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Hurukawa et al.

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[54] **ELECTRON GUN ASSEMBLY WITH IMPROVED UNITARY LENS SYSTEM**

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[52] **U.S. Cl.** **313/452,** 315/16

[51] **Int. Cl.** **H01j 29/56**

[58] **Field of Search** 313/82, 83, 452; 315/5.34, 315/5.39, 5.49, 14, 15, 16

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[57] **ABSTRACT**

An electron gun assembly for use in a cathode ray tube provided with a main lens system for focusing electrons emitted from a cathode electrode, comprising at least three focusing electrodes aligned on the same imaginary axis extending from said cathode electrode to form with an anode electrode at least two separated lenses on said axis when voltages are applied. The two lenses form a unitary lens having a large aperture in which the object point (i.e., cross-over point) for the lens formed of a first and a second grid electrode is located at the focal position of the lens on the cathode side and the trace of the emitted electron beam becomes nearly parallel with said axis between said two lenses. Thus, the radius of the resulting beam spot becomes smaller and the focusing characteristics are improved.

12 Claims, 4 Drawing Figures

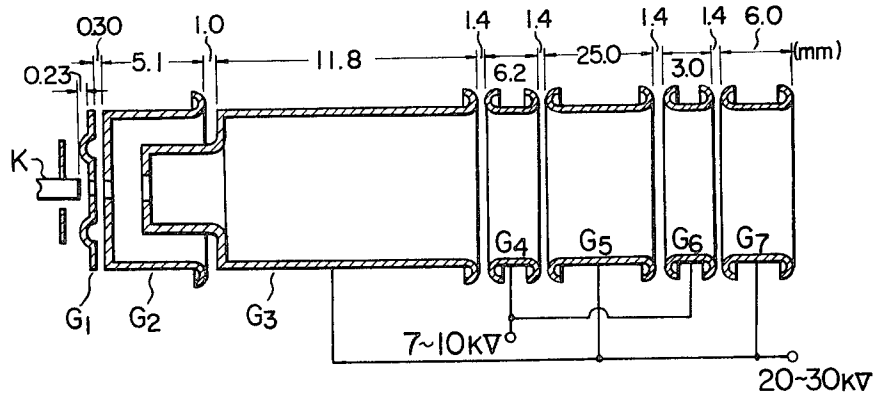


FIG. 1

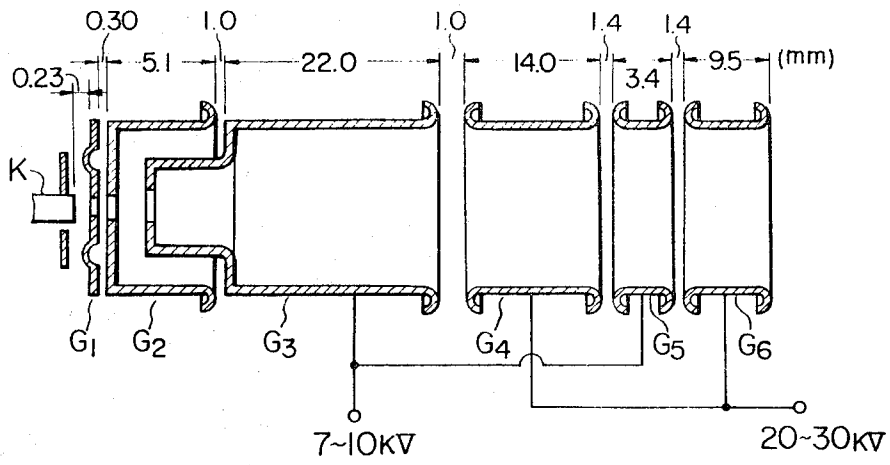

0.30
1.0
1.0
1.4
1.4
0.23
5.1
22.0
14.0
3.4
9.5
(mm)
K
G1
G2
G3
G4
G5
G6
7~10KV
20~30KV

FIG. 2

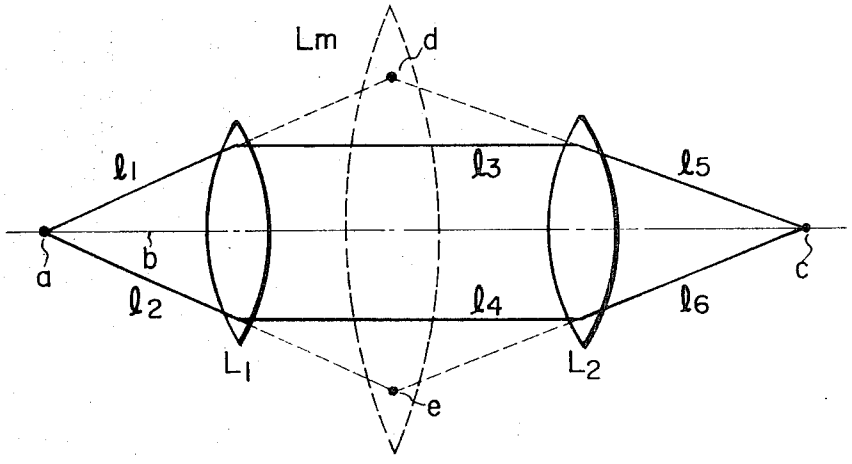

Lm
d
l1
l3
l5
a
b
c
l2
l4
l6
L1
L2
e

FIG. 3

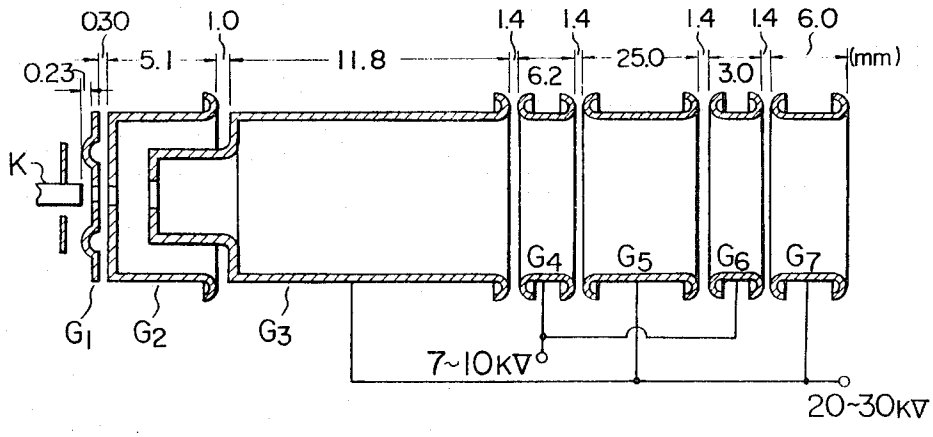
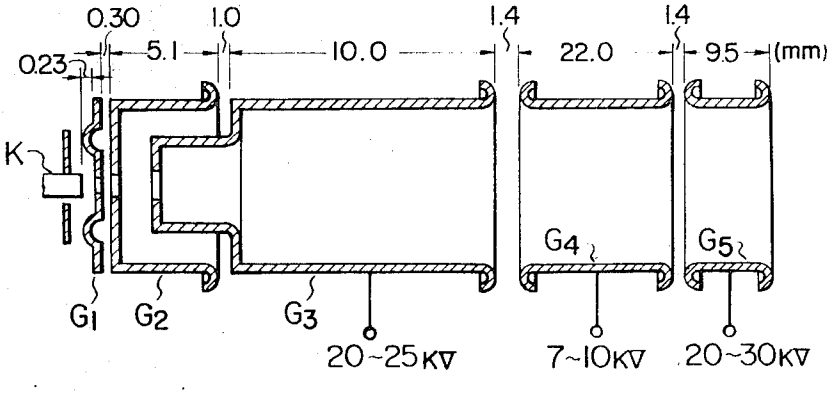

