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(54) ELECTRON GUN ASSEMBLY FOR USE IN MULTI-BEAM TYPE CATHODE RAY TUBE

(71) We, HITACHI LIMITED, a corporation organised and existing under the laws of Japan, of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, 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 multi-beam type electron gun assembly having a plurality of electron guns.

A three-beam type electron gun assembly, as a typical example of the multi-beam type electron gun assembly for use in a cathode ray tube, is often utilized in a colour picture tube in which three electron guns are disposed in the neck of the envelope of a colour picture tube which comprises a fluorescent screen, a funnel and the neck. Each electron gun comprises a first grid electrode provided with a cathode and a plurality of other grid electrodes beyond the first grid electrode and aligned in the direction from the neck to the screen of the envelope of the picture tube. These grid electrodes have predetermined potentials adapted so as to form both a prefocussing lens system and a main focussing lens system between predetermined electrodes of the plurality.

In a typical prior art construction of the electron gun assembly of the type referred to above, it is usual to assemble three independent electron guns together on a supporting member, for example made of glass, to form a triangular or in-line assembly. However, in assembling the three independent electron guns together on the glass supporting member, there are various difficulties. It is necessary to align the respective electron guns in the axial direction and to assemble the electron guns in correct relative positions. Moreover, this construction increases the number of component elements and hence the cost of assembling them, so that the size and the weight of the electron gun assembly cannot be reduced beyond certain limits.

To obviate these difficulties, in recent

years it has been proposed to modify such a typical prior construction and construct as an integral unit a particular group of grid electrodes among the grid electrodes of respective electron guns, the grid electrodes to be grouped in use having applied thereto the same potential and providing the same function. According to this construction, it is possible to decrease the number of the component elements, to simplify the assembling work and to reduce the size and weight as compared with said typical prior art construction. Integral formation of respective identical grids constituting the main focussing lenses results in improved accuracy in assembly of the electron gun assembly; the characteristics of the electron gun assembly being thus enhanced to a substantial extent. This integral grid unit is formed by the following method. Firstly, a cup-shaped member is formed, the bottom of which is provided with three openings arranged in predetermined positions, each opening being used for the passage of one electron beam travelling within the corresponding electron gun, the openings having a predetermined diameter. Secondly, another cup-shaped member is formed having a bottom provided with openings for positioning coaxial with the openings of the first-mentioned cup-shaped member, each opening being used for the same purpose as in said first-mentioned cup-shaped member. These two cup-shaped members are disposed to oppose each other with a predetermined spacing between their bottom end walls so that openings thereof correspond with each other, thus forming the integrally formed grid unit. According to this construction, the edges of the openings of respective bottom end walls will not be positioned at a uniform distance from the side walls of the opposing cup-shaped member unless the cross-sections of the cup-shaped members are circular and the axis of each opening coincides with that of the respective opposing cup-shaped member. Under practical conditions, when a predetermined potential is applied to the pair of cup-shaped members spaced from

each other a predetermined distance, the potential distribution between opposed openings will necessarily be affected by the side walls of the opposing cup-shaped members. In other words, the potential distribution, which would otherwise be rotationally symmetrical with respect to the axes of the openings, will be materially affected by the edge effect of the side walls.

Accordingly to obviate such an adverse effect, it has been further proposed to provide cylindrical tubes around the peripheries of the openings and directed axially towards the insides of the said cup-shaped members so as to eliminate the above-mentioned effect. To form the cup-shaped members, press work is desirable in view of easiness and accuracy in the process. However, it is impossible to obtain a cup shaped member that has rims integrally formed along the peripheries of the openings having the same function as the above-mentioned cylindrical tubes, because the depth attained by the pressing process has to be limited with respect to the relationship between the diameter of the openings and the permissible pressed depth in connection with the raw material and so forth. Accordingly, the effect of a rim such as can be formed by pressing is really limited to increasing the breakdown voltage of the opposed grid structures. In other words, by forming the electron lens system with a grid in which inadequate pressed depth is achieved compared with the opening diameter, the resulting nonuniform potential distribution between opposed openings causes an asymmetry with respect to the axis of the electron lens, which in turn results in an increase in the astigmatism of the lens.

