

Oct. 22, 1963

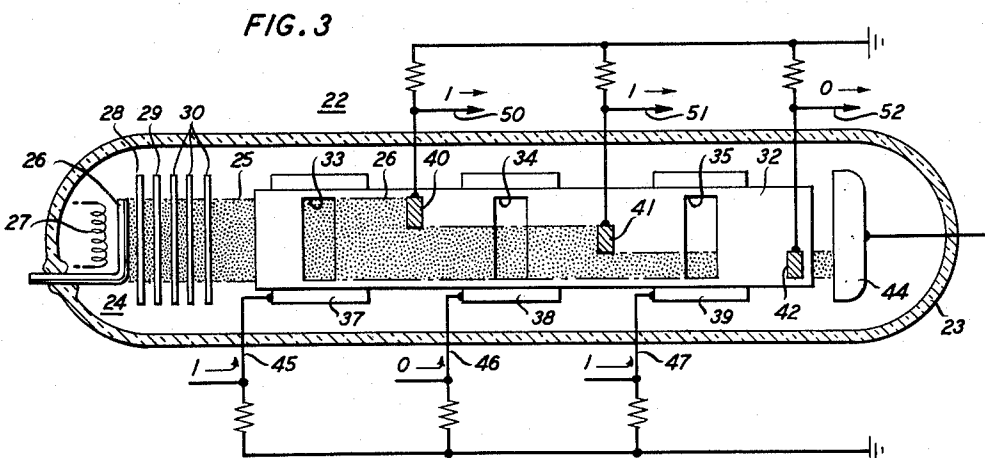
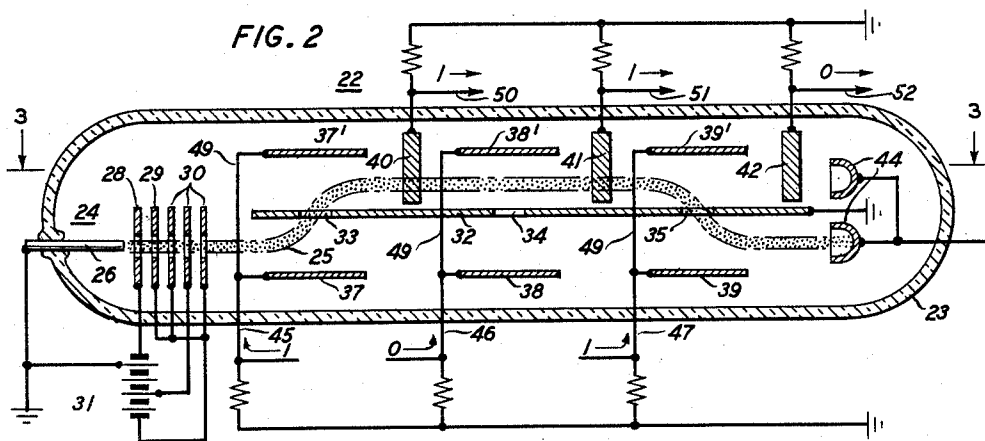
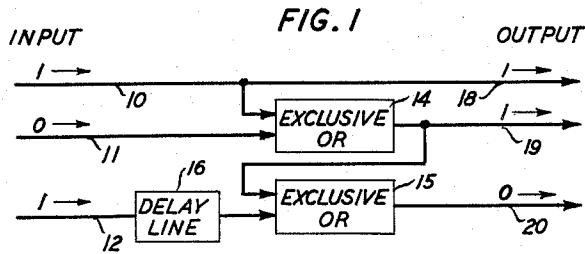
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3,108,203

