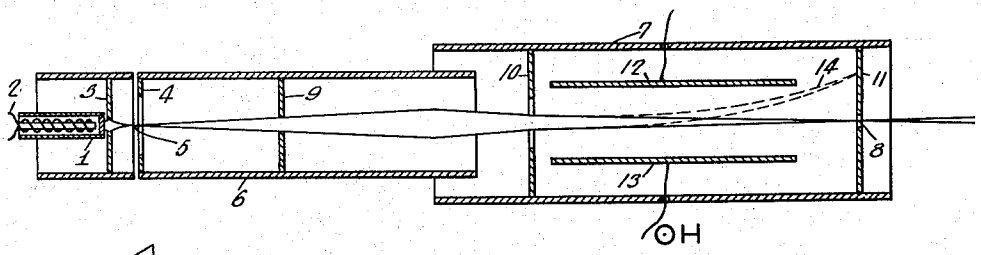
Feb. 24, 1942. H. BRANSON 2,274,586

CATHODE RAY TUBE

Filed Feb. 25, 1939 2 Sheets-Sheet 1

Fig. 1.



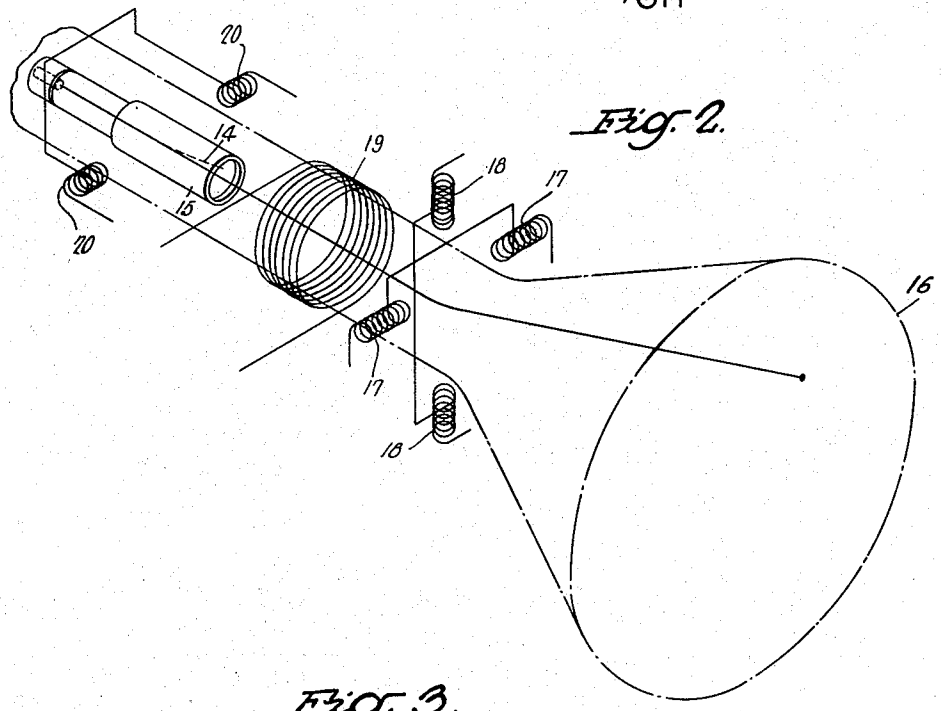
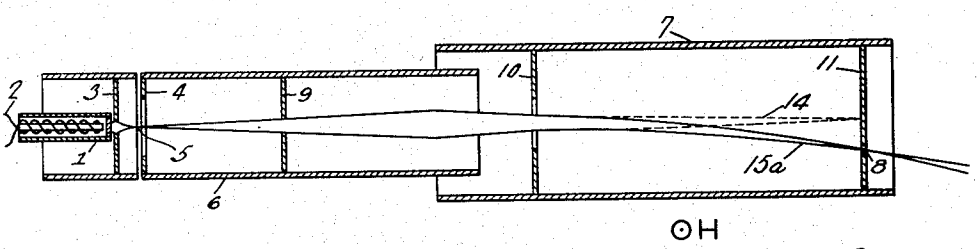


Fig. 2.

Fig. 3.



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Filed Feb. 25, 1939 2 Sheets-Sheet 2

Fig. 4.

