

PATENT SPECIFICATION

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- (21) Application No. 60124/72 (22) Filed 29 Dec. 1972
 (31) Convention Application No. 2 360/71 (32) Filed 30 Dec. 1971 in
 (33) Japan (JA)
 (44) Complete Specification published 23 July 1975
 (51) INT. CL.² H01J 29/48
 (52) Index at acceptance
 H1D 4A4 4A7 4E3A 4E3Y 4K4



(54) ELECTRON GUN ASSEMBLY WITH IMPROVED UNITARY LENS SYSTEM

(71) We, HITACHI, LTD., a Japanese Body Corporate 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 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. The invention also relates to a cathode ray tube.

Conventional electron guns having a lens function and used generally in cathode ray tubes include unipotential type and bipotential type. 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 bipotential 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.

[Price 33p]

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 electrode becomes, the easier becomes the third 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 bipotential type and 13 to 18 mm in unipotential type and improvements in the focusing characteristics should also be managed in such restricted regions. According to one aspect of the present invention there is provided a cathode ray tube having a fluorescent screen, 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 the fluorescent screen, the main lens system comprising at least two electron lens

systems, aligned on a common central axis with the cathode, each electron lens system being formed of a plurality of aligned lens electrodes and means for connecting potential sources to the respective lens electrodes, the main lens system being positioned with respect to the cathode so that the cross-over point of the electron beam emitted from the cathode and produced by the prefocusing lens system is positioned substantially at the focal point of the electron lens system of the main lens system closest to the cathode, thereby collimating the electron beam substantially parallel to the common central axis of the main lens system between the two electron lens systems of the main lens system.

According to another aspect of the present invention there is provided an electron gun assembly for use in a cathode ray tube, the assembly comprising 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, the 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 the electron gun, the main lens system being positioned with respect to the prefocusing lens system so that the cross-over point of the electron beam is positioned substantially at the focal point of the individual lens system closest to the cathode, thereby causing the 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 the main lens system.

Illustrative embodiments of the present invention will now be described with reference to the accompanying drawings, in which:—

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

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

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

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

Figure 1 shows an embodiment of the electron gun according to the invention and Figure 2 illustrates the principles of the electron gun of Figure 1. In Figure 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 Figure 2. Thus, a bipotential type lens system is formed between electrodes G_3 and G_4 corresponding to lens L_1 in Figure 2, and a unipotential type lens system is formed by electrodes G_4 to G_6 corresponding to lens L_2 in Figure 2. Electrodes G_1 and G_2 together comprise a pre-focussing lens system. 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, as indicated by traces l_5 and l_6 , are then 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 trajectories 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 trajectories 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 between electrodes g_4 and g_6 are disposed on

(13)

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.

5 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
10 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
20 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
25 G_7 . 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
30 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 both of these embodiments,
35 electrodes G_1 and G_2 comprise a prefocusing lens system.

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
40 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
45 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
50 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
55 is formed by two lenses. Therefore, an electron gun assembly having a thin beam spot diameter and excellent focusing characteristics can be provided easily.

60 WHAT WE CLAIM IS:

1. A cathode ray tube having a fluorescent screen, at least one electron gun assembly provided with a prefocusing lens system and a main lens system for focusing
65 an electron beam emitted from at least one

cathode on the fluorescent screen, the main lens system comprising at least two electron lens systems, aligned on a common central axis with the cathode, each electron lens system being formed of a plurality of
70 aligned lens electrodes and means for connecting potential sources to the respective lens electrodes, the main lens system being positioned with respect to the cathode so that the cross-over point of the electron
75 beam emitted from the cathode and produced by the prefocusing lens system is positioned substantially at the focal point of the electron lens system of the main lens system closest to the cathode, thereby collimating the electron beam substantially
80 parallel to the common central axis of the main lens system between the two electron lens systems of the main lens systems.

2. A cathode ray tube as claimed in
85 claim 1, in which the two electron lens systems of the main lens system have a common electrode disposed between said two lens systems, the axial length of the common electrode being larger than the
90 diameter thereof.

3. A cathode ray tube as claimed in claim 1 or 2, in which the two lens systems of the main lens system are formed of one
95 bipotential type lens system and one unipotential type lens system.

4. A cathode ray tube as claimed in claim 1 or 2, in which both the two lens systems of the main lens system are formed of bipotential type lens systems.
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5. A cathode ray tube as claimed in claim 1 or 2, in which both of the said two lens systems of the main lens system are formed of unipotential type lens systems.

