

TITLE OF THE INVENTION

METHOD AND APPARATUS FOR ASSEMBLING ELECTRON GUN

BACKGROUND OF THE INVENTIONField of the Invention:

The present invention relates to a method of and apparatus for assembling an electron gun disposed in a glass bulb, which forms a cathode-ray tube, and arranged to emit electron beams, and more particularly to a method of and apparatus for assembling an electron gun with which displacement between a first grid and a second grid can be corrected to accurately join the first grid and the second grid to each other.

Description of Related Art:

An electron gun for emitting electron beams has cathodes for emitting electron beams and a plurality of grids disposed coaxially to control, accelerate and converge the electron beams.

A first grid disposed at the lowest position among the plural grids is composed of three single grids, through which electron beams emitted from red, green and blue cathodes are allowed to pass, and then intersected at the center of one main lens. Each of the three single grids of the first grid has an aperture for allowing the electron beam discharged from each of the cathodes of the colors to pass through.

The second grid has, in the bottom face thereof, three beam transmission apertures. The three single grids forming the first grid are joined to the bottom face of the second grid

in such a manner that the beam transmission apertures of the three single grids coincide with beam transmission apertures formed in the bottom face of the second grid. The electron gun is structured in such a way that the cathodes and the first grid are connected to a color-signal output circuit (not shown). In response to a color signal output from the color-signal output circuit, the electron gun emits electron beams.

Note that each of the three grids forming the first grid is called a "first grid" except for individual explanation to unify the designation.

The first grid and the second grid of the electron gun have been joined to each other by an apparatus 100 for assembling an electron gun structured, for example, as shown in Figs. 1 and 2.

The apparatus 100 for assembling an electron gun has a first-grid holding mechanism 101 for holding the first grid, a second-grid holding mechanism 102 for holding the second grid, a first-grid position data detection mechanism 103 for detecting position data of the first grid, a second-grid position data detection mechanism 104 for detecting position data of the second grid, a first-grid locating mechanism 105 for moving the first grid to a predetermined position on the X- and Y-axes, a control unit (not shown) for controlling the operation of the first-grid locating mechanism 105 in accordance with position data of the first grid and the second grid detected by the first-grid position data detection

mechanism 103 and the second-grid position data detection mechanism 104, a first-grid elevation mechanism 106 for upwards moving the first grid to bring the same into contact with the second grid and a joining mechanism 107 for joining the first grid and the second grid to each other.

When the first grid and the second grid are joined to each other by the apparatus 100 for assembling an electron gun, the first grid is held by the first-grid holding mechanism 101 and the second grid is held by the second-grid holding mechanism 102.

Then, the first-grid position data detection mechanism 103 and the second-grid position data detection mechanism 104 detect the positions of the first grid and the second grid, respectively.

Specifically, each of the first-grid position data detection mechanism 103 and the second-grid position data detection mechanism 104 includes a CCD camera 108, an optical lens 109 and an irradiation unit 110. The first-grid position data detection mechanism 103 is illuminated by the irradiation unit 110, after which the CCD camera 108 picks up the image of the beam transmission aperture enlarged by the optical lens 109, and then image data is received by the control unit. The second-grid position data detection mechanism 104 is illuminated by the irradiation unit 110, after which the CCD camera 108 picks up the image of the image of the beam transmission aperture enlarged by the optical lens 109, and then image data is received by the control unit.

Then, the control unit calculates the position of the center of the beam transmission aperture of the first grid and that of the second grid in accordance with image data supplied from the first-grid position data detection mechanism 103 and the second-grid position data detection mechanism 104, respectively. Then, the control unit controls the operation of the first-grid locating mechanism 105 in accordance with values obtained by calculations in such a manner that the position of the center of the beam transmission aperture of the first grid and that of the second grid coincide with each other.

When the first grid has been located to the predetermined X- and Y-axes position by the first-grid locating mechanism 105, the first grid is moved upwards so as to be brought into contact with the bottom face of the second grid. At this time, the central position of the beam transmission aperture of the first grid and that of the second grid have been made coincide with each other. The first-grid elevation mechanism 106 has a compressive spring 111 for controlling the contact pressure between the first grid and the second grid. That is, the contact pressure between the first grid and the second grid is determined by the quantity of compression/expansion of the compressive spring 111.

The first grid is, in a state of contact with the second grid, joined to the second grid by the joining mechanism 107. The joining mechanism 107 includes, for example; a laser welding machine which emits laser beams to the joint portion

between the first grid and the second grid to weld the joint portion with laser beams.

Since the first grid is composed of the three grids as described above, the first grid and the second grid can be joined to each other by repeating the above-mentioned process three times.