0.30
1.0
1.4
1.4
1.4
1.4
6.0
0.23
5.1
11.8
6.2
25.0
3.0
(mm)
K
G4
G5
G6
G7
G1
G2
G3
7~10KV
20~30KV

FIG. 4


0.30
1.0
1.4
1.4
0.23
5.1
10.0
22.0
9.5
(mm)
K
G4
G5
G1
G2
G3
20~25KV
7~10KV
20~30KV

ELECTRON GUN ASSEMBLY WITH IMPROVED UNITARY LENS SYSTEM

This invention relates to an electron gun and more particularly to an electron gun assembly for use in a cathode ray tube having an improved beam spot and halo characteristics.

Conventional electron guns having a lens function and used generally in cathode ray tubes include unipotential type and bipotential type lens configuration, as defined in the Proceedings of the IRE, Volume 24, No. 8, Aug., 1936, pages 1108 – 1110. A unipotential lens is one in which the potential (or the index of refraction) on the two sides of the lens is the same; whereas, if the potential on the two sides of the lens is different, the lens will be called a bipotential lens. In a unipotential type electron lens system, three focusing electrodes are disposed on an imaginary axis, and a high voltage of e.g., 25 kV is applied to two of said focusing electrodes disposed on respective outer sides while a voltage nearly equal to zero is applied to the central focusing electrode to form a main lens assembly. In a bopotential type electron lens system, two focusing electrodes are disposed on an imaginary axis, the one of which is supplied with a high voltage of about 25 kV and the other of which is supplied with an intermediate voltage of 3 to 6 kV to form a main lens assembly. In electron guns of the above types, respective electrodes are disposed to form one main lens and a cross-over image is focused on a fluorescent screen by this one main lens.

Among the electron guns of the above structures, said bipotential electron guns can have a small aberration and hence good beam spot characteristics but require a high voltage of e.g., 3 to 6 kV for a focusing electrode and hence have problems in the breakdown voltage, and the influence of variations in the high voltages.

Further, said unipotential electron guns have an advantage that the adjustment of focus can be done at low voltages and is influenced little by variations in the high voltage, while they have inferior beam spot characteristics to those of said bipotential electron guns. Yet further, electron guns of these types have various disadvantages such that a halo may appear when the beam spot characteristics are to be improved and thereby the focusing characteristics may be deteriorated.

For solving these problems, there has been proposed an electron gun having an elongated third focusing electrode to improve the beam spot characteristics. In such electron guns, however, the longer the third electrode becomes, the easier becomes the generation of a halo and the worse become the focusing characteristics. The generation of a halo is suppressed by lengthening the distance between the first and the second focusing electrodes, but there is a limitation to such a modification. There is also proposed an electron gun in which the aperture of the first focusing electrode is made smaller to decrease the halo, but it is accompanied with a drawback that the service life of the gun becomes extremely short. From these reasons, in generally used conventional guns, the length of the third focusing electrode is usually 15 to 20 mm in the bipotential type and 13 to 18 mm in the unipotential type and improvements in the focusing characteristics should also be managed in such restricted regions.

Therefore, an object of this invention is to provide an electron gun assembly for use in a cathode ray tube, which forms a novel electron lens system.

Another object of this invention is to provide an electron gun assembly which has a thin beam spot diameter and good halo and focusing characteristics.

According to an embodiment of this invention, there is provided in a cathode ray tube having an electron gun provided with a main lens system for focusing the electron beam emitted from a cathode on a fluorescent screen, an electron gun assembly comprising a main lens system consisting of at least two aligned lens systems, the cross-over point of the electron beam emitted from said cathode electrode being positioned substantially at a focal point of the lens system of said main lens system on the cathode side, thereby collimating the electron beam substantially parallel to the central axis of the two lens systems of said main lens system between said two lens systems.

Other objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a cross section of the main portion of an embodiment of the electron gun assembly according to the invention;

FIG. 2 illustrates the operational principles of the electron gun shown in FIG. 1; and

FIGS. 3 and 4 are cross sections of the main portions of other embodiments of the invention, respectively.