ELECTRON BEAM TUBE FOR TRANSLATING GRAY CODE TO BINARY CODE

Filed Dec. 29, 1960

3 Sheets-Sheet 1



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FIG. 4

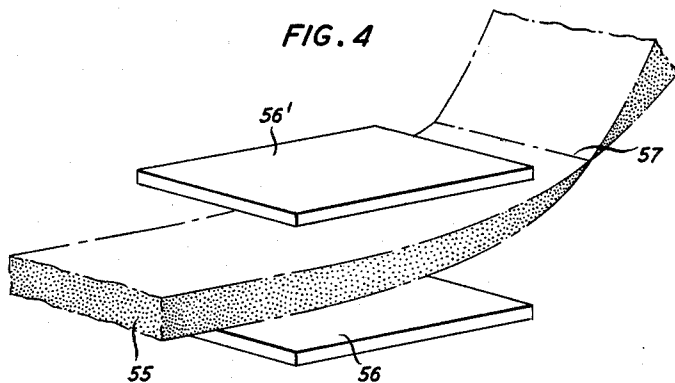
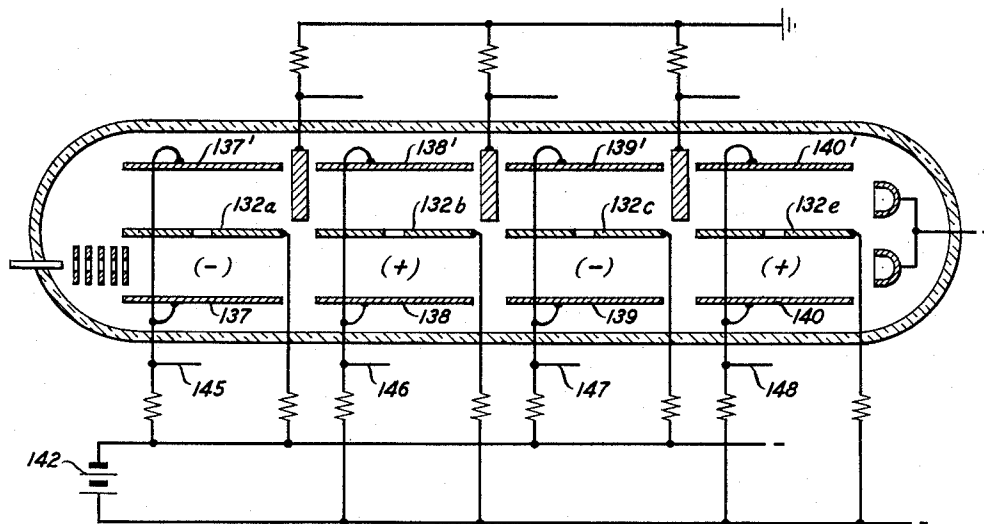


FIG. 6



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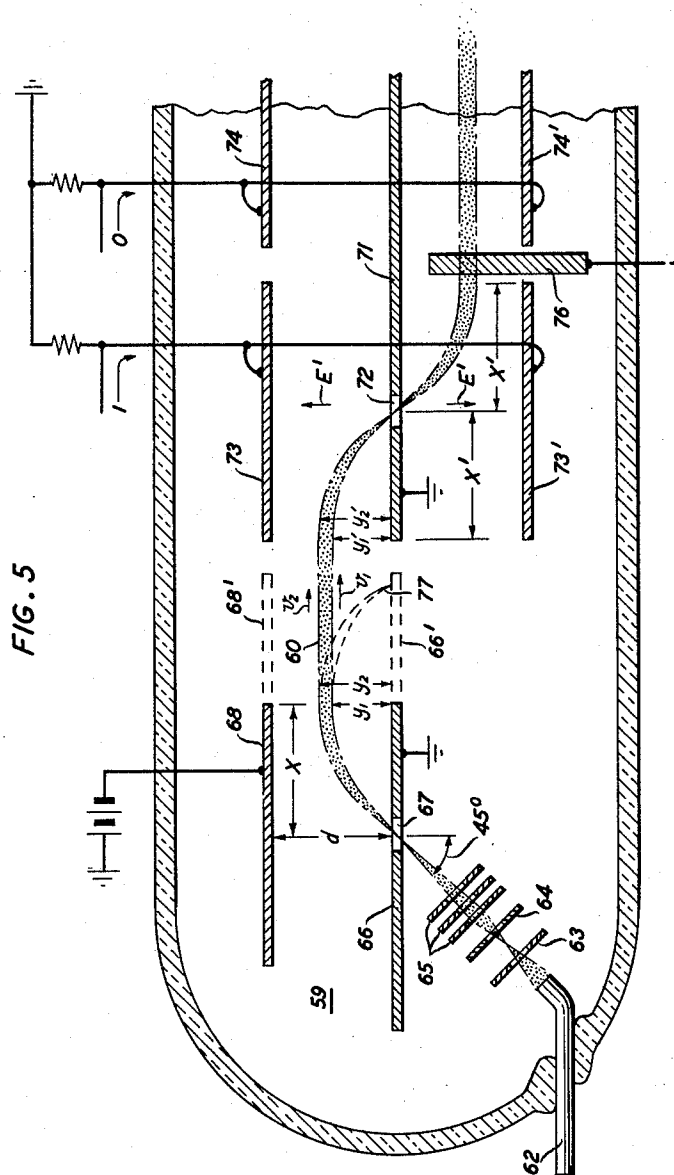
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3 Sheets-Sheet 3



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3,108,203
ELECTRON BEAM TUBE FOR TRANSLATING
GRAY CODE TO BINARY CODE
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Telephone Laboratories, Incorporated, New York,
N.Y., a corporation of New York
Filed Dec. 29, 1960, Ser. No. 79,323
21 Claims. (Cl. 315-8.5)

This invention relates to electron beam devices and, more particularly, to apparatus for translating a Gray code to a binary code.