Accordingly, it is an object of this invention to provide an improved multi-beam type electron gun assembly for use in a cathode ray tube in which the grid electrodes of respective electron guns in use having the same potential applied thereto and having the same function are constructed as an integral structure providing a symmetrical potential distribution.

Another object is to provide an improved multi-beam type electron gun assembly for use in a cathode ray tube including an improved grid structure which can decrease the astigmatism of the electron lens system, thus improving the focussing characteristics of the tube and providing an assembly suitable for use in a cathode ray tube for producing clear and sharp images.

According to the invention there are provided, in a multi-beam type electron gun assembly for use in a cathode ray tube, a plurality of electron guns, including a plurality of cathode electrodes and a plurality of grid electrode structures which are con-

stituted with a plurality of common electrodes comprising each grid electrode which has identical function in respective electron guns, said common electrodes being formed integrally and with one of said common electrodes comprising a hollow side wall member, forming an enclosure surrounding all paths of the electron beams, and an end member comprising two plate members, each plate member having a plurality of circular openings for the passage of the electron beams and each opening being provided with an axially extending peripheral rim formed integrally along the respective peripheries of said openings, said rims being closely aligned respectively by superposing said plate members one upon the other to have an aggregate axial height not less than half the diameter of said opening, whereby an electric field during operation produced in the neighbourhood of said openings is not materially affected in an adverse sense by the presence of the side wall member.

In said one common electrode, the side wall member and one of the plate members may be formed together as a cup-shaped integral unit, to which the other plate member is secured. Alternatively the side wall and two plate members may be separately formed and secured together to form an assembled unit.

The common electrode may be assembled so that the rims of the plate members are axially opposed and extend towards each other, or alternatively so that they extend in the same axial direction.

The invention will be more fully understood from the following detailed description of prior art constructions and some embodiments of the invention shown, by way of example, in the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation showing one example of an electron gun assembly including a prior art grid structure;

Fig. 2 is a sectional view of the electron gun structure shown in Fig. 1 taken along the line II—II;

Fig. 3 is a sectional view taken along the line III—III in Fig. 2 and shows the construction of an opening of the prior art grid structure;

Fig. 4 is a longitudinal sectional view of a prior art grid structure disposed to define a main electron lens;

Fig. 5 is a perspective view of one example of plate members in accordance with the invention;

Fig. 6 is a longitudinal sectional view of opposed grid structures each utilising an assembly of the plate members shown in Fig. 5;

Fig. 7 is a sectional view of a modified example of the assembly of the plate members; and

Fig. 8 is a sectional view of another modified embodiment of the invention.

In recent years an electron gun assembly as shown in Fig. 1 has been proposed and used in view of various advantages which it provided. The construction is characterized in that a particular group of the grid electrodes of respective electron guns to operate at the same potential and performing the same function are formed as an integral grid structure unit using pressings, in order to eliminate the disadvantage of assembling three independent electron guns together on a supporting member as had been the earlier practice. Discussion will be developed by taking a bipotential type multi-beam electron gun assembly as an example hereinafter, but it should be noted that the present invention is not restricted to a bipotential type electron gun assembly.

Fig. 1 shows a three beam type electron gun assembly for use in a colour picture tube with a triangular arrangement consisting essentially of the first grid electrodes, 7A, 1B and 1C, the second grid electrodes 2A, 2B and 2C, the third grid electrode 34, the fourth grid electrode 5 and the cathode electrode with a heater (not shown) associated with the first grid electrodes. These component elements are disposed at definite relative spacings and are secured to supporting members 6 such as glass beads or the like. The first and second grid electrodes are provided for each electron gun. The third grid electrode 34 comprises a pair of opposed cup shaped members 3 and 4 with their abutting open ends welded together. The bottom of the cup shaped member 4 is provided with three openings 4A, 4B and 4C corresponding to a predetermined arrangement of the electron guns. These openings are coaxial with openings 33 provided in axial projections 32 at the bottom of the cup shaped member 3, which extends into the interior of the second grid electrodes 2A, 2B and 2C (see Fig. 4). The fourth grid electrode 5 is also cup shaped and its bottom is provided with openings 5A, 5B and 5C corresponding to the openings 4A, 4B and 4C at the bottom of the cup shaped member 4. Openings 4A, 4B and 4C and 5A, 5B and 5C are positioned to oppose each other with a predetermined spacing therebetween. These openings are surrounded by axially extending rims which are formed by pressing and have a height h . As is well known in the art, this construction is effective to increase the breakdown voltage between opposed grid electrodes 34 and 5. This construction also improves the symmetry of the electric field between the edges of opposed openings depending upon the height of the rim.