As described above, the conventional apparatus 100 for assembling an electron gun is arranged in such a manner that the control unit controls the operation of the first-grid locating mechanism 105 in accordance with position data detected by the first-grid position data detection mechanism 103 and the second-grid position data detection mechanism 104. Therefore, the positions of the first grid and the second grid are made coincide with each other with a somewhat satisfactory accuracy.

Each of the first and second grids of the electron gun is a small member provided with the small beam transmission apertures each having a diameter of about 1.0 mm to about 0.2 mm. It leads to a fact that the electron gun suffers from inhibition of appropriate transmission of electron beams between the first grid and the second grid even if the deviation between the positions of the first grid and the second grid is very small.

However, the conventional apparatus 100 for assembling an electron gun encounters a somewhat error which is made attributable to the movement of the first-grid locating mechanism 105 and that of the first-grid elevation mechanism

106. Moreover, the attitude of the first grid or the second grid is sometimes changed when the first grid is brought into contact with the second grid. Therefore, the first grid and the second grid somewhat deviated from each other are undesirably joined to each other and thus adequate transmission of the electron beams cannot sometimes be performed.

The positions of the first grid and the second grid, which are joined to each other by laser beam welding or the like, are deviated from each other attributable to distortion occurring during the joining process.

However, the conventional apparatus 100 for assembling an electron gun has no means for detecting the deviation between the first grid and the second grid. Therefore, a defective electron gun formed by the joining operation performed in the state where the first grid and the second grid are deviated from each other is introduced into a following process. Thus, there is apprehension that the electron gun is disposed in the glass bulb forming the cathode-ray tube which is mounted into a television receiver.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a method and an apparatus for assembling an electron gun which significantly prevent deviation between a first grid and a second grid occurring when a joining operation has been performed and which detect deviation between the joined first grid and the second grid to inhibit introduction of a defective

product into a following step.

To achieve the above-mentioned object, according to one aspect of the present invention, there is provided a method of assembling an electron gun including: a position data detection step for detecting position data of each of a first grid and a second grid having beam transmission apertures; a position coincidence step for making coincide the position of the first grid and the position of the second grid with each other in accordance with position data detected in the position data detection step; a deviation data detection step for detecting deviation between the first grid and the second grid after the position coincidence step has been performed; a deviation modifying step for modifying the deviation between the first grid and the second grid in accordance with deviation data detected in the deviation data detection step; and a joining step for joining the first grid and the second grid to each other after the deviation modifying step has been performed.

The method of assembling an electron gun according to the present invention has the deviation data detection step for detecting deviation between the joined first grid and the second grid even if the deviation takes place and the deviation modifying step which modifies the deviation.

An apparatus for assembling an electron gun including: a first-grid holding mechanism for holding a first grid; a second-grid holding mechanism for holding a second grid; a first-grid position data detection mechanism for detecting

position data of the first grid; a second-grid position data detection mechanism for detecting position data of the second grid; a deviation data detection mechanism for detecting deviation data between the first grid and the second grid; a first-grid locating mechanism for moving the first grid to a predetermined position; a control unit for controlling the operation of the first-grid locating mechanism; and a joining mechanism for joining the first grid and the second grid to each other.

The apparatus for assembling an electron gun according to the present invention is arranged in such a manner that the control unit controls the operation of the first-grid locating mechanism in accordance with position data detected by the first-grid position data detection mechanism and position data detected by the second-grid position data detection mechanism to make coincide the positions of the first grid and the second grid with each other. Then, the control unit controls the first-grid locating mechanism to modify the deviation between the first grid and the second grid.

The apparatus for assembling an electron gun according to the present invention has the structure that the deviation data detection mechanism detects deviation data between the first grid and the second grid even if the deviation takes place between the first grid and the second grid, the positions of which have been made coincide with each other by the first-grid locating mechanism. In accordance with detected deviation data, the control unit controls the operation of the first-grid

locating mechanism. Therefore, the deviation between the first grid and the second grid can be modified.

Other objects, features and advantages of the invention will be evident from the following detailed description of the preferred embodiments described in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view showing an essential portion of a conventional apparatus for assembling an electron gun;

Fig. 2 is a right-hand side view showing an essential portion of the conventional apparatus for assembling an electron gun;

Fig. 3 is a schematic view showing an electron gun;

Fig. 4 is a perspective view showing a first grid;

Fig. 5 is a perspective view showing a second grid;

Fig. 6 is a front view showing an essential portion of an apparatus for assembling an electron gun according to the present invention;

Fig. 7 is a partially-cut left-hand side view showing the apparatus for assembling an electron gun shown in Fig. 6;

Fig. 8 is a schematic view showing a state of layout of a deviation detection mechanism;

Fig. 9 is a flow chart of a method of assembling an electron gun according to the present invention;

Fig. 10 is a plan view showing an image of a right-hand edge of a beam transmission aperture of the first grid and that

of the second grid picked up by a deviation data detection mechanism;

Fig. 11 is a plan view showing an image of a left-hand edge of the beam transmission aperture of the first grid and that of the second grid picked up by the deviation data detection mechanism;

Fig. 12 is a plan view showing an image synthesized by a control unit; and

Fig. 13 is a side view showing a state where the first grid and the second grid have been joined to each other.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described with reference to the drawings.

