March 30, 1965 J. E. HOPKINS 3,176,184

ELECTRON DEFLECTION SYSTEM FOR IMAGE REPRODUCTION INCLUDING FLAT TUBE AND PLANAR CATHODE

Filed Feb. 20, 1961 2 Sheets-Sheet 1

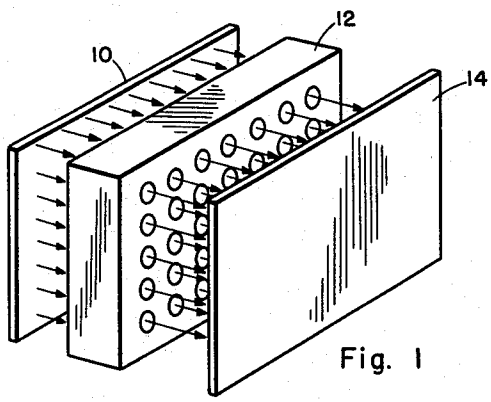


Fig. 1

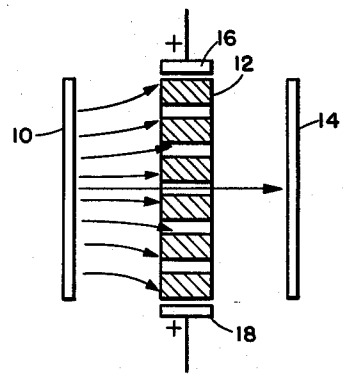


Fig. 2

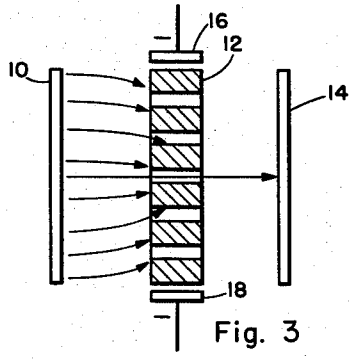


Fig. 3

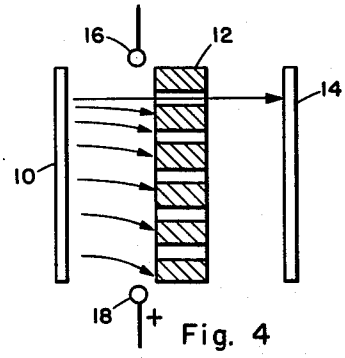


Fig. 4

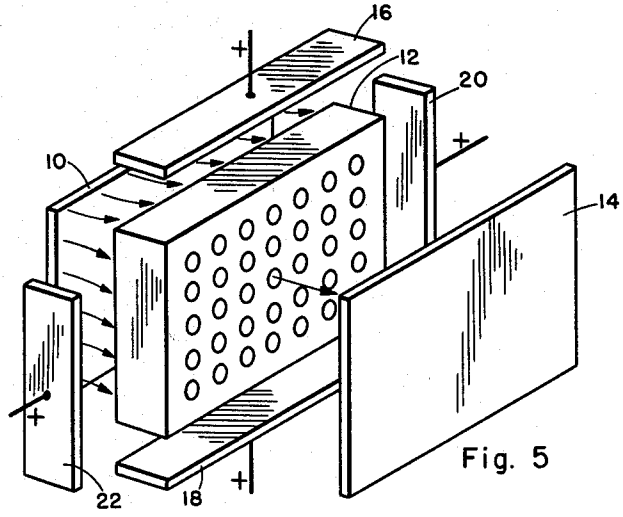


Fig. 5

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ELECTRON DEFLECTION SYSTEM FOR IMAGE REPRODUCTION INCLUDING FLAT TUBE AND PLANAR CATHODE

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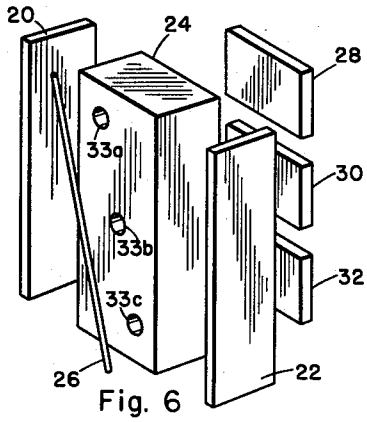


