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Veith

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[54] **ELECTROSTATIC LENS FOR CATHODE RAY TUBES**

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[30] **Foreign Application Priority Data**

June 25, 1970 Germany .... P 20 31 486.7

[52] **U.S. Cl.** .... **315/16,** 315/31 R, 315/31 TV, 313/85

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

[58] **Field of Search** .... 315/16, 31, 14, 15, 315/31 R, 31 TV; 313/82, 85, 82 R

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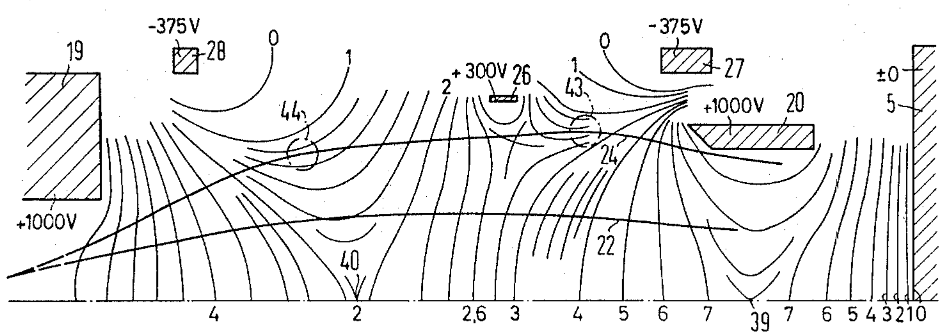
[57] **ABSTRACT**

An electrostatic lens constructed of cylindrical tube sections for cathode ray tubes having two terminal electrodes and a center electrode. The terminal electrodes have a high positive potential applied to them. The center electrode is sub-divided into two parts, and a correcting electrode is inserted between these parts. The correcting electrode has a potential applied thereto which is more positive than the potential of the center electrode, and less positive than the potential of the terminal electrodes.

