

PATENT SPECIFICATION

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(54) ELECTRON GUNS FOR USE IN CATHODE RAY TUBES

(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 an electron gun, and more particularly to an electron gun for use in cathode ray tubes.

The main lens of an electron gun utilized in a cathode ray tube is generally classified into two types, that is the bipotential type and the unipotential type. In the case of the bipotential type main lens, it is possible to form a sharply defined beam spot but as the beam current increases, the quality of the beam spot is gradually degraded. In the case of the unipotential type main lens, the quality of the beam spot is not influenced by the beam current, but the beam spot is not sharply defined. Consequently, with these types of the main lenses, if one tries to decrease the size of the beam spot, the aberration would tend to increase. For this reason, there is a limit for the sharpness of the beam spot.

It has also been proposed to construct a main lens system from a plurality of discrete lens systems so as to successively focus an electron beam by the discrete lens systems. However, as this construction requires a number of lens systems, it is necessary to increase the length of the electron gun.

In each of the known electron guns, the design of the electron lens system is such that the electron beam will pass through a region outside the axial region of the electron lens system, and if one tries to obtain a high density electron beam, the aberration of the electron lens system will be increased, thus making it difficult to form a sharply defined beam spot on a fluorescent screen.

Accordingly, it is an object of this invention to provide an improved electron gun for use in a cathode ray tube.

A further object of this invention is to provide an improved electron gun capable of forming a sharply defined electron beam spot without increasing aberration.

According to one aspect of the invention there is provided an electron gun wherein a main electron lens system is constituted by a plurality of independent electron lens stages each comprising three substantially coaxial electrodes and wherein each of said lens stages other than the last is adapted to operate at a greater intensity than that of the next succeeding lens stage.

According to a further aspect of the invention an electron gun includes a main electron lens system comprising a first lens stage and at least one succeeding independent lens stage, each of the lens stages comprising three substantially coaxial electrodes and the electrode arrangement being such that when the lens stages all operate unipotentially each lens stage other than the last has a larger intensity than the next succeeding lens stage.

In the accompanying drawings, by way of example:

Fig. 1 is a schematic longitudinal section of an electron gun embodying the invention; and

Figs. 2 and 3 are diagrams showing other embodiments of this invention.

A preferred embodiment shown in Fig. 1 comprises a cathode electrode 1, and the first to the seventh control electrodes 2 to 8, of which the third control electrode 4, the fifth control electrode 6 and the seventh control electrode 8 are connected to a source of high voltage E_a having a voltage of from 10 to 30 KV, whereas the fourth control electrode 5 and the sixth control electrode 7 are connected to a focusing source E_b having a

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voltage of from 0 to 6 KV. Control electrodes 4 to 8 constitute two unipotential type electron lens systems 9 and 10. According to this invention, the intensity or the beam focusing power of the lens system 9 constituting the first stage of the lens system is made larger than that of the lens system 10 constituting the second stage. Thus, the main electron lens system is constituted by these two lens systems 9 and 10. More particularly, the main electron lens system of the electron gun is comprised by two unipotential type electron lens systems 9 and 10 which are less susceptible to the effect of the variations in the high voltage, and the intensity of the first stage lens system 9 located closer to the cathode electrode 1 is made larger than that of the second stage lens system 10, thereby causing the electron beam to pass through regions close to the axis of the electron gun.

With this design, the electron beam entering into the main electron lens system from a prefocusing system is strongly refracted and its diameter is decreased. In addition, as the electron beam is gradually focused by two electron lens systems 9 and 10, it is possible to form a more sharply defined beam spot than the conventional electron gun, without increasing the aberration. Furthermore, as the main electron lens system is comprised by two lens systems it is possible to construct the main electron lens system with a relatively large electrode opening so that the aberration can be further decreased.

As above described, the invention provides an electron gun having a small aberration, particularly for an electron beam of high density, and can form a sharply defined beam spot.

The basic feature of this invention, that is, the feature of making the intensity of the first stage lens system larger than that of the second stage lens system, can be accomplished by:

1. increasing the length of a particular electrode of the electrodes comprising the first stage electron lens system to which a low

voltage is impressed, that is the length l_1 of the fourth control electrode 5 shown in Fig. 1, relatively to the corresponding electrode of the second stage, or by

2. increasing the spacings between control electrodes comprising the first stage electron lens system, that is the spacings l_2 and l_7 between the third and fourth control electrodes 4 and 5 and between the fourth and fifth control electrodes 5 and 6, relatively to the corresponding spacings of the second stage.

In the case of a particular electron gun for use in a colour picture tube, the various electrodes shown in Fig. 1 have the following dimensions.

Example 1.

