Aug. 20, 1957 J. T. McNANEY 2,803,769

CATHODE RAY APPARATUS

Filed July 7, 1952 3 Sheets-Sheet 1

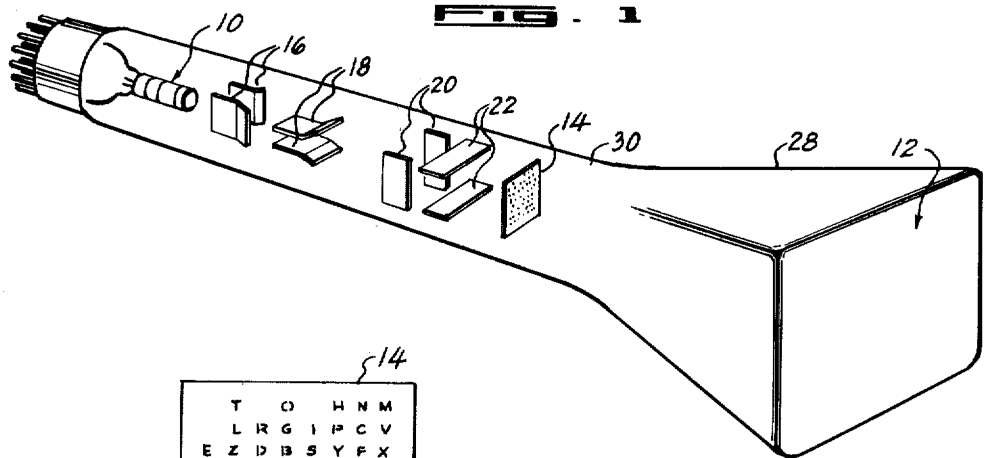

FIG. 1

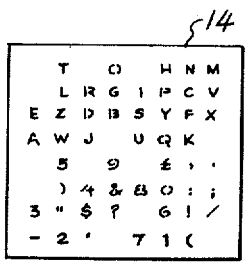

FIG. 2

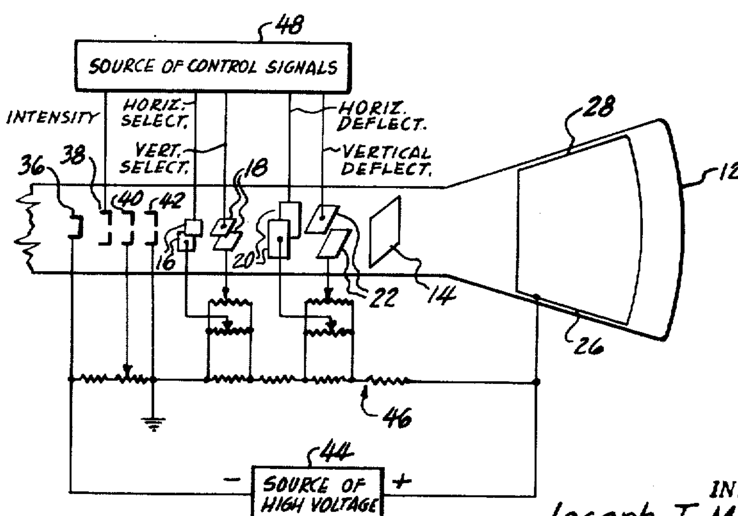

FIG. 3

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Aug. 20, 1957 J. T. McNANEY 2,803,769

