Sept. 12, 1950

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CATHODE-RAY TUBE WITH TARGET CONTROLLED DEFLECTING PLATES

2,522,291

Filed Sept. 20, 1945

4 Sheets-Sheet 1

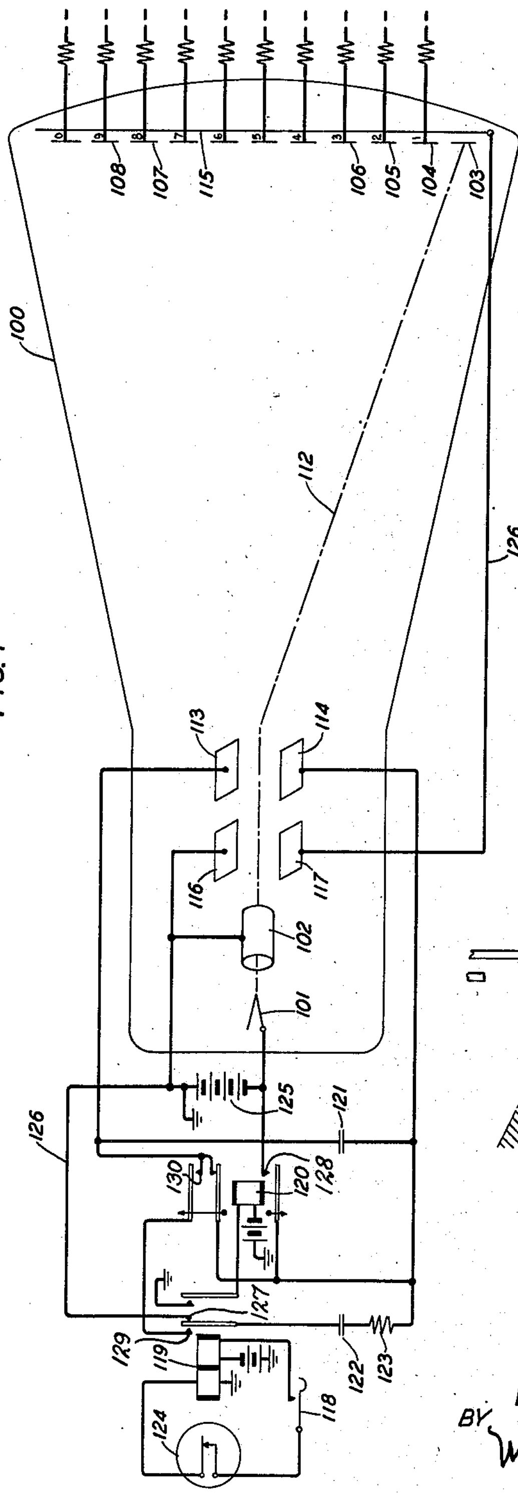

FIG. 1

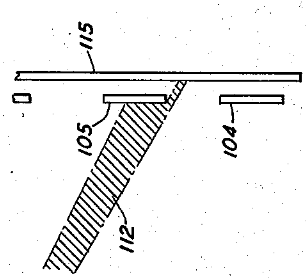

FIG. 2

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4 Sheets-Sheet 2

FIG. 5

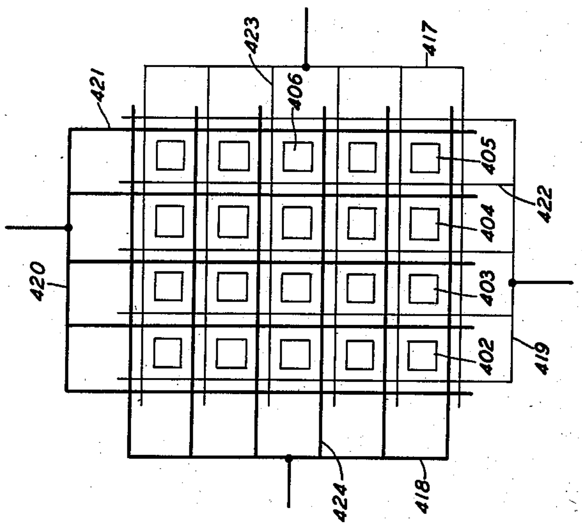
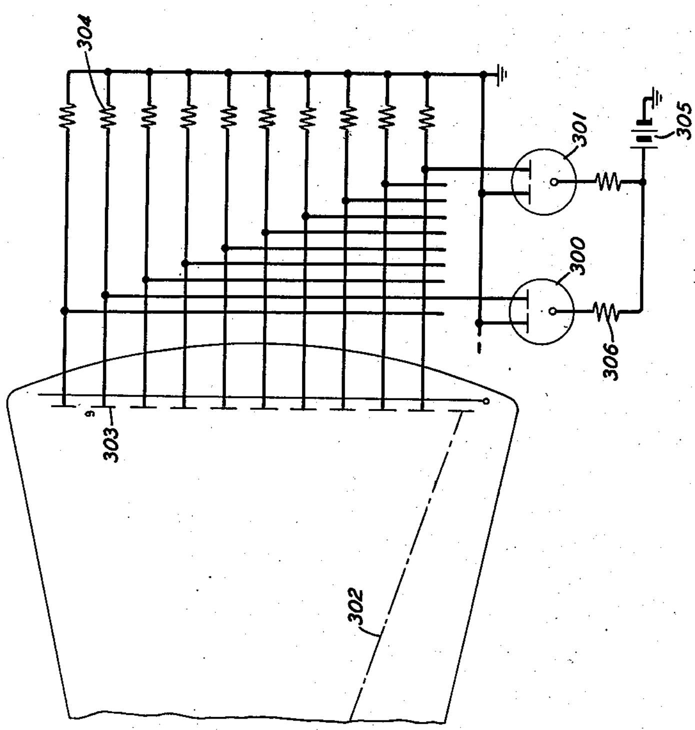