6. A cathode ray tube as claimed in
105 claim 3, including successively aligned first, second, third, fourth, fifth and sixth electrodes on the same axis as the cathode, first and second electrodes forming the prefocusing system, the third and fourth electrodes
110 forming the bipotential type lens system, and the fourth, fifth and sixth electrodes forming the unipotential type lens system.

7. A cathode ray tube as claimed in claim
115 6, in which the axial length of the fourth electrode is larger than the diameter thereof.

8. A cathode ray tube as claimed in claim 4, including successively aligned first, second, third, fourth and fifth electrodes on the same axis as the cathode, the first
120 and second electrical forming the prefocusing lens system the third and fourth electrodes and said fourth and fifth electrodes forming the respective bipotential type lens systems.
125

9. A cathode ray tube as claimed in claim 8 in which the axial length of the fourth electrode is larger than the diameter thereof.

10. A cathode ray tube as claimed in claim 5, including successively aligned first, 130

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.

5 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
10 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_7 . 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 both of these embodiments, electrodes G_1 and G_2 comprise a pre-focussing lens system.

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.

60 WHAT WE CLAIM IS:

1. A cathode ray tube having a fluorescent screen, at least one electron gun assembly provided with a prefocusing lens system and a main lens system for focusing
65 an electron beam emitted from at least one

cathode on the fluorescent screen, the main lens system comprising at least two electron lens systems, aligned on a common central axis with the cathode, each electron lens system being formed of a plurality of aligned lens electrodes and means for connecting potential sources to the respective lens electrodes, the main lens system being positioned with respect to the cathode so that the cross-over point of the electron beam emitted from the cathode and produced by the prefocusing lens system is positioned substantially at the focal point of the electron lens system of the main lens system closest to the cathode, thereby collimating the electron beam substantially parallel to the common central axis of the main lens system between the two electron lens systems of the main lens systems.

2. A cathode ray tube as claimed in claim 1, in which the two electron lens systems of the main lens system have a common electrode disposed between said two lens systems, the axial length of the common electrode being larger than the diameter thereof.

3. A cathode ray tube as claimed in claim 1 or 2, in which the two lens systems of the main lens system are formed of one bipotential type lens system and one unipotential type lens system.

4. A cathode ray tube as claimed in claim 1 or 2, in which both the two lens systems of the main lens system are formed of bipotential type lens systems.

5. A cathode ray tube as claimed in claim 1 or 2, in which both of the said two lens systems of the main lens system are formed of unipotential type lens systems.

6. A cathode ray tube as claimed in claim 3, including successively aligned first, second, third, fourth, fifth and sixth electrodes on the same axis as the cathode, first and second electrodes forming the prefocusing system, the third and fourth electrodes forming the bipotential type lens system, and the fourth, fifth and sixth electrodes forming the unipotential type lens system.

7. A cathode ray tube as claimed in claim 6, in which the axial length of the fourth electrode is larger than the diameter thereof.

8. A cathode ray tube as claimed in claim 4, including successively aligned first, second, third, fourth and fifth electrodes on the same axis as the cathode, the first and second electrical forming the prefocusing lens system the third and fourth electrodes and said fourth and fifth electrodes forming the respective bipotential type lens systems.

9. A cathode ray tube as claimed in claim 8 in which the axial length of the fourth electrode is larger than the diameter thereof.

10. A cathode ray tube as claimed in claim 5, including successively aligned first,



second, third, fourth, fifth, sixth and seventh electrodes on the same axis as the cathode, the first and second electrodes forming the prefocusing system and the third, fourth and fifth electrodes and the fifth, sixth and seventh electrodes forming the respective unipotential type lens systems.

11. An electron gun assembly as claimed in claim 10, in which the axial length of said fifth electrode is larger than the diameter thereof.

12. An electron gun assembly for use in a cathode ray tube, the assembly comprising at least one electron gun provided with a prefocussing lens system and a main lens system for focusing an electron beam emitted from at least one cathode on a fluorescent screen, the 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 the electron gun, the main lens system being positioned with

respect to the prefocusing lens system so that the cross-over point of the electron beam is positioned substantially at the focal point of the individual lens system closest to the cathode, thereby causing the electron beam to have a substantially uniform transverse dimension of flux and a central axis in parallel with the axis of the electron gun between said individual lens systems forming the main lens system.

13. An electron gun assembly substantially as hereinbefore described with reference to and as shown by Figures 1 and 2 or Figures 3 and 4 of the accompanying drawings.

14. A cathode ray tube including at least one electron gun assembly as claimed in claim 13.

J. A. KEMP & CO.,
Chartered Patent Agents,
14 South Square,
Gray's Inn,
London WC1R 5EU.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1975.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



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