

PATENT SPECIFICATION

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(54) IMPROVEMENTS RELATING TO CATHODE STRUCTURES

(71) We, RCA CORPORATION, a corporation organised under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of assembling a cathode electrode having an emissive surface at a precise spacing distance S from the confronting surface of an apertured grid.

In one type of electron gun, the surface of the electron-emissive coating on a cathode is axially positioned a spacing distance S from a control grid G1. The cathode and grid are fixed to, and electrically insulated from, one another by glass support rods. The electron gun also includes a cathode support and at least one additional screen grid or G2 grid, which is spaced from the control grid or G1 grid. When the emissive surface of the cathode is positioned too close to the G1 grid, arcing between the cathode and the G1 grid may occur, and the G2 voltage cutoff value may change. A very small change in the spacing distance S, such as 0.001 inch, may change the G2 voltage cutoff value of the electron gun by about 40 volts.

In one prior method of mounting a cathode at a spacing distance S from a grid, the G1 and G2 grids are fixed in known spaced position with respect to each other. Then, a probe is inserted through the apertures in the G2 grid and G1 grid in a direction of the desired future position of the cathode until a shoulder on the probe bears against the G2 grid. Since the aperture sizes of the G1 and G2 grids are the same diameter, the probe references against the G2 grid, and not the G1 grid. The probe may be used with a capacitance-bridge-measurement system or with an air-

gauge-measurement system, as is known. In either case, the probe and the G1-G2 grid assembly are advanced until the measurement between the cathode and the G2 grid is within a desired range, indicating that the cathode and the G1 grid are also a desired spacing distance S apart. Then, the cathode is fixed in position using this measurement and the known distance between the G1 and the G2 grids. In this prior mounting method, at least the variation in the thickness of the G1 grid, the variation in the thickness of the G2 grid, and the variation of the G1 and G2 grid spacing result in errors in setting the cathode to grid G1 spacing distance S. These errors may cause cathode to G1 grid arcing and/or high electron-gun-cutoff voltage values which may result in improper tube operation or shortened operating life of the tube or electron gun. In addition, as electron guns become smaller in size, the sizes of the apertures in the G1 and G2 grids may become too small to construct a suitable measurement probe which can be inserted through the apertures. This problem occurs when the aperture diameters are smaller than about 0.025 inch.

In another prior method, a cathode is positioned within the cathode support in an approximate spaced position from the G1 grid. Then, a light is projected into the space formed between the cathode and the G1 grid. The resulting image of the space is optically magnified on a screen positioned outside the electron gun. The space is then adjusted while monitoring the optically-magnified image until the desired spacing distance S is obtained. This method requires that there be no obstructions within or around the electron-gun structure which prevent obtaining a direct image of the space. In one practice it is necessary to form a depression in the protuberance which usually surrounds the aperture in the grid to provide clearance for projecting a direct image of the space. This method is

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not suitable where a depression cannot be formed in the grid protuberance such as where the protuberance is necessary to eliminate side emission from cathode, or the configuration of the electron-gun structure does not permit obtaining a projected image of the identical space.

According to the present invention there is provided a method of assembling a cathode and an apertured grid of an electron gun with an emissive surface of said cathode spaced at a distance S from the confronting surface of said grid, said cathode being mounted within a cathode support in axial alignment therewith, said method comprising fixing said grid and said cathode support in predetermined positions relative to each other, supporting said cathode in alignment with said grid but spaced therefrom, positioning a measuring probe assembly between said grid and said cathode, adjusting said confronting surface and said emissive surface to respective distances Y and Z respectively from a reference line, the sum of said distances Y and Z being equal to a reference distance X when said grid and said cathode are on opposite sides of said reference line and the difference between said distances Y and Z being equal to said reference distance X when said grid and cathode are on the same side of said reference line, removing said probe assembly from between said opposed surfaces, decreasing the separation of said cathode and grid by a distance X—S whereby said cathode is located within said cathode support with said emissive surface spaced said distance S from said confronting grid surface and fixing said cathode to said cathode support.