The binary code has long been employed as a convenient method of transmitting information because it consists merely of a series of on-or-off pulses. However, as explained in the patent of Gray, 2,632,058, issued March 17, 1953, the encoding of information into a binary code often requires relatively complicated apparatus that is susceptible to error. The Gray patent discloses a different on-or-off pulse code that can be more readily encoded. Sometimes known as the inverted binary or the reflected binary code, this code will hereafter be referred to as the Gray code. The Gray application defines and explains both the binary code and the Gray code.

Although encoding into the Gray code is often desirable, it is not always feasible to make an entire communication system responsive to the Gray code, particularly where such use would require the replacement of numerous elements that are responsive to the binary code. Accordingly, various types of Gray code to binary code translators are presently used in communication systems for translating Gray codes to binary codes. These translators, as will be explained hereinafter, require a relatively long time for the translation operation and are characterized by a rather large number of separate electronic components.

It is an object of this invention to reduce the time necessary for translation of a Gray code to a binary code.

It is another object of this invention to translate a Gray code to a binary code by means of a single electronic component.

More specifically, it is an object of this invention to translate a Gray code to a binary code by means of a single electron beam device.

These and other objects of my invention are attained in an illustrative embodiment thereof, comprising an electron beam device. The various features of the invention can perhaps be best appreciated by summarizing briefly the structure and operation of the entire illustrative device.

The beam device comprises an electron gun for projecting a ribbon-like electron beam and a plurality of identical pairs of parallel deflection plates, axially spaced along the device. An apertured shield plate extends between, and parallel to, the deflection plates. The ribbon beam is projected between the shield plate and one of the deflection plates. Each of the pairs of deflection plates is energized by one digit of an incoming Gray code such that when a "one" or an "on" pulse appears, the beam is deflected through one of the shield plate apertures and thereafter flows on the opposite side of the shield plate. A target electrode is interposed between successive deflection plates on one side of the shield plate, such that when the beam is forced to flow on this side of the shield plate, it impinges on one or more of the targets. Successive targets are staggered to intercept different portions of the beam. The output of each target represents one digit of a binary code. As the beam passes through each successive pair of deflection plates, it is deflected through an aperture to the opposite side of the shield if an "on" pulse appears on that pair of plates. With this arrangement, the output signals of the target electrodes are binary translations of the incoming Gray code.

It is a feature of this invention that the electron beam be injected into the device with a transverse velocity spread such that the product of the kinetic energy of any electron and its distance from the shield plate is substantially constant. As will be explained hereinafter, any deflection of an electron beam tends to defocus the beam, or make it diverge. If the deflection voltages applied to each of the plates are properly correlated with the length and separation of the plates, the above-described velocity spread in the electron beam can compensate for this effect and prevent the harmful divergence that would otherwise result.

It is another feature of this embodiment that the ribbon electron beam be focused to a crossover line and thereafter be electrostatically deflected through 45 degrees before being injected between the shield plate and the deflection plates. By this expedient, the desired transverse velocity spread can fairly easily be produced within the beam.

It is a feature of another embodiment of this invention that successive pairs of deflection plates be biased by electrostatic focusing potentials of opposite polarity. In addition to deflection defocusing, space-charge forces within the beam tend to make it diverge. By biasing successive pairs of deflection plates at opposite polarities, the known principles of periodic electrostatic focusing can be employed to prevent the beam from diverging. The Gray code potentials are superimposed on the focusing potentials to deflect the beam as described above.

These and other objects and features will be more clearly understood with reference to the following detailed description, taken in conjunction with the accompanying drawing in which:

FIG. 1 is a schematic illustration of a device from the prior art for translating a Gray code to a binary code; FIG. 2 is a schematic illustration of one embodiment of this invention;

FIG. 3 is a view taken along lines 3-3 of FIG. 2;

FIG. 4 illustrates deflection defocusing;

FIG. 5 is a schematic illustration of another embodiment of my invention; and

FIG. 6 is a schematic illustration of still another embodiment of my invention.

Referring now to FIG. 1, there is shown a translator of the prior art, the purpose of which is to translate an incoming Gray code into the binary form. The following table indicates the binary and Gray code forms of the Arabic numerals 0 to 7:

Arabic	Binary Code	Gray Code
0	000	000
1	001	001
2	010	011
3	011	010
4	100	110
5	101	111
6	110	101
7	111	100

The derivations of both the binary code and the Gray code are explained in the aforementioned Gray application.