Preferred embodiments of the invention will be described hereinbelow referring to FIGS. 1 to 4.

FIG. 1 shows an embodiment of the electron gun according to the invention and FIG. 2 illustrates the principles of the electron gun of FIG. 1. In FIG. 1, letter k denotes a cathode for emitting electrons, G_1, G_2, G_3, G_4 and G_5 the first, second, third, fourth and fifth grid electrodes respectively, and G_6 an anode. These electrodes are aligned on the same imaginary axis. The longitudinal (axial) length of the fourth grid electrode G_4 is selected larger than the tube diameter.

When predetermined respective voltages are applied to the respective electrodes in the illustrated structure, two electron lenses L_1 and L_2 are formed. For example, a voltage of 7 to 10 kV is applied to the third and fifth grid electrodes and a voltage of 20 to 30 kV is applied to the fourth grid electrode and the anode. The electron lenses thus formed by said voltage application can be schematically represented by the diagram of FIG. 2. Thus, a bipotential type lens system is formed between electrodes G_3 and G_4 corresponding to lens L_1 in FIG. 2, and a unipotential type lens system is formed by electrodes G_4–G_6 corresponding to lens L_2 in FIG. 2. When electrons are supplied through a point source (object point i.e., cross-over point) *a* which is located at the focal length of the first lens L_1 in front of the first lens L_1, the electrons diverge toward the first lens as indicated by traces l_1 and l_2 and then are deflected by the first lens L_1 to become parallel to the axis *b*. Namely, the first lens L_1 is arranged to work as a collimating lens, or the focal point of the electron lens L_1 is positioned at the object point *a*. The electrons collimated by the first lens L_1 proceed in a path indicated by traces l_3 and l_4 in parallel to the imaginary axis *b* toward the second lens L_2 and then are deflected by the second lens L_2 as indicated by traces l_5 and l_6 and focused on a point *c* on the imaginary axis *b*. In this case, as seen

from the points *a* and *c* on the imaginary axis *b*, the existence of two lenses L_1 and L_2 is equivalent to the existence of a large aperture main lens L_m on the line connecting the cross points *d* and *e* of the extensions of the traces l_1, l_2, l_5 and l_6. Thus, the aberrations are greatly reduced. Here, one of the most important things is that the focusing electrode assembly should be so arranged that the traces of the electrons deflected by the lens L_1 become parallel to the imaginary axis *b*. This means that the object point should approach the focal point of the first electron lens L_1. Further, in the case when the traces of the electron beam l_3 and l_4 are parallel to the imaginary axis *b*, even if the electrode is elongated and the beam spot is made thinner, the aberrations are not affected much and there is no danger that the halo and the focusing characteristics will deteriorate.

In the above embodiment, two electron lenses consisting of one bipotential type lens formed between electrodes G_3 and G_4 and one unipotential type lens formed by electrodes G_4–G_6 are disposed on an imaginary axis to form one large aperture lens. The present invention, however, is not limited to this and can be applied to various electron lens systems.

Namely, this invention can be applied similarly to the electron guns provided with a combination of two unipotential type electron lenses and to the electron guns provided with a combination of two bipotential type electron lenses. Embodiments for these cases are shown in FIGS. 3 and 4 respectively.

In FIG. 3, a voltage of 20 to 30 kV is applied to the third and fifth electrodes G_3 and G_5 and the anode G_7, and another voltage of 7 to 10 kV is applied to the fourth and sixth electrodes G_4 and G_6. Then, two unipotential type lenses corresponding to the lenses L_1 and L_2 of FIG. 2 are formed at the fourth and sixth grid electrodes G_4 and G_6. In the embodiment of FIG. 4, a voltage of 20 to 25 kV is applied to the third grid electrode G_3, a voltage of 7 to 10 kV to the fourth electrode G_4, and a voltage of 25 to 30 kV to the anode G_5. Bipotential type lenses corresponding to the lenses L_1 and L_2 of FIG. 2 are formed in the gaps between the respective adjacent electrodes. In the embodiments of FIGS. 3 and 4, the axial length of the respective fifth and fourth grid electrodes respectively located between the lenses L_1 and L_2 are taken larger than the diameter of the electrode.