FIG. 3



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CATHODE-RAY TUBE WITH TARGET CONTROLLED DEFLECTING PLATES

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FIG. 4

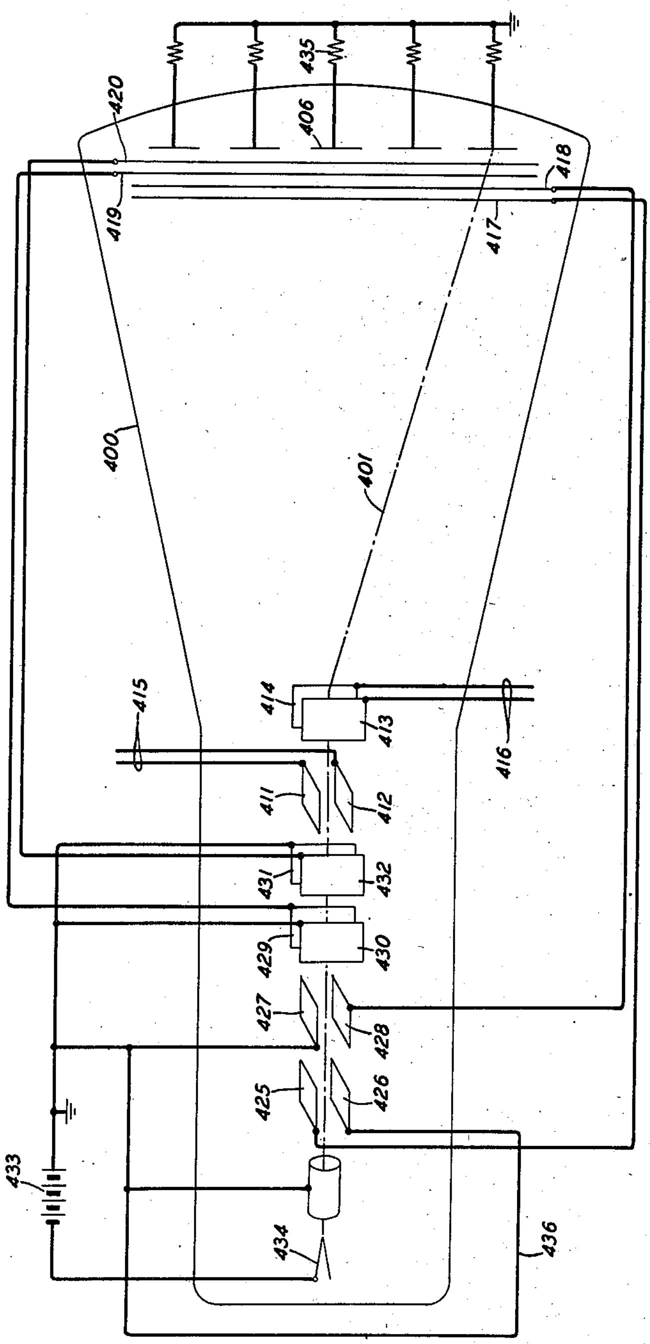

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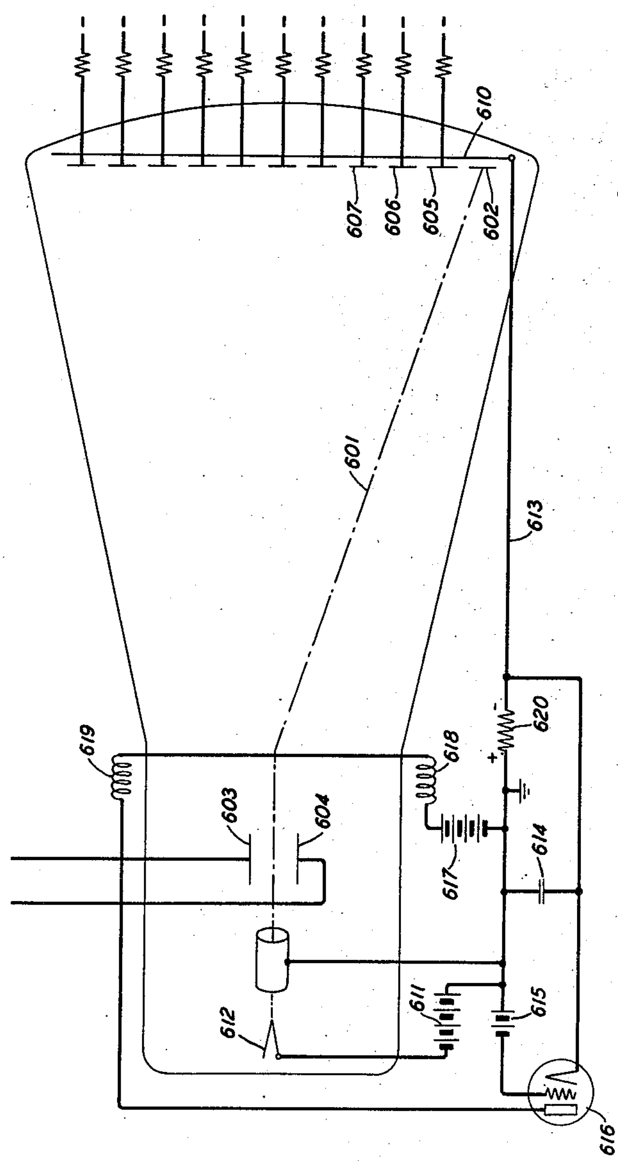
FIG. 6



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UNITED STATES PATENT OFFICE

2,522,291

CATHODE-RAY TUBE WITH TARGET CONTROLLED DEFLECTING PLATES

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Application September 20, 1945, Serial No. 617,631

20 Claims. (Cl. 315—21)

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This invention relates to electrical signal translating devices and particularly to those of the electronic type.

Objects of the invention are to extend the field of usefulness of electronic devices and to make them more readily applicable to electrical systems for such purposes as selection, distribution, registration, repetition and for other signal translating functions.

Another object is to increase the accuracy, dependability and general utility of electronic beam devices.

The use of electron-beam tubes has been proposed heretofore for a wide variety of purposes in electrical systems particularly where sensitivity of control and high speed of operation are essential requirements. Among other proposals these tubes have been suggested for use as selectors, the variable incoming signal currents serving to control the movement of the beam to select a desired one of a plurality of electrodes to which suitable work circuits are connected. Since the precision with which the electron beam is moved over the object electrodes or into positions bearing desired relations with respect to said electrodes depends upon the signal and controlling currents or potentials applied to the control elements of the tube, any variation such as an increase, diminution, dissipation or other change in the magnitude of these currents or potentials will have its effect upon the movement and position of the electron beam. For example, it may be desirable in a beam selector to advance the electron beam under the control of incoming signals to a predetermined electrode and to hold the beam on such electrode as an indication of the selection made. If the signal potentials are too strong or too weak or if they tend to leak off and dissipate, the beam will not be accurately positioned with respect to the electrode, or, if positioned accurately, it may gradually shift its position, thus impairing the effect of the intended selection.

With the foregoing difficulties in mind, applicant has devised a novel means for securing and maintaining a high degree of precision in the operation of electron-beam devices. More specifically, applicant has devised an electron-beam tube in which special electrodes are provided for the purpose of preventing any unwanted deviation of the beam from its intended location with respect to the working electrodes of the tube. Once the beam has been moved into a desired position with respect to a working electrode, it is accurately maintained in that position by the

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presence of said special or auxiliary electrodes. If for any reason it tends to depart from its proper position, potentials are established on the special electrodes which operate automatically to restore the beam to its proper position.