$l_1 = 0.19\text{mm}$, $l_2 = 0.25\text{mm}$, $l_3 = 1.1\text{mm}$,
 $l_4 = 6.8\text{ mm}$, $l_5 = 1.4\text{ mm}$, $l_6 = 10.0\text{mm}$,
 $l_7 = 1.4\text{ mm}$, $l_8 = 28\text{ mm}$, $l_9 = 1.4\text{mm}$,
 $l_{10} = 3.4\text{ mm}$, $l_{11} = 1.4\text{ mm}$, $l_{12} = 9.5\text{mm}$,
and
 $l_{13} = 8.9\text{ mm}$.

Example 2.

$l_1 = 0.19\text{mm}$, $l_2 = 0.25\text{mm}$, $l_3 = 1.1\text{mm}$,
 $l_4 = 6.8\text{ mm}$, $l_5 = 2.4\text{ mm}$, $l_6 = 6.0\text{mm}$,
 $l_7 = 2.4\text{ mm}$, $l_8 = 28\text{ mm}$, $l_9 = 1.4\text{mm}$,
 $l_{10} = 6.0\text{ mm}$, $l_{11} = 1.4\text{ mm}$, $l_{12} = 9.5\text{mm}$,
and
 $l_{13} = 8.9\text{ mm}$.

Instead of connecting the fourth control electrode 5 and the sixth control electrode 7 to common source Eb, it is also possible to connect these control electrodes 5 and 7 to different focusing sources Eb₁ and Eb₂ having voltages of from 0 to 6 KV. In the same manner, the third, the fifth and seventh control electrodes 4, 6 and 8 may be connected to independent sources.

Fig. 2 diagrammatically shows such a connection diagram and the following table shows typical examples of the voltages of the various sources.

TABLE

Example	Ea ₁	Ea ₂	Ea ₃	Eb ₁	Eb ₂
1	25 KV	25 KV	25 KV	5.8 KV	6.8 KV
2	30	30	30	9.4	9.4
3	13	13	13	4.2	4.2
4	30	25	25	8.6	6.8
5	30	25	20	8.6	5.4

It will be appreciated that examples 4 and 5 do not, strictly speaking, employ unipotential operation. However the lens stages operate in the same manner as a strictly unipotential lens with the same characteristics, and hence the operation is still, generally speaking, of the unipotential type.

Although in the foregoing embodiments the main electron lens was comprised by two unipotential type electron lens systems it should be understood that the invention is by no means limited to this construction but that the main electron lens system can also be constituted by a plurality of more than two uni-

potential type electron lens systems so long as the intensity of each preceding lens system can be made to be stronger than that of the succeeding lens system. Again, it is possible to obtain a lens effect of substantially large diameter as in the forgoing embodiments, so that the electron beam passes through the region of small aberration.

Fig. 3 shows such modification which is different from that shown in Fig. 1 in that additional electrodes 11 and 12 are added. Source Ea may have a voltage of from 12 to 30 KV and source Eb a voltage of from about 2.4 to 10 KV. The embodiment shown in Fig. 3 can also form a sharply defined electron beam spot without increasing the aberration. Typical dimensions relating to the various electrodes are as follows:

$l_1 = 0.19\text{mm}$, $l_2 = 0.25\text{mm}$, $l_3 = 1.1\text{mm}$,
 $l_4 = 7.8\text{ mm}$, $l_5 = 1.4\text{ mm}$, $l_6 = 8.0\text{mm}$,
 $l_7 = 1.4\text{ mm}$, $l_8 = 10.0\text{mm}$, $l_9 = 1.4\text{mm}$,
 $l_{10} = 5.0\text{ mm}$, $l_{11} = 1.4\text{ mm}$, $l_{12} = 10.0\text{mm}$,
 $l_{13} = 8.9\text{ mm}$, $l_{14} = 1.4\text{ mm}$, $l_{15} = 3.4\text{ mm}$,
 $l_{17} = 1.4\text{ mm}$, $l_{18} = 9.5\text{ mm}$.

Although the invention has been shown and described in terms of some preferred embodiments thereof it should be understood that many changes and modifications will be obvious to one skilled in the art without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:

1. An electron gun for use in a cathode ray tube wherein a main electron lens system is constituted by a plurality of independent electron lens stages each comprising three substantially coaxial electrodes, and wherein each of said lens stages other than the last is adapted at a greater intensity than that of the next succeeding lens stage.

2. An electron gun for use in a cathode ray tube and including a main electron lens system comprising a first lens stage and at least one succeeding independent lens stage, each of the lens stages comprising three substantially coaxial electrodes and the electrode arrangement being such that when the lens stages all operate unipotentially each lens stage other than the last has a larger intensity than the next succeeding lens stage.

3. An electron gun according to either of the preceding claims, wherein the length of the intermediate low voltage electrode of a greater intensity lens stage is made larger than

that of the intermediate low voltage electrode of the next succeeding lens stage.

4. An electron gun according to any one of the preceding claims, wherein the spacing between the electrodes of a greater intensity lens stage is larger than that between the electrodes of the next succeeding lens stage.

