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CATHODE RAY TUBE GUN CONSTRUCTION

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Fig. 1

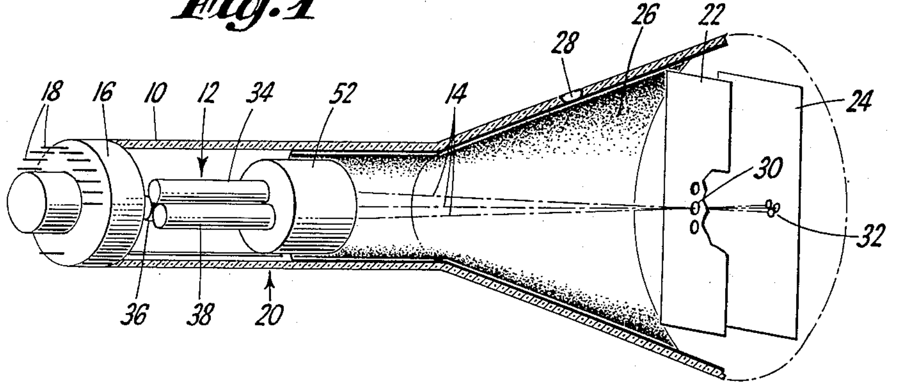
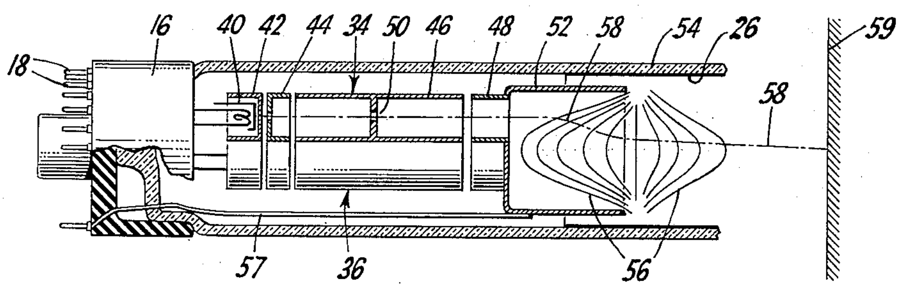
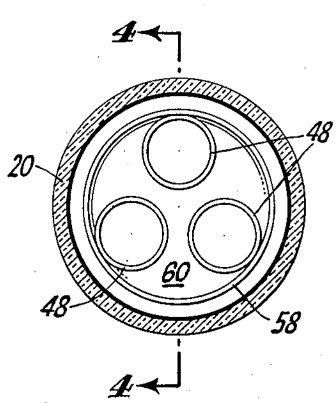


Fig. 2





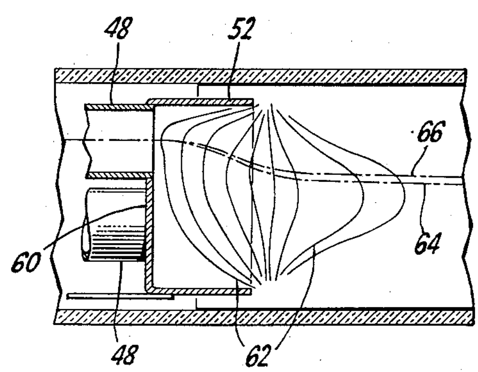


Fig. 3

Fig. 4

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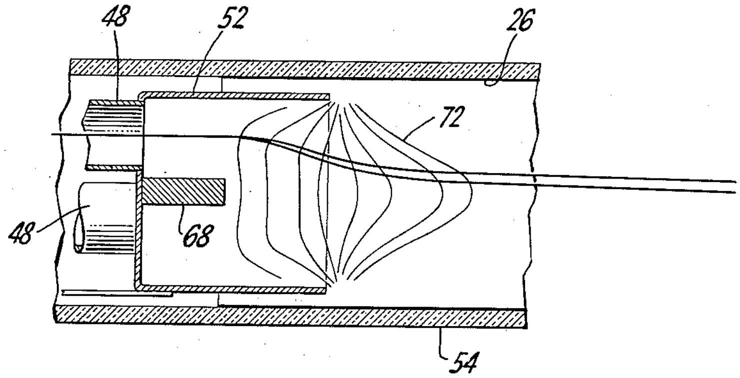