A feature of the invention is an electron tube having a coordinate field of selectable electrodes together with means for preventing the beam from deviating in any direction from a selected one of the electrodes on which it has been positioned.

Another feature of the invention is an electron-beam tube having electromagnetic means for correcting and adjusting the position of the beam with respect to the working electrodes.

The foregoing and other features of the invention will be discussed more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 illustrates the invention when applied to an electron-beam tube having a single array of objective anodes;

Fig. 2 is an enlarged fragmentary view showing the relation between the beam and the electrodes;

Fig. 3 illustrates one possible arrangement of work circuits connected to the anodes of the tube;

Fig. 4 illustrates the invention applied to a tube having a coordinate field of objective anodes;

Fig. 5 is an end view of the tube of Fig. 4 showing the field of objective anodes and a grid-work of auxiliary electrodes for correcting deviation of the beam; and

Fig. 6 is an alternative structure in which the correction of the beam is effected by electromagnetic means.

Referring now to the drawings and particularly to Figs. 1 and 2, the electron-beam translating device here illustrated includes a sealed vessel **100** containing means for developing a stream or beam of electrons and causing the beam to impinge selectively on any desired one of a series of objective anodes. The stream of electrons is developed by a cathode **101** and propagated by an accelerating anode **102** toward the forward end of the vessel or tube **100** where it is capable of engaging any one of a series of target anodes **103**, **104**, **105**, **106**, etc. The anode **103** serves as a normal-position target on which the beam **112** falls when no signals are being received from the incoming circuits. Anodes **104**, **105**, **106**, etc., correspond to the ten numerical values of a digit of the decimal system. The movement of the beam **112** over the anodes is controlled by a pair of deflector plates 113 and 114. By applying voltages of different values to the plates 113 and 114 the beam 112 is caused to advance to corresponding ones of the objective anodes 104, 105, 106, etc. When the circuits are in their normal condition the beam 112 rests on the normal anode 103 either by virtue of the disposition of the accelerating anode 102 or by a biasing voltage applied to the plates 113 and 114 in any suitable manner or by an additional set of control plates.

The forward end of the tube is also equipped with an auxiliary electrode, the purpose of which is to hold the beam in a selected position. This auxiliary electrode comprises a plate 115, which is disposed behind the objective anodes 104, 105, 106, etc., and in such a position that the beam 112 impinges on said electrode when it is not in full engagement with some one of the objective anodes. The impingement of the beam on the auxiliary electrode 115 sets up a voltage, which depends for its magnitude upon the degree of exposure to the beam, and which is applied across the control plates 116 and 117 for the purpose of correcting the beam deviation.

It will be obvious that electron-beam devices of the type disclosed in Fig. 1 may be suitable for a wide variety of purposes. In particular they are useful where it is desirable to store or register information, such as numbers or other characters, for present or future use. Such an application is illustrated in Fig. 1 where incoming electrical impulses from a transmitting dial are received and translated by the tube into a corresponding position of the beam.

A description will now be given of the operation of the tube and its associated impulse circuit. When it is desired to transmit to the tube 100 a series of impulses representing a given number, the key 118 is operated to close an obvious circuit for relay 119. Relay 119 in turn closes an operating circuit for slow-release relay 120. The operator now manipulates the dial 124, for example, to the number nine position and upon release of the dial from this position, a series of nine impulses is transmitted. On the opening of the circuit for the first impulse relay 119 releases, but relay 120, being slow, maintains its armatures in their attracted position. A charging circuit for condenser 122 may now be traced from the positive grounded pole of battery 125 over conductor 126, back contact 127 of relay 119, condenser 122, contact-protective resistor 123, front contact 128 of relay 120 to the negative pole of battery 125. A definite predetermined charge is accumulated on condenser 122 during the open period of the impulse. At the end of this first open period the dial contacts close and relay 119 reoperates. The charged condenser 122 is now connected to the larger condenser 121 for the purpose of transferring its charge thereto. The circuit for this transfer may be traced from the upper terminal of condenser 122 through the front contact 129 of relay 119, front contact 130 of relay 120, condenser 121, resistor 123 to the opposite terminal of condenser 122. Upon the next opening of the dial contacts relay 119 releases, and condenser 122 is recharged for the second impulse. When the dial contacts close at the end of the second impulse, relay 119 operates, and the charge on condenser 122 is transferred to condenser 121 where it is added to the charge representing the previous impulse. In like manner, each of the succeeding impulses results in the addition of an incremental charge to the condenser 121.