An electron gun 1 for emitting electron beams is arranged to emit the electron beams in accordance with a color signal output from a color-signal output circuit. For example as shown in Fig. 3, the electron gun 1 has a cathode 2 for emitting electron beams and a plurality of grids G_1 , G_2 , G_3 , G_4 and G_5 disposed coaxially and at predetermined intervals to control, accelerate and converge the electron beams emitted from the cathode 2. The plural grids G_1 , G_2 , G_3 , G_4 and G_5 are supported and integrated by a pair of insulation support members 3 and 4 made of glass or the like.

The electron gun 1 has a plurality of terminals (not shown) connected to the cathode 2, the first grid G_1 and the like. The terminals are connected to the color-signal output

circuit (not shown).

The cathode 2 is composed of a red color cathode for emitting red electron beams, a green cathode for emitting green electron beams and a blue cathode for emitting blue electron beams. Each of the three cathodes is inclined to make a predetermined angle in such a manner that the electron beams emitted from the three cathodes intersect at the center of the main lens.

The first grid G_1 among the plural grids G_1 , G_2 , G_3 , G_4 and G_5 for controlling, accelerating and converging the electron beam emitted from the cathode 2 is composed of three single grids, for example, as shown in Fig. 4. The first grid G_1 is disposed at a predetermined position in such a manner that electron beams emitted from the red cathode, the green cathode and the blue cathode are allowed to pass through the three single grids so as to be intersect at the center of one main lens. Each of the three grids of the first grid G_1 has a beam transmission aperture 5 for allowing the electron beam emitted from each of the accommodated cathodes.

The second grid G_2 has three beam transmission apertures 6, for example, as shown in Fig. 5. The three single grids forming the first grid G_1 are joined to the bottom face of the second grid G_2 in such a manner that each beam transmission aperture 5 coincides with the beam transmission aperture 6 in the bottom face of the second grid G_2 .

The electron gun 1 has the structure that the cathodes in respective colors and the first grid G_1 are connected to the

color-signal output circuit (not shown) through terminals so as emit the electron beams in response to a color signal output from the color-signal output circuit.

The first grid G_1 and the second grid G_2 of the electron gun 1 are joined to each other by using an apparatus 10 for assembling the electron gun 1 which is structured, for example, as shown in Figs. 6 and 7. Fig. 6 is a front view showing an essential portion of the apparatus 10 for assembling the electron gun 1, and Fig. 7 is a left-hand side view showing an essential portion of the apparatus 10 for assembling the electron gun 1.

The apparatus 10 for assembling the electron gun 1 has a first-grid holding mechanism 11 for holding the first grid G_1 , a second-grid holding mechanism 12 for holding the second grid G_2 , a first-grid position data detection mechanism 13 for detecting position data of the first grid G_1 , a second-grid position data detection mechanism 14 for detecting position data of the second grid G_2 , a deviation data detection mechanism 15 for detecting deviation data between the first grid G_1 and the second grid G_2 , a first-grid locating mechanism 16 for moving the first grid G_1 to a predetermined position, a control unit (not shown) for controlling the operation of the first-grid locating mechanism 16 and a joining mechanism 17 for joining the first grid G_1 and the second grid G_2 to each other.

The first-grid holding mechanism 11 has three holding portions 11a, 11b and 11c disposed in series in such a way that

the holding portions 11a, 11b and 11c are able to individually hold the three single grids. Each of the three holding portions 11a, 11b and 11c of the first-grid holding mechanism 11 is able to individually hold each of the single grids by, for example, a hydraulic cylinder.

The first-grid holding mechanism 11 is connected to the first-grid locating mechanism 16 so as to be moved to a predetermined position when the first-grid locating mechanism 16 performs the locating operation.

The second-grid holding mechanism 12 has a structure to stably hold the second grid G_2 in such a manner that the second grid G_2 is pressed from the right and left sides by, for example, a pair of hydraulic cylinders.

Each of the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14 includes an image pickup mechanism disposed in parallel to the vertical axis. Image data picked up by the image pickup mechanism is processed by the control unit so that the positions of the first grid G_1 and the second grid G_2 are detected.

Specifically, the first-grid position data detection mechanism 13 includes a CCD camera 13a, an optical lens 13b and an illuminating unit 13c. The first-grid position data detection mechanism 13 is illuminated by the illuminating unit 13c so that the image of the beam transmission aperture 5 of the first grid G_1 enlarged by the optical lens 13b is picked up by the CCD camera 13a. Image data picked up by the CCD camera

13a is received by the control unit as position data of the first grid G_1 so that the position of the first grid G_1 is detected.

