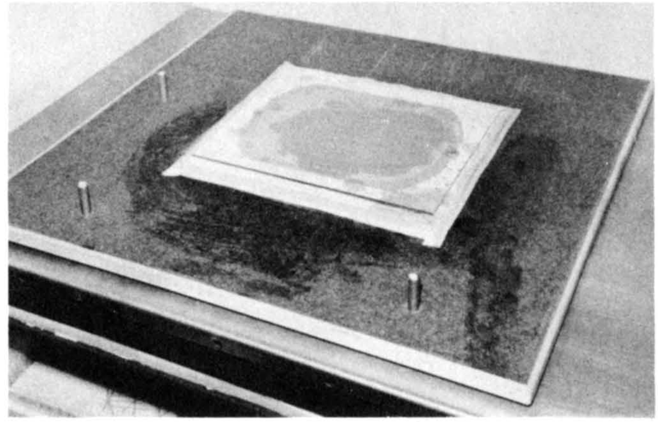

Fig. 11- Wet gelatin stencil ready for transfer to printing screen.

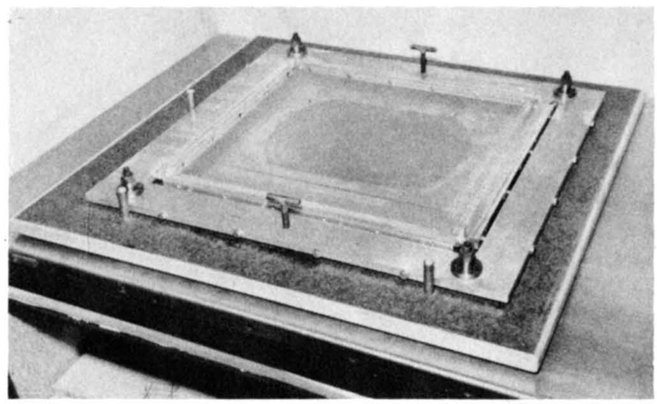

Fig. 12- Gelatin stencil being transferred to printing screen.

until all unexposed gelatin has been washed away. The exposed insoluble gelatin remains in contact with the Vinylite. The temperature of the wash water is brought slowly down to 68 degrees F to shrink the pattern slightly. This is done to compensate for a distortion that is produced by the printing process, as will be explained in the following paragraph. The wet gelatin stencil ready for transfer to the printing screen is shown in Fig. 11. The Vinylite with the attached pattern is placed on a wire mesh and allowed to dry. Fig. 12 shows the gelatin stencil being transferred to the wire mesh. The Vinylite is then removed while the the gelatin remains on the mesh.

Phosphor-Dot Printing

Before application of the phosphor-dot pattern to the glass plate, the plate must be cut to the proper shape and two holes to fit the alignment pins must be drilled. For printing, the plate is placed on the printing table shown in Fig. 13, where it is held by a vacuum chuck

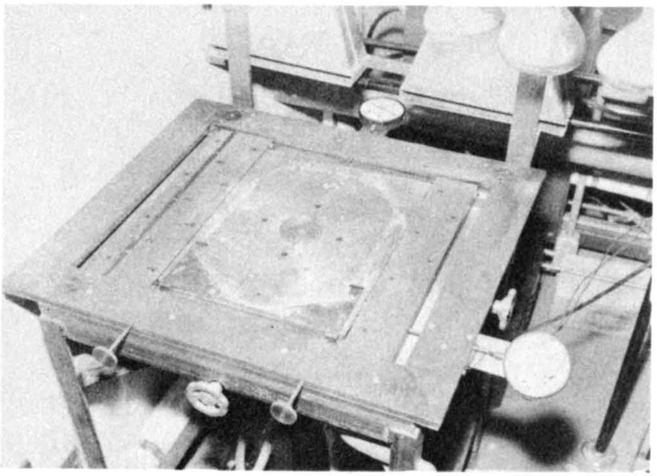

Fig. 13– Top view of printing table.

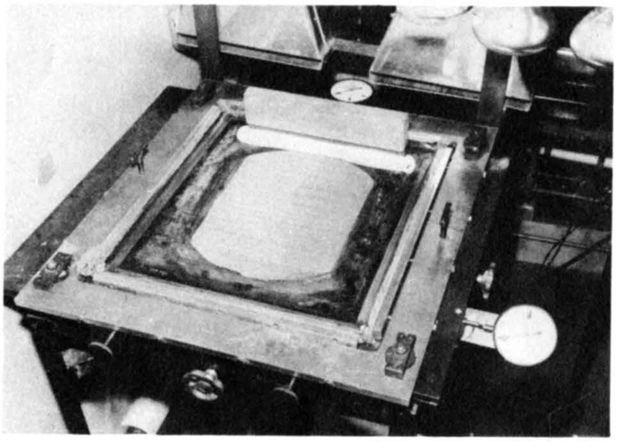

Fig. 14– Phosphor paste on printing screen in position to be squeegeed through gelatin stencil.

under the mesh-supported gelatin stencil. Before the vacuum is drawn, the glass plate is aligned with the stencil so that the holes in the glass come under the corresponding openings in the gelatin. Next, the blue phosphor paste is placed at one end of the top surface of the stencil as illustrated in Fig. 14. A squeegee is moved across the top surface of the printing screen forcing the phosphor through the stencil in a pattern corresponding to that of the gelatin. When the stencil is removed, the plate bears a printed dot pattern which matches the original dot array. The process of drawing the squeegee over the printing screen causes a slight elongation of the pattern in the direction of motion. In the previous paragraph it was mentioned that the pattern is shrunk just prior to being attached to the printing screen. This shrinking is done so as to compensate for the elongation of the pattern during the printing process. Usually a trial print is made and compared with a contact print of the original Kodalith dot array to check the accuracy of reproduction.