It will be noted that the condenser 121 is connected across the control plates 113 and 114, wherefore the increasing charges applied to the condenser cause the application of increasing voltages to said control plates. Each of these voltage increments is just sufficient to advance the electron beam 112 from one anode to the next. That is to say, the voltage applied to plates 113 and 114 in response to the first impulse causes the beam 112 to move from the normal anode 103 to the No. 1 anode 104, the increased voltage resulting from the second impulse causes the beam to move from anode 104 to the No. 2 anode 105, and likewise for each succeeding impulse until the beam 112 is finally brought to rest on the No. 9 anode 108.

By careful design it is possible to derive voltage values that will bring the beam 112 into accurate relationship with the successive objective anodes. However, it is sometimes desirable to permit tolerable variations in the manufacturing of apparatus, and it is also well known that condenser charges have a tendency to leak away with time. With these considerations in mind it will be seen that the beam 112 may not always occupy a fully centered relationship with respect to the objective anode to which it has been driven. Assume, for example, that the charge on condenser 121, which drives the beam to one of the objective anodes, such as anode 105, gradually becomes diminished as a result of leakage. As the charge diminishes, the beam 112 slowly returns towards its normal position and in so doing impinges to some extent on the auxiliary electrode 115. This relationship is more clearly illustrated in Fig. 2. A circuit may now be traced from the positive pole of battery 125, deflector plates 116 and 117, conductor 126, auxiliary electrode 115 thence over the beam 112, cathode 101 to the negative pole of battery 125. The voltage applied to plates 116 and 117 in this circuit is of such a polarity that it prevents further downward movement of the beam and thus prevents it from wandering off the anode 105. It will be noted from Fig. 2 that the greater the deviation of the beam the greater the exposure on the electrode 115 and consequently the more pronounced is the restoring potential applied to the plates 116 and 117.

The objective anodes 104, 105, 106, etc., may be connected to any suitable type of work circuit. In the drawings resistors are illustrated, and in Fig. 3 the voltages developed in these resistors serve to operate responsive devices such as discharge tubes 300, 301, etc. To consider the example chosen, if the beam 302 is driven to the No. 9 objective anode 303, the current flowing by way of the beam and anode 303 through resistor 304 develops a voltage which is applied across the control electrodes of the tube 300. This voltage causes the tube to ionize, whereupon current flows from the positive pole of battery 305, resistor 306, across the anode-cathode gap of the tube 300 thence to ground. The voltage developed in the resistor 306 may be used for any suitable purpose such as indication or control.

It will be noted that the beam 112 may impinge briefly on the auxiliary electrode 115 as it steps from one objective anode to the next. This, of course, is not objectionable since the voltage developed by the engagement of the beam with the electrode 115 is in the direction to move the beam to the next desired anode. However, it is obvious that the circuits may be designed to prevent the engagement of the beam with the auxiliary electrode until the beam has finally been positioned on the desired anode. One method is to make use of the well-known virtual beam during the impulsing interval, converting it to a real beam as soon as the impulse operation has been completed.

When it is desired to release the beam after it has served its purpose, key 118 is opened, and relay 119 releases and opens the circuit of relay 120. After an interval relay 120 releases and in so doing closes a short circuit around the condenser 121. Condenser 121 becomes fully discharged, and the beam 112 returns to its normal position anode 103.

The tube 400 shown in Figs. 4 and 5 is provided with a coordinate field of objective anodes, and the beam 401 is driven in two coordinate movements to select any desired one of the anodes. The number of anodes may be chosen to suit the requirements; for example, the field may include 100 anodes arranged in ten rows of ten anodes per row. In the drawings only twenty anodes 402, 403, 404, 405, etc., have been shown for the sake of simplicity.

The beam 401 is driven in a vertical direction by means of deflector plates 411 and 412 for the purpose of selecting a horizontal row of anodes and is driven horizontally by deflector plates 413 and 414 to select a particular anode in the horizontal row. The voltages for driving the beam are supplied to plates 411—412 and 413—414 over circuits 415 and 416.