In the device of FIG. 1 successive digits of an incoming Gray code are respectively transmitted to incoming conductors 10, 11 and 12. Conductors 10 and 11 are connected to an input end of an "exclusive OR" circuit 14. Conductor 12 is connected to the input end of an "exclusive OR" circuit 15, via a delay line 16. Output conductors 18, 19 and 20 respectively conduct successive digits of an output binary code which is a translation of the input Gray code. Output conductor 19 is also connected to the input of circuit 15. Circuits 14 and 15

are gate circuits which release an output pulse upon the reception of only a single input pulse, and do not release a pulse upon the reception of simultaneous pulses; hence, the term "exclusive OR" circuit.

Assume that the input Gray code is 101 (Arabic numeral 6). In this case, there is a pulse on line 10, no pulse on line 11, and a pulse on line 12. The pulse on line 10 is transmitted directly to output line 18 and to the input of circuit 14. Only one single pulse is received by circuit 14 and so an output pulse appears on output conductor 19. The pulse on line 12 is delayed by delay line 16 so that it reaches circuit 15 simultaneously with the pulse from conductor 19. Because two simultaneous pulses are received by circuit 15, no pulse is transmitted on output conductor 20. A pulse on any of the lines represents the digit 1 while no-pulse (off) represents 0. Hence, the binary code transmitted by output conductors 18, 19 and 20 is 110 (Arabic numeral 6), which is the binary code translation of the input Gray code on lines 10, 11 and 12.

The purpose of delay line 16 is to compensate for the delay of circuit 14. If a code having a higher number of digits were used, a correspondingly higher number of exclusive OR circuits would have to be used. Each succeeding pulse would have to be delayed to compensate for the delay in all of the preceding circuits. It can be appreciated that if the delay of each exclusive OR circuit is t seconds, the time necessary for translation is $(n-1)t$ seconds, where n is the number of digits of the incoming Gray code. Further, the number of exclusive OR circuits that are necessary is equal to $(n-1)$.

Referring now to FIG. 2, there is shown an electron beam device 22 embodying the principles of the present invention which, by itself, is capable of translating a Gray code into a binary code in a small period of time. At one end of an evacuated envelope 23 is an electron gun 24 for forming and projecting a ribbon electron beam 25. The shape of electron beam 25 can be appreciated from FIG. 3 which is a view taken along lines 3-3 of FIG. 2. For purposes of illustration, electron gun 24 is shown as comprising a cathode 26, a cathode heater 27, a control electrode 28, an accelerating electrode 29, and a focusing lens 30 of the type known in the art as the Einzel lens. The various electrodes are connected in a known manner to a battery 31. Arranged axially along the device is a shield plate 32 having three apertures 33, 34 and 35. Extending parallel with shield plate 32 are three pairs of deflection plates 37-37', 38-38' and 39-39'. Interposed successively behind each of the upper deflection plates 37', 38' and 39' are three target electrodes 40, 41 and 42. At the opposite end of envelope 23 from electron gun 24 is a collector 44.

In the device of FIG. 2 successive digits of an incoming Gray code are respectively transmitted via input conductors 45, 46 and 47 to deflection plates 37-37', 38-38' and 39-39'. The deflection plates of each pair are interconnected by conductors 49. As in the device of FIG. 1, an "on" pulse represents the digit 1, while an "off" or no-pulse represents the digit 0. Each "on" pulse is a voltage pulse that is negative with respect to ground. Shield plate 32 is at ground potential as are the deflection plates when no pulse is applied.

Assume that the Gray code for the Arabic numeral 6 (101) is applied by applying a pulse to input conductor 45, no-pulse to input conductor 46, and a pulse to input conductor 47. The electric field produced between the grounded shield plate 32 and deflection plate 37 as a result of the negative pulse on conductor 45 forces the electron beam 25 away from deflection plate 37 and through aperture 33. Likewise, the electric field between deflection plate 37' and shield plate 32 re-deflects the beam so that the beam flows parallel with shield plate 32 upon leaving the electric field. Part of the beam then

impinges on target electrode 40 and a negative pulse is produced on output line 50.

As seen in FIG. 3, the portion of the beam not intercepted by target electrode 40 then flows between shield plate 32 and deflection plate 38'. Inasmuch as no potential difference is created between deflection plate 38' and shield plate 32, the beam is not deflected and a portion of it thereafter impinges on target electrode 41. Another negative pulse is thereby released by output conductor 51.

As the beam flows between deflection plate 39' and shield plate 32, the electric field produced by the application of a negative pulse on input conductor 47 deflects the beam away from plate 39' through aperture 35. The beam is thereafter collected by collector 44. Because the beam does not impinge on target electrode 42, no-pulse is released on output conductor 52 which is the equivalent of the digit 0. It can be appreciated that the output binary code 011 is a translation of the input Gray code 101.