The second-grid position data detection mechanism 14 includes a CCD camera 14a, an optical lens 14b and an illuminating unit 14c. The second-grid position data detection mechanism 14 is illuminated by the illuminating unit 14c so that the image of the beam transmission aperture 6 of the second grid G_2 enlarged by the optical lens 14b is picked up by the CCD camera 14a. Image data picked by the CCD camera 14a is received by the control unit as position data of the second grid G_2 so that the position of the second grid G_2 is detected.

In accordance with position data above, the control unit operates the first-grid locating mechanism 16 and controls the operation of the first-grid locating mechanism 16. In accordance with the control performed by the control unit, the first-grid locating mechanism 16 locates the first grid G_1 in such a manner that the center of the beam transmission aperture 5 of the first grid G_1 is aligned coaxially with the center of the beam transmission aperture 6 of the second grid G_2 .

The first-grid locating mechanism 16, for example, includes an X- and Y-axial movement mechanism 18 and a Z-axial movement mechanism 19. Each of the X- and Y-axial movement mechanism 18 and the Z-axial movement mechanism 19 has a drive portion for moving the first grid G_1 held by the first-grid holding mechanism 11 in response to a signal output from the

control unit.

At this time, the X- and Y-axial movement mechanism 18 of the first-grid locating mechanism 16 initially locates the X- and Y-axes directions of the first grid G_1 in response to the signal supplied from the control unit. Then, the deviation data detection mechanism 15 modifies the deviation detected by the deviation data detection mechanism 15, and then the Z-axial movement mechanism 19 moves the first grid G_1 in the Z-axial direction so as to bring the first grid G_1 into contact with the bottom face of the second grid G_2 .

The Z-axial movement mechanism 19 has a compression spring 20 for controlling the contact pressure between the first grid G_1 and the second grid G_2 . The contact pressure between the first grid G_1 and the second grid G_2 is determined in accordance with the quantity of compression/expansion of the compression spring 20.

As described above, the first-grid locating mechanism 16 moves the first grid G_1 to a predetermined position in such a manner that the centers of the beam transmission aperture 5 of the first grid G_1 and the beam transmission aperture 6 of the second grid G_2 coincide with each other.

The deviation data detection mechanism 15 includes a pair of image pickup mechanisms 21 and 22, for example, as shown in Fig. 8, disposed diagonally in such a way as to make a predetermined offset angle from the perpendicular axis, the image pickup mechanisms 21 and 22 being bilaterally symmetrical with respect to the vertical axis. In this embodiment, each

of the pair of the image pickup mechanisms 21 and 22 has an offset angle of about 30° made from the vertical axis. The pair of the image pickup mechanisms 21 and 22 are disposed to have extension lines from their central axis which are intersect at the central point of the beam transmission aperture 5 of the first grid G_1 .

Similarly to the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14, the pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 has CCD cameras 21a and 22a, optical lenses 21b and 22b and illuminating units 21c and 22c.

The deviation data detection mechanism 15 divides and photographs the right and left edges of each of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 located by the first-grid locating mechanism 16.

Specifically, the left-hand image pickup mechanism 21 of the pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 causes the CCD camera 21a thereof to pick up the image of the right-hand edge of each of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 illuminated by the illuminating unit 21c and enlarged by the optical lens 21b. Image data picked up by the CCD camera 21a is received by the control unit.

The right-hand image pickup mechanism 22 of the pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 causes the CCD camera 22a thereof

to pick up the image of the left-hand edge of each of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 illuminated by the illuminating unit 22c and enlarged by the optical lens 22b. Image data picked up by the CCD camera 22a is received by the control unit.

The control unit synthesizes image data items picked up by the pair of the image pickup mechanisms 21 and 22 respectively to approximate image data to ellipses. The deviation of the coordinates of the positions of the centers of the two ellipses is detected as the deviation between the center of the beam transmission aperture 5 of the first grid G_1 and that of the beam transmission aperture 6 of the second grid G_2 .

The control unit again moves the first-grid locating mechanism 16 in accordance with deviation data above to modify the deviation.

The first grid G_1 , the deviation of which has been modified, is brought to the bottom face of the second grid G_2 of the Z-axial movement mechanism 19 of the first-grid locating mechanism 16, as described above. Then, the joining mechanism 17 joins the contact portions of the first grid G_1 and the second grid G_2 to each other.

The joining mechanism 17 includes, for example, a laser welding machine. The joining mechanism 17 emits laser beams to the contact portions of the first grid G_1 and the second grid G_2 so that the contact portions are welded with laser beams. Thus, the first grid G_1 and the second grid G_2 are

welded to each other.