CATHODE RAY APPARATUS

Filed July 7, 1952 3 Sheets-Sheet 2

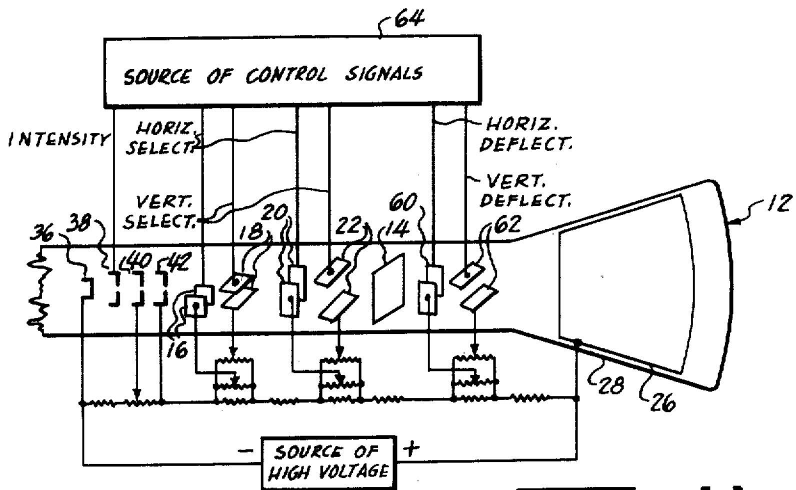

FIG. 4

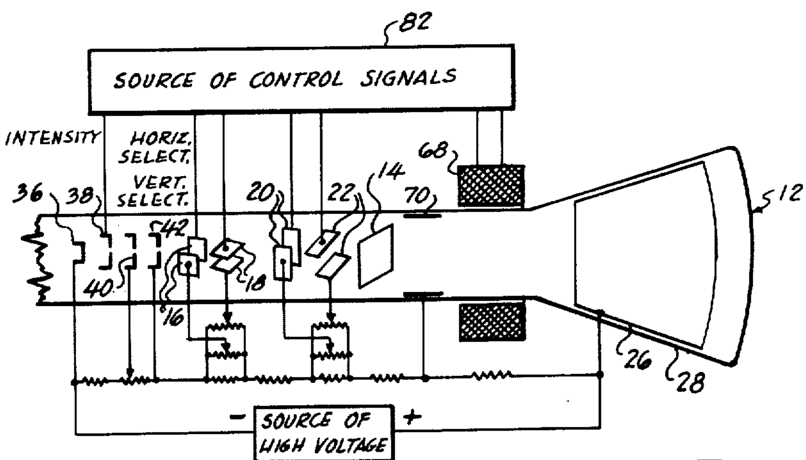

FIG. 5

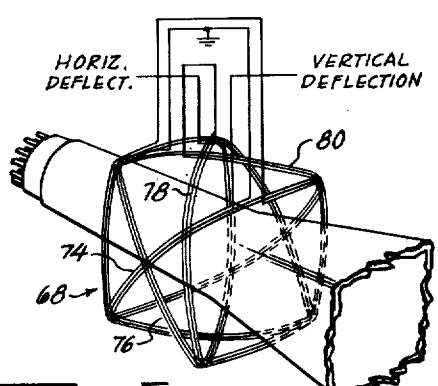

FIG. 6

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Aug. 20, 1957 J. T. McNANEY 2,803,769