In the following description, it will be seen how an improved main focussing lens

system can be achieved with the integrally formed grid electrode according to the invention.

The material of the grid electrode should be nonmagnetic, durable to heat encountered during use and fabrication, and should not adversely affect, either directly or indirectly, the phosphors of the picture tube. Further, it must be light and have excellent workability. However, it is difficult to obtain a material having all of these desirable characteristics. At present, the best one is nonmagnetic stainless steel containing 16% of chromium and 14% of nickel for example.

Where openings are provided for the bottoms of the cup shaped members 4 and 5 made of such material, the ratio of the height h of the rim formed by pressing to the inner diameter D of the opening is about 0.3 or less. With this ratio, however, it is difficult to improve sufficiently the symmetry of the electric field between opposed openings. More particularly, as shown in Fig. 4, the distance between the rim of an opening, for example 4A or 5A, of the cup-shaped member 4 and the side wall of the opposing cup-shaped member 5 or 4 is not uniform around the opening, so that when a potential is applied across them, the electric field established between the rims of opposed openings 4A and 5A is not uniform. This results in astigmatism of the main electron lens formed by the third and fourth grid electrodes, which in turn impairs the focussing characteristics of the electron beam. However, when the height h of the rim exceeds a certain limit, the adverse effect of the side wall upon the electric field between the walls of opposed openings can be made negligible, thereby providing a uniform electric field. It has been found that the value of the ratio h/D at which this advantageous effect occurs is generally given by $h/D \geq 0.5$.

In accordance with the invention, this object of achieving a uniform electric field between the walls of opposed openings can be accomplished by providing two plate members having aligned circular openings at predetermined positions for at least one of the end surfaces of the grid structures which are opposed to form the main electron lens.

Fig. 5 illustrates one example of a pair of perforated plate members for an electron gun assembly embodying the invention. Three circular openings 41 and 51 for respective plate members 40 and 50 are arranged in an equilateral triangular configuration, but it should be understood that these three openings could alternatively be arranged in-line.

The respective openings are formed with axial rims 42 and 52, the maximum height 130

h of which must be determined dependent upon the spacing between adjacent openings and the ease of the pressing process dependent on the characteristics of the material. After forming the openings and rims, the two plate members 40 and 50 are superimposed and welded together at their peripheries 43 and 53. Upon fabrication, the rims 42 and 52 around corresponding pairs of openings are brought to oppose each other. Further, as shown in Fig. 6, the plate members are welded to the ultimately opposed end surfaces of the cup-shaped members 34 and 5, the side walls of which provide the corresponding hollow side wall members of the invention. By interposing superposed plate members between the opposed end surfaces of the cup shaped members 34 and 5, the effective height of the rim around opening 45 of the resultant grid electrode is increased beyond $2h$, thus effectively preventing the adverse effect of said edge effect. As a result, it is possible to form a uniform electric field between opposed openings. Although in this embodiment two plate members are joined with the edges opposed to each other, it is also possible to join two plate members 401 and 501 with their edges directed in the same axial direction, as shown in Fig. 7. With this latter construction, it is also possible to increase the effective height of the rim beyond $2h$ and to establish a uniform electric field between the rims of opposed openings. The construction of the plate members to be secured to the third grid electrode 34 and that of the plate members to be secured to the fourth grid electrode 5 may be different, the appropriate construction being determined by the characteristics of the electron gun.