Fig. 6

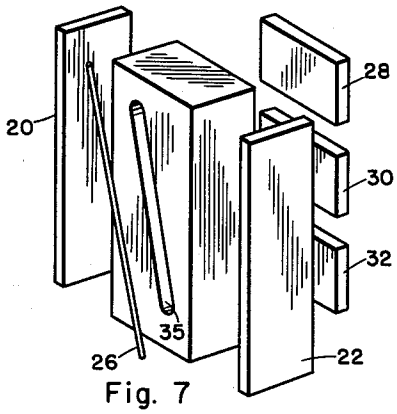


Fig. 7

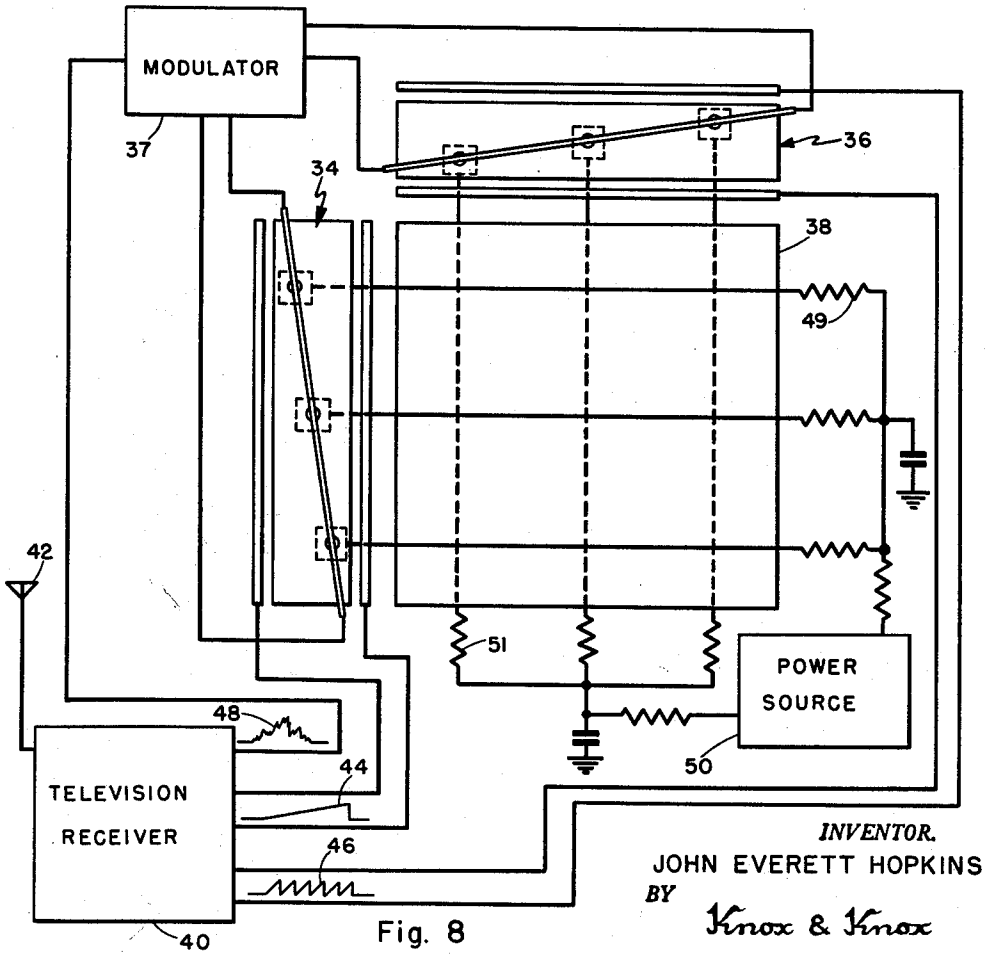


Fig. 8

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3,176,184

ELECTRON DEFLECTION SYSTEM FOR IMAGE REPRODUCTION INCLUDING FLAT TUBE AND PLANAR CATHODE

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7 Claims. (Cl. 315—13)

This invention relates to an electron discharge device, and more particularly to a deflection system and display system therefor.

There is an increasing need for extremely large television screens that can be viewed by many people from different parts of a room. One such need arises in military offices whereby many individuals are concerned with the deployment of forces. Another such need arises in train, plane, and bus depots, where everyone is interested in the times of arrivals and departures. Many other such needs exist, the above being exemplar.

One approach to obtaining large screen displays used standard electron beam deflection techniques and a television tube. Here a pencil-like ray of electrons had its trajectory curved so that the beam impinged sequentially on selected portions, thus producing sequential spots of light that formed the display. The size of the display produced by this approach was limited by the amount of curving that could be imposed on the electron beam.