CATHODE RAY APPARATUS

Filed July 7, 1952 3 Sheets-Sheet 3

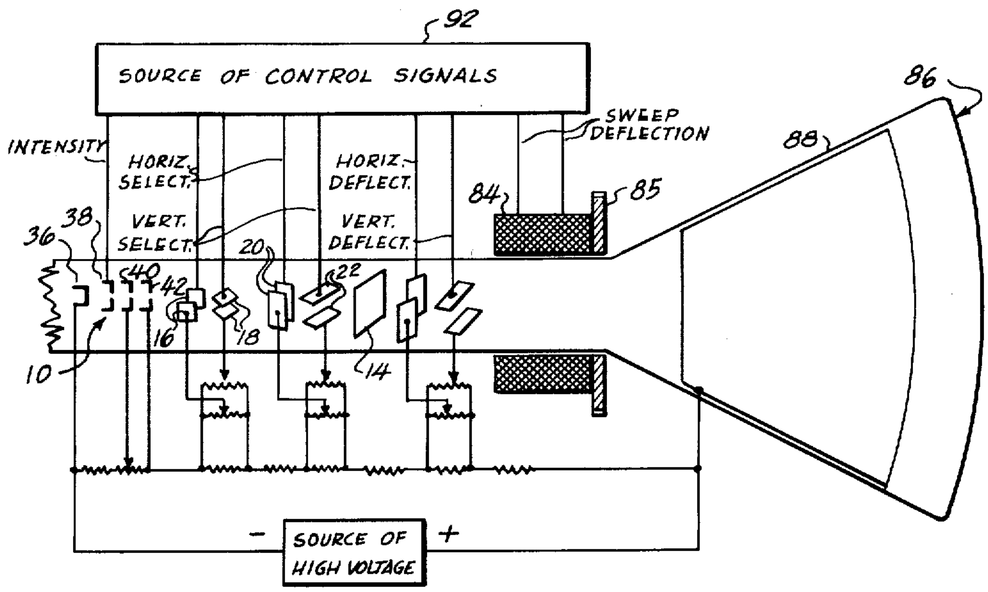

FIG. 7

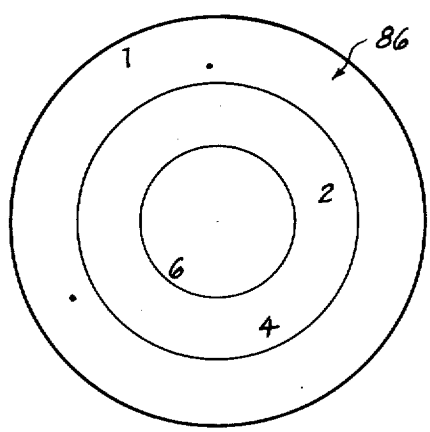

FIG. 8

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CATHODE RAY APPARATUS

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Application July 7, 1952, Serial No. 297,480

9 Claims. (Cl. 313—77)

This invention relates to improved cathode-ray apparatus for selectively displaying images having predetermined shapes, such as characters.

The apparatus of my invention is particularly suitable for displaying information at high speeds, and it may be employed with suitable recording apparatus to provide a printed record of the displayed information. One suitable recording arrangement is disclosed in my co-pending application Serial No. 295,589.

If desired, the apparatus may be arranged to provide a display which is suitable for direct visual observation.

I have found that the beam of electrons of a cathode-ray tube may be shaped so that its cross-section is in the form of selected characters, and that the beam of electrons can be directed to any part of the viewing screen of the tube after it has been shaped. With such an arrangement, a plurality of characters may be displayed at one time, and the characters may be displayed on substantially any part of the screen of the tube, say along lines if desired.

In accordance with my invention, I provide a solid member located along the path of the beam of electrons in a cathode-ray tube. A plurality of apertures are provided in the solid member for controlling the cross-sectional shape of the electron beam, and the individual apertures are shaped in the form of the configurations to be displayed, say in the form of characters. A pair of deflection systems are located intermediate the electron gun of the tube and the solid member for deflecting the electron beam and causing it to pass through selected individual apertures in the solid member where it is shaped in the form of the selected apertures.

In one embodiment of the invention, the two deflection systems are employed both to direct the electron beam through the selected apertures and also to position the electron beam so that it is directed to common predetermined locations on the longitudinal axis or the screen of the tube.

In another embodiment of the invention the two deflection systems are employed to direct the electron beam through selected apertures in the solid member so that the electron beam is disposed perpendicularly with respect to the solid member as it passes through the selected apertures, and a third deflection system is provided for directing the electron beam to predetermined locations on the screen of the tube. Such an arrangement permits the use of an apertured solid member having greater thickness than that of the first embodiment of the invention, and it minimizes undesired distortion of the electron beam as it passes through the selected apertures.

If desired, a further deflection system may be employed to provide a PPI presentation on the screen of the tube.

The cathode-ray tubes of my present invention are of less complex construction than those disclosed in the above patents, and in addition, they may be employed to display images on substantially any part of the screen of the tube.