Fig. 8 shows another embodiment of this invention, in which only one plate member is separately formed, the other plate member and the corresponding side wall member being formed together as a cup-shaped integral unit. In the earlier embodiments, two separately formed plate members are in each case used to increase the effective depth of the peripheral rim of the opening. However, according to the embodiment shown in Fig. 8, it is possible for the rim height to be effectively doubled by superposing a separately formed plate member 402 upon the end wall of the cup-shaped grid electrode 4, which end wall provides one of the plate members of the invention, and to establish a uniform electric field between the opposed openings. In this case, the known cup-shaped members 4 and 5 of Figs. 3 and 4 can be used without any modification thereof so that unnecessary tooling is effectively avoided. Needless to say, this member 402 is applicable for the

grid 5 in the same manner as is shown in Fig. 8.

Further, while the invention has been described in terms of a bipotential type electron gun assembly arranged in a triangular configuration, the invention is also applicable to electron gun assemblies of the inline type and unipotential type.

Further, in the illustrated example of Fig. 6, an assembly of the perforated plate members of the invention is secured to the third grid electrode 34 and another to the fourth grid electrode 5. However, the invention is not limited to this specific construction but instead an assembly of the perforated plate members may be secured to either one of the third or fourth grid electrodes.

The invention may also be applied to an electron gun assembly wherein the openings in the fourth grid electrode are displaced in the radial direction with respect to the openings in the third grid electrode for the purpose of providing a convergence effect, or to an electron gun assembly of the type wherein a convergence electrode is attached on one end of the assembly for the purpose of providing a convergence effect.

Instead of making the heights of the rims of the plate members 40 and 50 equal, the height may be different between the two plates. It is only necessary to make the total height of the edges provided for the plate members 40 and 50 sufficiently larger than the height h of the rim of the known construction shown in Figs. 3 and 4.

The above embodiment is explained in terms of the grid which constitutes the main focussing lens system, but it should be noted that this invention is applicable to the grids other than the grid constituting this lens system.

As described hereinabove, in the electron gun assembly embodying the invention, the height of the axial rims surrounding the openings of the grid structures, which are used to form a main electron lens, is increased sufficiently to make astigmatism of the main electron lens negligibly small, thus producing clear picture images.

WHAT WE CLAIM IS:—

1. A multi-beam type electron gun assembly for use in a cathode ray tube to produce electron beams directed towards a fluorescent screen of the tube, wherein there are provided a plurality of electron guns including a plurality of cathode electrodes and a plurality of grid electrode structures which are constituted with a plurality of common electrodes comprising each grid electrode which has identical function in respective electron guns, said common electrodes being formed integrally and with one of said common electrodes comprising a



h of which must be determined dependent upon the spacing between adjacent openings and the ease of the pressing process dependent on the characteristics of the material. After forming the openings and rims, the two plate members 40 and 50 are superimposed and welded together at their peripheries 43 and 53. Upon fabrication, the rims 42 and 52 around corresponding pairs of openings are brought to oppose each other. Further, as shown in Fig. 6, the plate members are welded to the ultimately opposed end surfaces of the cup-shaped members 34 and 5, the side walls of which provide the corresponding hollow side wall members of the invention. By interposing superposed plate members between the opposed end surfaces of the cup shaped members 34 and 5, the effective height of the rim around opening 45 of the resultant grid electrode is increased beyond $2h$, thus effectively preventing the adverse effect of said edge effect. As a result, it is possible to form a uniform electric field between opposed openings. Although in this embodiment two plate members are joined with the edges opposed to each other, it is also possible to join two plate members 401 and 501 with their edges directed in the same axial direction, as shown in Fig. 7. With this latter construction, it is also possible to increase the effective height of the rim beyond $2h$ and to establish a uniform electric field between the rims of opposed openings. The construction of the plate members to be secured to the third grid electrode 34 and that of the plate members to be secured to the fourth grid electrode 5 may be different, the appropriate construction being determined by the characteristics of the electron gun.