Fig. 5

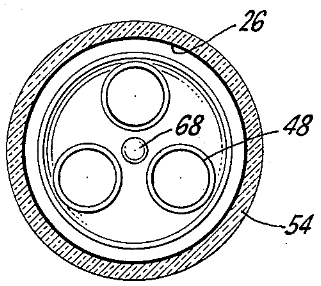

Fig. 6

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CATHODE RAY TUBE GUN CONSTRUCTION

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This invention relates to electron discharge devices, such as cathode ray tubes. More specifically, it relates to improved forms of electrostatic lenses, and associated structures for use in such devices. While the invention, as will be apparent after reading the specification and claims, is capable of broad application, it will be illustrated here in association with a color television picture tube.

Several types of color television picture tubes commonly known today employ multiple electron guns each of which produces an electron beam aimed at and guided to the picture reproducing area of the tube in such a way as to excite one of a number of corresponding color phosphors. In one such tube, three guns are mounted with their axes parallel, and the electron beams they generate are caused to converge at a common meeting point on a grid or aperture mask associated with the image display screen. The converged beams penetrate the grid or mask and diverge onto color phosphor bearing portions of the screen where they selectively produce the colored elements of a picture. The amount of convergence required to bring all of the beams to the same spot on the screen depends upon the tube geometry, and varies in degree depending upon the portion of the screen on which beams are being converged. Each tube type therefore has its own required static and dynamic convergence operating conditions. The term "static convergence" describes the amount of convergence required to bring the beams together at the center of the screen and the term "dynamic convergence" refers to variable convergence which must be added to produce convergence at other portions of the screen.

Various sorts of structures have been devised for producing the required convergence of the beams. One family of structures employs electromagnetic deflection fields which behave like optical prisms and are applied to the tubes at the electron gun exits. Electrostatic deflecting plates or electrostatic converging lenses may also be employed at the exit of the guns for this purpose. As between the two types, the electrostatic convergence type of color gun structure is thought preferrable to the electromagnetic type because of the simpler structures, the reduced number of external components, and the reduced number of power supplies required. Tubes employing electrostatic convergence have been commercially produced in the 15 inch envelope size with bipotential electrostatic convergence lenses. This invention relates to convergence lenses of this type.

In bipotential lens structures used to produce beam convergence, two electrodes are employed in the lens producing structure, one electrode, the so-called convergence electrode, being a cylinder or cup extending over the open ends of three parallel, triangularly disposed, electron guns towards the screen of the tube and operated at a potential equal to that applied to the last gun electrodes. The other portion of the lens producing structure may be an extension of the aquadag anode coating on the inside of the cathode ray tube neck which overlaps the convergence electrode, or it may be a cylinder supported by the gun mount. It is operated at the anode potential of the cathode ray tube, a potential much higher than any other applied to the electron gun of the tube. In 15 inch color tubes employing such guns, the final anode voltage is ordinarily of the order of 20 kilovolts and the static voltage applied to the convergence electrode for converging the beams at the center of the screen is approximately half the anode voltage, about 10 kilovolts. The ratio of convergence electrode voltage to anode voltage is therefore about 1:2.

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It is customary in cathode ray tubes of this type to bring the convergence electrode voltage lead out through the base of the cathode ray tube, since to take it directly out through the glass neck of the tube would introduce special structural problems in the tube as well as in structures which must be fitted around the neck of the tube. When the convergence voltage is 10 kilovolts, it is difficult to provide an electrode structure and tube basing arrangement which will permit bringing the convergence lead out of the tube base without undesirable effects. Troubles are encountered which result from the presence of the high voltage on this lead. For example, current leakage sometimes occurs inside of the stem on the surface of the glass due to paths created by faulty getter distribution, material thrown off the cathode, or other surface dirt. Electrolysis of the glass of the stem may be harmfully increased. Leakage on the glass outside of the stem but inside of the tube base occurs due to undesired material collecting on the glass, such as dirt or moisture. Arc-over sometimes occurs in the space within the base due to carelessly placed leads and the effects of humidity. While the base pin to which the convergence lead is connected may be intentionally placed as far away as possible from the pins to which other, lower voltage, connections are made, the placement of the leads within the base may be faulty, bringing them too close together and facilitating breakdown. Similar troubles may be encountered within the socket and within the leads which lead up to the socket.

