June 5, 1951 N. D. GLYPTIS 2,555,850

ION TRAP

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Fig. 1.

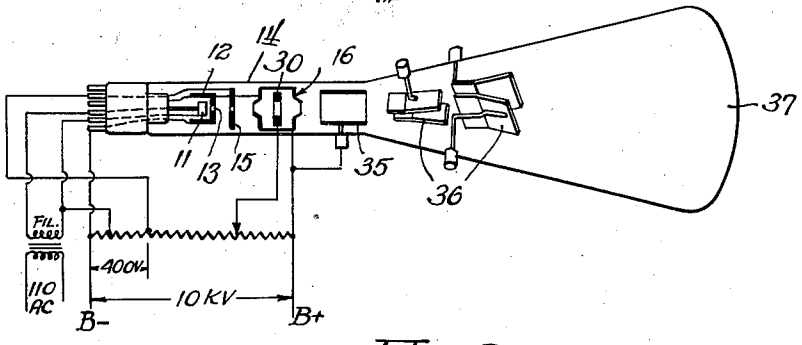
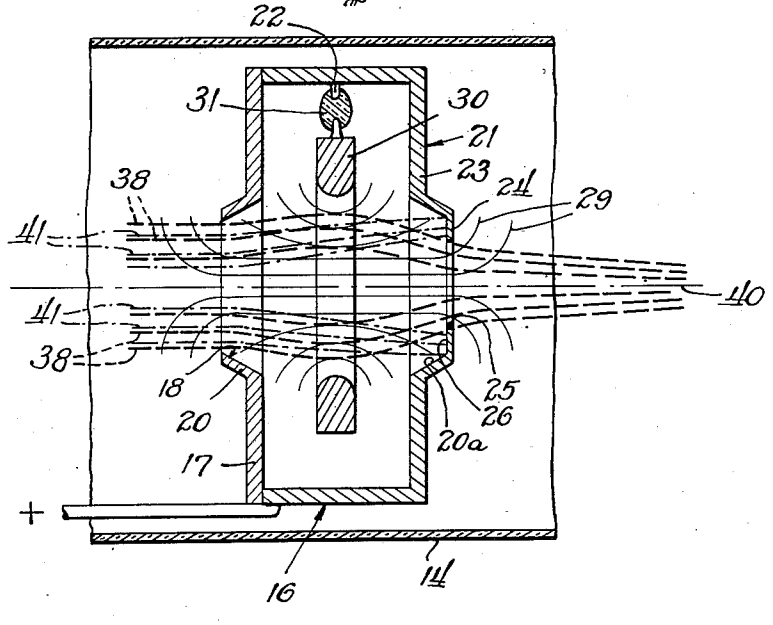


Fig. 2.



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ION TRAP

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The present invention relates to the control of ions and electrons in electron discharge tubes.

Electrons are negatively charged minute particles which are planetary to nucleus to form atoms. Whenever an atom loses or gains one or more electrons it is called an ion. A positive ion lacks one or more electrons while a negative ion possesses one or more extra electrons.

In cathode ray tubes, whether they be gas filled or high vacuum, a stream of electrons are emitted from a cathode and directed to impinge upon a target such as an electrode, a fluorescent screen or a photographic plate. Generally, the cathode is indirectly heated and surrounded by a grid structure comprising a disc having an aperture through which the stream of electrons are emitted. The emitted stream is conducted through accelerating and focusing elements including masking apertures to provide a beam of reasonably small section when it strikes the target.

However, it has been found that negative ions which are very deleterious to a high potential target such as a fluorescent screen, are present in large quantities in the beam. These negative ions emanate from positive ion bombardment of the cathode surface which, when thereby bombarded, surrenders negative ions. A further source of negative ions arises wherever positive ions strike other electrodes or atoms are hit by electrons.

Negative ions reaching the target give up their extra electrons by low velocity transition, become sluggish atoms manifested by deposits on the target sometimes referred to as black coat, ion spot or ion cross. This impairs operation, deteriorates the target, and shortens tube life.

Efforts have been made heretofore to remove the negative ions from the cathode ray but they have been less than 50% effective in most cases, and those which are the best distort the beam from its highly desirable round-pencil form. Moreover, ion traps heretofore used do not remove negative ions developed by ionization taking place within the lens system of cathode ray tubes. Not only this, but the adjustment and operation of existing traps are delicate and easily unbalanced.

A principal object of the present invention is to trap and harmlessly disperse practically all of the negative ions in devices employing electron guns before the target is impinged by the beam, particularly those where a stream of electrons is beamed to strike fluorescent screens.