By mentally reviewing the response of device 22 to various input Gray codes, one can verify that the output of output conductors 50, 51, and 52 will always be the binary code translation of the input Gray code on input conductors 45, 46 and 47. Suppose, for example, the input Gray code was 010 (Arabic numeral 3). In that case, electron beam 26 would be deflected away from deflection plate 38 through aperture 34 and would impinge on target electrodes 41 and 42, but not on target electrode 40. There would, therefore, be negative pulses on output conductors 51 and 52 but not on output conductor 50. The output code 011 (Arabic numeral 3) would be a correct binary translation of the incoming Gray code.

Moreover, by merely extending the length of the tube and the number of deflection plates, target electrodes and shield plate apertures, one can increase the number of digits to be translated. The only delay involved is the transit time of the electron beam from cathode 26 to collector 44. In most cases, this time is so short that no compensation for it is necessary.

Whenever an electron beam is electrostatically deflected, as in the device of FIG. 2, it tends to converge, and then diverge. This phenomenon, known as deflection defocusing, is illustrated in FIG. 4. If the electrons of a ribbon electron beam 55 are traveling in parallel lines at the same velocity and are deflected by a pair of electrostatic deflection plates 56-56', they will be focused to a line 57 and will thereafter diverge. Line 57 is referred to as the crossover line. Obviously, this action can be harmful to the operation of the device of FIG. 2 if a relatively large number of deflection plates are used.

FIG. 5 illustrates an electron gun 59 that forms and projects a ribbon electron beam 60 that can be deflected without being defocused. Electron gun 59 comprises a cathode 62, a control electrode 63, an accelerating electrode 64, a lens 65, a grounded plate 66 having an aperture 67, and a negatively biased plate 68. The beam is injected into a device of the type shown in FIG. 2 comprising a grounded shield plate 71 having an aperture 72, two pairs of deflection plates 73-73' and 74-74', and a target electrode 76.

The voltages on lens 65 are adjusted in a known manner such that the beam will be focused or crossover at aperture 67. The cathode is inclined at a 45 degree angle with respect to the plate 66. The beam is then deflected by the electric field E that is produced by the potential difference between plates 66 and 68. If plates 66 and 68 were extended as shown by dotted lines 66' and 68', the beam would describe an approximate parabola and be focused on a crossover line 77 of imaginary plate 66'. This phenomenon is explained in "Theory and Design of Electron Beams," by Pierce, D. Van Nostrand and Company, pages 20-23. It can be

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shown that the horizontal distance x of the maximum point on the parabolic path from aperture 67 is equal to

$$\frac{V_c}{E}$$

where V_c is voltage of the cathode with respect to plate 66.

Expressing this relationship in terms of the voltage on plate 68 gives:

$$x = \frac{V_c}{E} = \frac{V_c d}{V_d} \quad (1)$$

where V_d is the voltage on plate 68 and d is the separation of plates 66 and 68. The mean height of beam 60 at the maximum of its parabolic path can be shown to be:

$$\frac{y_1 + y_2}{2} = \frac{V_c}{2E} = \frac{V_c}{2V_d} d = \frac{x}{2} \quad (2)$$

where

$$\frac{y_1 + y_2}{2}$$

is the mean height of beam 60 at distance x .

According to my invention, plates 66 and 68 are terminated at the distance x from aperture 67 at which beam 60 is at the maximum of its parabolic path. At this point, the electrons have substantially no vertical velocity components, and they thereafter flow in a horizontal direction. The beam does, however, have a transverse velocity spread. The electrons nearer the grounded plate 66 travel at a faster horizontal velocity v_1 than those which are nearer the negative plate 68 and which travel at a slower velocity v_2 . It is this velocity spread that would make the beam focus on line 77 if the electric field E were extended beyond the distance x .

More specifically, the beam would focus on line 77 because the product of the kinetic energy of each electron and its distance from plate 66 is uniform across a transverse section of the beam at the maximum of its parabolic path. This relationship can be expressed as:

$$\frac{1}{2} m v_n^2 y_n = K \quad (3)$$

where v_n is the velocity of any electron n , y_n is the height of electron n from plate 66, and K is a constant. The distances y_1 and y_2 of electrons traveling at velocities v_1 and v_2 , respectively, are therefore given by:

$$\frac{1}{2} m v_1^2 y_1 = \frac{1}{2} m v_2^2 y_2 \quad (4)$$

If the conditions of Equation 3 are met as the beam enters the deflection region of deflecting plates 73—73' and if the conditions of Equations 1 and 2 are fulfilled when the beam is deflected by deflecting plates 73—73' and 74—74', the beam will crossover as it passes through an appropriate aperture in shield plate 68, and as it leaves successive deflecting regions, it will have no vertical (diverging) velocity components. The deflection electric field E' produced between plates 73 and 71 by an input pulse is therefore adjusted to fulfill the conditions:

$$x' = \frac{V_c}{E'} = \frac{V_c d'}{V_d'} \quad (5)$$

and:

$$\frac{y_1' + y_2'}{2} = \frac{V_c}{2E'} = \frac{V_c}{2V_d'} d' = \frac{x'}{2} \quad (6)$$

where

$$\frac{y_1' + y_2'}{2}$$

is the mean height of beam 60 from shield plate 71, E' is the deflection electric field produced between deflection plate 73 and shield plate 71, V_d' is the deflection voltage applied to deflection plate 73, d' is the separation of plates 73 and 71, and x' is the distance between the upstream edge of shield plate 71 and aperture 72.

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Under these conditions, the beam will describe one-half of a parabola as it travels the horizontal distance x' . Because of its transverse velocity spread, the beam will crossover as it flows through aperture 72. The beam enters and leaves aperture 72 at a 45 degree angle because of the relationship of the distances x' and

$$\frac{y_1' + y_2'}{2}$$

as expressed in Equation 5. Hence, the conditions are proper for a repetition of the operation that occurred in the electron gun 59; deflection field E' between plates 73' and 71 will deflect the beam through one-half of a parabola in the horizontal distance x' and the beam will be injected into the deflection region between plates 71 and 74' with no vertical velocity components, but with the horizontal velocity spread given by Equation 3. The process can thereafter be repeated without defocusing electron beam.

It should be pointed out that the purpose of electron gun 59 is to inject an electron beam that has the velocity spread given by Equation 3. Other methods may be used for producing this type of beam. For example, if the voltage on the cathode is varied over a transverse portion thereof, it may be possible to produce the required velocity spread. It should also be noted that although FIG. 5 is drawn to a scale that shows distance x as being equal to distance x' , the invention is not intended to be so limited.

Besides deflection defocusing, the space-charge forces within the beam of the device of FIG. 2 tend to make the beam diverge. These forces result from the mutual repulsion of the negatively charged electrons of the beam. Generally, the space-charge forces are small in comparison with the deflection forces. The device of FIG. 2 can, however, be easily modified as shown in FIG. 6 to compensate for space-charge forces if such compensation is desired.

In chapter XI of the aforementioned Pierce book, it is explained that an electron beam can be focused (prevented from diverging) through the use of a spatially alternating electrostatic field. This method of compensating for space-charge forces is known as electrostatic periodic focusing. The device of FIG. 6 makes use of this method through the substitution of a number of discrete shield elements 132a, 132b, 132c and 132e, for the single shield plate 32 of FIG. 2. Alternate deflection plates 137—137', 139—139' and alternate shield elements 132a, 132c are connected to the negative pole of a D.-C. source 142. The remaining deflection plates, 138—138', 140—140' and shield elements 132b, 132e, are connected to the positive pole of source 142. The electron beam passes first through a negative potential region between plates 137'—137', then a positive potential region between plates 138'—138', and experiences the focusing effects of a periodic spatially alternating electrostatic field. Deflection fields are superimposed on the focusing fields by applying "on" pulses to input conductors 145 and 147 that are negative with respect to the voltage on deflection plates 137—137' and 139—139', and by applying "on" pulses to input conductors 146 and 148 that are negative with respect to the voltage on deflection plates 138—138' and 140—140'.

The above-described embodiments are intended only to be illustrative of my invention. For example, the electron beam of the device of FIG. 6 could be deflected by applying positive pulses to the shield elements 132a through 132e. Various known electron guns could alternatively be substituted for those shown in the devices of FIGS. 2 and 6. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of my invention.

What is claimed is:

1. A translating device comprising: means for forming

and projecting a ribbon electron beam along a path; apertured beam shielding means extending parallel with said path; a plurality of pairs of deflecting plates arranged axially along said path, each of said pairs comprising two plates on opposite sides of a single aperture in said shielding means; a target electrode between each successive pair of deflecting plates; and means for transmitting one digit of a Gray code to each of said pairs of deflecting plates.

2. A translating device comprising: an apertured shield plate; means for forming and projecting a ribbon electron beam parallel with said shield plate; a plurality of pairs of deflection plates arranged axially and parallel with said shield plate; each of said pairs comprising two plates on opposite sides of said electron beam and a single aperture of said apertured shield plate; a short-circuit connection between the plates of each pair; a target electrode between each successive pair of deflecting plates; means for transmitting one digit of a Gray code to each of said deflecting plates; and means for transmitting one digit of a binary code from each of said target electrodes.