All of the above listed troubles require that positive preventative steps be taken in the process of manufacturing a tube, steps which inevitably contribute to increased cost to the consumer. Added inspections and care are required to insure cleanliness. Special structures must be employed to encase the convergence voltage lead during its passage between the pin and the glass wall of the tube. One solution to the problem has been to fill the base of the tube with an insulating plastic. Another has been to use combined local applications of an insulating compound and insulating sleeves. Structures such as these are labor consuming and poorly adaptable to modern processing methods. The problem becomes acute with progress towards the larger sized picture tubes such as the 21-inch size in which approximately 27 kilovolts is applied to the anode, necessitating the application of 13 kilovolts of static convergence voltage and 1 kilovolt of dynamic convergence voltage to the convergence electrode.

It is an object of this invention to provide an electrostatic convergence lens structure in which the necessary convergence voltage is reduced to a value substantially less than half the anode voltage, thus permitting the use of higher voltages on the final anode of color picture tubes without the presence of the above mentioned difficulties.

Examination of electron lens field configurations and the associated structures required to produce them has heretofore led tube designers to believe that there were certain limitations on the structures employed which could not be exceeded. In the case of the convergence lens having three guns terminating in a convergence electrode cup, for example, it has been thought that the depth (length) of the cup should not be less than its diameter. It was felt that reducing the depth of the cup, which otherwise would assist in lowering the required convergence voltage by reducing the strength of the convergence portion of the lens, would produce astigmatic distortion of the beams as a result of disturbance of the axially symmetrical field produced by lens structures in which the limitations were observed. The field disturbance would result from projection of the first, or convergent, portion of the lens field into the gun openings. For this reason, previous designs of cathode ray tubes employing electrostatic convergence have utilized a depth to diameter ratio in the convergence electrode of at least approximately 1.

We have found however, that it is possible to reduce the strength of the convergence portion of the field produced by the action of the convergence electrode and the anode by shaping the convergence fields produced by cylindrical electrodes of the conventional sort. In structures produced according to the teachings of this invention, the ordinary relationships between the cylinder lengths, cylinder diameters, focal lengths, and voltage ratios of a simple bipotential lens are changed by shaping the convergence portion of the lens field by means of the addition of special electrodes or repositioning and reshaping of portions of the existing electrode structure. In lenses produced by structures built in accordance with the teachings of the invention, the angle of incidence of electrons on the equipotential surfaces first encountered as a beam enters the converging portion of the lens field is made more nearly perpendicular. The reduced converging action in the low potential region of the converging lens, accomplished by approximately the same amount of diverging action in the high potential region, permits a higher ratio of anode to convergence voltage for the same focal length.

Other advantages of the improved convergence lens structure are: capability of producing equal or better focussed electron spots under conditions where poorer spots would have been predicted heretofore; reduction in magnitude of static and dynamic convergence voltages required for proper convergence of the beams anywhere on the aperture mask; reduction in color tube failure due to minimization of the likelihood of arcing of the convergence electrode voltage supply lead in the base of the tube; and, due to the shortened gun structure achieved with some embodiments of the invention, a significant reduction in overall tube length, permitting the use of shallower cabinets in color television sets using the shortened tubes.

The above mentioned advantages and objects and others which will occur to the reader skilled in the art are achieved through the application of the principles of the invention as shown by way of example in the illustrations, described in detail below, and variously defined in the appended claims.

FIG. 1 is a side view in partial cross-section of a cathode ray tube embodying applicants' invention;

FIG. 2 is a side view in partial cross-section of a gun employing electrostatic convergence as taught by the prior art;

FIG. 3 is an end view looking into the convergence electrode of FIG. 2;

FIG. 4 is a view in partial cross-section of the convergence electrode end of the gun of the cathode ray tube of FIG. 1, illustrating one embodiment of applicants' invention;

FIG. 5 is a view in partial cross-section of a portion of the convergence lens structure of a color tube gun according to an alternative embodiment of applicants' invention; and

FIG. 6 is an end view, looking into the convergence electrode of FIG. 5.