It is therefore the principal object of my invention to provide an improved apparatus for displaying television pictures on large screens without distortion.

The attainment of this object and others will be realized from the following specification, taken in conjunction with the drawings, of which

FIGURE 1 is diagrammatic as are all of the figures, and is a representation of the cathode emitter, the element hereinafter referred to as the "block" and the electron collector, in perspective, showing the positional relationship of these principal portions of the invention;

FIGURE 2 is a cross sectional view of FIGURE 1 illustrating positive electron beam deflection;

FIGURE 3 is similar to FIGURE 2 but showing negative beam deflection;

FIGURE 4 is similar to FIGURE 3 showing wire instead of plate deflection elements;

FIGURE 5 is a perspective view showing two pairs of deflection plates;

FIGURE 6 is a perspective view of a second embodiment;

FIGURE 7 is a perspective view of a third embodiment; and

FIGURE 8 is a schematic diagram showing structure similar to that in the embodiments of FIGURES 7 and 8, in combination with a visual display system.

Broadly speaking, my invention contemplates a control member of significant thickness which may be a sheet but which will be herein referred to simply as a block of material having tunnel structure of either an elongated tunnel or slot or a plurality of tunnels extending therethrough. Electrons are directed at the tunnels in such a way that they would normally pass through. A deflection system, disposed to be effective in a plane normal to the tunnel structure, curves the trajectory of most of the electrons so that they strike the block or the sides of the tunnel or tunnels. Selected electrons however are unaffected, where the deflective effects cancel, and they traverse the tunnel or tunnels to impinge on an electron collector.

As shown in FIGURE 1, I use a cathode 10, shown as a flat plate, which emits electrons from all portions thereof. Positioned adjacent the cathode is a block 12 having a plurality of parallel tunnels therethrough, although as will be later shown, the block may actually be a sheet of perforated material.

As may be seen in FIGURES 2 and 3 some of the electron streams traverse the tunnels and emerge as a plurality of discrete electron beams; while others are stopped by the block 12. On the other side of the block 12 is an electron collector 14, such as a fluorescent screen of the type widely used in the television art. This collector attracts the electrons from the cathode and glows where the electrons impinge. In FIGURE 1, fluorescent screen 14 would glow in a plurality of spots, thus producing a uniformly lighted screen.

FIGURE 2 shows a cross sectional view of the apparatus of FIGURE 1. Here deflection plates 16 and 18 are at the same positive potential, and establish a deflecting field transverse to the tunnels. The electrons emitted by cathode 10 are attracted toward the nearest positively charged deflection plate. As a result the electron streams are divergent, rather than parallel as in FIGURE 1.

While the foregoing and subsequent explanations and illustrations use electrostatic deflecting fields, the same results may be obtained by properly oriented electromagnetic deflection fields.

The marginal electrons are thus caused to approach the block 12 at an angle, which causes them to be trapped by the surface thereof or tunnel walls. Since the central electron stream is equally spaced from the deflection plates 16 and 18, the effects of the two deflection plates cancel each other, and the central electron stream is unaffected. Its electrons therefore traverse the tunnel, and impinge on the central area of fluorescent screen 14, thus producing a single centrally positioned line of light.

As may be seen from FIGURE 3, when the deflection plates have identical negative potentials applied thereto, the marginal electron streams are repelled by the negatively charged deflection plates 16 and 18, and are converged. Here too, the marginal electron beams are trapped by the deflection control member or the walls of the tunnels; while the central electron stream transits freely through its tunnel to strike the fluorescent screen 14.

It may thus be seen that when identical potentials are applied to the deflection plates, only the central electron beam produces a line of light. While the term "deflection field" has been used, it will be realized that it has a converging or diverging effect, rather than the uniform deflecting effect of prior-art deflecting fields.

My inventive concept has several important advantages over prior-art approaches. Firstly, the electron beam that is used is not deflected, and therefore does not suffer any cross sectional distortion. Secondly, since this electron beam is not deflected, the power previously necessary to change the trajectory is no longer needed. Thirdly, in order to intercept the underside electron streams, they are merely deflected a small amount, thus minimizing the deflection signal required. Fourthly, the cathode and collector may be closely spaced, thus producing a viewing device that has a large area and a small thickness.