A further object is to provide a cathode ray

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tube in which a magnetic flux causes different trajectories to exist between the paths of electrons and the negative ions to eliminate the latter without need for extra or additional prongs or external equipment on the tube.

Another object of the invention is to accelerate a columnated cathode ray sufficiently that negative ions therein have an inertia which carries them through a magnetic field with little if any deflection.

A further object of the invention resides in defocusing negative ions along a collision trajectory while simultaneously focusing a stream of electrons to a round beam form to clear a barrier.

The invention is further characterized by separating ions from an electron beam at the last limiting aperture of the electron gun before it is put into use with a screen or target.

These being among the objects of the invention, other and further objects, including simplicity of construction and of operation, will appear from the drawing, the description relating thereto, and the appended claims.

Referring to the drawing:

Fig. 1 is a plan view, partly diagrammatical, showing a cathode ray television tube embodying the invention; and

Fig. 2 is an enlarged longitudinal section through the gun portion of the tube illustrating the structural characteristics of the embodiment of the invention.

Although the invention may find embodiment with external ring-like electromagnets if a unipotential lens is split, it is preferred to employ an internal axial permanent magnet, sometimes referred to as a ring magnet, located between two axially spaced windows or apertures of the focusing electrode or just ahead of the last aperture through which an electron beam is confined to flow. The inner margin of the ring magnet is located slightly outside the path of direct flow between the two windows, and the downstream or exit window is made smaller than the upstream or entrance window.

With this arrangement the electron flow diverges slightly as it passes beyond the entrance window. Then when it reaches the concentrated restricted field of the magnet, the field of flux which is generally parallel to the tube axis at this point will sharply deflect the flow of electrons to initiate convergence as the flow approaches the exit window. However, the negative ions, being heavier, do not respond appreciably to the magnetic field deflection as rapidly as the lighter electrons, and their inertia due to ac-

celerated speed persists sufficiently that they continue along a different trajectory and strike the marginal wall around the last window where their effect is dissipated as heat, or as a deposit, or bounce back as harmless atoms. The electrons in the flow are converged sufficiently to pass as a circular beam through the last window substantially free of harmful negative ions for use beyond the window without appreciable loss of electrons.

Tests have revealed that 90% of the negative ions can thereby be eliminated and the remaining 10% disperse themselves without reaching the target to which the electron beam is directed, thus reducing fouling, improving longevity, and eliminating the need for other elements to inhibit or remedy damage done by negative ions. Moreover, given a predetermined emissivity more electrons will be conserved and concentrated for use in the resulting beam than heretofore possible with conventional ion traps.

The invention is illustrated in connection with a cathode ray tube such as a television tube 10. The electron emitter comprising a filament (not shown) surrounded by a cup is indicated at 11 as located inside the usual control grid 12 which has a window 13 through which electron-ion generation is emitted along the axis 40 of the cylindrical portion 14 of the tube. The electron component of the emission is represented in broken lines 38 while the ion component is represented in dotted lines 41.

From the grid the emission passes through an accelerating anode 15 into the focusing device or electrode 16 which constitutes the structure shown in Fig. 2. Acceleration is desirable because it increases the velocity and therefore the inertia of the negative ions to carry them along a predetermined trajectory.

The focusing device preferably comprises a metal plate member 17 having an entrance window or aperture 18 therethrough at the narrow end of an outwardly extending frusto-conical wall 20. The plate member 17 covers a metal cup member 21 having cylindrical sides upon which inward protuberances 22 are preferably provided halfway down its sides. The bottom wall 23 of the cup member is symmetrical sectionally with respect to the plate 17 except that a radial flange 24 is provided on the narrow end of the frusto-conical portion 20*a*, which flange 24 has an exit opening 25 of a size smaller than the entrance opening 18. The inner face of the flange around the opening 25 will be referred to generically as an interception or collision wall 26.

An axial or ring magnet 30 having an inside diameter approximately the same as the wide portion of the frusto-conical walls 20 and 20*a* is mounted coaxially with and preferably midway between openings 18 and 25 by glass beads 31 fused to the protuberances 22, the magnet being mounted in the cup 21 before the plate 17 is secured in place in any suitable way establishing electrical connection. If not electrically connected to provide the same potential, the focusing action may be controlled by varying the potential between the two walls 20 and 20*a* as desired, in which case it is preferred to have the second window at a higher potential to take further advantage of a divergence of the negative ion trajectory ahead of the window 25 which would accompany same. Moreover, although the magnet may be connected to the same potential, it is preferred to connect it to a different potential than the walls 20 or 20*a* to give it static as well as magnetic properties.