Ethylcellulose dissolved in amyl alcohol is used as a binder for all of the phosphors. The viscosity is adjusted to give the correct flow of phosphor so that the proper amount will be deposited on the plate to obtain a round dot. If the mixture is too thin, the resulting dots will be too large.

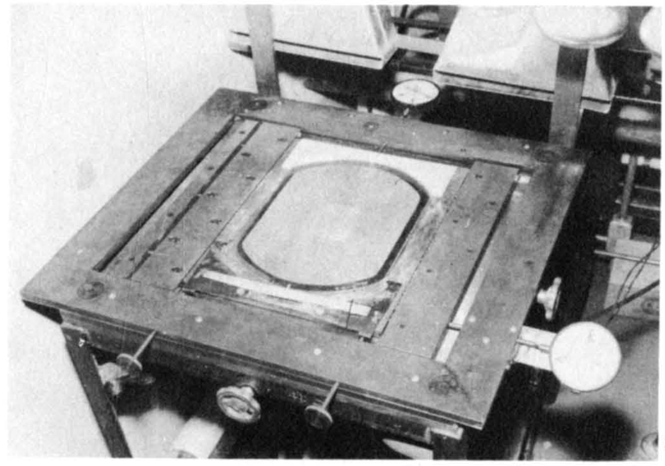

Fig. 15– Phosphor-dot plate on printing Table ready to be moved to position for printing next phosphor.

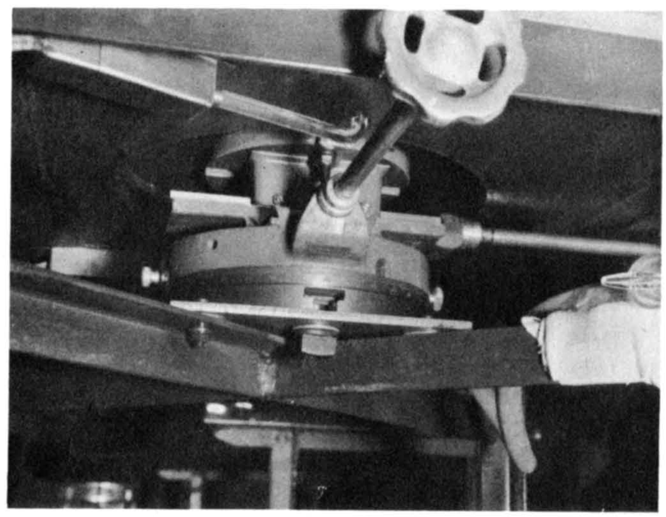

Fig. 16– Close up of cross-feed mechanism for positioning phosphor-dot plate on printing table.

After the first array of dots has been printed, the stencil is removed, cleaned, and replaced in its original position. The glass plate is then moved by a cross-feed arrangement to the proper position for the printing of the

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red phosphor. As seen in Fig. 15, the position of the glass plate is determined by accurate dial gauges. The motion is controlled by a cross-feed mechanism which is separately pictured in Fig. 16. In a similar manner the green phosphor is printed. Since it has been found necessary to build up the dots by printing each color two or three times, the different color phosphors are printed in rotation so as to maintain good contact between the stencil and the glass plate.

As a final check, the phosphor-dot plate is placed back on the lighthouse to see that the light spots from the point light source fall on the blue-emitting phosphor dots. At the same time, a microscopic inspection is made of the phosphor dots to assure proper nesting of the red-emitting and green-emitting phosphor dots with respect to the blue-emitting phosphor dots.

Aluminizing of the Phosphor-Dot Plate

After the dots have all been printed, the phosphor-dot plate is baked in air to burn out the binder. When cool, the plate is sprayed with a solution of potassium silicate and dried to bond the phosphor to the glass. The screen is then filmed, aluminized, and rebaked. A photograph of the completed phosphor-dot plate is shown in Fig. 17.