FIGURE 4 shows how an off-center line of light may be produced. Here the deflecting electrodes are shown as wires, rather than plates. A potential of zero volts is applied to deflection wire 16, while a positive potential is applied to deflection wire 18. As a result, the electron stream adjacent deflection wire 16 passes undisturbedly through its tunnel to produce a line of light near the upper edge of fluorescent screen 14; whereas the other electron streams have curved trajectories that cause them to be trapped by the surface of block 12 or the walls of the tunnels therein. If the uppermost electron stream is attracted by 18, it may be necessary to apply a counteracting potential to wire 16.

To produce lines of light at other areas of the fluorescent screen, the potential applied to one deflection element

may be increased and/or a negative potential may be applied to the other deflection element; in this way changing the position of the unaffected or neutral zone, and electrons pass through the tunnel at this zone without deflection.

It may thus be seen that the position of the light line is established by the difference between the potentials applied to the deflection plates; this difference being a "deflection signal" that may involve potentials that are positive, negative, or zero—and whose magnitudes depend on the size, spacing, sensitivity, etc., of the structures.

The foregoing discussion has dealt with vertical positioning of the light line, but it will be realized that if the control member were a block as shown in FIGURE 1, there would be produced a horizontal line of light spots. In order to convert this line to a single spot of light the structure of FIGURE 5 uses an additional pair of deflection plates, 20 and 22. If identical potentials are applied to each plate, a single centrally positioned spot of light would be produced. The spot of light may be positioned as desired by suitable deflection signals applied to the plates. In this way, sequential deflection signals produce sequentially positioned light spots that trace out the desired light pattern.

Cathode 10 may be a sheet of material that emits electrons when heated or illuminated, or it may comprise a cold emitter of the type described on pages 94–96 of the April 1959 issue of Popular Science.

The block 12 is preferably a conductive material, so that it may conduct away those electrons impinging thereon; graphite being one suitable material. While member 12 has been described as a block, its thickness may be reduced to that of a fabric or a perforated sheet.

In the embodiment of my invention thus far described, the cathode, block, and the fluorescent screen are the same size, and adjacently positioned. At times it may be desired to have a larger screen, or to position the screen at a different location than the control equipment. This result may be obtained by the apparatus of FIGURE 6. Here the deflection plates 20 and 22 are used, but the block 24 contains a series of tunnels, three being shown, that are positioned along a diagonal line, each tunnel being horizontally and vertically offset from the others. In this embodiment the cathode may take the form of an electron emitting wire 26 that is diagonally aligned with the tunnels of the block 24. Positioned directly behind the tunnel are electron collectors 28, 30, and 32.

This embodiment operates as follows: If no potential were applied to the deflection plates electrons from the wire would traverse each of the tunnels 33*a*, 33*b*, and 33*c*. If though identical positive potentials are applied to deflection plates 20 and 22, the electrons from the upper end of wire 26, being near deflection plate 20, would curve away from the observer, and would thus miss the upper tunnel. Similarly electrons from the lower end of wire 22, being near deflection plate 22, would curve toward the observer, and would thus miss the lower tunnel. However, electrons from the central portion of the wire are equally distant from each deflection plate, and are therefore not affected. These central electrons therefore traverse the central tunnel to strike collector 30. By variation of the potentials of the deflection plates a neutral zone can be affected at any tunnel position.

If the potential applied to deflection plate 20 is decreased to zero, the upper electron stream is undisturbed or disturbed to a lesser degree, and travels through the upper tunnel to impinge on collector 28. Similarly if the potentials applied to the deflection plates are reversed, electrons traverse the lower tunnel to strike collector 32.

While only three tunnels have been shown, a large number may be used. The tunnels are spaced apart vertically, a suitable distance, so that collectors may be positioned behind them; while the horizontal separation is sufficient to assure that only a single tunnel, at the zone where the electrostatic or electromagnet effects cancel, is used at a time.

Alternatively, the embodiment of FIGURE 7 may be used. Here the line of tunnels is replaced by a diagonal slot or elongated tunnel 35. The increased area of the slot or elongated tunnel 35 utilizes more electrons than the tunnel embodiment, while the selection of the energized collector is controlled by the deflection signal as previous described.

The embodiments of FIGURES 6 and 7 may be used to produce light patterns of large size by the following method, as illustrated in FIGURE 8. Here reference characters 34 and 36 indicate structures of the type shown in FIGURES 6 and 7, a modulator being connected to each cathode wire for a reason to be discussed later. The collectors of each structure 34 and 36 are connected to the wires of a gridwork as shown, and a sheet of electroluminescent material 38 is positioned between the separate grids.