Once the beam is positioned upon a selected anode it is held in position and prevented from deviating in any direction by means of four auxiliary electrodes 417, 418, 419 and 420. Each one of these auxiliary electrodes includes a plurality of parallel extensions which collectively form a frame or boundary for each of the individual objective anodes, as seen in Fig. 5. For example, the anode 406 is bounded on the right by the extension 421 of electrode 420, on the left by extension 422 of electrode 419, on the upper side by extension 423 of electrode 417, and on the lower side by extension 424 of electrode 418. Electrode 417 is connected to plate 425 of the pair of vertical deflecting plates 425—426, which serve to apply a vertical correction to the beam in one direction. Similarly the auxiliary electrode 418 is connected to plate 428 of the pair of vertical deflecting plates 427—428, which serve to apply a vertical correction in the opposite direction. Auxiliary electrode 419 is connected to plate 429 of the pair of horizontal deflecting plates 429—430, which serve to apply a horizontal correcting movement of the beam to the right as seen in Fig. 5. Similarly the electrode 420 is connected to plate 432 of the pair of horizontal deflecting plates 431—432, which serve to apply a horizontal correcting movement of the beam to the left.

To explain the operation of the translating tube shown in Fig. 4 assume that a voltage is applied over circuit 415 to the deflector plates 411 and 412 and that this voltage is sufficient to move the beam in a vertical direction to the third horizontal row of objective anodes. Assume also that a voltage is applied over circuit 416 to the plates 413 and 414 and that this voltage is sufficient to deflect the beam along the selected horizontal row until it engages the desired anode 406. In this position of the beam the work circuit may be traced from the negative pole of battery 433, cathode 434, beam 401, anode 406, resistor 435 to the grounded positive pole of battery 433. The voltage developed in the resistance 435 may be used for any suitable purpose.

If during the time the beam 401 is positioned on the anode 406 the voltage on the deflecting plates 411 and 412 varies in such a manner as to cause the beam to digress upwardly, a portion of the beam will engage the extension 423 on the auxiliary electrode 417. This engagement of the beam with the auxiliary electrode causes a correcting voltage to be applied to the plates 425 and 426 over a circuit which may be traced from the positive pole of battery 433, conductor 436, plate 426, plate 425, auxiliary electrode 417, beam 401, cathode 434 to the negative pole of battery 433. The polarity of the voltage thus applied to the plates 425 and 426 is such that the beam is returned downwardly to its proper position with respect to the anode 406. On the other hand if the voltage across the plates 411 and 412 varies in the opposite sense, the beam 401 digresses in a downward direction and encounters the extension 424 on the electrode 418. A circuit is now closed, similar to the one above traced, for applying a correcting voltage to the deflector plates 427 and 428. In this case, however, the correcting voltage is of the opposite polarity and acts on the beam to return it in an upward direction to its centered position on the anode 406. Should the voltage on the plates 413 and 414 increase somewhat in magnitude, the beam 401 is diverted to the right and engages the extension 421 on the electrode 420. This applies a correcting voltage to the plates 431 and 432 of a polarity to restore the beam to its correct position. Likewise a reduction of the voltage on plates 413 and 414 permits the beam to deviate to the left where it engages the extension 422 on the electrode 419, and a correcting voltage of the opposite polarity is applied to the plates 429 and 430 for restoring the beam.

In the modification disclosed in Fig. 6 of the drawing the correction of the beam is accomplished by means of an electromagnetic field. Normally the beam rests on the normal position anode 602. When a voltage is applied to the deflector plates 603 and 604, the beam is driven over the objective anodes 605, 606, 607, etc., until it comes to rest on the desired one of these anodes. If the beam deviates from its position on the selected anode and consequently engages the auxiliary electrode 610, a circuit is established from the negative pole of battery 611, cathode 612, beam 601, electrode 610, conductor 613 thence in parallel through resistor 620 and condenser 614 to the positive pole of battery 611. The condenser 614 acquires a charge in this circuit, the polarity of which opposes the biasing battery 615 and causes the tube 616 to conduct. Current now flows over a circuit traceable from the positive pole of battery 617 through the coils 618 and 619, anode and cathode of tube 616 thence in parallel through condenser 614 and resistor 620 to the negative pole of battery 617. The current flowing in coils 618 and 619 sets up a magnetic field which acts on the beam 601 to restore it to its correct position.

It will be understood that many variations may be made in the details of the structures and circuits illustrated herein. Numerous variations in the disposition of the anodes, in the shape and location of the correcting electrode, and in other structural features will suggest themselves to those skilled in the art.

What is claimed is:

1. An electronic beam device comprising a plurality of target anodes, means opposite said anodes for projecting an electron beam thereto, auxiliary electrode means adjacent and laterally beyond said anodes for intercepting electrons in said beam directed to pass by said anodes, means for driving said beam over said anodes, and means for effecting a definite relation between said beam and a particular one of said anodes comprising means for deflecting said beam and coupled to said auxiliary electrode means to be controlled in accordance with the beam current impinging upon said auxiliary electrode means.