The apparatus 10 for assembling the electron gun 1 according to the present invention and having the above-mentioned structure has the deviation data detection mechanism 15 which detects deviation if deviation takes place between the first grid G_1 and the second grid G_2 located by the first-grid locating mechanism 16. In accordance with detected deviation data, the control unit controls the operation of the first-grid locating mechanism 16 so that deviation between the first grid G_1 and the second grid G_2 is modified. Therefore, the apparatus 10 for assembling the electron gun 1 is able to accurately join the first grid G_1 and the second grid G_2 to each other so that the focusing characteristic of the assembled electron gun 1 is improved.

Since the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 of the apparatus 10 for assembling the electron gun 1 are disposed diagonally with respect to the vertical axis, the apparatus 10 for assembling the electron gun 1 is significantly effective when the diameter of the beam transmission aperture 5 of the first grid G_1 is larger than that of the beam transmission aperture 6 of the second grid G_2 , or when the diameter of the beam transmission aperture 5 of the first grid G_1 is smaller than that of the beam transmission aperture 6 of the second grid G_2 , by 50 μm or smaller.

The apparatus 10 for assembling the electron gun 1 detects the distance between the first grid G_1 and the second grid G_2

by measuring the difference between the diameter of the ellipse, to which the beam transmission aperture 5 of the first grid G_1 has been approximated, and that of the ellipse to which the beam transmission aperture 6 of the second grid G_2 has been approximated. Therefore, the cutoff characteristic of the electron gun 1 can easily be controlled.

A method of assembling the electron gun 1 by using the apparatus 10 for assembling the electron gun 1 having the above-mentioned structure will now be described.

As shown in Fig. 9, the method of assembling the electron gun 1 includes setting step S1 for setting the first grid G_1 to the first-grid holding mechanism 11 and the second grid G_2 to the second-grid holding mechanism 12; position data detection step S2 for detecting position data of each of the first grid G_1 and the second grid G_2 ; position coincidence step S3 for locating the first grid G_1 and the second grid G_2 in accordance with data detected in the position data detection step S2; deviation data detection step S4 for detecting deviation data between the first grid G_1 and the second grid G_2 after the position coincidence step S3 has been performed; deviation modifying step S5 for modifying the deviation between the first grid G_1 and the second grid G_2 in accordance with deviation data detected in the deviation data detection step S4; joining step S6 for joining the first grid G_1 and the second grid G_2 to each other after the deviation modifying step S5 has been performed; and deviation confirmation step S7 for confirming existence of the deviation between the first grid G_1 and the

second grid G_2 after the joining step S6 has been performed.

Although the three single grids forming the first grid G_1 is named generically as the first grid G_1 to simplify the description of this specification, the position data detection step S2 to the deviation confirmation step S7 must be performed in such a manner that each of the single grids forming the first grid G_1 must be processed. Therefore, after the process for joining the single grid corresponding to, for example, the red cathode to each other has been completed, the process is returned to the position data detection step S2 to join the single grid corresponding to the green cathode to each other. After the process for joining the single grid corresponding to the green cathode has been completed, the process is returned to the position data detection step S2 to join the single grid corresponding to the blue cathode to each other.

As described above, the processes from the position data detection step S2 to the deviation confirmation step S7 are repeated three times so that the process for joining the first grid G_1 and the second grid G_2 to each other is completed.

The process for assembling the electron gun 1 is performed in such a manner that the setting step S1 is initially carried out so that the three single grids forming the first grid G_1 aligned to the cathode 2 are respectively held by the holding portions 11a, 11b and 11c of the first-grid holding mechanism 11. Moreover, the second grid G_2 is held by the second-grid holding mechanism 12.

Then, the position data detection step S2 is performed in

such a manner that position data of each of the first grid G_1 and the second grid G_2 is detected. The process for detecting position data is performed by the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14.

As described above, the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14 have the CCD cameras 13a and 14a, the optical lenses 13b and 14b and the illuminating units 13c and 14c. The CCD cameras 13a and 14a of the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14 pick up the images of the beam transmission apertures 5 and 6 illuminated by the illuminating units 13c and 14c and enlarged by the optical lenses 13b and 14b. Image data picked up by the CCD cameras 13a and 14a is, as position data of the first grid G_1 and the second grid G_2 , received by the control unit so that the positions of the first grid G_1 and the second grid G_2 are detected.

Then, the position coincidence step S3 is performed so that the positions of the first grid G_1 and the second grid G_2 are located. The locating process is performed in such a manner that the control unit operates and controls the operation of the first-grid locating mechanism 16 in accordance with position data detected in the position data detection step S2.

In accordance with position data of the first grid G_1 and the second grid G_2 detected in the position data detection step

S2, the control unit calculates the positional relationship of the first grid G_1 with respect to the second grid G_2 . In accordance with the calculated positional relationship, the control unit controls the operation of the first-grid locating mechanism 16.

