

Jan. 19, 1960

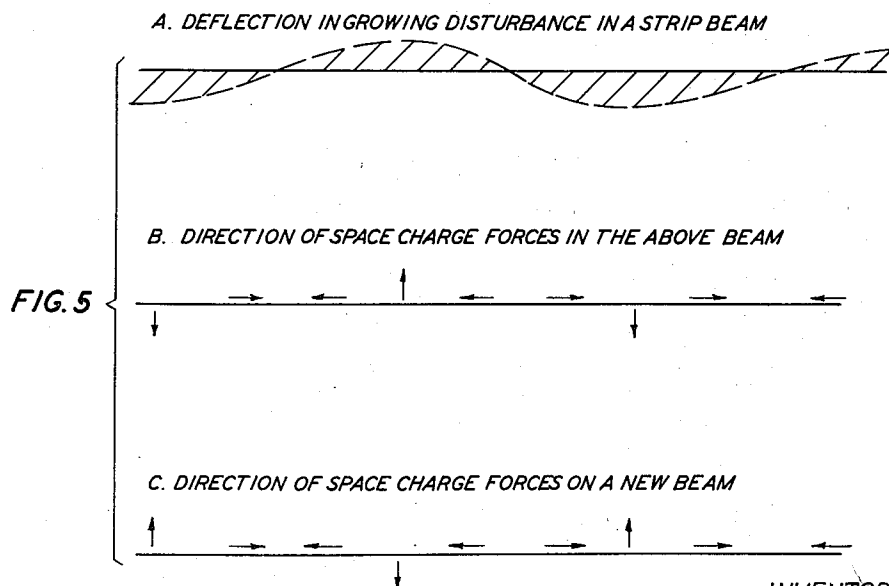
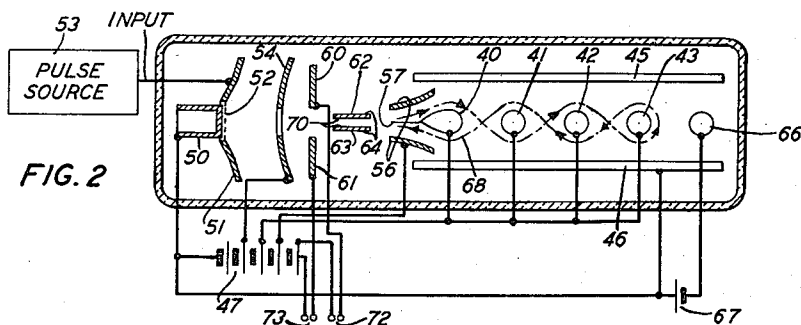
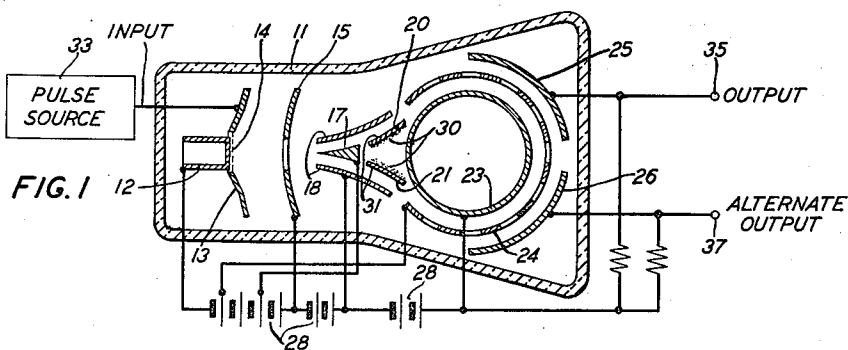
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2,922,069