In the above embodiments, the purpose of collimating the electron beam between the electron lenses parallel to the axis can be achieved by changing the voltages applied to the respective electrodes and/or the lengths of the respective grid electrodes constituting the electron lenses.

Further, the length of the third grid G_3 is designed to be approximately equal to the focal length of the electron lens L_1. Practically, the length of this third grid G_3 is determined from the relation to the magnification ratio of the electron lenses L_1 and L_2, the distance of the focal point (i.e., image plane) *c* from the electron lens L_2, etc.

As is described above, according to the electron gun assembly of the invention, one apparent main lens of a large aperture is formed by two lenses. Therefore, an electron gun assembly having a thin beam spot diameter and excellent focusing characteristics can be provided easily.

What is claimed is:

1. An electron gun assembly for use in a cathode ray tube having at least one electron gun provided with a prefocusing lens system and a main lens system for focusing an electron beam emitted from at least one cathode on a fluorescent screen, said main lens system comprising at least two individual lens systems each formed of a plurality of aligned lens electrodes whose axes correspond to the central axis of said electron gun, said main lens system being positioned with respect to said prefocusing lens system so that the cross-over point of said electron beam is positioned substantially at the focal point of the individual lens system closest to said cathode, thereby causing said electron beam to have a substantially uniform transverse dimension of flux and a central axis in parallel with the axis of said electron gun between said individual lens systems forming said main lens system.

2. In a cathode ray tube having at least one electron gun assembly provided with a prefocusing lens system and a main lens system for focusing an electron beam emitted from at least one cathode on a fluorescent screen, said main lens system comprising at least two electron lens systems aligned on a common central axis with said cathode, each electron lens system being formed of a plurality of aligned lens electrodes and meams for connecting potential sources to the respective lens electrodes, said main lens system being positioned with respect to said cathode so that the cross-over point of the electron beam emitted from said cathode is positioned substantially at the focal point of the electron lens system of said main lens system closest to the cathode, thereby collimating the electron beam substantially parallel to said common central axis of said main lens system between said two electron lens systems.

3. An electron gun assembly according to claim 2, in which said two electron lens systems have a common electrode disposed between said two lens systems, the axial length of said common electrode being larger than the diameter thereof.

4. An electron gun assembly according to claim 2, in which said two lens systems are formed of one bipotential type lens system and one unipotential type lens system.

5. An electron gun assembly according to claim 2, in which both of said two lens systems are formed of bipotential type lens systems.

6. An electron gun assembly according to claim 2, in which both of said two lens systems are formed of unipotential type lens systems.

7. An electron gun assembly according to claim 4, wherein said two electron lens systems are formed of successively aligned first, second, third, fourth, fifth and sixth electrodes on the same axis as said cathode, said third and fourth electrodes forming a bipotential type lens system, and said fourth, fifth and sixth electrodes forming a unipotential type lens system.

8. An electron gun assembly according to claim 7, in which the axial length of said fourth electrode is larger than the diameter thereof.

9. An electron gun assembly according to claim 5, wherein said two electron lens systems are formed of successively aligned first, second, third, fourth and fifth electrodes on the same axis as said cathode, said third and fourth electrodes and said fourth and fifth electrodes forming respective bipotential type lens systems.

10. An electron gun assembly according to claim 9, in which the axial length of said fourth electrode is larger than the diameter thereof.

11. An electron gun assembly according to claim 6, wherein said two electron lens systems are formed of successively aligned first, second, third, fourth, fifth, sixth and seventh electrodes on the same axis as said cathode, said third, fourth and fifth electrodes and said fifth, sixth and seventh electrodes forming respective unipotential type lens systems.

12. An electron gun assembly according to claim 11, in which the axial length of said fifth electrode is larger than the diameter thereof.

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