2. An electrical beam device comprising a plurality of fixed electrodes arranged in spaced relation, means opposite said electrodes for producing a beam of energy for engagement with said fixed electrodes, an auxiliary electrode adjacent and so disposed with respect to said fixed electrodes that said beam impinges on said auxiliary electrode when it is not in full engagement with some one of the fixed electrodes, means for moving said beam into engagement with a predetermined one of said fixed electrodes, and means responsive to the impingement of the beam on said auxiliary electrode in the event the beam fails to fully engage the predetermined fixed electrode for automatically adjusting the position of the beam in the direction of full engagement with said predetermined electrode, said means comprising beam control deflecting means activated by the energy derived from the beam by the auxiliary electrode.

3. An electrical beam device comprising a plurality of fixed electrodes arranged in spaced relation, means opposite said electrodes for producing a beam of energy for engagement with said electrodes, means for moving said beam into engagement with a particular one of said electrodes, auxiliary electrode means adjacent said electrodes for deriving energy from said beam in response to its departure from a predetermined relation with said particular electrode, and beam deflecting means for utilizing the energy derived from said beam by said auxiliary electrode means for automatically reestablishing said predetermined relation.

4. In an electrical beam device, a plurality of electrodes arranged in spaced relation, means opposite said electrodes for producing a beam of energy for engagement with said electrodes, means for moving said beam into a position to engage a particular one of said electrodes, means comprising an auxiliary electrode effective only when said beam recedes from a prescribed position of engagement with said particular electrode for deriving from the beam an amount of energy proportional to the recession, and beam deflecting means utilizing the energy derived from said beam by said auxiliary electrode means to restore the beam to its position of engagement with said particular electrode.

5. In an electrical beam device, a plurality of electrodes disposed in a coordinate field, means opposite said electrodes for producing a beam of energy for engagement with said electrodes, means for moving said beam into a position to engage a predetermined one of said electrodes, and beam deflecting means cooperating with auxiliary electrode means responsive to the departure in any direction of said beam from its position of engagement for restoring said beam to its said position of engagement with said predetermined electrode, said auxiliary electrode means having portions laterally beyond said electrodes.

6. An electrical beam device comprising a plurality of fixed electrodes arranged in a coordinate field, means opposite said electrodes for producing a beam of energy for engagement with said fixed electrodes, a plurality of auxiliary electrodes bordering each of said fixed electrodes and subject to engagement by said beam of energy, means for driving said beam into engagement with a predetermined one of said fixed electrodes, and beam deflecting means including said auxiliary electrodes and effective in response to the engagement of the beam with said auxiliary electrodes for maintaining said beam in its position of engagement with said predetermined fixed electrode.

7. The combination in a translating device of a plurality of fixed electrodes, means for producing a beam of energy for engagement with said electrodes, means for moving said beam to selectively engage a predetermined one of said electrodes, and electromagnetic means responsive to a departure of said beam from its position of engagement with said predetermined electrode for maintaining said beam in engagement with said predetermined electrode.

8. An electronic beam device comprising a sealed envelope, a series of fixed anodes arranged in spaced relation within said envelope, a cathode within said envelope for developing a beam of electrons for engagement with said fixed anodes, electrostatic deflector plates within said envelope for driving said beam into engagement with a predetermined one of said anodes, an auxiliary anode mounted in proximity to said fixed anodes and subject to engagement by said beam as it passes from one anode to another, a second set of deflector plates, and means comprising a feedback coupling from said auxiliary anode to said second deflector plates effective if said beam departs from its position of full engagement with said predetermined anode and into engagement with said auxiliary anode for applying a potential to said second set of deflector plates for the purpose of restoring said beam to its position of full engagement with said predetermined anode.

9. An electrical beam device comprising a plurality of target anodes, means opposite said anodes for projecting a beam of energy thereto, means for causing movement of said beam relative to said target anodes and for positioning said beam in engagement with a predetermined one of said target anodes, and means for maintaining said beam positioned on said target anode comprising an auxiliary electrode for intercepting said beam when it departs from said target anode and beam deflecting means coupled to said auxiliary electrode and energized by the beam energy intercepted by said auxiliary electrode.