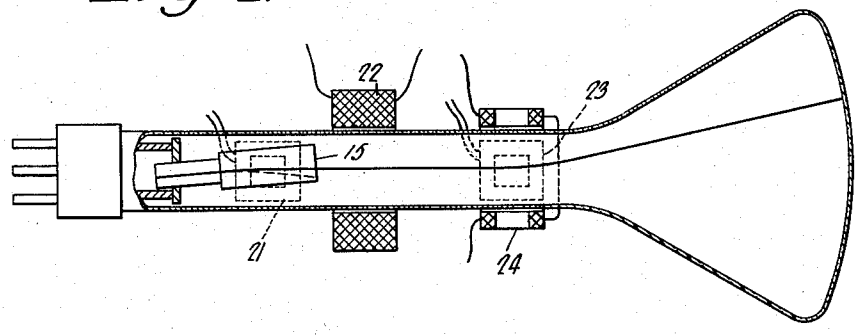


Fig. 5.

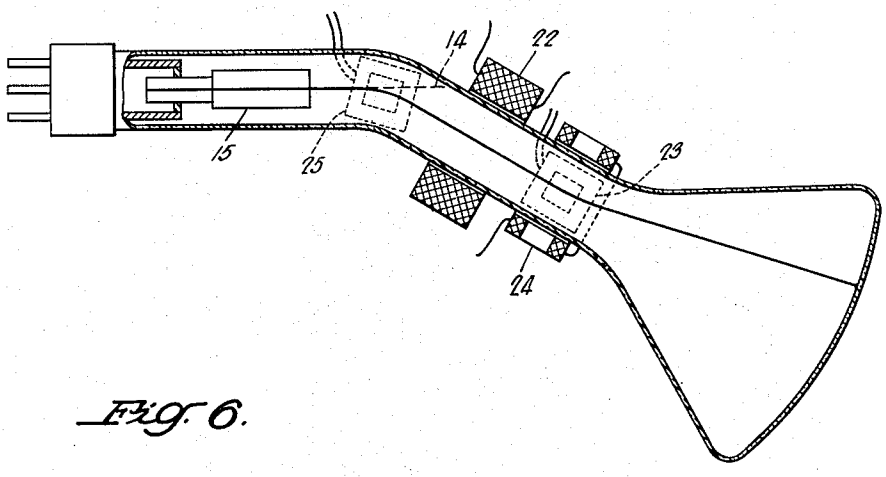
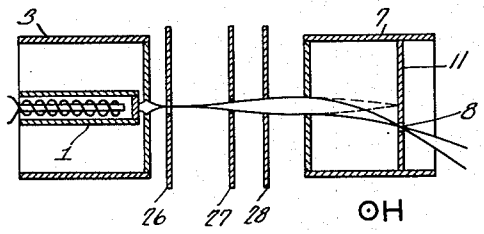


Fig. 6.



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UNITED STATES PATENT OFFICE

2,274,586

CATHODE RAY TUBE

Harry Branson, Philadelphia, Pa., assignor, by mesne assignments, to Philco Radio and Television Corporation, Philadelphia, Pa., a corporation of Delaware

Application February 25, 1939, Serial No. 258,488

4 Claims. (Cl. 250—157)

This invention relates to electron guns such, for example, as are used in cathode ray tubes to act as a source of electrons which may be employed to bombard a fluorescent screen and thereby produce visually observable phenomena whose characteristics are variable in response to an electrical signal or signals. More particularly, the invention relates to such an electron gun for use in a television system. Although the advantages realizable from the invention are most significant when it is employed in a television system, and although the application of the invention to such a system will be particularly described herein, it will be apparent that desirable results may be obtained when the invention is applied to other systems, and it is not intended to restrict the invention to the specific applications herein disclosed.

Electron sources and guns heretofore used are of divers forms and frequently contain a number of different parts or elements for performing various functions. In the past, most electron guns for use in television cathode ray tubes have employed incandescent cathodes as sources of electrons. A further feature of such guns resides in the employment of means for fasciculating the electrons from the source into a beam which may be deflected so as to cause it to traverse the surface of a screen composed of luminescent material. This fasciculating means may comprise either an electric or a magnetic focusing system, such as is familiar to those skilled in the art. Likewise the beam deflection may be accomplished either electromagnetically or electrostatically.