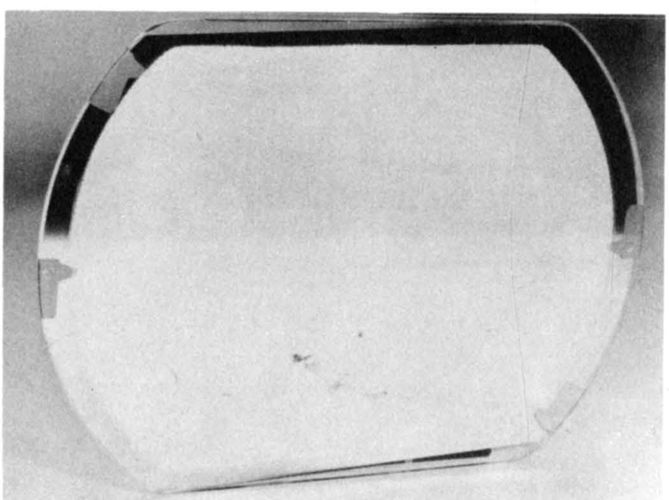

Fig. 17– Photograph of completed phosphor-dot plate.

Assembly of the Screen Assembly

The aluminized phosphor-dot plate is located on the spacer frame with the two alignment pins that pass through matching holes in the glass and the spacer frame at one end and through a hole in the glass and a corresponding slot in the spacer frame at the other end. In addition, clamp plates are screwed to the straight sides of the spacer frame which hold the glass against the spacer frame with a cushion of glass tape. Fig. 18 shows front and rear views of the screen assembly.

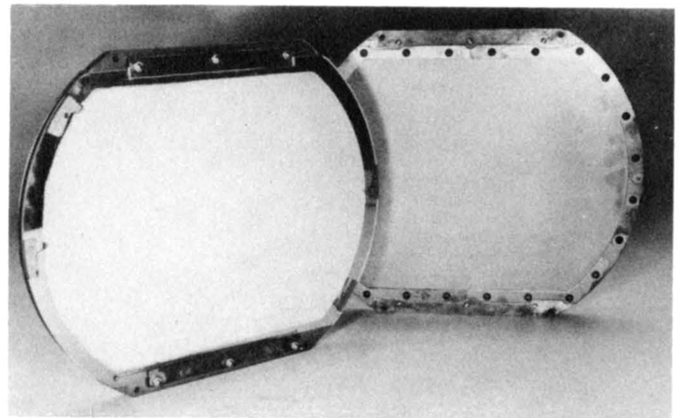

Fig. 18– Front and rear view of screen assembly.

Tube Fabrication

Many of the operations employed in the fabrication of the tri-color kinescope and in the final tube assembly are identical with those used in conventional kinescope manufacture. The procedures and component parts which will be discussed are those peculiar to this tube.

General Description

The essential features of the tube assembly may be noted in Fig. 19. Basically, the complete tube assembly consists of the following subassemblies:

1. Mount – Consists of essentially three cathode-ray guns mounted on a 14-lead stem complete with exhaust tubulation.

2. Magnetic Shield – A two-piece assembly consisting of a large metal frustum and a smaller cup which is welded to the small end of the frustum.

3. Neck-Funnel – Accurate-bore tubing joined to a special bulb to form the lower glass portion of the tube.

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4. Front Cap - Consists of a clear glass face plate sealed to a short, flanged metal frustum.

5. Main Tube Envelope - A large metal frustum to which is assembled the supporting posts for the screen assembly. In it is placed the magnetic shield.

6. Screen Assembly - Consists essentially of the aperture mask, spacer frame and tri-color phosphor-dot plate. Its specifications and fabrication are described in the previous section of this bulletin.

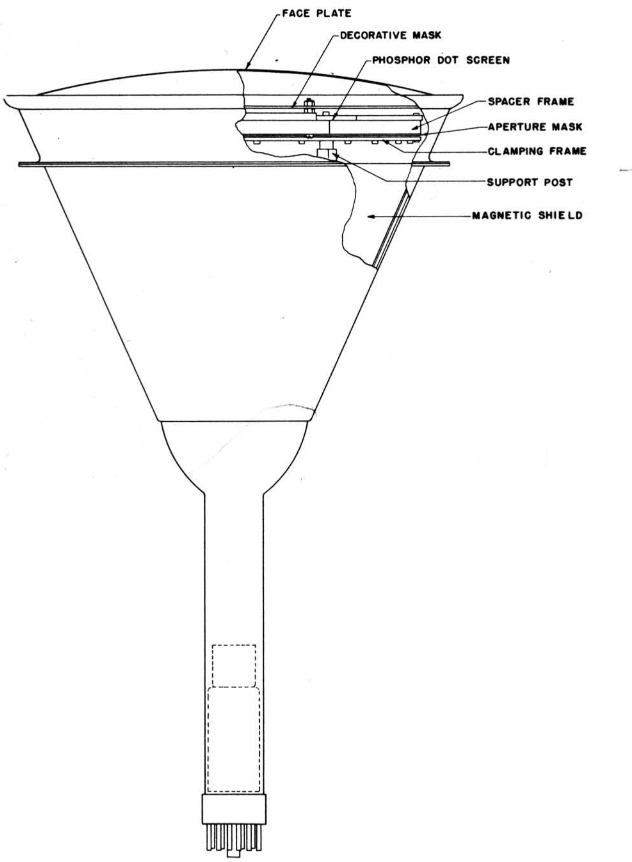

Fig. 19- Cut-away view of RCA tri-color kinescope C73293.