3. An electron discharge device comprising: a first flat conductor having an elongated aperture therein; a second flat conductor parallel to said first conductor; means for forming and projecting a ribbon electron beam through the aperture of said first conductor at an angle of substantially 45 degrees with respect to said first conductor; means for focusing said ribbon electron beam to a crossover line at said aperture; means comprising said first and second conductors and a source of direct current energy for causing said beam to flow parallel with said first and second conductors; flat apertured shielding means arranged parallel and axially with said first conductor; a plurality of axially arranged pairs of deflecting plates parallel with said shielding means; each pair of deflecting plates comprising a second plate that is axial with said second conductor, and a first plate that is on the opposite side of an aperture in said shielding means from said second plate; a target electrode between each successive first plate; and means for transmitting one digit of a Gray code to each of said pairs of deflecting plates.

4. An electron gun comprising: means including a pair of parallel plates for producing a substantially uniform electrostatic field; means for forming an electron beam and injecting it into said field at an angle therewith of substantially 45 degrees, whereby said beam is deflected; and means for focusing said beam to a crossover line at substantially the point at which it is injected into said electrostatic field; said electric field being terminated at a distance, from the point of beam injection, at which the beam is deflected substantially 45 degrees.

5. An electron gun comprising: a cathode for forming and projecting an electron beam; a first plate positioned at substantially 45 degrees with respect to said cathode and having an aperture therein and a first terminal edge; a second plate parallel to said first plate and having a second terminal edge that is parallel to, and directly opposite, said first terminal edge; means for projecting said electron beam through said aperture and toward said terminal edges; means for focusing said beam to a crossover line at said aperture; and means for biasing said second plate at a negative potential with respect to said first plate whereby said beam is deflected to flow parallel with said plates.

6. A translating tube comprising: an electron gun comprising a pair of parallel electron gun plates extending in an x direction, and defining a deflection region therebetween; means for forming and projecting a ribbon electron beam into said deflection region through an aperture in one of said plates at an angle of substantially 45 degrees with respect to said x direction; means for focusing said beam to a crossover line at said aperture; means comprising a source of electrostatic energy and said parallel plates for causing said beam to describe sub-

stantially one-half of a parabola and to emerge from said deflection region traveling in the x direction; flat apertured shielding means extending axially with one of said electron gun plates in the x direction; a plurality of axially arranged pairs of deflecting plates parallel with said shielding means; each pair of deflecting plates comprising a first deflecting plate that is axial with the other of said electron gun plates, and a second deflecting plate that is on the opposite side of an aperture in said shielding means from said first deflecting plate; means conductively connecting the first and second deflecting plates of each pair; a target electrode between each successive second deflecting plate; and means for transmitting one digit of a Gray code to each of said pairs of deflecting plates.

7. An electron beam device comprising: a plurality of pairs of deflection plates axially arranged along a path; a shield plate between each pair of deflection plates, each of said shield plates having an aperture therein; means for forming an electron beam and projecting it parallel with the path between a shield plate and a deflection plate; means for biasing alternate pairs of deflection plates and shield plates at a first electrostatic potential; means for biasing the remaining pairs of deflection plates and shield plates at a second electrostatic potential that is different from said first potential; a conductor interconnecting the deflection plates of each of said pairs; a target electrode between each successive pair of deflection plates; means for transmitting an electrical pulse representative of one digit of a Gray code to each of said pairs of deflection plates; and means for transmitting an electrical pulse representative of one digit of a binary code from each of said target electrodes.

8. An electron discharge device comprising: means for forming and projecting an electron beam along a first path; a plurality of means arranged along said first path for causing said beam to flow along a second path in response to an electrical pulse; a plurality of means arranged along said second path for causing said beam to flow along the said first path in response to an electrical pulse; and a plurality of target electrodes arranged along said second path.

9. An electron discharge device comprising: means for forming and projecting an electron beam along a first path; means comprising a plurality of deflection plates axially arranged along one side of the first path for deflecting said beam to a second path in response to an electrical pulse; an apertured shield plate extending between said first and second paths; a plurality of second deflection plates arranged along said second path for deflecting said beam to said first path in response to an electrical pulse; and a target electrode between each successive second deflecting plate.

10. The electron discharge device of claim 9 wherein said beam forming and projecting means comprises: a first plate having an aperture therein; a second plate; means for focusing said beam at said aperture and for projecting said beam through the aperture at an angle of substantially 45 degrees with respect to said first plate; and means comprising said first and second plates for deflecting said beam and causing it to flow along said first path.