Prior devices of this type have been found to be objectionable in that a black spot or blemish invariably appears upon the luminescent screen at the point where it is intercepted by the axis of the electron gun and its associated system, after the tube has been operated for a short time. It has been found that this spot is caused by the presence of negatively charged particles which are commonly referred to as heavy ions (see article by Bachman and Carnahan; Proceedings of the Institute of Radio Engineers; May, 1935, pp. 529–39). It appears that these ions are the result of impurities in the material of which the cathode is constructed, and that they are freed therefrom along with the electrons after the cathode has been heated to luminescence. Because of their considerably greater mass compared to that of the electrons, these particles travel much more slowly when subjected to the electric field which is used for the purpose of accelerating the electrons. Hence, when they are operated upon further by a magnetic field acting in a direction at right angles to their path, such as might be employed to deflect the beam of electrons in a television cathode ray tube, their direction is not appreciably altered. This is in consequence of the fact that the force exerted on such a charged particle traveling in a magnetic field is a function of its velocity as well as of its mass. As a result these ions continue on their course from the cathode to substantially the same spot on the fluorescent screen, regardless of how the electrons may be deflected. At all times, when the tube is being operated, this particular portion of the screen is subjected to bombardment by the ions which soon tend to destroy its fluorescent properties and to blacken it, thus deleteriously affecting the quality of the reproduced television picture.

One of the objects of the present invention is to provide a source of electrons or other such particles, having a particular ratio of charge-to-mass and being substantially free from particles having materially different ratios of charge-to-mass.

A further object of the invention is to provide a means for obtaining a beam of electrons which is entirely free from heavy ions, for use in a cathode ray tube.

A still further object of the invention is to provide a cathode ray tube system for use as a television picture tube, wherein there is no tendency for the screen to be deleteriously affected by heavy particles emitted from the cathode.

Still another object of the invention is to accomplish the aforesaid objects with a minimum of additional equipment and without appreciably altering the design of tubes heretofore used.

The operation of the device of the invention is dependent upon the principle that the force exerted upon an electrically charged particle moving in a magnetic field is proportional to its velocity, while that exerted upon the same particle by an electric field is not. This principle is, of course, well known and it has previously been applied to the separation of charged particles. Hence it will be desirable, before proceeding with the description of the disclosed embodiments, to explain briefly wherein the present invention differs from those devices heretofore used. According to the invention, the electrons from a hot cathode, as well as the heavy ions therefrom, are focused into a beam. This beam is then subjected to the influence of electromagnetic fields, which may be either electric, magnetic, or a combination of both, so as to separate the beam into two or more beams according to the various ratios of charge-to-mass of the particles contained in the original beam. A diaphragm or equivalent means is then interposed in the path of the particles in such a manner as to intercept all but the desired beam. Thus, in effect, a new source is formed which supplies only particles having a certain ratio of charge-to-mass. The electrons or other charged particles may then be refocused into a narrow beam which may be used to scan the screen of the

tube. It will be seen that a significant feature of the invention is the use of two focusing operations in the course of obtaining the ultimate electron beam for scanning purposes. By such repeated focusing it is possible, as will be seen later, to obtain a pure electron beam entirely free from negative ions. With this in mind, the details and operation of the invention may best be understood by reference to the accompanying drawings in which:

Figs. 1, 3, and 6 are cross-sectional views of several embodiments of electron gun structures constructed according to the invention; and

Figs. 2, 4, and 5 are illustrations of various cathode ray tube systems employing the electron gun structures shown in the figures above mentioned and described in this specification.

Referring first to Fig. 1, there is shown in longitudinal cross section one form of the electron gun in which both electric and magnetic fields are employed in the separation of the heavy ions from the electron stream. In this figure, 1 may be a source of electrons and also of heavy ions, as has been explained. It may be composed of some thermionically active material heated by means of the heater winding 2, which may be supplied with current from a suitable source. The emission from source 1 may be focused by means of an immersion lens of any suitable design and here shown as comprising the electrodes 3 and 4 to which suitable potentials may be supplied in a manner familiar to those skilled in the art, so as to form a cross-over point as indicated at 5. The cylinders 6 and 7 may constitute the elements of bipotential electron lens, and are connected to sources of suitable potentials, as is common practice in the art, so as to focus the electrons at a point indicated at 8. In order that there may be a good focus, it is desirable to include in the system a diaphragm or stop 9 which limits the width of the beam so that only electrons which are substantially paraxial are admitted to the lens. A further diaphragm 10 may be used in connection with the second anode 7 to restrict the region in which the lines of equal electrostatic potential are curved to form the lens. Still another diaphragm 11 is placed at the end of the second anode, in which there is a small hole at point 8 which may be made just large enough to permit the passage of the electron beam.