My co-pending application Serial No. 298,603, now

Patent No. 2,735,956 issued February 21, 1956, discloses cathode-ray tubes which are similar to those of the present invention, but which differ in that a single deflection system is employed intermediate the electron gun and the apertured solid member for directing the electron beam through selected apertures in the solid member.

The present invention is explained with reference to the drawings, in which:

Fig. 1 is a perspective view of one embodiment of the invention;

Fig. 2 shows one suitable matrix arrangement for the beam-shaping member of Fig. 1;

Fig. 3 is a diagram showing the tube of Fig. 1 connected to sources of potentials;

Fig. 4 is a diagram showing an alternative embodiment of the invention employing three deflection systems for controlling the electron beam;

Fig. 5 is a diagram showing a modification of the embodiment shown in Fig. 4;

Fig. 6 illustrates a suitable coil assembly for use in the embodiment shown in Fig. 5;

Fig. 7 shows another embodiment of the invention which is suitable for providing PPI presentations on the screen of the tube; and

Fig. 8 shows a typical display which may be produced on the screen of the tube shown in Fig. 7.

The cathode-ray tube shown in Fig. 1 has an electron gun **10** of a conventional type located at one end of an evacuated glass envelope, and a target or screen **12** located at the other end. Various types of screens may be employed, the type of screen being determined by the manner in which the displayed information is used. Ordinarily, a short-persistance type luminescent material is preferable when the displayed information is to be recorded photographically. When the displayed information is to be viewed directly, a medium-persistence luminescent material, such as fluorescent phosphor P–4, is preferable. If the information is to be displayed over long periods of time, dark trace viewing screens may be employed.

A matrix **14** is located along and disposed at right angles with respect to the path of the electron beam of the tube. The matrix is provided with apertures shaped in the form of the images to be displayed on the screen of the tube, say in the form of characters as shown in Fig. 2. The characters are ordinarily the letters of the alphabet, the numbers 1 to 9, and any desired punctuation marks and symbols.

The matrix **14** serves to shape the electron beam by interrupting the electrons which approach or strike the solid portions of the matrix and by permitting the other electrons of the beam to pass through the selected apertures. The matrix may be composed of substantially any solid material, and it may be either conductive or non-conductive.

In the embodiment of the invention shown in Fig. 1, the material of which the matrix is composed should be thin so that it will not cause undesirable distortion of the electron stream as it passes through the apertures. A matrix composed of copper is particularly suitable because of the ease with which the character-shaped apertures may be formed by etching or engraving. Material having a thickness of .002 inch is suitable for a matrix of the type shown in Fig. 2 in which the portion of the matrix within which the apertures are located measures .625 inch by .625 inch.

The particular order in which the characters are laid out in the matrix depends primarily on the application of the tube and the type of control signals to be used. The layout shown in Fig. 2 is suitable for tubes which are employed to display information which is represented by five- or six-digit binary code signals.

A set **16** of horizontal selection plates and a set **18** of vertical selection plates are provided for controlling the horizontal and vertical deflection of the electron beam immediately after it is projected from the electron gun.

A second deflection system comprising a pair of horizontal deflection plates **20** and a pair of vertical deflection plates **22** is provided for further deflecting the electron beam after it traverses the selection plates **16, 18.**

The selection plates **16, 18** and the deflection plates **20, 22** are employed to cause the electron beam to pass through selected individual apertures in the matrix, the shaped beam being caused to impinge upon the screen of the tube.

The spacing between the deflection plates **20, 22** is larger than the spacing between the selection plates **16, 18** in order to accommodate the beam of electrons at any of its possible locations after it is deflected by the selection plates **16, 18.** Each pair of the deflection plates **20, 22** is arranged to provide an electric field across an area which is somewhat larger than the area in which the apertures are located in the matrix **14**, and each pair of the deflection plates **20, 22** is positioned to provide a field having substantially uniform density along planes disposed perpendicularly with respect to the longitudinal axis of the tube so that the beam of electrons is deflected uniformly at all of the various locations through which the beam may be projected.