11. An electron gun comprising: a cathode for forming and projecting an electron beam; a first plate positioned at substantially 45 degrees with respect to said cathode and having an aperture therein and a first terminal edge; a second plate parallel to said first plate and having a second terminal edge that is parallel to, and directly opposite, said first terminal edge; said cathode comprising means for projecting said electron beam through said aperture and toward said terminal edges; means for focusing said beam to a crossover line at said aperture; means for biasing said cathode at a first negative potential with respect to said first plate; and means for biasing said second plate at a second negative po-

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tential with respect to said first plate; said potential substantially fulfilling the relationship:

$$x = \frac{V_c d}{V_d}$$

where x is the distance between said aperture and said first terminal edge, V_c is the first negative potential, V_d is the second negative potential, and d is the separation of said first and second plates.

12. An electron gun comprising: means, including a pair of parallel plates, for producing a substantially uniform electrostatic field; one of said plates having a positive electrostatic polarity and the other plate having a negative electrostatic polarity; means for forming an electron beam and injecting it into said field at an angle; said electrostatic field being terminated at a distance x from the point of beam injection, which is substantially determined by the relationship

$$x = \frac{V_c}{E}$$

where V_c is the voltage of the cathode with respect to the positively biased plate, and E is the intensity of the electrostatic field.

13. The electron gun of claim 12 wherein the mean distance of said electron beam from the positively biased plate at the termination of the electric field is substantial equal to

$$\frac{V_c}{2E}$$

14. The electron gun of claim 13 further comprising means for focusing said beam to a crossover line at substantially the point at which it is injected into said electrostatic field.

15. An electron discharge device comprising: means for forming and projecting a beam of electrons along a first path; means comprising a first plurality of deflection plates axially arranged along one side of said first path for deflecting said beam to a second path in response to an electrical pulse; means comprising a second plurality of deflecting plates axially arranged along one side of said second path for deflecting said beam to said first path in response to an electrical pulse; a target electrode between each successive one of said second plurality of deflecting plates; an apertured shield plate extending between said first and second paths; said forming and projecting means further comprising means for projecting electrons at velocities substantially determined by

$$\frac{1}{2}mv_n^2 y_n = K$$

where m is the mass of an electron, v_n is the velocity of any electron, y_n is the perpendicular distance of said any electron from said apertured shield plate, and K is a constant.

16. The electron discharge device of claim 15 wherein said beam forming and projecting means comprises: a cathode; a first plate positioned at substantially 45 degrees with respect to said cathode and having an aperture therein and a first terminal edge; a second plate parallel to said first plate and having a second terminal edge that is parallel to and directly opposite to said first terminal edge; said cathode comprising means for projecting said electron beam through said aperture and toward said terminal edges; means for focusing said beam to a crossover line at said aperture; means for biasing said cathode at a first negative potential with respect to said first plate,

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and means for biasing said second plate at a second negative potential with respect to said first plate; said potentials substantially fulfilling the relationship

$$x = \frac{V_c d}{V_d}$$

where x is the distance between said aperture and said first terminal edge, V_c is the first negative potential, V_d is the second negative potential, and d is the separation of said first and second plates.

17. The electron discharge device of claim 15 wherein the length of any deflection plate is substantially equal to

$$\frac{2V_c'}{E'}$$

where V_c' is the voltage of the cathode with respect to said shield plate and E' is the electric field produced in response to said electrical pulse to said any deflection plate.

18. The electron discharge device of claim 17 wherein the mean distance of said first path to said deflection plate is substantially equal to

$$\frac{V_c'}{2E'}$$

19. An electron discharge device comprising: means for forming and projecting a ribbon electron beam along a first path; means comprising a plurality of first deflection plates axially arranged along one side of said first path for deflecting said beam to a second path in response to an electrical pulse; means comprising a plurality of second deflecting plates axially arranged along one side of said second path for deflecting said beam to said first path in response to an electrical pulse; and a plurality of target electrodes arranged along said second path; one of said target electrodes being positioned between each successive one of said second deflection plates; and each of said target electrodes being positioned to intercept a different portion of said ribbon electron beam.

20. The electron discharge device of claim 19 wherein: each of said first deflection plates is substantially coextensive with a corresponding second deflection plate; and wherein each first deflection plate is separated from its corresponding and coextensive second deflection plate by an apertured shielding means.

21. An electron discharge device having a central axis and comprising: apertured shielding means extending along said central axis; a plurality of first deflection plates axially extending along one side of said shielding means; a plurality of second deflection plates axially extending along the other side of said shielding means; each of said second deflection plates being coextensive with a corresponding first deflection plate; a short-circuit connection between corresponding first and second deflection plates; means for forming and projecting an electron beam between said shielding means and said one of said first deflection plates; and a plurality of target electrodes, one of said target electrodes being positioned between successive ones of said second deflection plates, and each of said target electrodes being staggered with respect to the other target electrodes.

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