The invention permits an accurate establishment of the spacing distance S directly with respect to the cathode and G1 grid (not directly with respect to the cathode and G2 grid). This eliminates the accumulation of measurement errors which may vary the actual spacing distance from that of the desired precise spacing distance S. In addition, the novel method also may be used with a G1 grid having a protuberance which surrounds the G1 grid aperture and which extends in the direction of the cathode since the spacing distance S is determined independently of the configuration of at least the G1 grid. The method of the invention provides an accurate cathode-G1 grid spacing distance S, which eliminates cathode-G1 grid arcing and provides a more precise setting of the G2 cutoff voltage value.

In the drawing:

Figure 1 is an axial sectional view of an electron gun assembly assembled in accordance with an embodiment of the invention.

Figure 2 is a side elevational view of a span-set apparatus used in assembling the gun assembly of Figure 1.

Figure 3 is a top elevational view of the apparatus of Figure 2.

Figure 4 is a sectional view on section 4—4 of the apparatus of Figure 3.

Figure 5 is an enlarged partial view of a portion of the apparatus shown in Figures 2 through 4.

Figure 1 illustrates an inline electron-gun assembly 21 prior to assembly with a cage (not shown) and a stem (not shown). The inline electron-gun assembly 21 comprises three electron guns 22a, 22b and 22c, which are shown aligned in the sectional plane of Figure 1. The three electron guns include a common control grid or G1 grid 23, a common screen grid or G2 grid 24, a common first accelerating and focusing grid or G3 grid 25, a common second accelerating and focusing grid or G4 grid 26, and a common shield cap (not shown), all fixedly spaced along two glass support rods 27a and 27b (Figures 1 and 5). The G1 grid 23 and the G2 grid 24 are two closely spaced plates each having three small aligned apertures 28a, 28b and 28c and 29a, 29b and 29c respectively. The G4 grid 26 includes three apertures each aligned on the axis of the corresponding guns with the aligned apertures of grids 23 and 24. Grid 26 also includes a grid flange 30 having a surface normal to the parallel axes of the three guns.

Each electron gun also includes a separate cathode 31 attached to a cathode-support sleeve 32. The cathode-support sleeves 32 are fixed to the two glass rods 27a and 27b. Each cathode 31 is closed at the forward end 33 by a cap 34 having an end coating 35 of electron-emissive material. The outside or emissive surface 36 of the electron-emitting coating 35 on each cathode 31 is spaced a precise spacing distance S from the confronting surface 37 of the G1 grid 23 adjacent the apertures, by the method which will be described. The assembly without the cathodes 31 is a partial assembly 20.

Figures 2, 3 and 4 illustrate apparatus known in the art as a "span-set unit" 38. The span-set unit 38 comprises a first carriage assembly 39 for holding the mount, a second carriage assembly 40 for holding the cathode, a measurement-probe assembly 41 and a welding assembly 42, all being positioned on a frame 43.

The span-set unit 38 is designed to separately support a gun and a cathode on a central machine axis 44, for assembly. Since each mount includes three electron guns 22a, 22b and 22c, the span-set unit 38 is adapted to index the axis of each electron

gun into alignment with the machine axis 44.

The first carriage assembly 39 includes slide rods 45, slide-rod supports 46, a front carriage 47 and a rear carriage 48, each slidably mounted on the slide rods 45 with linear bearings 49. A tandem air-cylinder unit 50 is connected between the frame 43 and the rear carriage 48.

The tandem air-cylinder unit 50 includes a first air cylinder 51 and a second air cylinder 52. The front and rear carriages 47 and 48 respectively are connected by a vernier-adjustment means 53. The vernier-adjustment means 53 comprises a threaded shaft, which moves the front carriage 47 about 0.008 inch per revolution with respect to the rear carriage 48. A first adjustable stop 54 is attached to the frame 43 to limit the forward movement of the front carriage 47.