Preferably, the tube shown in Fig. 1 is also provided with an intensifier anode **26** (See Fig. 3) of a conventional type located adjacent the screen **12**. By way of example, the intensifier anode may be an aquadag coating around the interior of the glass envelope of the tube.

The preferred embodiment of my invention employs a square screen **12**, and the side walls **28** which extend between the screen and the cylindrical body portion **30** of the cathode-ray tube are substantially flat. In such an arrangement the four surfaces of the intensified anode are substantially flat, and the electric field produced by the intensifier anode does not have an adverse effect upon the linearity of information displayed on the screen of the tube.

A circular screen may be employed if desired. However, the conventional type intensifier anode employed in such tubes is of conical shape, and such anodes cause a slight amount of curvature in the display of information on the screen of the tube. Such curvature is undesirable when the tube is employed to display information which is intended to be aligned on the viewing screen, say along a straight line.

Fig. 3. is a diagram showing the tube of Fig. 1 connected to sources of potentials for operating the tube.

The electron gun **10** is a conventional type having a cathode **36**, a control electrode **38**, a focusing electrode **40**, and an accelerating electrode **42**.

A source **44** of high voltage is connected between the cathode **36** and the intensifier anode **26**. A voltage divider **46** is connected across the source **44** of high voltage to provide suitable operating potentials for the focusing and accelerating electrodes and the selection and deflection plates. The focusing and accelerating electrodes and the selection and deflection plates are maintained at potentials corresponding to their relative positions with respect to the cathode and the intensifier anode, in accordance with conventional cathode-ray tube design practice. However, the potential applied to the focusing electrode **40** is adjusted so that the cross-section of the electron beam is larger than the highly-focused beam which is employed in ordinary cathode-ray tubes. The focusing voltage is adjusted to provide an electron beam having a diameter which is just large enough to cover the individual apertures in the matrix.

As shown in Fig. 3, the matrix 14 is floating. If a conductive matrix is employed, it may be connected to a suitable point along the voltage divider; however, I have found that the potential at which the matrix is maintained has little effect upon the operation of the tube.

The control signals which are applied to the tube are determined by the displays to be presented. The source **48** of control signals may be manually operated, or it may operate automatically in response to code signals.

The source **48** of control signals serves to provide potentials to the selection plates **16**, and **18** and to the deflection plates **20, 22** for deflecting the electron beam so that it passes through selected individual apertures in the matrix **14** and so that the electron beam is directed to common predetermined locations on the longitudinal axis or on the screen of the tube. The signals which are applied to the plates **16, 18** and **20, 22** are interrelated because the potentials which are applied to the selection plates **16, 18** are determined both by the characters which are to be selected and by the potentials applied to the deflection plates **20, 22** for directing the beam of electrons toward the predetermined locations.

Preferably the control electrode **38** is baised to cutoff, and the source **48** provides a signal coincident with the selection and deflection signal which raises the voltage of the electrode **38** and permits the electron gun to produce a beam of electrons only during the periods when the respective images are to be displayed.

For example, if a message is to be displayed on the screen of the cathode-ray tube, coincident signals are applied by the source **48** to the tube elements **38, 16, 18, 20** and **22** for each character to be displayed. The potentials applied to the selection plates **16, 18** cause the electron beam to be deflected so that it passes through the character-shaped apertures in the required sequence, and the potentials applied to the deflection plates **20, 22** cause the electron beam to be directed so that the successive characters are displayed on the screen in the desired positions, say along one or more lines.

Fig. 4 illustrates another embodiment of the invention in which a deflection system is employed intermediate the matrix **14** and the screen of the tube for controlling the positions at which the images are displayed on the screen.