10. An electrical beam device comprising means for producing a beam of energy, a target anode opposite said means, means for deflecting said beam to a position of engagement upon said target anode, an auxiliary electrode adjacent said anode and placed so that said beam impinges upon it when not in full engagement with said target anode, and deflecting means coupled to said auxiliary electrode for exerting a restoring force upon said beam in proportion to the degree of exposure of said auxiliary electrode to said beam.

11. An electronic beam device comprising

means for producing a beam of electrons, a series of target anodes opposite said means located in a line, means for moving said beam along said line of anodes, auxiliary electrodes subject to impingement by said beam, located on both sides of and parallel to the line of said target anodes, and means for restricting the movement of said beam to a path between said auxiliary electrodes comprising beam deflecting means electrically connected to said auxiliary electrodes and energized when the electron beam deviates from said path to impinge upon one of said auxiliary electrodes.

12. An electronic beam device comprising means for producing a beam of electrons, a plurality of target anodes opposite said means, a plurality of auxiliary electrodes positioned relative to said target anodes to form a frame about each target, means for positioning said beam substantially within the frame of any one target, and beam deflecting means energized when said beam impinges upon any of said auxiliary electrodes for moving said beam towards a centered position within said frame.

13. An electrical beam device comprising means for producing a beam of energy, a group of target areas opposite said means, auxiliary electrodes adjacent said target areas, means for moving said beam into one of said target areas, and deflecting means energized when said beam tends to drift out of said target area, into impingement with an adjacent auxiliary electrode, for retaining said beam within said target area.

14. An electrical beam device comprising means for producing a beam of energy, a group of target areas opposite said means and bounded by auxiliary electrodes, means for positioning said beam on any one of said target areas, and deflecting means energized when said beam drifts from its position with respect to said target area, into impingement with a boundary auxiliary electrode, for containing the beam substantially within the target area.

15. An electron discharge device comprising a target having an edge extending in one coordinate direction of a two coordinate plane system, means opposite one face of said target for projecting an electron beam thereto, means for deflecting said beam in the second coordinate direction, and means for controlling the position of said beam in said second direction to position said beam upon said target, said controlling means comprising an auxiliary electrode opposite the other face of said target and extending beyond said edge to intercept electrons in said beam which pass beyond said target and a feedback connection between said auxiliary electrode and said deflecting means.

16. An electron discharge device comprising a plurality of imperforate targets having corresponding edges extending in one coordinate direction of a two coordinate plane system, means to one side of said targets for projecting a concentrated electron stream thereto, means for deflecting said stream in the second coordinate direction of said system, and means for controlling the position of said stream in said second direction, said controlling means comprising means to the other side of said targets and responsive to electrons in said stream which pass to said other side, and connected in feedback relation to said deflecting means.

17. An electron discharge device comprising target means including a plurality of imperforate elements having corresponding edges extending in one coordinate direction of a two coordinate plane system, means to one side of said target means for projecting a concentrated electron stream to said elements, means for deflecting said stream in the second coordinate direction of said system, and means for controlling the position of said stream in said second direction, said controlling means comprising electron receiving means to the other side of said target means and extending beyond said edges to intercept electrons in said stream which pass by said edges, said controlling means comprising also a direct conductive feedback circuit between said electron receiving means and said deflection means energized proportionately to the stream current to said electron receiving means.

18. An electron discharge device comprising a row of imperforate target electrodes having corresponding edges extending substantially normal to the direction of said row, means to one side of said target electrodes for projecting a concentrated electron stream thereto, means for deflecting said stream in said direction to selectively direct said stream to impinge upon any one of said target electrodes, and means for controlling the deflecting force due to said deflecting means comprising auxiliary electrode means mounted to the other side of target electrodes and extending beyond said edges to intercept electrons in said stream which pass by any of said edges, said controlling means comprising also a direct conductive feedback connection between said auxiliary electrode means and said deflecting means.

19. An electron discharge device comprising a plurality of targets mounted in a row, an auxiliary electrode having a portion laterally adjacent one side of said targets and extending in the direction of said row, means opposite said targets for projecting an electron beam thereto, a first deflecting means for deflecting said beam over said targets in said direction, a second deflecting means for deflecting said beam normal to said direction, and means for controlling the position of said beam in said normal direction comprising said auxiliary electrode, said second deflecting means and a feedback coupling between said auxiliary electrode and said second deflecting means.

20. An electron discharge device in accordance with claim 19 comprising a second auxiliary electrode laterally adjacent the other side of said targets and extending in the direction of said row, and wherein said controlling means comprises a third deflecting means for deflecting said beam in said normal direction and a feedback coupling between said second auxiliary electrode and said third deflecting means.

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