An assembly holding fixture 55 (Figures 3 & 5) is attached to the front carriage 47 on a cross slide 56. The fixture 55 includes mandrel pins 57 and a flange-receiving surface 58. An indexing means 59 (Fig. 3) is mounted on the front carriage 47 behind the cross slide 56 to index the fixture 55 and the partial assembly 20 positioned therein. Each index position aligns one electron-gun axis on the machine axis 44, as previously described. The indexing means 59, shown in Figure 3, includes a cam 60, a first operating member 61 and a second operating member 62. The cam 60 is rotationally mounted on a center pivot 63 directly behind the cross slide 56, as shown in Figure 3. The cam 60 includes three radial surfaces 64a, 64b and 64c equiangularly spaced thereon, each surface corresponding to one of the three index positions of the cross slide 56. The cam 60 is maintained in contact with the cross slide 56 with a spring 65 connected therebetween.

The second carriage assembly 40 includes a cathode-support carriage 66 and a cathode-holding fixture 67 (Figs. 3 & 5). The cathode-holding fixture 67 includes a mandrel portion 68 for supporting the cathode in a fixed position. The cathode-support carriage 66 is moved in a direction along the axis 44 by a servo drive motor 69 and drive means 70.

The measurement-probe assembly 41 includes probe-support members 71 slidably positioned within vertical guide bearings 72 that are attached to the frame 43. A probe-head assembly 73 is positioned on top of the probe-support members 71. The probe-support members 71 are raised by lift means 74 engaging the probe-support members 71, as shown in Figure 4. The lift means 74 includes a lift lever 75 attached to a pivot shaft 76 at one end and engaging the

probe-support members 71 at the other end. An operating lever 77 is also connected to the pivot shaft 76 at one end and at the other end to the piston rod 78 of a lift cylinder 79, which is pivotally mounted to the frame 43. A second adjustable stop 80 is attached to the frame 43 to permit raising the probe-head assembly 73 until it is in the desired vertical position horizontally aligned with the machine axis 44.

The probe-head assembly 73 includes a first gauge 81 and a second gauge 82 (Figure 5). Gauge 81 extends from the probe-head assembly 73 along the machine axis 44 in the direction of a mount 20, clamped into the machine. A second gauge 82 extends from the probe-head assembly 73 along the machine axis 44 in the direction of the emitting surface 36 on a cathode 31, fixed in the machine for assembling to the mount 20.

The first gauge 81 is an air gauge such as catalog No. 882S4, marketed by Moore Products Co., Springhouse, Pa. Referring to Figure 5, the first gauge 81 includes a nozzle 83 which extends from the probe-head assembly 73 towards the G1 grid 23. The air gauge 81 is part of an air-measurement unit. Movement of the nozzle 83 with respect to the surface 37 of the G1 grid 23 changes the back pressure within the first gauge 81 and consequentially provides a measurement on an air-gauge meter 84 related to the spacing distance between the end of the nozzle 83 and the confronting surface 37 of the G1 grid 23.

The second gauge 82 is an insulated rod 85, which extends from the probe-head assembly 73 towards the cathode 31. The insulated rod 85 is part of a capacitance-measurement unit 86. The capacitance-measurement unit 86 comprises a capacitance-measurement bridge circuit and a null meter 87, as is known. A suitable capacitance-measurement bridge circuit is described in U. S. patent No. 3,156,029.

Figure 5 illustrates the relationship of the G1 grid 23, probe-head assembly 73, the first gauge 81, the second gauge 82 and the cathode 31 after a reference distance X is established.

The welding assembly 42 includes four welding-gun air cylinders 88a through 88d and four welding guns 89a through 89d radially extending towards the attachment position of the cathode 31 and cathode support sleeve 32.