The metal envelope employed consists of two parts. The shorter and large diameter frustum contains the face plate. The longer frustum contains the mounting for the screen assembly and the magnetic shield. Attached to the neck end of the metal envelope is the neck-funnel assembly which houses the electron guns or mount.

Front Cap Subassembly

The upper or larger-diameter frustum is formed on the 16AP4 spinning mandrel. It is cut to the proper length and the neck end is flanged so that it may be welded to the lower frustum. The curved face plate is sealed to the larger diameter frustum in the usual fashion. Then, the inside of the frustum is blackened to minimize light reflections. This subassembly is called the front cap and is shown in Fig.20.

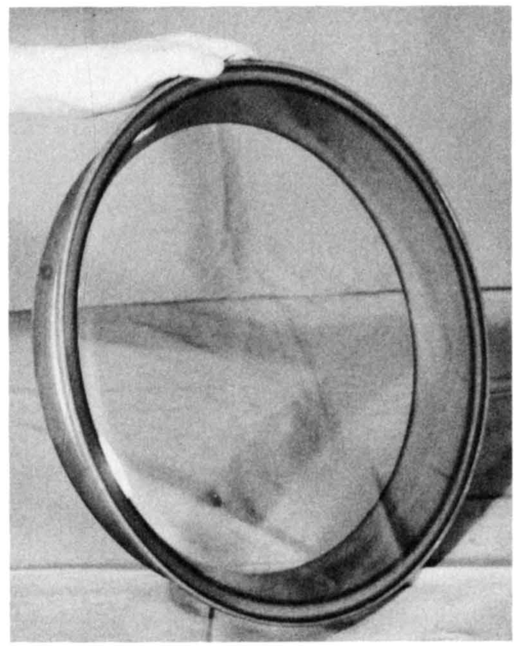

Fig. 20- Photograph of front cap assembly.

Main Tube Envelope

The longer or lower frustum is also formed on the 16AP4 spinning mandrel. After being cut to the proper length, the larger end is flanged to the same outside diameter as the flange of the upper frustum so that they may be welded together in subsequent operations. The frustum is then inserted in a drill jig and the mounting holes for the screen assembly support posts are drilled. The mounting screws for the posts are inserted and the head of each screw is welded with a vacuum tight weld to the metal envelope. The longer frustum, with the screws welded in position and one of the support posts attached, is illustrated in Fig. 21. The longer screw shown nearer the neck end of each post is used to hold the internal magnetic shield.

After mounting, the tops of the four posts are machined to a flat plane. The holes in the

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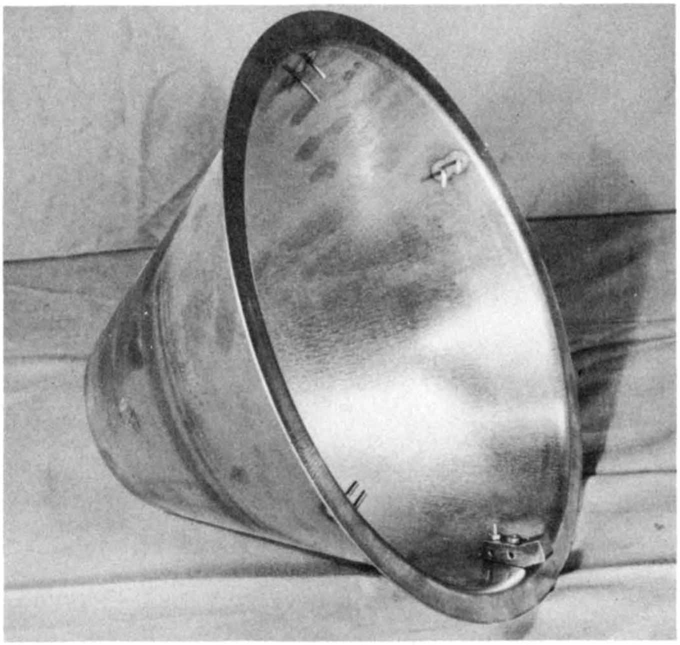

Fig. 21– Photograph of main tube envelope with welded screws and one of the four mounting posts attached.

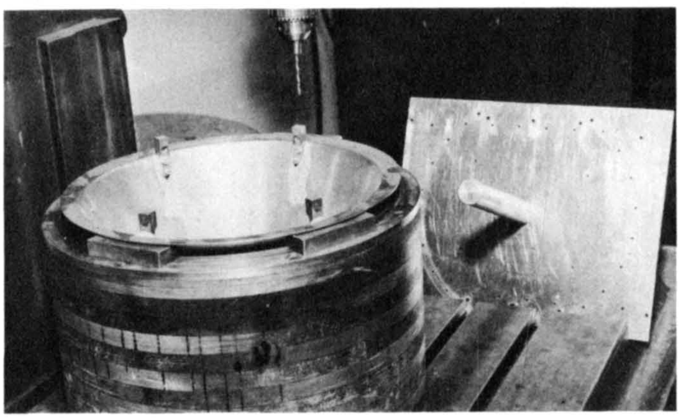

Fig. 22– Drilling jig used to drill mounting posts.

posts for the screen assembly mounting are accurately located by means of a special drill jig. Fig. 22 shows the special drill jig employed for this operation. The actual drilling process using this jig is illustrated in Fig. 23. The upper portion of each hole is reamed and the lower portion is threaded to receive a mounting screw.