5. An electron gun according to any one of the preceding claims, wherein said main electron lens system comprises two unipotential type electron lens stages.

6. An electron gun according to claim 5, wherein the electron lens system comprise a common electrode which provides the third electrode of the first of said two stages and the first electrode of the second of these stages.

7. An electron gun according to claim 6, wherein the first electrode of the first stage, the common electrode and the third electrode of the second stage are interconnected for connection to a common source of one voltage, and the intermediate electrodes of both stages are interconnected for connection to another common source of different voltage.

8. An electron gun according to any one of claims 1 to 5, wherein said main electron lens system comprises three unipotential type electron lens stages.

9. An electron gun according to claim 8, wherein the electron lens system comprises two common electrodes one of which provides the third electrode of the first lens stage and the first electrode of the second lens stage, and the other of which provides the third electrode of the second stage and the first electrode of the third stage.

10. A cathode ray tube embodying an electron gun according to any one of the preceding claims.

11. A cathode ray tube according to claim 10 connected to control voltage sources for the lens system, the arrangement and control voltages being such that in use each of the independent lens stages operates as a unipotential system.

12. An electron gun for a cathode ray tube substantially as hereinbefore described with reference to the accompanying drawings.

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potential type electron lens systems so long as the intensity of each preceding lens system can be made to be stronger than that of the succeeding lens system. Again, it is possible to obtain a lens effect of substantially large diameter as in the forgoing embodiments, so that the electron beam passes through the region of small aberration.

Fig. 3 shows such modification which is different from that shown in Fig. 1 in that additional electrodes 11 and 12 are added. Source Ea may have a voltage of from 12 to 30 KV and source Eb a voltage of from about 2.4 to 10 KV. The embodiment shown in Fig. 3 can also form a sharply defined electron beam spot without increasing the aberration. Typical dimensions relating to the various electrodes are as follows:

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 $l_4 = 7.8\text{ mm}$, $l_5 = 1.4\text{ mm}$, $l_6 = 8.0\text{mm}$,
 $l_7 = 1.4\text{ mm}$, $l_8 = 10.0\text{mm}$, $l_9 = 1.4\text{mm}$,
 $l_{10} = 5.0\text{ mm}$, $l_{11} = 1.4\text{ mm}$, $l_{12} = 10.0\text{mm}$,
 $l_{13} = 8.9\text{ mm}$, $l_{15} = 1.4\text{ mm}$, $l_{16} = 3.4\text{ mm}$,
 $l_{17} = 1.4\text{ mm}$, $l_{18} = 9.5\text{ mm}$.

Although the invention has been shown and described in terms of some preferred embodiments thereof it should be understood that many changes and modifications will be obvious to one skilled in the art without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:

1. An electron gun for use in a cathode ray tube wherein a main electron lens system is constituted by a plurality of independent electron lens stages each comprising three substantially coaxial electrodes, and wherein each of said lens stages other than the last is adapted at a greater intensity than that of the next succeeding lens stage.

2. An electron gun for use in a cathode ray tube and including a main electron lens system comprising a first lens stage and at least one succeeding independent lens stage, each of the lens stages comprising three substantially coaxial electrodes and the electrode arrangement being such that when the lens stages all operate unipotentially each lens stage other than the last has a larger intensity than the next succeeding lens stage.

3. An electron gun according to either of the preceding claims, wherein the length of the intermediate low voltage electrode of a greater intensity lens stage is made larger than

that of the intermediate low voltage electrode of the next succeeding lens stage.

4. An electron gun according to any one of the preceding claims, wherein the spacing between the electrodes of a greater intensity lens stage is larger than that between the electrodes of the next succeeding lens stage.

5. An electron gun according to any one of the preceding claims, wherein said main electron lens system comprises two unipotential type electron lens stages.

6. An electron gun according to claim 5, wherein the electron lens system comprise a common electrode which provides the third electrode of the first of said two stages and the first electrode of the second of these stages.

7. An electron gun according to claim 6, wherein the first electrode of the first stage, the common electrode and the third electrode of the second stage are interconnected for connection to a common source of one voltage, and the intermediate electrodes of both stages are interconnected for connection to another common source of different voltage.

8. An electron gun according to any one of claims 1 to 5, wherein said main electron lens system comprises three unipotential type electron lens stages.

9. An electron gun according to claim 8, wherein the electron lens system comprises two common electrodes one of which provides the third electrode of the first lens stage and the first electrode of the second lens stage, and the other of which provides the third electrode of the second stage and the first electrode of the third stage.

10. A cathode ray tube embodying an electron gun according to any one of the preceding claims.

11. A cathode ray tube according to claim 10 connected to control voltage sources for the lens system, the arrangement and control voltages being such that in use each of the independent lens stages operates as a unipotential system.

12. An electron gun for a cathode ray tube substantially as hereinbefore described with reference to the accompanying drawings.

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