8 Claims, 5 Drawing Figures



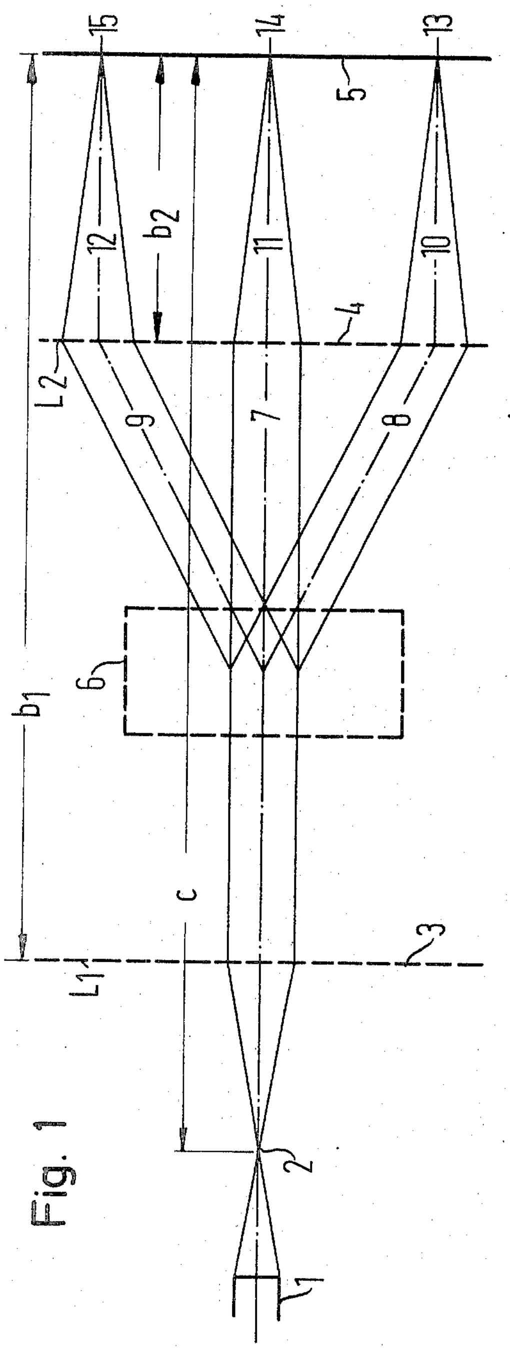


Fig. 1

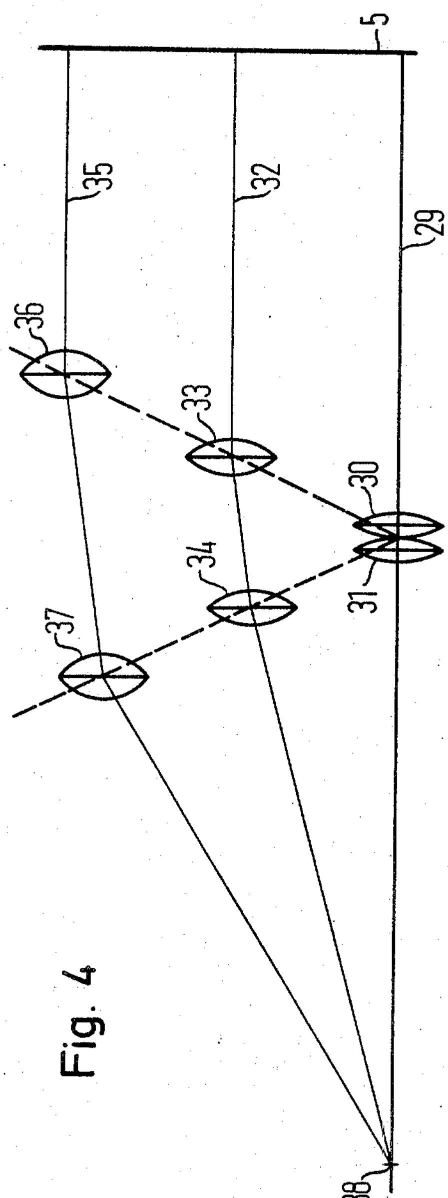


Fig. 4

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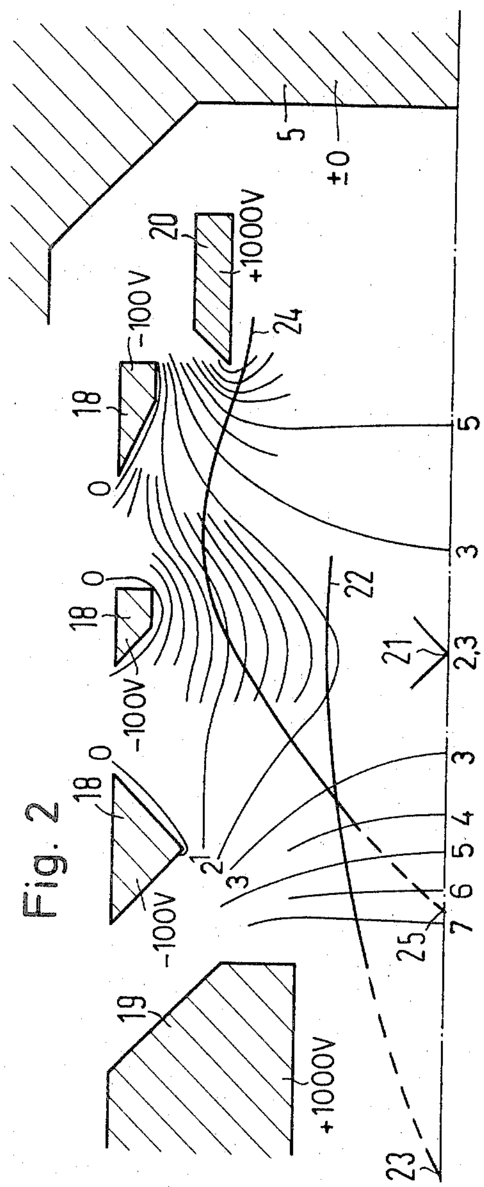