The first-grid locating mechanism 16, under control of the control unit, locates the first grid G_1 in such a manner that the center of the beam transmission aperture 5 of the first grid G_1 aligns with the center of the beam transmission aperture 6 of the second grid G_2 .

Then, the deviation data detection step S4 is performed so that deviation data between the located first grid G_1 and the second grid G_2 is detected. That is, the process for locating the first grid G_1 and the second grid G_2 is performed in the position coincidence step S3. However, deviation sometimes takes place between the located first grid G_1 and the second grid G_2 attributable to an error of position data detected by the first-grid position data detection mechanism 13 and the second-grid position data detection mechanism 14 or an operational error of the first-grid locating mechanism 16. Accordingly, the foregoing deviation is detected in the deviation data detection step S4.

The process for detecting deviation data is performed in such a manner that the deviation data detection mechanism 15 picks up the right and left edges of each of the beam transmission aperture 5 of the first grid G_1 and the beam transmission aperture 6 of the second grid G_2 after which the

control unit processes the picked up images.

As described above, the deviation data detection mechanism 15 includes the image pickup mechanisms 21 and 22 diagonally disposed to make a predetermined angle from the vertical axis and arranged to be bilaterally symmetrical with respect to the vertical axis. Moreover, the extension lines of the central axes of the pair of the image pickup mechanisms 21 and 22 intersect at the central point of the beam transmission aperture 5 of the first grid G_1 .

The pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 has CCD cameras 21a and 22a, optical lenses 21b and 22b and illuminating units 21c and 22c. The deviation data detection mechanism 15 divides the right and left edges of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 located by the first-grid locating mechanism 16 into the right-hand section and the left-hand section to pick up the images of the right and left edges.

Specifically, the CCD camera 21a of the left-hand image pickup mechanism 21 of the pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 picks up the image of the right-hand end of each of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 illuminated by the illuminating unit 21c and enlarged by the optical lens 21b, the image picked up as described being formed as shown in Fig. 10. Image data picked up by the CCD camera 21a is received by the control unit.

The CCD camera 22a of the right-hand image pickup mechanism 22 of the pair of the image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 picks up the image of the left-hand end of each of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 , illuminated by the illuminating unit 22c and enlarged by the optical lens 22b, the image picked up as described being formed as shown in Fig. 11. Image data picked up by the CCD camera 22a is received by the control unit.

The control unit synthesizes image data items respectively picked up by the pair of the image pickup mechanisms 21 and 22 and approximates image data to ellipses, for example, as shown in Fig. 12. The deviation between the coordinates of the central positions of the two ellipses is detected as the deviation between the center of the beam transmission aperture 5 of the first grid G_1 and that of the beam transmission aperture 6 of the second grid G_2 .

After the deviation between the first grid G_1 and the second grid G_2 has been detected in the deviation data detection step S4, the deviation modifying step S5 is performed so that deviation is modified.

The process for modifying the deviation is performed in such a manner that the control unit again operates the first-grid locating mechanism 16 and controls the operation of the first-grid locating mechanism 16 in accordance with deviation data detected in the deviation data detection step S4.

The X- and Y-axial movement mechanism 18 of the first-grid locating mechanism 16 is moved in the X- and Y-axial directions under control of the control unit to modify the deviation between the first grid G_1 and the second grid G_2 to be included in a permissible range. After the deviation between the first grid G_1 and the second grid G_2 has been modified to be included in the permissible range, the Z-axial movement mechanism 19 of the first-grid locating mechanism 16 moves in the Z-axial direction under control of the control unit to bring the first grid G_1 into contact with the bottom face of the second grid G_2 . Since the deviation between the first grid G_1 and the second grid G_2 has been modified, the center of the beam transmission aperture 5 of the first grid G_1 and the beam transmission aperture 6 of the second grid G_2 coincide with each other.

Then, the joining step S6 is performed so that the first grid G_1 and the second grid G_2 are joined to each other.

The process for joining the first grid G_1 and the second grid G_2 to each other is performed by the joining mechanism 17. The joining mechanism 17 includes, for example, a laser welding machine. The joining mechanism 17 emits laser beams to the contact portions of the first grid G_1 and the second grid G_2 to weld the contact portions with the laser beams so that the first grid G_1 and the second grid G_2 are joined to each other, as shown in, for example, Fig. 13.

In the final deviation confirmation step S7, whether or not the first grid G_1 and the second grid G_2 are deviated from

each other is confirmed. The deviation confirmation step S7 is performed in order to prevent flow of the deviated first grid G_1 and the second grid G_2 to the following process if the deviation takes place attributable to the welding operation performed in the joining step S6.