This embodiment of the invention is the same as that disclosed in Fig. **3** except that a pair of horizontal deflection plates **60** and a pair of vertical deflection plates **62** are provided intermediate the matrix **14** and the screen of the tube. The spacing between the deflection plates **60, 62** is similar to that between the plates **20, 22** in order to accommodate the beam of electrons at any of its possible locations after it traverses the matrix. Each pair of the deflection plates **60, 62** is positioned to produce a field having a substantially uniform density along planes disposed perpendicularly with respect to the longitudinal axis of the tube in order to provide uniform deflection of the beam of electrons at all of the various locations through which the beam may be projected.

In this embodiment of the invention, the plates **16, 18** and **20, 22** are employed to direct the electron beam through selected apertures in the matrix, and the deflection plates **60, 62** are employed to control the position at which the respective images are displayed on the screen of the tube. The source **64** of control signals is arranged to provide suitable potentials to the plates **20, 22** for causing the electron beam to be disposed perpendicularly with respect to the matrix **14** as it passes through the selected apertures. Thus, the selection plates **16, 18** are employed to deflect the electron beam in accordance with the respective characters to be displayed, and the plates **20, 22** are employed to deflect the electron beam so that it extends substantially parallel to the longitudinal axis of the tube as it passes through the matrix **14**.

With the arrangement shown in Fig. 4, the thickness of the material of which the matrix is composed may be greater than that of the matrix employed in the embodiment shown in Figs. 1 and 3. This is because the electron beam is disposed perpendicularly with respect to the matrix as it passes through the selected apertures, and hence the side walls of the apertures in the matrix do not cause undesirable distortion of the electron beam. The use of a matrix composed of a thick material is advantageous in that the narrow portions of the matrix which must be employed to support the material which defines such characters as the number 8 tend to burn out when they are subjected to an intense stream of electrons. I have found that a matrix composed of glass having a thickness of .02 inch is satisfactory for tubes of conventional size.

Fig. 5 illustrates a modification of the tube shown in Fig. 4, in which an electromagnetic deflection arrangement is employed to control the position of the images displayed on the screen of the tube, instead of the electrostatic arrangement shown in Fig. 4.

The tube shown in Fig. 5 is the same as that shown in Fig. 4 except that a coil assembly **68** is substituted for the deflection plates **60, 62**, and an auxiliary anode **70** is provided intermediate the matrix **14** and the coil assembly **68**.

The auxiliary anode **70** may be an aquadag coating around the interior of the cylindrical body portion of the glass envelope, for example, and it serves to maintain the required speed and focus of the electrons of the beam to provide clearly defined images on the screen of the tube. The potential at which the auxiliary anode **70** is maintained is determined by the position of the anode with respect to the electron gun **10** and the intensifier anode **26**, in accordance with conventional cathode-ray tube design techniques.

Since the electron beam of the tube is projected through a large number of positions in order to select the various characters to be displayed, the magnetic fields produced by the coil assembly **60** must be arranged to act upon the beam in any of the various locations through which the beam may be projected. In order to provide uniform deflections of the beam, each of the magnetic fields should be of substantially uniform density along planes disposed perpendicularly with respect to the longitudinal axis of the tube.

The coil assembly shown in Fig. 6 illustrates a suitable coil arrangement for providing the required magnetic fields. A pair of horizontal deflection coils **74, 76** are disposed at right angles with respect to one another. A pair of vertical deflection coils **78, 80** are also disposed at right angles to one another, and the coils of the respective pairs are radially displaced 90° with respect to one another around the tube.

The individual pairs of coils are connected in series, and when energized, provide magnetic fields disposed at right angles to the longitudinal axis of the tube and also at right angles with respect to one another. Since the coils of each pair are disposed at right angles with respect to one another, their magnetic fields combine to provide fields of substantially uniform density along planes disposed perpendicularly with respect to the longitudinal axis of the tube.

The power requirements for the deflection coils of Fig. 6 are several times greater than the power requirements for standard television deflection coils because the coils of Fig. 6 are located farther from the electron gun and because they must be energized to produce magnetic fields of substantially uniform density throughout the cross-section of the tube.

The source **82** for control signals for the arrangement shown in Fig. 5 may be the same as that of Fig. 4 except that the horizontal and vertical deflection signals are currents which are suitable for energizing the coil assembly **68**.