FIG. 1 of the drawings illustrates the general scheme of a typical color television reproducing tube in which an aperture mask is utilized to assist in the production of a color picture. The tube is provided with an envelope **10** into one end of which is sealed a multiple gun **12** capable of producing three cathode ray beams **14**. Connections to various electrodes of the gun portion of the tube are made by means of leads extending backwards from the mount to the base **16** where they penetrate the envelope of the tube (see FIG. 2) and are connected to the pins generally designated **18**. Connections to the gun are not made through the neck portion **20** of the tube because they would interfere with the passage of tightly fitted auxiliary components which must be slid down over the neck of the tube. The opposite viewing end of the tube is provided with phosphor dot bearing screen surface **24** and aperture mask **22** so disposed that the electron beams **14**, will be caused to strike first the mask and then, finding apertures to travel on to the screen. The beams are accelerated towards the screen after they leave the guns by means of anode **26**, which may be found as a conductive coating on the inside of the cone of the tube connection to the coating being accomplished by means of a connective member penetrating the wall of the tube, such as the button **28** or the flanges utilized in some structures to seal on the face plate.

In the form of a cathode ray tube here illustrated, each one of the apertures **30** on the aperture mask **22** is associated with a group of three color phosphors **32** appearing on the screen portion of the tube. The disposition of the guns, aperture mask, and screen dots, is such that, as the bundle of cathode ray beams **14** is directed through a given aperture **30**, each of the beams strikes one of the three dots, so that if a beam is turned on the phosphor associated with the gun from which the beam emanates will be excited. Since the phosphor colors correspond to primary colors similar to those employed in the color television picture camera, controlled variation of individual beam currents in accordance with color picture intelligence produces controlled variation of the light output of the three dots which, due to optical combination of the very fine spots by the eye of the viewer, results in a blended color presentation.

FIG. 2 illustrates a color gun which is capable of producing three beams and which is built according to the prior art. The tri-color gun consists of three guns, **34**, **36**, and **38** mounted side by side so that the gun axes form the apices of a prism as best seen in the view of FIG. 1. Inasmuch as each of the guns **34**, **36**, and **38** is the same, only one of them is shown in section. Each of the guns has a cathode and heater portion **40**, contained within a first grid **42**, a second grid **44**, a third grid **46** and a fourth grid **48** all of which are generally tubular in nature and may or may not be provided with masking apertures **50**, depending upon the individual design of the electron producing portion of the guns. The cathodes **40**, the first grids **42**, to which color signals are supplied, and the second grids are ordinarily provided with separate leads to the outside of the tube, while the third grids are ordinarily tied together, as are the fourth grids. The individual fourth grids **48** each extend into the rear wall of cup shaped convergence electrode **52**. Convergence electrode **52**, as will be seen from FIG. 2, extends in turn into the cathode ray tube neck portion **54** of the final anode **26**. The conventional convergence electrode structure is shown as a cup having cylinder walls of a length equal to the diameter of the cup. For illustrative purposes, the course of the conecting lead from the convergence electrode voltages is shown as it extends to the tube base.

The interaction of the convergence electrode and the final anode when the proper operating potentials are applied produces a field which has a general configuration as shown by the equipotential lines **56**. The action of the convergence lens field on electrons which have left the cathode and have been shaped, according to conventional techniques into a beam traveling from the upper gun **34** is illustrated by the trajectory shown as the dark line **58** which represents the path taken by a typical electron traveling from the cathode **40** of the gun **34** to a target electrode or plane **59** which, for our purposes, may be considered the equivalent of the aperture mask **22** of FIG. 1. The course of an electron leaving the gun is gradually altered as it traverses the convergence portion of the field towards the axis of the tube. As the electron passes into the divergent portion of the field, its course is once more altered, this time in the opposite direction, so that its final path is close to and gradually convergent upon the axis of the tube. If allowed to continue toward the aperture mask undeflected, the electron will eventually be on the axis of the tube when it reaches the mask.