Fig. 2

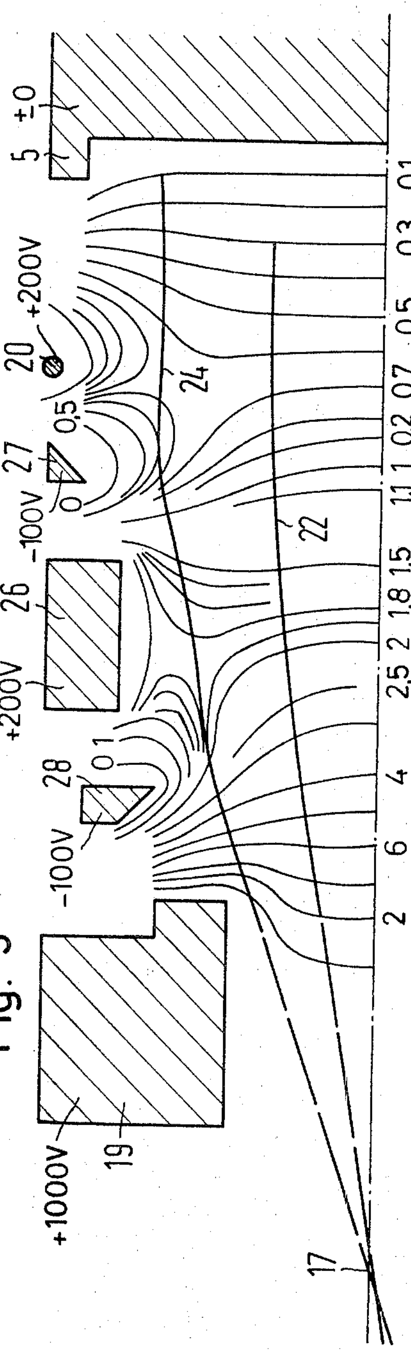

Fig. 3

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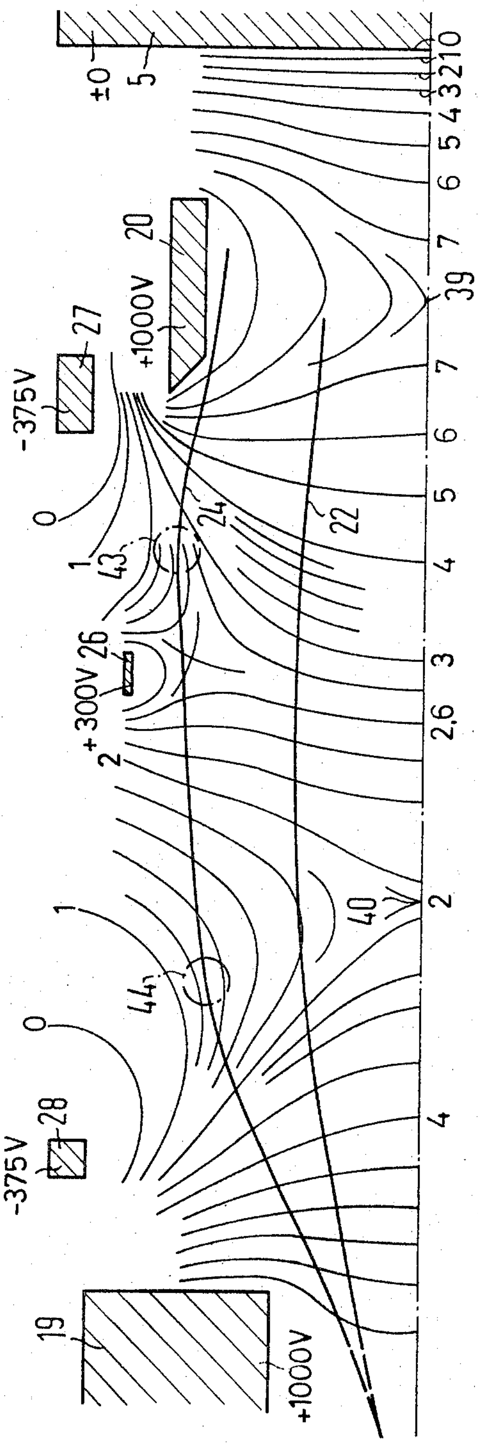

Fig. 5

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ELECTROSTATIC LENS FOR CATHODE RAY TUBES

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The field of art to which this invention pertains is cathode ray tubes having electrostatic lens systems.

SUMMARY OF THE INVENTION

It is an important feature of the present invention to provide an improved electrostatic lens for a cathode ray tube.

It is also a feature of the present invention to provide an electrostatic lens for a cathode ray tube which eliminates distortion.

It is an object of the present invention to provide a cathode ray tube having an electrostatic lens system which includes a pair of terminal electrodes and a center electrode which is sub-divided into two parts having a correction electrode positioned between those two parts.

It is another object of the present invention to provide an electrostatic lens for a cathode ray tube as described above wherein a high positive potential is applied to the terminal electrodes and a negative potential is applied to the center electrodes with a potential applied to the correcting electrode which is more positive than the potential on the center electrode.

These and other objects, features and advantages of the invention will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of the beam path for a cathode ray tube according to the present invention.

FIG. 2 is an illustration of the electrostatic field and how they influence the beam passing through the tube in a prior art arrangement.

FIG. 3 is a schematic of the type shown in FIG. 2 illustrating the improvement of the present invention in controlling the path of the beam through the tube.