HIGH SPEED COUNTING AND SWITCHING TUBES

Filed July 15, 1958

3 Sheets-Sheet 1



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FIG. 3

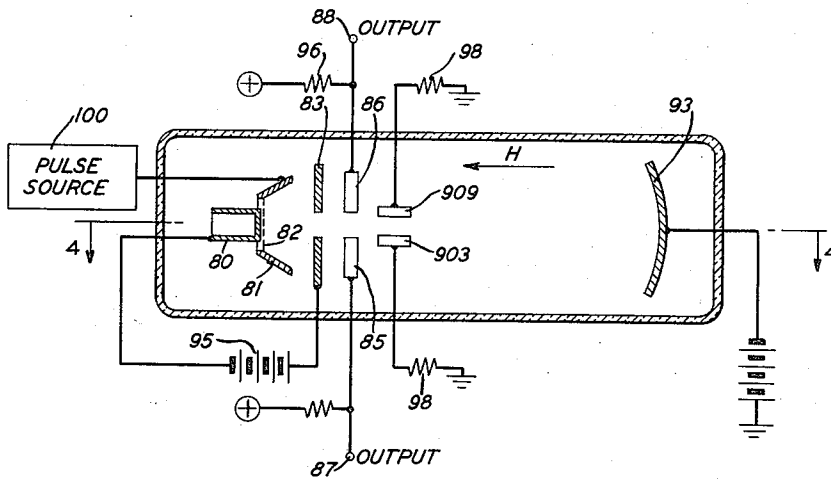
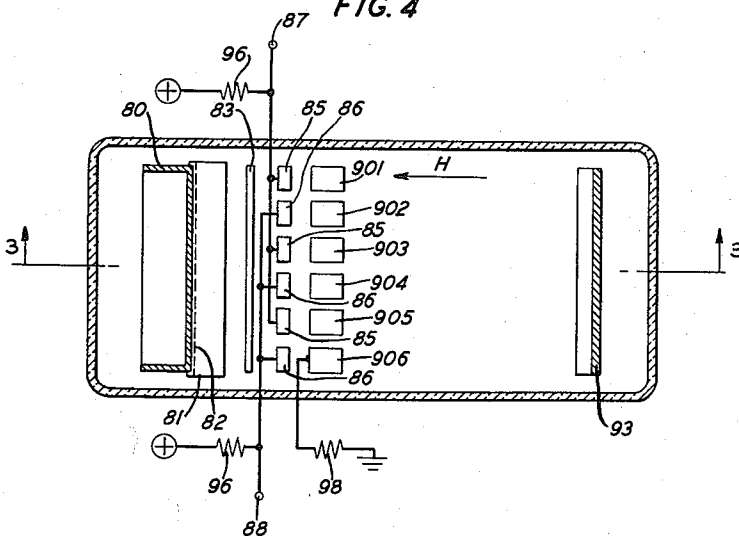


FIG. 4



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FIG. 6

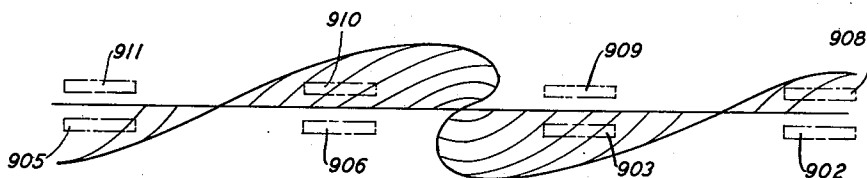
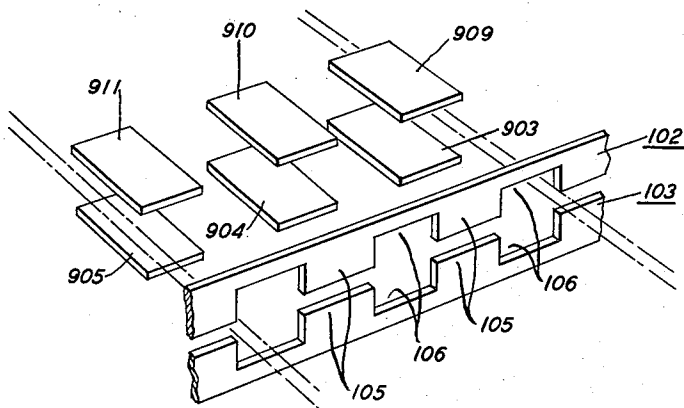


FIG. 7



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2,922,069

HIGH SPEED COUNTING AND SWITCHING
TUBES

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Application July 15, 1958, Serial No. 748,746

19 Claims. (Cl. 315—8.5)

This invention relates to electron beam devices and, more particularly, to devices capable of performing counting and switching functions in the millimicrosecond range.