This embodiment of FIGURE 8 operates as follows: Television receiver 40, has an antenna 42 to pick up the usual television signals. Receiver 40 contains deflection generator circuits that produce a vertical sawtooth deflection signal 44 and a horizontal deflection signal 46. Receiver 40 also produces a video signal 48. The use of these signals is well known in the art, but the following simplified explanation will be offered.

The vertical deflection signal 44 is applied to structure 34, and causing electrons to traverse the upper tunnel and strike the upper collector. Electric current then flows through the upper horizontal wire and load resistor 49 to power source 50. Similarly, the horizontal deflection signal 46 is applied to structure 36, and causing electrons to strike the left-most collector; an electric current then flowing through the left-most vertical wire and load resistor 51 to power source 50.

It was pointed out that a modulator 37 was connected to each electron emitting cathode wire of structures 34 and 36. Modulator 37 is energized by video signal 48, and causes the number of electrons emitted by the cathode wire of structure 34 to vary cyclically from a maximum to a minimum. This causes the potential at the upper horizontal wire to vary cyclically. Simultaneously, modulator 37 causes the number of electrons emitted by the cathode wire of structure 36 to also vary cyclically in a similar but opposite manner; that is, when the electrons from structure 34 are at their maximum, the electrons from structure 36 are at their minimum. This means that the potential of the left-most vertical wire is at a state that is opposite that of the upper horizontal wire. Thus the electroluminescent material between these wires has a high potential difference across it, and in glows. This high potential difference does not exist at any other intersection, so they stay dark.

Alternatively, the number of electrons may be varied cyclically by other means, such as a control grid positioned anywhere in the path of the electrons.

As the television signal changes, it controls the amplitude of the modulation, and thus the potential difference between the energized wires. For example, if the instantaneous television signal corresponds to a light area, such as the sky, modulator 37 produces a large potential difference between the horizontal and vertical wire. This large potential difference causes the electroluminescent material between the wires to glow brightly. If on the other hand, the instantaneous television signal corresponds to a dark cloud, modulator 37 produces a smaller potential difference; which causes the electroluminescent material to glow faintly. When the instantaneous television signal corresponds to the black trunk of a tree, modulator 37 produces such a small potential difference between the wires that the electroluminescent material does not glow at all. In this way the brightness of the spot of light corresponds to the instantaneous television signal.

The deflection signals from receiver **40** are used as follows: At a given instant they energize the deflection plates of structures **34** and **36** in such a way that the uppermost and left-most wires are energized. These produce a spot of light in the upper left hand corner, the brightness of the spot corresponding to the instantaneous television signal. At the next instant, the vertical deflection signal **44** is of substantially the same magnitude, since it is changing slowly, so that the upper wire remains energized. However, the horizontal deflection signal **46** has changed substantially, and energizes structure **36** so that the middle wire is energized. Thus an area in the upper center portion of the screen now glows, its brightness corresponding to the instantaneous television signal. In a similar manner, the spot of light moves horizontally across the upper wire. At this time the vertical deflection signal has changed enough to energize the middle wire connected to structure **34**, and the spot of light now moves horizontally across the middle wire. Thus any or all portions of the electroluminescent material may be caused to glow.

It will be noted that since structures **34** and **36** have freely moving electrons, they must be in an evacuated envelope, but that the wire grids, where the electrons move in the wires, and electroluminescent material does not need this treatment. This condition obviates the breakage problem associated with prior-art large screens which require that the entire structure be evacuated, and thus subject to atmospheric pressure.

It is understood that minor variation from the form of the invention disclosed herein may be made without departure from the spirit and scope of the invention, and that the specification and drawing are to be considered as merely illustrative rather than limiting.

I claim:

1. The combination comprising:
a control member having a plurality of tunnels therethrough;
means for directing electron streams toward said control member, said electron streams having trajectories that are parallel to said tunnels, whereby selected said electron streams may traverse said tunnels to emerge as a plurality of parallel electron beams; an electron collector;
means for curving the trajectory of undesired said electron streams so that they miss their associated tunnels to impinge on the surface of said member and the walls of said tunnels, said trajectory curving means comprising means for establishing a deflection field transverse to said tunnels, whereby only a selected said electron stream traverses its associated tunnel to impinge upon said electron collector.