FIG. 4 is an analog of the arrangement of FIG. 3 showing how solid lenses affect the path of a beam of light.

FIG. 5 is a schematic similar to FIG. 3 showing an alternate form of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to an electrostatic lens for a cathode ray tube where the lens is constructed of cylindrical sections. The lens includes two terminal electrodes having a high positive potential and a center electrode having a lower or negative potential. The center electrode is divided into two sections with a correcting electrode positioned between the two sections. The correcting electrode has a potential which is higher than the potential of the center electrode.

An electrostatic lens is of particular importance in such electron ray tubes in which the amount of caustic, decreases the quality of the tube.

In an electrostatic cathode ray tube, the beam extends at an angle relative to the axis of the tube after being deflected. Since, however, it must finally hit the target or screen perpendicularly, it is necessary under all circumstances to redirect the beam back into the axial direction after deflection. This must happen between the deflection center and the target with the help of an electrostatic lens.

Such unipotential lenses however generally result in considerable caustic which means that the sharpness of the picture toward the edges of the picture is diminished and also the picture is distorted in the shape of a pincushion.

It is one of the objects of this invention to avoid as far as possible this distortion with a unipotential lens by the use of a correction electrode.

This is accomplished by dividing the center electrode described above into two parts and inserting a correcting electrode between the separated parts. The correcting electrode then has a potential applied thereto which is more positive than the potential applied to the parts of the center electrode.

Referring to the drawings in greater detail, FIG. **1** shows schematically the beam paths in an electrostatically focused cathode ray tube. The beams which come from the cathode **1** form a crossover at a point **2** and pass through the lenses **3** and **4** onto the target **5.** A deflection device **6** is located between the lenses **3** and **4.** Therefore the power of refraction of the lens **4** must be selected to be such a magnitude that all the beams such as illustrated by the numerals **7, 8** and **9** which are deflected by the deflection means **6** hit the target **5** in a perpendicular direction.

The most important element in the electrostatic system is the lens **4.** In order to consider the quality of the lens each of the beams **10, 11** and **12** may be followed from their striking points **13, 14** and **15** on the target back through the lenses to determine whether they converge at the same deflection center.

In FIG. **2,** a prior art arrangement is shown in which the various electrodes produce the potential fields illustrated by the substantially parallel wavy lines. In FIG. **2** the two terminal electrodes are designated by the numerals **19** and **20.** These are maintained at a voltage of approximately 1000 volts. The center electrode is designated by the numeral **18** and is maintained at a negative potential of approximately 100 volts. In this arrangement the center electrode is shown as being in three parts though actually each part is electrically coupled to each other as one single unit.

It has been found that within the electrostatic field, about in the center of the center electrode, a saddle-point area **21** forms so that while the inner beam **22** is deflected in the expected manner (intersecting the axis at **23**), the outer beam **24** which extends into proximity with the negative electrode **18** intersects the axis at a point **25** which is much closer to the target. This typical fault of the unipotential lens is prevented by the arrangement of the present invention shown in FIG. **3** where the center electrode **18** is divided into two partial electrodes and a less negatively biased electrode such as the ring **26,** is positioned between the partial electrodes.

The advantageous arrangement shown in FIG. **3** causes the beams to converge at the same deflection point **17.** As explained, the center electrode is divided into two parts, and a less negative ring **26** is inserted between the two parts **27** and **28.** The insertion of the positive electrode **26** in the arrangement of FIG. **3** produces an effect from the individual lenses which has the shape of a double cone.

The action of the correcting lens in FIG. **3** may be understood by reference to an optical analog shown in FIG. **4.** The two lenses **30** amd **31** which touch each other represent the lens arrangement for the inner beam, and the remaining lenses **33** through **37** represent respectively the lenses for the beams **32** and **35** which are positioned outwardly from the inner beam **29.**

The power of refraction of a pair of lenses is determined by the following formula:

$$1/F = 1/f_1 = 1/f_2 - d/f_1 \cdot f_2$$

In the above, f represents the focal length of the respective lenses and d represents the distance between the lenses. Accordingly the combined power of refraction is weaker when the separate lenses are further apart. Therefore, in order to obtain the same refraction to a common point **38** for all three beams **29, 32,** and **35,** the power of refraction of the separate lenses must increase in a direction outwardly from the radial axis. This is symbolized by the use of thicker lenses **36** and **37** and gradually thinner lenses **30** and **31.**

The unipotential lens of FIG. **3,** preserves the field ahead of the target. As the potential-line path shows, an electrode arrangement has been utilized ahead of the target which provides a substantially uniform electric field at the target. However, in this arrangement it is necessary to tolerate the fact that the field strength is essentially less than it would desirably be for a cathode ray tube. Accordingly a second embodiment has been developed in which the field strength ahead of the target reaches substantially higher levels.