Method of Operation

A partial assembly 20 is loaded on the mount-holding fixture 55, and a cathode 31 is loaded on the cathode-holding fixture 67. Figure 5 illustrates the spaced position of the cathode 31 and partial assembly 20 prior to assembly of the cathode 31 within the

cathode-support sleeve 32, at the precise spacing distance S. The partial assembly 20 is positioned on the holding fixture 55 supported by the G4 grid 26. The axis of the first electron gun 22a is coincident with the machine axis 44, the grid apertures 26' are concentrically positioned over the mandrel pins 57, and the G4 grid flange 30 is clamped against the flange-receiving surface 58 of the holding fixture 55. A cathode 31 is positioned on the fixture 67 on axis 44 and supported axially with respect to the internal diameters in a mandrel portion 68. The base of the open end of the cathode 31 is held against a shoulder on the mandrel portion 68 of the cathode-holding fixture 67.

The span-set unit 38 is then operated by actuating manual start switches (not shown) to raise the measurement-probe assembly 41 against the second adjustable stop 80 (Figure 2). At this position, the axes of the first and second gauges 81 and 82 respectively are coincident with the machine axis 44 (Fig. 5). With the measurement-probe assembly 41 in the raised position, a first switch 90 is activated, and a second switch 91 is inactivated. Activating the first switch 90 operates the first air cylinder 51 of the tandem air-cylinder unit 50 to move the partial assembly 20 over the first gauge 81 with the surface 37 of the G1 grid 23 adjacent the end of the gauge nozzle 83. The first air cylinder 51 of the tandem air-cylinder unit 50 moves both the front carriage 47 and rear carriage 48 about 3/4 inch until the front carriage 47 contacts the present first stop 54 (Figure 2). The operator then manually rotates the vernier-adjustment means 53 to move the front carriage 47 with respect to the rear carriage 48 until a zero meter reading is obtained for the first gauge 81. With the first gauge 81 at zero, a distance Y is established between the reference line 92 of the measurement-probe assembly 41 and the surface 37 of the G1 grid 23.

The movement of the carriages 47 and 48 also initiates a fourth switch 95. The fourth switch 95 operates the servo motor 69, which moves the cathode 31 towards the second gauge 82. When the cathode 31 is a precise distance from the end of the second gauge 82, the null meter 87 for the capacitance-measurement unit 86 is at zero. The distance Z between the reference line 92 of the measurement-probe assembly 41 and the electron-emissive surface 36 of the cathode 31 is established with the second gauge 82 at null.

The sum of the distances Y and Z is equal to a reference distance X. The distance X is accurate to within a total tolerance of 0.0002 inch. The operator then actuates two

cycle switches 94 which activate the assembly cycle. First, the first air cylinder 51 of the tandem air-cylinder unit 50 operates to retract the first and rear carriages 47 and 48 to move the partial assembly 20 away from the first gauge 81 on the probe-head assembly 73. Retracting the carriages 47 and 48 activates the third switch 93, which lowers the measurement-probe assembly 41. As the measurement-probe assembly 41 moves down, the second switch 90 is activated to operate both the first and second air cylinders 51 and 52 of the tandem air cylinder unit 50. The operation of the first air cylinder 51 of the tandem air-cylinder unit 50 returns the first carriage assembly 39 to the unretracted position, and the operation of the second air cylinder 52 of the tandem air-cylinder unit 50 moves the first carriage 39 through a distance equal to the reference distance X less the desired grid-cathode spacing distance S against a preset second stop 54. At this position, the cathode 31 is within the cathode-support sleeve 32 with the emissive surface 36 a precise spacing distance S from the face of the G1 grid 23. For the inline-mount assembly previously described, the distance X is 4.0000 ± 0.0001 inch, and the spacing distance S is 0.0050 ± 0.0001 inch.

With the front and rear carriages 47 and 48 against the preset second stop 54, the fifth switch 96 is activated, which operates pneumatic cylinder 88a through 88d for each welding gun 89a through 89d to move the welding guns into contact with the cathode-support sleeve 32, and cycles the welding control to fixedly weld the cathode 31 to the cathode-support sleeve 32 while maintaining the precise spacing distance S.