2. The combination of claim 1 wherein said deflection field comprises components in orthogonal directions.

3. A deflection system comprising:
a control member comprising an elongated block of material having tunnel structure extending therethrough in one direction;
means for directing electrons in said direction into all parts of said tunnel structure;
means for curving the trajectory of undesired electrons so that they do not traverse said tunnel structure, said means comprising a pair of deflectors positioned along opposite edges of said block, means to apply electrical potential on said deflectors, and means to vary the proportional potential on said opposed deflectors to produce a zero effect in a limited zone of said tunnel structure and an electron deflecting field at all other portions of said tunnel structure.

4. A deflection system comprising:
a control member comprising an elongated block of material having tunnel structure extending therethrough in one direction;
means for directing electrons in said direction into all parts of said tunnel structure;

means for curving the trajectory of undesired electrons so that they do not traverse said tunnel structure, said means comprising a pair of deflectors positioned along opposite edges of said block;
means to vary the potential on said opposed deflectors to produce a zero effect in a limited zone of said tunnel structure and an electron deflecting field at all other portions of said tunnel structure; and
an electron collector positioned on the side of said member remote from said means for directing electrons, whereby electrons traversing said tunnel structure impinge on said collector in a pattern corresponding to the variation of said potential.

5. A deflection system comprising:
a first control member comprising an elongated block of material having tunnel structure extending in one direction therethrough and disposed on a line substantially between opposite corners thereof;
first means for directing electron streams in said direction into said tunnel structure, said electron directing means comprising an elongated wire cathode positioned adjacent to and in parallel alignment with said tunnel structure;
first means for curving the trajectory of undesired electrons so that they do not traverse the corresponding portions of said tunnel structure, said means comprising a pair of deflection plates positioned along opposite edges of said block;
a second control member;
second means for directing electrons;
second means for curving the trajectory of undesired electrons;
a plurality of electron collectors positioned adjacent each of said first and second control members on the side thereof remote from said means for directing electrons, whereby electrons traversing said tunnel structure impinge on the corresponding collector;
a first grid of wires, a selected wire of said first grid being connected to a collector associated with said first control member;
a second grid of wires, a selected wire of said second grid being connected to a collector associated with said second control member, said wires of said first and second grids being perpendicular to each other and constituting a gridwork;
said first control member, said first means for directing electrons, and said first means for curving being interoperatively disposed at one edge of said gridwork, and all the corresponding said second means being interoperatively disposed at an adjacent edge of said gridwork; and
a sheet of electroluminescent material positioned between said first and second grids.

6. A deflection system comprising:
a first control member comprising an elongated block of material having tunnel structure extending in one direction therethrough and disposed on a line substantially between opposite corners thereof;
first means for directing electron streams in said direction into said tunnel structure, said electron directing means comprising an elongated wire cathode positioned adjacent to and in parallel alignment with said tunnel structure;
first means for curving the trajectory of undesired electrons so that they do not traverse the corresponding portions of said tunnel structure, said means comprising a pair of deflection plates positioned along opposite edges of said block;
a second control member;
second means for directing electrons;
second means for curving the trajectory of undesired electrons;
a plurality of electron collectors positioned adjacent each of said first and second control members on

the side thereof remote from said means for directing electrons, whereby electrons traversing said tunnel structure impinge on the corresponding collector;

a first grid of wires, a selected wire of said first grid being connected to a collector associated with said first control member;

a second grid of wires, a selected wire of said second grid being connected to a collector associated with said second control member, said wires of said first and second grids being perpendicular to each other and constituting a gridwork;

said first control member, said first means for directing electrons, and said first means for curving being interoperatively disposed at one edge of said gridwork, and all the corresponding said second means being interoperatively disposed at an adjacent edge of said gridwork;

a sheet of electroluminescent material positioned between said first and second grids; and

means for modulating said electron streams of said

first control member in a first phase and said electron streams of said second control member in an opposite phase.

7. The combination of claim 6 including a television receiver having means for producing horizontal deflection signals, vertical deflection signals, and video signals;

means for applying said horizontal deflection signals to the trajectory curving means associated with one of said control members;

means for applying said vertical deflection signals to the trajectory curving means associated with the other of said control members; and

means for applying said video signal to said modulating means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,558,019	Toulon	June 26, 1951
2,803,769	McNaney	Aug. 20, 1957
2,988,668	Lincoln et al.	June 13, 1961