Although the deviation between the first grid G_1 and the second grid G_2 can be modified in the deviation modifying step S5, an error made when the first grid G_1 is moved in the Z-axial direction by the Z-axial movement mechanism 19 or a thermal distortion generated in the joining step S6 sometimes causes deviation between the first grid G_1 and the second grid G_2 to again take place which exceeds the permissible range. Accordingly, the deviation confirmation step S7 detects the deviation between the first grid G_1 and the second grid G_2 generated after the deviation modifying step S5 has been performed. Thus, introduction of the defective product into the following process is inhibited.

The process for confirming the deviation in the deviation confirmation step S7 is performed by using the deviation data detection mechanism 15, which is used in the deviation data detection step S4. That is, the right and left image pickup mechanisms 21 and 22 forming the deviation data detection mechanism 15 pick up the right and left edges of the beam transmission apertures 5 and 6 of the first grid G_1 and the second grid G_2 which have been joined to each other. Then, picked up image data is supplied to the control unit. The control unit synthesizes image data and approximates image data

to ellipses. Thus, the deviation between the coordinates of the centers of the two ellipses is detected as the deviation between the center of the beam transmission aperture 5 of the first grid G_1 and that of the beam transmission aperture 6 of the second grid G_2 .

If the deviation between the first grid G_1 and the second grid G_2 detected as described above exceeds a permissible range, the first grid G_1 and the second grid G_2 are determined to be defective product and thus removed from the process for assembling the electron gun 1 so that introduction of the defective first grid G_1 and the second grid G_2 into the following process is inhibited.

As described above, the process from the position data detection step S2 to the deviation confirmation step S7 must be performed for each of the single grids forming the first grid G_1 . Therefore, after the process for joining the single grid corresponding to, for example, the red cathode has been completed, the process is returned to the position data detection step S2 to join the single grid corresponding to the green cathode. After the process for joining the single grid corresponding to the green cathode has been completed, the process is returned to the position data detection step S2 to join the single grid corresponding to the blue cathode.

As described above, the processes from the position data detection step S2 to the deviation confirmation step S7 are repeated three times so that the process for joining the first grid G_1 and the second grid G_2 to each other is completed.

The method of assembling the electron gun according to the present invention has the deviation data detection step S4 for detecting deviation between the first grid G_1 and the second grid G_2 which have been located in the position coincidence step S3 if deviation takes place, and then the deviation is modified in the deviation modifying step S5. Therefore, the accuracy of joining the first grid G_1 and the second grid G_2 to each other can be improved and thus the focusing characteristic of the electron gun can be improved.

Since the method of assembling the electron gun according to this embodiment is arranged in such a manner that the pair of the image pickup mechanisms 21 and 22 disposed diagonally with respect to the vertical axis detect deviation, the deviation between the first grid G_1 and the second grid G_2 can be detected when the diameter of the beam transmission aperture 5 of the first grid G_1 is larger than that of the beam transmission aperture 6 of the second grid G_2 or when the diameter of the beam transmission aperture 5 of the first grid G_1 is smaller than that of the beam transmission aperture 6 of the second grid G_2 by 50 μm or smaller.

The method of assembling the electron gun according to this embodiment is arranged to detect the distance between the first grid G_1 and the second grid G_2 by measuring the difference between the diameter of the ellipse, to which the beam transmission aperture 5 of the first grid G_1 is approximated, and that of the ellipse to which the beam transmission aperture 6 of the second grid G_2 is approximated.

Therefore, the cutoff characteristic of the electron gun 1 can easily be controlled.

Since the method of assembling the electron gun according to this embodiment includes the deviation confirmation step S7 for confirming whether or not the first grid G_1 and the second grid G_2 are deviated from each other after the joining step S6 has been performed, introduction of a defective product to the following step can be prevented if deviation takes place between the first grid G_1 and the second grid G_2 attributable to thermal distortion or the like occurring because of the welding operation.

When the method of assembling the electron gun according to this embodiment is arranged in such a manner that the amount of change in the deviation between the first grid G_1 and the second grid G_2 occurring before and after the joining step S6 is stored as data and the quantity of correction is determined in accordance with stored data when the process for assembling the electron gun is performed, defective products can be decreased.

The method of assembling the electron gun according to the present invention has the deviation data detection step for detecting deviation between the first grid and the second grid which have been located in the position coincidence step if deviation takes place, and then the deviation is modified in the deviation modifying step. Therefore, the accuracy of joining the first grid and the second grid to each other can be improved and thus the focusing characteristic of the

electron gun can be improved.

Since the method of assembling the electron gun according to the present invention is arranged in such a manner that the pair of the image pickup mechanisms disposed diagonally with respect to the vertical axis detect deviation, the deviation between the first grid and the second grid can be detected when the diameter of the beam transmission aperture of the first grid is larger than that of the beam transmission apertures of the second grid.