Neck-Funnel Subassembly and its Attachments to the Main Tube Envelope

Two-inch neck tubing of accurate bore is cut to the correct length. One end is flared to obtain the proper contour for beam clearance, and correct location of the reference line.

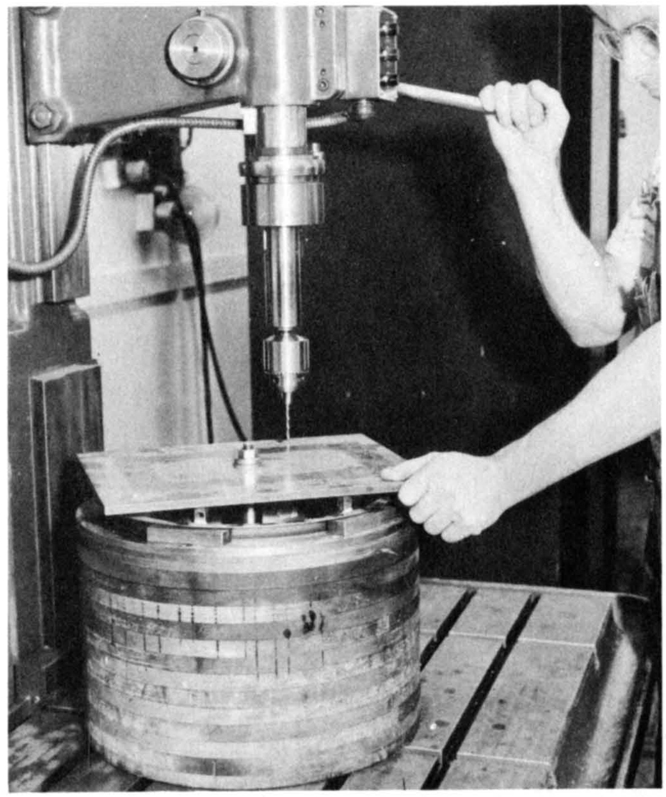

Fig. 23– Drill press showing four posts being drilled.

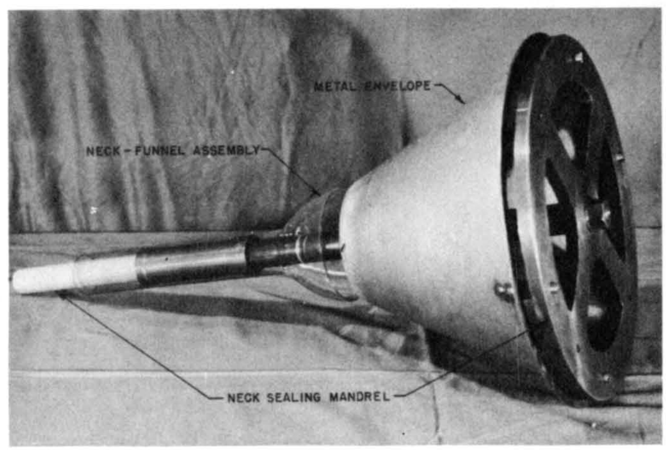

Fig. 24– Metal frustrum and neck funnel shown on sealing mandrel.

This unit is then assembled to a glass bulb and sealed to form the neck-funnel assembly. This assembly may be seen in the lower portion of Fig. 24. In Fig. 24 is seen the jig which fastens to the four mounting posts previously mounted on the longer frustum and in turn to which an inside, neck-sealing mandrel is fastened. This makes the center line of the neck coincide with the center of the screen and also be normal to it. The neck-funnel to metal-

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envelope seal is made maintaining the distance between the reference line and the top of the posts within very close tolerances. The lower end of the neck is flared for ease of mount insertion prior to mount seal. The inside of the glass neck and funnel is coated down to a point just below the top of the mount location with conductive graphite coating.

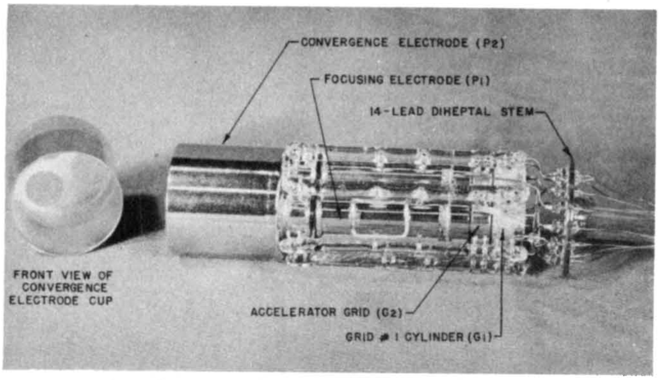

Fig. 25- Photograph of mount with separate view of convergence electrode cup.