In the space between the diaphragms 10 and 11, electric and magnetic fields are set up in such relation that the force exerted upon each of the electrons in the beam by the electric field will be substantially equal in magnitude and opposite in direction to the force exerted by the magnetic field. The electric field may be set up by the application of the proper potentials to the deflecting plates shown in the figure at 12 and 13. The magnetic field may be set up by using coils of suitable design whose axes are perpendicular to the axis of the electron beam such, for example, as are shown at 20 in Fig. 2, which shows a complete cathode ray tube system employing as a source of electrons the gun of Fig. 1. The direction of this field is indicated in Fig. 1 by the symbol of an arrow directed out from the plane of the paper at H. In the fields as thus set up by the deflecting plates and coils as shown in Figs. 1 and 2, it will be apparent that, along any line drawn through the axis of the undeflected beam and perpendicular thereto, there is no change in sign of electric potential gradient in such field within the bounds of the undeflected beam. This condition inherently obtains when the deflecting plates and coils are disposed in the manner shown in these figures. In Fig. 2, the gun is shown at 15 mounted in a glass envelope 16. The system is equipped with deflecting coils 17 and 18 for horizontal and vertical scanning, which may be supplied with suitable deflecting voltages.

When the electric and magnetic fields associated with the electron gun have been so adjusted that they cancel each other's effect upon the electrons of the beam, it will be found that while the electrons continue in a straight line, the heavy ions are deflected, by the unbalanced portion of the electric field, along the curved path indicated at 14 in Figs. 1 and 2. At the end of the tubular electrode 7, the apertured diaphragm 11 permits the electrons to pass while other particles are intercepted thereby. By the preliminary focusing of the particles emitted from the cathode, it is possible to obtain a beam whose cross section is very small at the point 8. It is therefore possible to make the hole in the diaphragm 11 of very small diameter without intercepting any appreciable number of the electrons. When this is done it will be seen that fields of only very small magnitude are required in order to deflect the ions so that none of them will pass through the aperture. It is preferable, therefore, in practicing the invention, to focus the beam so that the cross-over point occurs at the plane of the diaphragm 11 as illustrated. The amount of deflection shown in the figures is, of course, exaggerated in order to show more clearly the mode of operation of the device. It is also conceivable that the ions emitted from the source may be of different masses and have different velocities, in which case only those having velocities most nearly equal to the velocity of the electrons need be considered in estimating the amount of deflection required. By means of the system just described a new source of electrons is formed at the aperture in the diaphragm 11 and it is necessary to focus these electrons into a beam of small cross section which may be accomplished by means of a focusing coil as shown at 19 in the embodiment of Fig. 2.

Fig. 3 shows an embodiment which is identical in structure with that of Fig. 1 with the exception that the electrostatic deflecting plates 12 and 13 are omitted and the hole 8 for the passage of the electron beam is not centrally located. This embodiment is so arranged as not to require the use of an electric field but requires only a magnetic field which is set up in the region between diaphragms 10 and 11. The electrons and the ions, because of their differences in velocity and mass are deflected by different amounts and impinge upon the diaphragm 11 at different distances from the center. A hole is provided at the point 8 where the electron beam 15a would strike the diaphragm so as to permit the beam to pass. It will be realized, of course, that the beam of electrons as it emerges from the gun will not be parallel to the axis of the gun structure. Hence, it will be necessary to tilt the gun structure slightly when it is mounted in a cathode ray tube. However, since the eccentricity of the hole in the diaphragm need not be very great if the beam is properly focused, the amount of the tilting may be very small and will not make the gun inconvenient to introduce into tubes of the conventional design. In Fig. 4 the gun structure just described is shown mount-

ed in the neck of the tube at 15. The coil 21 serves to set up the deflecting field for separating the beam into its components, while the coil designated 22 is for refocusing the pure electron stream. 23 and 24 are the horizontal and vertical deflecting coils for scanning purposes.

Here again, as in the embodiments of Figs. 1 and 2 where both electric and magnetic deflecting fields were employed, it will be seen that in the deflecting field set up by the coil 21 there will be no change in sign of electric potential gradient along any line drawn through the axis of the undeflected beam and perpendicular thereto.