Fig. 8 shows another embodiment of this invention, in which only one plate member is separately formed, the other plate member and the corresponding side wall member being formed together as a cup-shaped integral unit. In the earlier embodiments, two separately formed plate members are in each case used to increase the effective depth of the peripheral rim of the opening. However, according to the embodiment shown in Fig. 8, it is possible for the rim height to be effectively doubled by superposing a separately formed plate member 402 upon the end wall of the cup-shaped grid electrode 4, which end wall provides one of the plate members of the invention, and to establish a uniform electric field between the opposed openings. In this case, the known cup-shaped members 4 and 5 of Figs. 3 and 4 can be used without any modification thereof so that unnecessary tooling is effectively avoided. Needless to say, this member 402 is applicable for the

grid 5 in the same manner as is shown in Fig. 8.

Further, while the invention has been described in terms of a bipotential type electron gun assembly arranged in a triangular configuration, the invention is also applicable to electron gun assemblies of the in-line type and unipotential type.

Further, in the illustrated example of Fig. 6, an assembly of the perforated plate members of the invention is secured to the third grid electrode 34 and another to the fourth grid electrode 5. However, the invention is not limited to this specific construction but instead an assembly of the perforated plate members may be secured to either one of the third or fourth grid electrodes.

The invention may also be applied to an electron gun assembly wherein the openings in the fourth grid electrode are displaced in the radial direction with respect to the openings in the third grid electrode for the purpose of providing a convergence effect, or to an electron gun assembly of the type wherein a convergence electrode is attached on one end of the assembly for the purpose of providing a convergence effect.

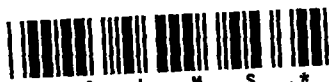
Instead of making the heights of the rims of the plate members 40 and 50 equal, the height may be different between the two plates. It is only necessary to make the total height of the edges provided for the plate members 40 and 50 sufficiently larger than the height h of the rim of the known construction shown in Figs. 3 and 4.

The above embodiment is explained in terms of the grid which constitutes the main focussing lens system, but it should be noted that this invention is applicable to the grids other than the grid constituting this lens system.

As described hereinabove, in the electron gun assembly embodying the invention, the height of the axial rims surrounding the openings of the grid structures, which are used to form a main electron lens, is increased sufficiently to make astigmatism of the main electron lens negligibly small, thus producing clear picture images.

WHAT WE CLAIM IS:—

1. A multi-beam type electron gun assembly for use in a cathode ray tube to produce electron beams directed towards a fluorescent screen of the tube, wherein there are provided a plurality of electron guns including a plurality of cathode electrodes and a plurality of grid electrode structures which are constituted with a plurality of common electrodes comprising each grid electrode which has identical function in respective electron guns, said common electrodes being formed integrally and with one of said common electrodes comprising a



- hollow side wall member, forming an enclosure surrounding all paths of the electron beams, and an end member comprising two plate members, each plate member having a plurality of circular openings for the passage of the electron beams and each opening being provided with an axially extending peripheral rim formed integrally along the respective peripheries of said openings, said rims being closely aligned respectively by superposing said plate members one upon the other to have an aggregate axial height not less than half the diameter of said opening, whereby an electric field during operation produced in the neighbourhood of said openings is not materially affected in an adverse sense by the presence of the side wall member.
2. A multi-beam type electron gun assembly according to claim 1, wherein said side wall member and one of said plate members are formed together as a cup-shaped integral unit.
3. A multi-beam type electron gun assembly according to claim 1, wherein said side wall member and said plate members comprising a common electrode are formed respectively as a unit.
4. A multi-beam type electron gun assembly according to any one of the preced-

ing claims, wherein said plate members are superposed on each other such that said rims on the respective plate members are oppositely directed.

5. A multi-beam electron gun assembly according to any one of claims 1 to 3, wherein said plate members are superposed on each other such that said rims on the respective plate members extend in the same axial direction.

6. A multi-beam electron gun assembly according to any of claims 1 to 5, wherein said plate members are mounted on both opposed ends of the adjacent grid structures.

7. A multi-beam electron gun assembly according to any of claims 1 to 6, wherein a main focussing lens is formed between openings opposed to each other.

8. A multi-beam type electron gun assembly substantially as hereinbefore described with reference to Figs. 5 to 8 of the accompanying drawings.

MICHAEL BURNSIDE & COMPANY,
Chartered Patent Agents,
36 Westminster Palace Gardens,
Artillery Row,
London, SW1P 1RR.
Agents for the Applicants.