Since the method of assembling the electron gun according to the present invention has the structure that the deviation data detection mechanism detects deviation data if deviation takes place between the first grid and the second grid after the locating operation has been performed by the first-grid locating mechanism and the control unit controls the operation of the first-grid locating mechanism in accordance with detected position data, deviation between the first grid and the second grid can be modified.

Therefore, the method of assembling the electron gun according to the present invention is able to accurately join the first grid and the second grid to each other so that the focusing characteristic of the assembled electron gun is improved.

Since the apparatus for assembling the electron gun is structured such that the deviation detection mechanism is composed of the pair of the image pickup units disposed diagonally with respect to the vertical axis, the first grid

and the second grid can accurately be joined to each other when the diameter of the beam transmission apertures of the first grid is larger than that of the beam transmission apertures of the second grid or when the diameter of the beam transmission aperture of the second grid is smaller than that of the beam transmission aperture of the second grid in such a manner that the difference is very small. .

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form can be changed in the details of construction and in the combination and arrangement of parts without departing from the spirit and the scope of the invention as hereinafter claimed.



WHAT IS CLAIMED IS:

1. A method of assembling an electron gun comprising:

a position data detection step for detecting position data of each of a first grid and a second grid having beam transmission apertures;

a position coincidence step for making coincide the position of said first grid and the position of said second grid with each other in accordance with position data detected in said position data detection step;

a deviation data detection step for detecting deviation between said first grid and said second grid after said position coincidence step has been performed;

a deviation modifying step for modifying the deviation between said first grid and said second grid in accordance with deviation data detected in said deviation data detection step;

and

a joining step for joining said first grid and said second grid to each other after said deviation modifying step has been performed.

2. A method of assembling an electron gun according to claim 1, wherein said deviation data detection step is a step in which a pair of image pickup mechanisms disposed diagonally with respect to an axis and bilaterally symmetrical with respect to the axis pick up images of right and left edges of beam transmission apertures of said first grid and said second grid, after which the picked up images are processed so that



deviation data between said first grid and said second grid is detected.

3. A method of assembling an electron gun according to claim 2, wherein detection of deviation data between said first grid and said second grid is performed by measuring the distance between the center of said beam transmission aperture of said first grid and the center of said beam transmission aperture of said second grid.

4. A method of assembling an electron gun according to claim 1, further comprising a deviation confirmation step for confirming whether or not said first grid and said second grid are deviated from each other, said deviation modifying step being performed after said joining step has been performed.

5. A method of assembling an electron gun according to claim 4, wherein said deviation confirmation step is a step in which a pair of image pickup mechanisms disposed diagonally with respect to an axis and bilaterally symmetrical with respect to the axis pick up images of right and left edges of beam transmission apertures of said first grid and said second grid, after which the picked up images are processed so that whether or not said first grid and said second grid are deviated from each other is confirmed.

6. A method of assembling an electron gun according to



claim 5, wherein the confirmation whether or not said first grid and said second grid are deviated from each other is performed by measuring the distance between the center of said beam transmission aperture of said first grid and the center of said beam transmission aperture of said second grid.

7. An apparatus for assembling an electron gun comprising:

- a first-grid holding mechanism for holding a first grid;
- a second-grid holding mechanism for holding a second grid;
- a first-grid position data detection mechanism for detecting position data of said first grid;

- a second-grid position data detection mechanism for detecting position data of said second grid;

- a deviation data detection mechanism for detecting deviation data between said first grid and said second grid;

- a first-grid locating mechanism for moving said first grid to a predetermined position;

- a control unit for controlling the operation of said first-grid locating mechanism; and

- a joining mechanism for joining said first grid and said second grid to each other, wherein

said control unit controls the operation of said first-grid locating mechanism in accordance with position data detected by said first-grid position data detection mechanism and position data detected by said second-grid position data detection mechanism to make coincide the positions of said



first grid and said second grid with each other, and then controls the operation of said first-grid locating mechanism in accordance with deviation data detected by said deviation data detection mechanism to modify deviation between said first grid and said second grid.

8. An apparatus for assembling an electron gun according to claim 7, wherein

said deviation data detection mechanism has a pair of image pickup mechanisms disposed diagonally with respect to an axis and bilaterally symmetrical with respect to the axis, and images picked up by said image pickup mechanisms are processed by said control unit so that deviation data between said first grid and said second grid is detected.

9. An apparatus for assembling an electron gun according to claim 8, wherein said control unit measures the distance between the center of a beam transmission aperture of said first grid and the center of a beam transmission aperture of said second grid to measure the amount of deviation between said first grid and said second grid.

10. An apparatus for assembling an electron gun according to claim 9, wherein said deviation detection mechanism confirms whether or not said first grid and said second grid are deviated from each other after said joining mechanism has joined said first grid and said second grid to each other.