For the sake of illustration of the invention, it should be pointed out that the design parameters of the gun and the dimensions of the cup as well as the distance from the screen in a 15 inch tube demand, for incidence of the beam from upper gun **34** on the desired aperture **30** at the aperture mask **22**, that 20 kilovolts be supplied to the anode **26** and 10 kilovolts be supplied to the fourth grids and the convergence electrode **52**.

FIG. 4 illustrates one embodiment of applicants' invention. In this figure the beam generating portions of the guns have been omitted for the purposes of simplicity, but they will be understood to be the same as those generally illustrated in FIG. 2. As was the case with the convergence electrode **52** of FIG. 2, the cup-shaped convergence electrode **52** receives the ends of the fourth grids **48** in apertures in an end closure wall or bottom **60**. In this embodiment of the invention, the cup which forms the electrode **52** is approximately half as long as the cup is wide. The modified field which is produced by this sort of structure is illustrated by the equipotential lines **62**, and the relative difference in trajectory between an electron stream accelerated at the potentials utilized with the gun of FIG. 2 and the trajectory followed by electrons accelerated in the fields made possible by this structure has been shown by sketching in the equivalent previous trajectory **66** alongside the new trajectory **64**.

The altered effect of the lens produced by the structure of FIG. 4 results from deliberate shaping of the otherwise normal fields developed by a simple two-cylinder bipotential electrode structure as will be seen from the ensuing discussion.

The converging action of a simple bipotential lens upon spaced electron beams results from bending of the beams as they pass through the converging and diverging fields within the associated axially aligned cylindrical electrodes, the converging field being located within the electrode to which the lower potential is applied and the diverging field being located within the electrode to which the higher potential is applied. The strength of the lens depends upon the strength of the fields produced in the cylinders and the strength of the fields, in turn, is generally proportional to the potential difference between the electrodes. Because the converging field has a greater effect upon the electron beams than the diverging field, the net effect of the simple bipotential lens on separate, parallel beams is a change in direction as the beams leave the high potential side of the lens. The change in direction is away from parallel and towards the extended line of the lens axis. An increase in strength of the lens, produced by increasing the difference of potential between the electrodes, shortens the distance at which a given, non-axial, electron beam will cross the lens axis after leaving the lens field.

In the embodiment of the invention shown in FIG. 4, reduction of the convergence electrode potential so as to meet the problems set forth in the preamble above is accomplished by accepting the stronger field which results from the increase in potential difference across the lens while deliberately altering the field configuration within the lens in such a way as to reduce the effect of the strengthened lens upon the electron beams. This is done by shortening the convergence electrodes so as to cause interference between the convergence field and the end wall portion of the electrode, reducing the curvature of the equipotential lines in this region, and so reducing the convergent effect of the lens. Since the focal length of the gun assembly is principally determined by other conditions and so is fixed, the weakened "shaped" lens

produced by the shorter cup compensates for the increased strength of the lens due to the greater field strength.

The nature of the field configuration utilized in the shaped lens of FIG. 4 is demonstrated by the equipotential field lines **62**. Since the end closure portion of the cup **60** has rotational dissymmetry as a result of the gaps at the points of entry of the fourth grid electrodes **48**, and since there are plane electrode areas present in the back of the cup as well, the curvature of the equipotential lines in the region of the field closest to the back of the cup and on the lenss axis is no longer regular, and smooth as shown in FIG. 2 where the field is free of shaping, but may be characterized as flattened in the region of the plane surfaces and more sharply curved in the regions radially outward of the apertures. The overall effect is one of reduced field curvature at the points of entry of the beams and so bending of the beams as they travel through the lens is reduced. The potential gradient is thereby reduced at the points of electron entry from that value of potential gradient established adjacent the planar surfaces of the closure portion of cup **60**.

As indicated above, a good value of cup length for a convergence electrode having a diameter of 1½ inches and located in a tube neck having a 2 inch diameter has been found experimently to be about ¾ of an inch for triple gun structures having fourth grid diameters of ⅜ inch. Reduction of the convergence electrode length beyond this point results in noticeable distortion of the beams and increase in spot size. It has been found, too, that with further reduction in electrode length the focussing effect of the convex portions of the lens fields adjacent to the fourth grid apertures becomes quite pronounced and that the convergence electrode voltage required for proper convergence becomes negative, an undesirable condition from the point of view of the circuit designer. Changing the parts sizes relative to one another will, of course, produce changes in the optimum convergence electrode length determination.