FIG. **5** shows such an arrangement with corrected unipotential lens identified by the numerals **26, 27** and **28.** When the potential lines of FIG. **5** and FIG. **3** are compared, it can be recognized that by applying a higher voltage to the terminal electrode **20,** not only the field strength between 5 and 20 increases, but also two saddle-points **39** and **40** are developed. In the example of FIG. **3,** the potential increases steadily from the target to the entrance of the beam at the neck of the tube.

Nevertheless, due to the arrangement of the electrodes in FIG. **5,** the embodiment of FIG. **5** more closely approaches the optical analog shown in FIG. **4.**

After the unipotential lens is produced as described, the parallel beams **10, 11** and **12** (FIG. **1**) meet in one point in the deflection center **6** (by viewing the inverted beam path).

The main lens **4** has another essential function. It forms a part of the focusing system. Therefore it is an advantage to make the lens sufficiently strong so that its power of refraction is higher than the lens **3.** With the distances which are inserted in FIG. **1,** the following relation is valid for the enlargement which is to be obtained.

$$V = b_1/f_2\ (f_2 - b_2)/(c - b_1)\ b_2^2/f_2\ (c - b_1)$$

When the refraction power of the lens **4** increases, the entire focusing system is shifted toward the target. This means that the cross-over point **2** is decreased in size which has a favorable effect on resolution. As the formula for enlargement demonstrates, it can be changes simply into the expression: $V = b^2/c - b_1$ when f_2 is equal to b_2.

Therefore, the enlargement for a sufficiently small value of b_2 is smaller than 1. It can be even further decreased if f_2 is substantially less than b_2.

This results in an increase in sharpness.

Therefore the arrangement described above not only has the advantage of eliminating the use of a magnetic field in a cathode ray tube, but with a suitable selection of the power of refraction of the lens **4,** it can result in an increased resolution. Of course, since the magnetic field is omitted, the size of the target can be caused to increase to the point where it can considerably exceed the dimensions which are common today.

The deflection means **6** (FIG. **1**) can be designed as an electrostatic deflection means since the deflection center is located in the field free area of the tube.

I claim as my invention:

1. In a cathode ray tube, an electrostatic lens comprising:

- first and second terminal electrodes, spaced apart within the tube,
- means for applying the highest positive potential of potentials supplied to the lens to the terminal electrodes,
- said terminal electrodes shaped symmetrically around the axis of the tube,
- a center electrode disposed between the two terminal electrodes,
- means for applying a low potential which is lower than that applied to the terminal electrodes to said center electrode,
- said center electrode comprising two parts, and
- a correction electrode positioned between the two parts of the center electrode.

2. An electrostatic lens in accordance with claim **1** wherein the potential applied to said correction electrode is higher than that applied to said center electrode and substantially less than that applied to said terminal electrodes.

3. An electrostatic lens in accordance with claim **2** wherein all of said electrodes are formed of generally cylindrical sections, with the beam passing through the center thereof.

4. An electrostatic lens in accordance with claim **1** wherein, in combination as a main lens with a condenser lens for arrangement in a vidicon, the condenser lens located at the cathode side of the tube and the main lens located at the target side of the tube.

5. An electrostatic lens in accordance with claim **4** wherein the power of refraction of the main lens is at least as great as that of the condenser lens and wherein the distances of the main lens as from the target is at least as great as their respective focal lengths.

6. An electrostatic lens comprising:

- four electrodes formed of cylindrical sections,
- two of said electrodes constituting terminal electrodes spaced apart along a common axis for receiving the highest positive potential supplied to the lens applied thereto,
- a third, center electrode including two spaced apart sections for receiving a lower potential applied thereto,
- a fourth electrode, as a correction electrode, physically disposed between the two spaced apart sections of the center electrode for receiving a potential applied thereto which is higher than the level

of the center electrode and lower than the level of said two terminal electrodes, and

the third and fourth electrodes symmetrically arranged about the same common axis as that of said two terminal electrodes.

7. An electrostatic lens in accordance with claim 1 wherein the potential of said third, center electrode is negative.

8. An electrostatic lens in accordance with claim 7 wherein the potential of said fourth electrode as the correction electrode is in the order of 100 volts positive.

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