One of the three cathodes 31 is now precisely welded into position in the partial assembly 20, and both the first and second air cylinders 51 and 52 respectively retract the carriages 47 and 48 to their initial position. The indexing of the cross slide 57 occurs in two steps. During forward movement of the front carriage 47, the first operating member 61 strikes a cam follower on the cam 60 to rotate the cam 60 degrees. Since the cam 60 is formed with a dwell for this 60 degrees, no indexing occurs. Then, on rearward movement of the front carriage 57, the second operating member 62 strikes a cam follower on the cam 60 to rotate the cam a second 60 degrees. Since the cam 60 is formed with a 0.271-inch rise for this 60 degrees, the cross slide is now indexed to present the second radial surface 64b to the cross slide 56, and consequently to position the axis of the second gun 22b in alignment with the machine axis 44. A second cathode 31 is then loaded, and the cycle repeated to fixedly attach the second cathode 31 in the

second electron gun also at the precise spacing distance S. The insertion of the third cathode in the third electron gun 22c is also accomplished in the same manner as described for the first and second cathodes. After the third cathode is fixed within the mount 20, the mount 20 is unloaded for further processing, as is known. After fixing the third cathode, the span set unit is reset for processing a subsequent assembly.

Although the first reference distance Y and the second reference distance X are described as being established with air- and capacitance-type gauges, they may also be established with other type gauges such as by a manually-held micrometer of a gauge block. The only criterion is that the measurement means is preferably accurate within 0.0002 inch and must not damage the measured parts. The micrometer or gauge block may contact the emissive surface, but the entire surface of the emissive coating must be contacted and a low surface pressure must be used to prevent damage to the coating.

The invention is not limited to a particular type of cathode and may be used to space any cathode a precise spacing distance from a grid. Although a cathode having a coating of an emissive material thereon is described, a cathode such as a dispenser cathode where the emissive material is within a porous metal may also be spaced by the described method.

The invention is not limited to a particular type electron gun but may be used for a single electron-gun assembly, a delta electron-gun assembly or the inline electron-gun assembly described and further comprises cathode ray tubes including such assemblies.

Also, it is within the scope of the invention to provide a measuring device whereby the distances Y and Z (Figure 5) are measured from points on the same side of the reference position 92. Thus, the distances X would in fact be the difference of the distances Y and Z.

50 WHAT WE CLAIM IS:—

1. A method of assembling a cathode and an apertured grid of an electron gun with an emissive surface of said cathode spaced at a distance S from the confronting surface of

said grid, said cathode being mounted within a cathode support in axial alignment therewith, said method comprising fixing said grid and said cathode support in predetermined positions relative to each other, supporting said cathode in alignment with said grid but spaced therefrom, positioning a measuring probe assembly between said grid and said cathode, adjusting said confronting surface and said emissive surface to respective distances Y and Z respectively from a reference line, the sum of said distances Y and Z being equal to a reference distance X when said grid and said cathode are on opposite sides of said reference line and the difference between said distances Y and Z being equal to said reference distance X when said grid and cathode are on the same side of said reference line, removing said probe assembly from between said opposed surfaces, decreasing the separation of said cathode and grid by a distance X—S whereby said cathode is located within said cathode support with said emissive surface spaced said distance S from said confronting grid surface and fixing said cathode to said cathode support.

2. A method in accordance with claim 1 wherein said grid and cathode support are relatively fixed upon a first carriage assembly including a slidable platform, said cathode is mounted on a second carriage assembly, said distance X is established by adjusting the position of either or both of said carriage assemblies, and said cathode-to-grid spacing is decreased by moving said slidable platform of said first carriage assembly.

3. A method of assembling a cathode and apertured grid substantially as described with reference to the accompanying drawings.

4. A cathode and apertured grid assembly made by a method in accordance with any one of the preceding claims.

5. A cathode ray tube including a cathode and apertured grid assembly in accordance with claim 4.

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