Tube Mount

A photograph of the gun assembly or tube mount is shown in Fig. 25. The unique part employed is the convergence electrode cup shown beside the complete mount in Fig. 25. Because of the high voltage gradients involved, rolled-edge thimbles are used between the top of the focusing electrode cylinder and the small cylinders welded to the large convergence electrode cup. The assembly on the mandrel as shown in Fig. 26 starts with the large cup to which are welded three short cylinders by means of special eyelets. The focusing electrode cylinders are placed on the mandrel and are joined by a collar near the lower edge of the cylinders. These cylinders contain limiting apertures to produce fine spots. Accelerating electrode cylinders and conventional control grid-cathode assemblies matched for cutoff characteristics are next added. A high-frequency getter is welded to the focusing electrode cylinder on two of the three electron guns. Each getter is shielded to direct the getter flash toward the neck wall. The assembly is made a rigid unit by glass beading to hold the various components in line. This three-gun assembly is mounted on the 14-lead diheptal stem and at the same time the heaters, tied in parallel, are added. The stem has the usual glass exhaust tubing for subsequent seal to the exhaust system.

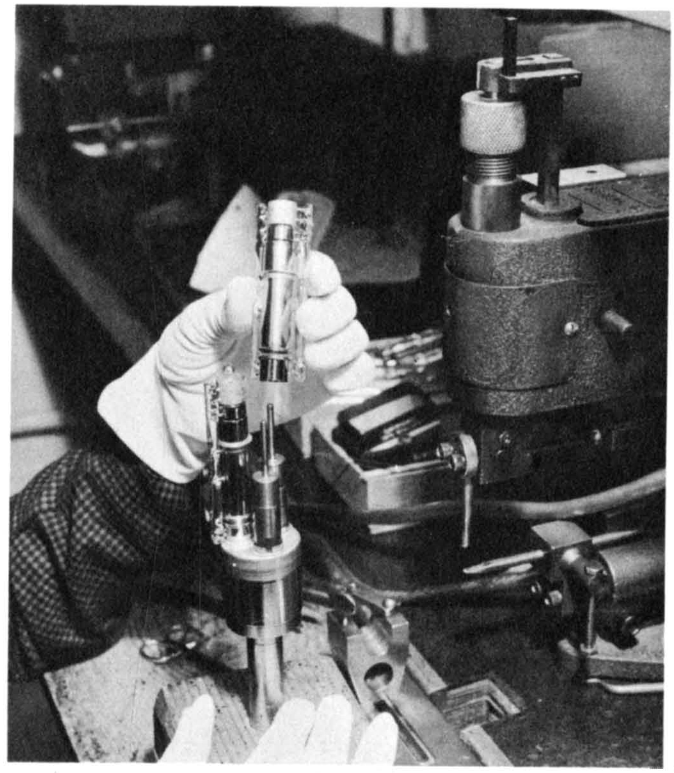

Fig. 26- Assembly of mount on mandrel.

The mount is sealed into the neck through the use of a sealing mandrel. This mandrel shown in Fig. 27 is inserted into the lower-frustum neck assembly and fastened to the four mounting posts. The gun is inserted into the neck and mandrel and then sealed into the neck. The alignment is such that the slot side of the screen assembly should be on the same side of the tube as the heater leads.

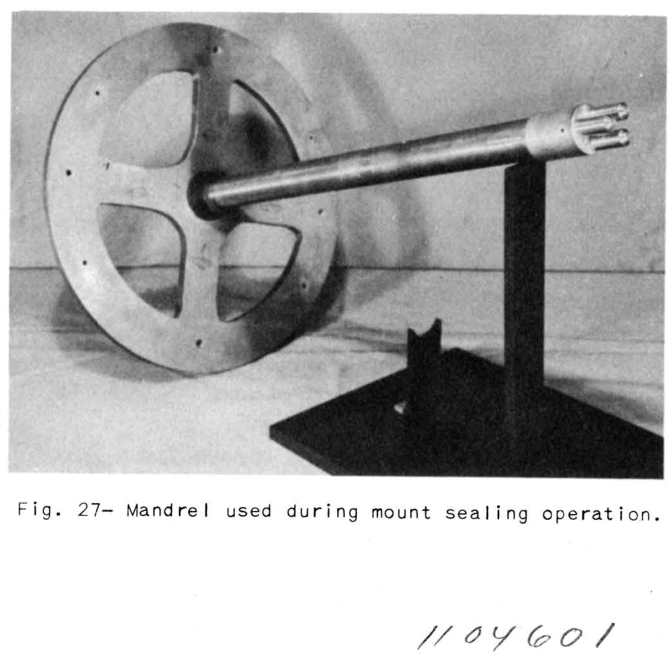

Fig. 27- Mandrel used during mount sealing operation.