Fig. 5 shows another variation of the invention as embodied in Fig. 3, in which the wall of the tube is made to serve the purpose of the diaphragm 11. The gun 15 comprises merely a focusing system and there is no cross field or diaphragm directly associated with it. However the neck of the tube may be bent as shown and a deflecting coil 25 placed at the bend. The gun is so located that the ions, which are not appreciably deflected by the magnetic field, continue on the path 14 and are intercepted by the wall of the tube. The electrons, on the other hand, are caused to be deflected in accordance with the curvature of the tube neck and are directed toward the screen. 22 is the final focusing coil, while 23 and 24 are respectively the horizontal and vertical deflecting coils.

Since one of the significant features of the invention is the preliminary focusing of the electrons and ions into a beam, and since it is desirable from the point of view of economy of space to do this in as short a distance as possible, it has been found advantageous, in certain cases, to use lens types other than those of the embodiments above described which, since they facilitate the explanation of the invention, have been used for purposes of illustration. A lens which accomplishes the focusing in a shorter distance is shown in Fig. 6. It comprises, in addition to a cathode 1 and an immersion lens system comprising 3 and 26, a series of diaphragms 26, 27, and 28 and the electrode 7. 27 and 7 are maintained at a high positive potential, such as 6000 volts, and may be connected together. The electrode 28 may be maintained at a substantially lower potential, such as 3000 volts, and the combination forms an electron lens system for focusing the particles in the manner shown. The electrode 26 serves by means of the voltage applied to it to control the cut-off of the beam or, in other words, determines the position of the cross-over point in the beam and thereby the size of the beam cross section at the plane of the diaphragm. The direction of the cross magnetic field is indicated by the arrowhead at H directed away from the plane of the paper. The remainder of the device functions in exactly the same manner as the device of Fig. 3 and there is no need to describe it further. Such a lens might, for example, be substituted in the system of Fig. 4 in place of that of Fig. 3.

Numerous variations in the above-described embodiments which are within the scope of the invention will occur to those skilled in the art. Thus any of the known types of immersion lenses may be used in place of those shown, and any form of focusing system may be employed subject only to the requirements of simplicity and efficiency. The fundamental idea of the invention will be seen to lie in the steps of:

(1) Focusing particles of different ratios of mass-to-charge into a beam.

(2) Subjecting the beams to cross fields in such a manner as to separate the one beam into several separate beams according to the mass and velocity of the particles.

(3) Intercepting all but the beam containing the desired particles.

(4) Refocusing the desired beam for use in scanning the screen of a cathode ray tube.

The invention is therefore not to be regarded as having any restrictions with respect to apparatus which may be employed to obtain the desired results, other than those imposed by the following claims which serve to define the scope of the invention. It should be noted that, throughout this specification and in the claims, the term "electromagnetic" is used to denote a field which may be either electric or magnetic or have components of both while the terms "electric" and "magnetic" refer always to the components.

I claim:

1. In a cathode ray tube having a luminescent screen adapted to be excited by electron bombardment and having a source which emits particles including both electrons and undesired electrically-charged particles having different ratios of charge-to-mass from said electrons and tending deleteriously to affect said screen, apparatus for preventing such deleterious effect upon said screen, comprising an apertured barrier interposed between said source and said screen, means for forming at least said electrons into a beam having a minimum cross-section in the immediate vicinity of said barrier, said aperture corresponding substantially in cross-section to said beam at the interception of said beam by said barrier, and means for deflecting said particles to cause said electrons but not said undesired particles to pass through said aperture whereby said electrons but not said undesired particles are permitted to impinge upon said screen.

2. A cathode ray tube as claimed in claim 1, characterized in the provision of a beam focusing means positioned in the path of the beam at a point between said apertured barrier and said screen.

3. A cathode ray tube having an evacuated envelope containing a fluorescent screen and an electron gun structure for producing a scanning beam directed at said screen, said gun having at least one anode cylinder and a source for forming a beam of particles including both electrons and undesired electrically charged particles having smaller ratios of charge-to-mass than said electrons, an apertured barrier at the exit end of said gun, a pair of oppositely charged electrodes within said anode cylinder for electrostatically deflecting said undesired particles away from the aperture of said barrier, and means for establishing a magnetic field between said electrodes and at right angles to said beam to nullify the deflection effect of said electrostatic deflecting means on said electrons and to direct them through said aperture.

4. A cathode ray tube as claimed in claim 3, characterized in the provision of electrostatic focusing means between said beam source and said barrier, and magnetic focusing means between said apertured barrier and said screen.

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