Fig. 7 shows an embodiment of the invention which is primarily suitable for providing PPI presentations in a radar receiver.

The horizontal and vertical selection arrangement and the horizontal and vertical deflection arrangement of this embodiment of the invention are the same as those shown in Fig. 4. In addition, a rotatable coil assembly **84** is provided for causing the electron beam to sweep radially across the screen of the tube, as is required in conventional PPI presentations.

The coil assembly **84** for this embodiment of the invention is arranged to provide a substantially uniform magnetic field across the section of the tube through which the electron beam is projected so as to provide uniform radial deflections of the electron beam without distorting the cross-sectional shape of the beam. This coil assembly may be similar to that shown in Fig. 6, and it is affixed to a gear **85** which may be coupled to suitable mechanisms (not shown) for rotating the assembly in synchronism with the antenna of the radar set.

Preferably, a circular screen **86** is employed in the tube shown in Fig. 7 so that conventional PPI-type displays may be presented on the screen. The portion **88** of the envelope which is located between the screen and the cylindrical body portion **30** of the tube is of conical shape, and hence the intensifier anode **90** is also of conical shape.

The cathode-ray tube of Fig. 7 is primarily suitable for use in radar systems which provide means for identifying friendly vessels or objects. For example, friendly vessels may be provided with transponders which transmit identifying code signals in response to the radar signals.

The source **92** of control signals may be the receiver of the radar system provided with suitable output circuits for producing control signals for the cathode-ray tube. When an identifying signal is received from a vessel, the source **92** provides selection signals which cause the beam of the cathode-ray tube to pass through the aperture in the matrix **14** corresponding to the identifying number or letter for the vessel. The source **92** also provides deflection signals which cause the identifying number or letter to be displayed at the location on the screen which represents the location of the vessel. When the radar system encounters a vessel which does not produce an identifying signal, the source **92** provides selection signals which cause the beam of the cathode-ray tube to pass through a circular aperture in the matrix **14**, and the source **92** also provides deflection signals which cause the resulting spot to be displayed at the location on the screen which represents the location of the vessel.

Fig. 8 illustrates a typical PPI presentation which may be produced on the screen of the tube shown in Fig. 7.

It will be apparent that the intensifier anodes **26** and **90** shown in Figs. 3, 4, 5 and 7 are not essential; however, it is preferable to provide such anodes because they increase the intensity and clarity of the displayed images. Also, it will be apparent that a conventional magnetic deflection system may be employed instead of the horizontal and vertical selection plates **16** and **18** shown in the various embodiments of the invention.

I claim:

1. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target, a solid member having a plurality of lineally arranged, character shaped apertures therein located between the source of electrons and the target, a first deflection means located intermediate the source of electrons and the solid member for deflecting the electron beam along two directions, and a second deflection means located intermediate the first deflection means and the solid member of further deflecting the electron beam along two directions and directing the electron beam through selected apertures in the solid member and to a common predetermined location.

2. In an evacuated container having a target at one end and a source of electrons for projecting a beam of electrons toward the target, a beam-shaping member located along the path of the electron beam for altering the cross-sectional shape of the beam in accordance with the portion of the beam-shaping member through which the elec-

tron beam is projected, a first deflection means located intermediate the source of electrons and the beam-shaping member for deflecting the electron beam along two directions, and a second deflection means located intermediate the first deflection means and the beam-shaping member for further deflecting the electron beam along two directions and directing the electron beam through selected portions of the beam-shaping member at a predetermined angle whereby all shaped electron beams converge at a common location.

3. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target, a solid member located along and disposed substantially perpendicularly with respect to the path of the electron beam, the solid member having a plurality of apertures therein, and a pair of deflection systems located intermediate the source of electrons and the solid member for directing the electron beam through selected individual apertures in the solid member and toward predetermined locations on the target, each of said deflection systems adapted to be responsive to a pair of signals which are a function of the position of the aperture to be selected and the desired position of the electron beam on the target.