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Magnetic Shield and its Attachments to the Main Tube Envelope

As shown in Fig. 28, the shield consists of two parts. The larger part is a metal frustum of a shape similar to the tube envelope frustum. The smaller cup-shape portion is welded to the larger part and extends down into the glass funnel. Cut into the side of the frustum are four flaps with mounting holes in them. As seen in Fig. 29, these flaps are used to fasten the shield to the mounting posts. The shield assembly must be annealed prior to assembly in the tube to remove residual magnetism.

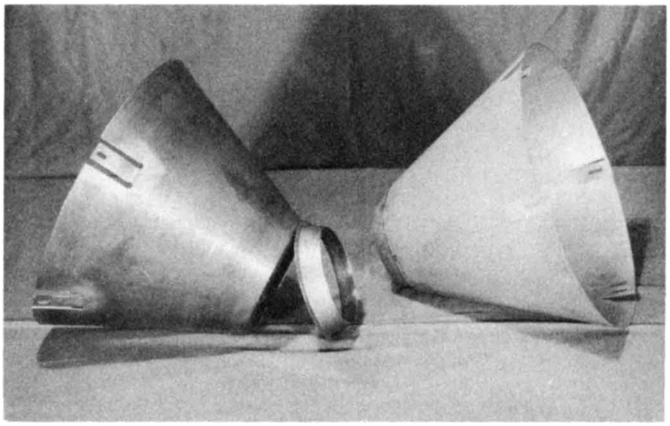

Fig. 28– Magnetic shield, before and after assembly

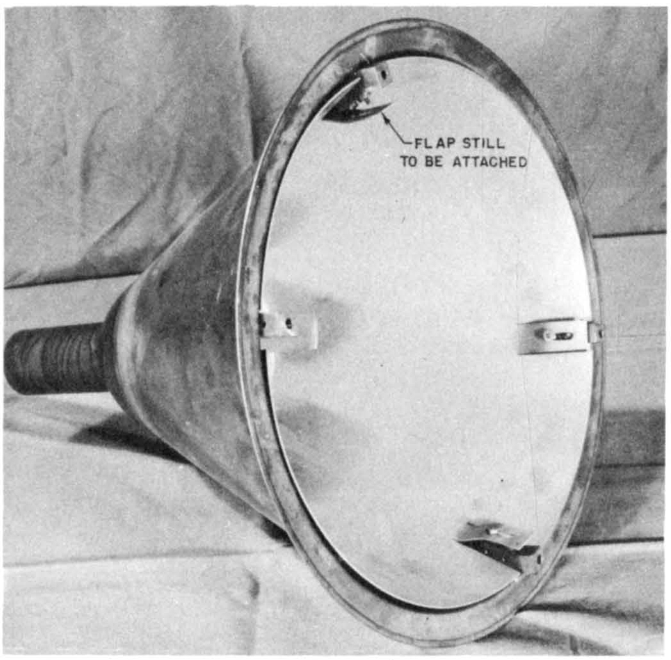

Fig. 29– Main tube envelope with posts and shield mounted, and neck coated.

After the mount is sealed into the neck, the magnetic shield is inserted inside the main tube envelope and fastened by the use of an additional nut on the longer of the two screws holding each mounting post. Fig. 29 shows the shield in its position inside the main tube envelope with one of the flaps still to be attached to a mounting post.

Attachment of Screen Assembly and Front Cap to the Main Tube Envelope

The screen assembly is fastened to the four posts, prior to which washers are placed between the screen assembly and the posts to assure correct spacing between the screen assembly and the reference line. A decorative mask is fastened across the top leaving the phosphor-dot screen visible. This assembly may be seen in Fig. 30.

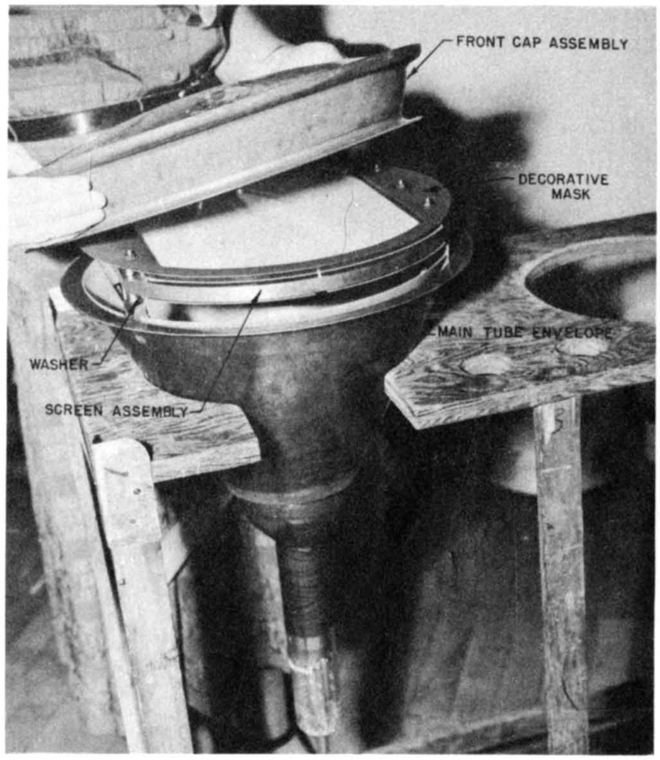

Fig. 30– Lowering front cap in place.