Beyond the focusing device, a second or high potential anode 35 may be provided, and either the usual static deflection pairs of plates 36 shown or magnetic deflecting coils can be used which deflect the focused beam to strike the screen 37 in a calculated way.

In the embodiment shown, the windows 18 and 25 of the focusing electrode are statically charged positive preferably at the maximum voltage on the anode 35 and the resulting action is to accelerate and focus the emissions from the cathode axially through the windows, the rays of emissions converging as they leave the focusing electrode to meet at a pencil point upon the screen.

However, having a calculated field of magnetic force and a calculated distance or difference in potential between the openings 18 and 25, the ions in their flight 41 are not deflected enough to pass through the smaller opening 25. They strike against the interception barrier 26 where they give up their negative charge and if they rebound they leave as harmless atoms which ultimately travel back to the grid or cathode.

Thus a diverging electron optical action of an immersion lens or a unipotential lens even when one electrode is lower in potential than either or both of the other two, can be balanced for electrons by calculating a collision electron trajectory therethrough, contracting electron trajectory by a restricted axial magnetic field so that the electron beam goes through a limiting aperture while the ion stream is defocused along the calculated collision trajectory with little deflection due to the magnetic component, or otherwise diffused to a tolerable ion concentration.

What is claimed is:

1. In a cathode ray tube the combination of an electron discharge cathode and a control electrode aligned with said cathode for generating a cathode ray, and an aligned focusing electrode including a barrier disposed around the center line of the ray, said barrier forming an element in a lens system, and magnet means disposed in front of said barrier and surrounding the ray for subjecting the cathode ray to magnetic flux at a predetermined point of concentration spaced from the barrier.

2. In a cathode ray tube the combination of an electron discharge cathode and control electrode for generating a cathode ray, a barrier having an opening at the center line of the ray, said barrier forming an element in a lens system, means disposed in front of said barrier and surrounding the ray for subjecting the cathode ray to magnetic lines of flux parallel to said ray at a predetermined point of concentration spaced from the barrier to converge the electron stream at the opening in the barrier.

3. An ion trap for electron discharge tubes comprising a unipotential lens having an entrance aperture and an exit aperture, said apertures being axially spaced and aligned and the exit aperture being smaller as defined by a surrounding collision barrier, and a ring magnet disposed between said apertures defining an opening larger than the entrance aperture.

4. An ion trap for electron discharge tubes comprising a lens having an entrance aperture and an exit aperture, said apertures being axially spaced and aligned and the exit aperture being smaller as defined by a surrounding collision barrier, and a ring magnet disposed between said apertures having an opening coaxial with the exit aperture.

5. In a cathode ray device the combination of a barrier having an opening therethrough, means for directing a stream of electrons and negative ions towards the barrier, and a magnet spaced from the barrier ahead of it for converging the stream of electrons at the opening in the barrier.

6. In a cathode ray device the combination of a plurality of spaced barriers having openings therethrough, means for directing an electron beam through two of the openings and a portion thereof against the last barrier, and a magnet spaced from the last barrier ahead of it for deflecting the flow of said electrons to converge the beam through the opening in the last barrier, leaving the flow of the heavier negative ions to collide with the last barrier.

7. A unipotential lens for cathode ray tubes including two spaced barriers having aligned windows, one barrier of which has a smaller window in it than the other, and magnet means disposed between said barriers and defining an opening aligned with said windows of a size larger than the larger window.

8. A unipotential lens for cathode ray tubes including two spaced walls having aligned windows, one window of which is smaller than the other, and a magnet disposed between said walls and defining an opening aligned with said windows of a size larger than the larger window.

9. A unipotential lens for cathode ray tubes comprising two spaced walls having aligned windows, one an exit window which is smaller than the other, and ring magnet means disposed between said walls and defining an opening aligned with said windows of a size larger than said other window.

10. A combination beam focusing and ion trap device for electron discharge tubes comprising a lens having entrance and exit electrodes defining an entrance aperture and an exit aperture respectively, said electrodes being charged electrostatically, and said apertures being axially spaced and disposed in aligned relationship on the tube axis, said exit aperture being smaller than the

entrance aperture, a ring magnet disposed between said apertures and coaxial therewith, and means for varying the electrostatic potential of said magnet.

11. An ion trap for electron discharge tubes comprising a lens system coaxial with the tube axis and adapted to focus a cathode ray, said lens system containing a barrier having an opening, means producing an effective magnetic field in advance of said barrier and surrounding said cathode ray whereby the electrons of said ray are focused through the barrier opening and the ions of said ray are intercepted by said barrier.

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