In many switching applications, such as in the computer field, for example, it is often desirable to obtain, in response to an applied series of predetermined input pulses, a desired sequential pattern of output pulses at an extremely rapid rate so as to actuate external circuitry for performing counting or switching functions. In order to perform these functions rapidly with a discharge device, such as in the millimicrosecond range, it is essential to have a system which has two or more equipotential states, the transition time of which is dependent primarily upon the electron beam.

Conventional counting and switching devices have exhibited relatively slow counting rates heretofore for several significant reasons. First, many of the present counting and switching devices operate within a gaseous atmosphere and, consequently, the discharge time is dependent upon the relatively slow ionization time of the particular gas that is employed. Second, many of the switching and counting devices used heretofore involve low beam current deflection circuitry. This is necessitated primarily because of the fact that space charge forces of an electron beam increase in magnitude in direct proportion to the beam current. Accordingly, to minimize space charge, which tends to spread the electron beam before reaching its target, low beam current deflection systems have been utilized. Disadvantageously, however, this decreases the sensitivity of the beam deflection system or, in other words, presents a time lag since the small beam deflecting currents do not effect an electrostatic deflecting field which can respond instantaneously and in a precise manner to a series of input pulses received at an extremely high rate. Third, many counting and switching devices of prior design require the utilization of external associated circuitry. This external circuitry necessitates the charging of stray circuit capacitances of comparatively large magnitudes and, consequently, impairs the response of such devices by the presence of long time constant circuitry.

Accordingly, it is an object of this invention to increase the rate of response of counting and switching devices.

It is another object of this invention to attain extremely high counting and switching rates in a device which is not dependent upon gas ionization time.

It is still another object of this invention to substantially eliminate the time lag characteristic of conventional low beam current deflection systems.

It is still another object of this invention to eliminate the external circuitry normally required and associated with conventional counting and switching devices and, consequently, substantially eliminate the stray capacitances and lead inductances associated therewith.

In accordance with one illustrative embodiment of my invention there is provided a beam type counting and

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switching device comprising an electron gun, a beam splitting electrode spaced a short distance from and in axial alignment with the electron gun, a deflection system comprising an inner and outer set of deflection plates, and a pair of curved electrodes defining alternate, i.e., clockwise and counterclockwise, paths of electron flow around the single loop between the current electrodes. In accordance with an aspect of my invention the two sets of deflection plates divide the beam into two sections of predetermined magnitude, the two sections traveling in opposite directions around the single loop course. As a result of an initial potential difference between the two sets of deflection plates, half of the beam is given a greater outward deflection than will permit it to circumnavigate the circular path and it is collected on one of two output electrodes. The other half of the beam follows a circular path and returns to the deflection system. In accordance with another aspect of this invention, each of the inner electrodes of the two deflection plates has a reflectionless surface and a secondarily emissive surface, the two electrodes being so aligned with the returning portion of the beam that electrons impinge upon the reflectionless surface of one electrode and on the secondarily emissive surface of the other electrode in such a manner that the inner electrode, previously more positive, becomes more negative with respect to the other inner electrode. This reversal in the potential difference between the two sets of plates changes the portion of the beam collected, as well as the output electrode, and likewise reverses the direction of the returning portion of the beam. Such a system in response to an applied signal permits at least two equilibrium states which are determined independently of gas ionization time, excessive lag time associated with very low beam currents, or long time constant external circuitry, all of which are common faults in prior art systems, as noted above.