In Fig. 30 is also shown the manner in which the front cap is lowered in place. The two metal frustums are welded together at the flanged portions by means of a Heliarc welder. This operation is pictured in Fig. 31.

Finishing Operations

The tube assembly is placed on a vertical exhaust position as illustrated in Fig. 32. The tube is baked at a maximum temperature of

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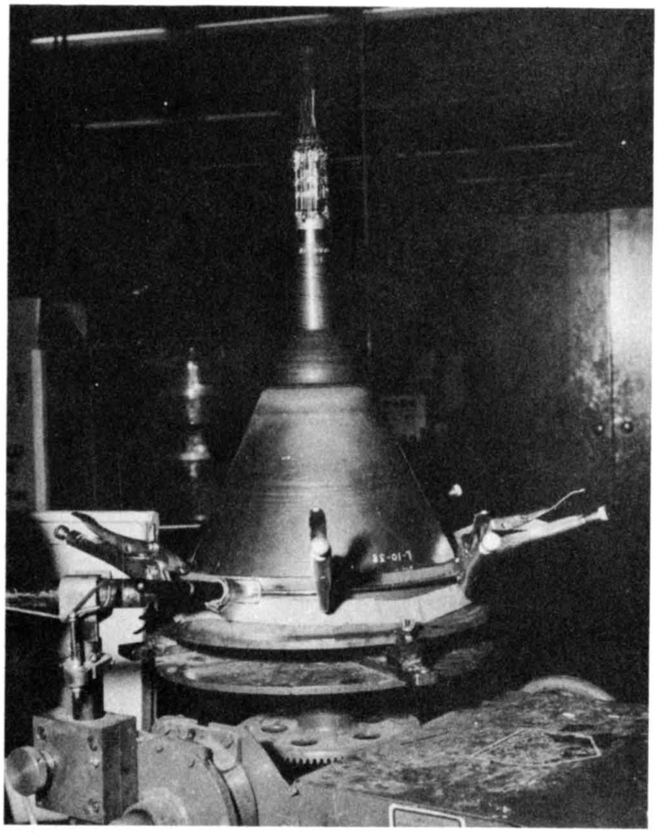

Fig. 31– Heliarc welder in operation.

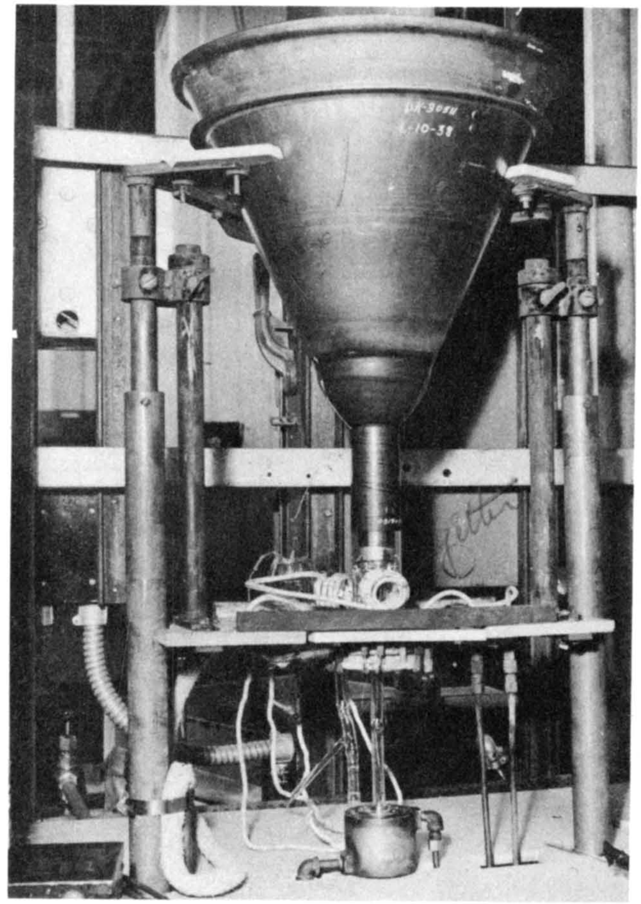

Fig. 32– Tube in exhaust position.

390 degrees C. and pumped to a high vacuum during bakeout. Cathode activation is also accomplished here. After tip-off, cooling must be gradual for protection of the screen assembly. Also seen in Fig. 32 are the coils which flash the getters.

The tube is then based by first placing basing cement along the upper or stem-side rim of the base on the low-voltage side only. After the stem leads are threaded into the base, the cement is cured. Upon clipping and soldering of the stem leads the tube is then placed on its side so that the high-voltage side of the base is down and an insulating thermo-setting plastic is poured through the hole in the base lug so as to fill the high-voltage half of the base. Curing of the plastic follows. This basing procedure is employed to prevent external arc-over.

Finally, the cathodes are aged, and an insulating, non-hydroscopic lacquer is sprayed on the glass area between the metal envelope and the reference line. The tube is now ready for test.

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