4. In a cathode-ray tube having a screen at one end and an electron gun at the other end for projecting a beam of electrons toward the screen, a solid member having a plurality of character-shaped apertures arranged substantially in rows therein and located between the electron gun and the screen, and a pair of deflection systems located intermediate the electron gun and the solid member for directing the electron beam through selected individual apertures in the solid member and toward predetermined locations selectively parallel to and on the longitudinal axis of the tube.

5. In an elongated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons longitudinally along the container toward the target, a beam-shaping member having lineally arranged, character shaped openings therein located along the path of the electron beam for altering the cross-sectional shape of the beam in accordance with the portion of the beam-shaping member through which the electron beam is projected, means located intermediate the source of electrons and the beam-shaping member for directing the electron beam through selected portions of the beam-shaping member along lines disposed substantially perpendicular to the beam shaping member, and means located intermediate the beam-shaping member and the target for directing the electron beam toward predetermined locations on the target.

6. In a cathode-ray tube having a screen at one end and an electron gun at the other end for projecting a beam of electrons toward the screen, a solid member having a grid of character-shaped apertures therein located between the electron gun and the screen, means located intermediate the electron gun and the solid member for directing the electron beam through selected apertures in the solid member along lines disposed substantially parallel to the longitudinal axis of the cathode-ray tube, said means comprising a first deflection system and a second deflection system having a pair of horizontal and a pair of vertical deflection plates located between said first deflection system and said solid member, the spacing between the horizontal deflection plates being larger than the maximum horizontal spacing between the apertures in the solid member and the spacing between the vertical deflection plates being larger than the maximum vertical spacing between the aperture in the solid member and means located intermediate the solid member and the screen for providing a pair of electron-deflecting fields for directing the electron beam toward predetermined locations on the screen, each field extending across an area which is at least as large as the area in which the apertures are located in the solid member and each field having substantially uniform density along planes disposed perpendicularly with respect to the longitudinal axis of the tube.

7. The apparatus of claim 6 wherein the means for providing a pair of electron-deflecting fields comprises a pair of horizontal and a pair of vertical deflection plates located inside the tube, the spacing between the horizontal deflection plates being larger than the maximum horizontal spacing between the apertures in the solid member and the spacing between the vertical deflection plates being larger than the maximum vertical spacing between the apertures in the solid member.

8. The apparatus of claim 6 wherein the means for providing a pair of electron-deflecting fields comprises a coil assembly located outside the tube and having four coils, two of the coils being disposed perpendicularly with respect to one another to provide a magnetic field along one direction and the other two coils being disposed perpendicularly with respect to one another to provide a magnetic field along a direction disposed at right angles with respect to the other magnetic field.

9. In an elongated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target, a solid member located between the source of electrons and the target and disposed substantially perpendicularly with respect to the longituidnal axis of the container, the solid member having a plurality of substantially aligned character shaped apertures therein, a first deflection system located intermediate the source of electrons and the solid member for directing the electron beam through selected apertures in the solid member along lines disposed substantially perpendicularly with respect to the solid member, and a second deflection system located intermediate the solid member and the target for directing the electron beam toward predetermined locations on the target, said first deflection system including a first deflection means adapted to be responsive to signals for providing both horizontal and vertical deflections being variable in accordance with the position of the selected aperture in the solid member and a second deflection means similar to said first deflection means and adapted to be responsive to signals related to said signals applied to said first means for also providing both horizontal and vertical deflections to said beam of electrons, said second deflection means being positioned with respect to said solid member to provide uniform horizontal and vertical deflection fields over said plurality of character shaped openings.

References Cited in the file of this patent

UNITED STATES PATENTS

2,283,383	McNaney	May 19, 1942
2,379,880	Burgess	July 10, 1945
2,473,691	Meacham	June 21, 1949
2,495,738	Labin et al.	Jan. 31, 1950
2,585,798	Law et al.	Feb. 12, 1952