Guns employing the 1:2 length to width ratio in the convergence electrode have been found to have a ratio of fourth grid to anode voltage of approximately .25, and require, for example, about 8 kilovolts for convergence when used with an anode supply of 27 kilovolts. It has been found that by experiment the optimum value of depth to width ratio for the convergence electrode cup dimensions is in the neighborhood of .5. If this value is increased, the undesirable effects of increasing the length of the tube employing such an electrode and increasing the required convergence voltage are produced. On the other hand, if the ratio is reduced significantly below this point, the focussing effect of the shaped convergence lens is increased with the result that too much focussing may be accomplished in the convergence lens leaving no room for the accomplishment of focussing in the focussing lenses. The accomplishment of concurrent convergence and focussing in a single lens while advantageous from the point of view of simplified, shortened gun structures is disadvantageous in that with the elimination of the focussing electrodes, limiting apertures would be required in the cylindrical electrode adjacent and connected to the convergence electrode. The current drawn by this arrangement would be undesirably high, requiring an undesirably expensive power supply capable of supplying substantial current at a high voltage. At some point, too, reduction of the cup length and the resulting reduction in curvature of the convergence portion of the lens will result in a net divergent lens action, since the divergent behaviour of the exit portion of the lens will be greater than the convergent behaviour of the entrance portion of the lens, resulting in a net divergent effect.

FIGS. 5 and 6 show an alternative embodiment of the invention in which the contours of the convergence portion of a bipotential lens are shaped by means of axial pin 68, mounted centrally of the bottom of the convergence electrode cup and of the apertures formed by the fourth grid cylinders. Suitable proportioning of the pin length to the cup length produces the modified field shape shown by the contour lines 72 outlining the equipotential lines. This arrangement produces a shaped field which is rotationally symmetrical with respect to the axis of the cylinder, being somewhat in the nature of dimpled hemispherical surface which is suitable for converging multiple beams at a lower voltage. The structure is inferior to the structure of FIG. 4 in one respect, namely, that it is somewhat longer, calling for greater tube length in color television applications. Further shaping of the field may be accomplished by changing the dimensions and shape of the field shaping pin.

Other types of structures embodying the invention will be visualized by workers skilled in the art. The configuration of the convergence portion of the bipotential lens field may be shaped according to the particular needs of an electronic structure by placing less reliance on the back wall of the cup electrode, or eliminating it altogether and depending upon changes in the shapes of the end portions of the electron beam supplying electrodes where they project into the convergence field. In other structures the bottom of the convergence electrode cup may be omitted, depending upon the fourth grid electrodes entirely for shaping of the convergence field.

While both of the structures shown above as illustrative embodiments of the invention have been associated with three gun color tube structures, they are equally suitable for producing deflection of one or more beams towards the axis of a bipotential lens in other situations. The teachings of the invention may be applied to other electron beam arrangements where the electron sources are spaced at some distance from the axis of the gun. In the case of an axially symmetrical structure, such as is shown in FIGS. 5 and 6, for example, the teachings of the invention could be utilized to produce varying amounts of convergence in a hollow cylindrical beam.

We claim:

1. An electron discharge device having: means for producing and directing a plurality of electron beams in the same direction; bipotential lens means having a convergence electrode for causing said beams to converge upon one another; said convergence electrode having means for reducing the potential gradient of said lens in the regions of entry of said electron beams, said last named means including a metallic electrode projecting into the field of said lens means centrally of said beams.

2. An electron discharge device having means for producing and directing a plurality of electron beams in the same direction, and bi-potential lens means positioned in the path of said beams having a convergence electrode with a tubular portion for causing said beams to converge upon one another, said convergence electrode having a given length and a metallic electrode projecting into said tubular portion centrally of said beams a distance less than said given length to shape the convergence lens by reducing the potential gradient of said lens in the regions of entry of said electron beams into the lens.

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