In another specific illustrative embodiment only one set of deflection plates is utilized and positioned adjacent the initial path of flow so as to determine which of two sinuous equipotential paths the beam will traverse. These sinuous paths of flow are established by a slalom focusing system. This system of focusing is fully described in U.S. Patent 2,857,548, issued October 21, 1958, of R. Kompfner-W. H. Yocom. The beam may extend along such a slalom course for any desired period of time, being reversed by a negative focusing electrode whereupon it returns along the opposite equipotential path. The deflecting plates are charged positively or negatively, as described in the above embodiment, with the secondary electrons emitted by the deflecting plate whose secondarily emissive surface is bombarded by the returning beam striking one of two output collectors depending upon which sinuous path the beam returns along. Such a structure possibly has the advantage over the single circular path of the above-described embodiment in that any lateral deviations of the electrons occurring in the prior embodiment result in a wider range of transit time, whereas, in accordance with this embodiment, such deviations are canceled out by the beam being reversed upon itself along an opposite sinuous path. Also, the focusing is stronger so that a higher beam current can be used; and the path is longer, increasing the charge stored in a pulse. This gives a larger control current, albeit a somewhat slower response time.

In still another specific illustrative embodiment of my invention a high speed counting and switching tube utilizes strip beam instability phenomenon. This type of beam instability is fully disclosed in a copending application of mine, Serial No. 560,547, filed January 23, 1956. Briefly described, such a beam, in either strip or hollow form, when confined by a magnetic focusing

field parallel thereto does not maintain its initial cross section, but proceeds to break up into multiple swirls or "spiral nebulae" because of an unstable condition. This effect results from a D.-C. disturbance in the beam, described as either a deflection or density variation, which gives rise to an unbalanced space charge field in such a direction as to further increase the disturbance in an exponential manner until eventually a complete breakup of the beam is effected. In accordance with another aspect of my invention, it is this ultimate breakup of the beam which is advantageously utilized as a control parameter. This particular embodiment of my invention comprises an electron gun for projecting a strip or ribbon beam, a reflection electrode, and a series of precharged deflection plates on opposite sides and across the width dimension of the beam. These deflection plates initiate a disturbance in the beam which increases in an exponential manner as it traverses the drift region. The beam is reflected back by the negative reflection electrode and collected on either of two distinct sets of output electrodes. The initially reflected beam has distinct bunches of charge, established by the "spiral nebulae" described above, which are of the proper phase to excite disturbances in the beam of electrons emerging in the gun in the same form and, thus, sustains the deflection. However, part of the returning beam impinges on certain of the deflecting plates leaving a negative charge on the previously positively charged plates which to a lesser degree excites the new beam in an opposite sense to that of the space charge forces of the returning beam. When the beam is momentarily interrupted, as by a negative pulse to the grid of the electron gun, the space charge of the returning beam disappears and the newly acquired electrode voltages cause the reverse excitation of a new beam. The new field configuration results in a major portion of the beam impinging upon the other of the two distinct sets of output electrodes, each pulse thus reversing the output voltage, and also upon the other of the deflection plates.

It is a feature of this invention that an electron beam in an electron discharge device be projected adjacent at least a pair of deflection plates having an initial charge thereon, the beam then being returned after traversal of a predetermined path partially or substantially to impinge on one or the other or both of the deflection plates, dependent on the initial charges on the plates.

It is another feature of this invention that at least one output electrode be positioned in the device to receive electrons only upon one of the two possible charge conditions of the deflection plates.

It is a further feature of this invention that the electron beam be returned back toward the electron gun so as to change the charge on the deflection plates by impingement thereon. Further in accordance with this feature of my invention the charge may be changed by electron collection, causing the plate to assume a negative potential, or by causing secondary emission, in which case the plate assumes a more positive potential.

It is still a further feature of my invention that the electron beam be pulsed, allowing the reversed charge conditions on the deflection plates, due to impingement thereon of the electron beam, to reverse its effect on the electron beam. In accordance with this feature of my invention, a specific output electrode has electrons directed thereto only on alternate pulsing of the electron beam, thereby enabling the tube to operate as a fast counting tube.

It is a feature of certain specific illustrative embodiments of my invention that the deflection plates cause the electron beam to traverse a slalom focusing structure in either of one or two directions, and therefore along one or the other of the two possible alternate paths, the electron beam being returned by the slalom structure back to the deflecting plates to impinge thereon, whereby the path chosen by the beam through the

slalom structure may be reversed. Further, in accordance with this feature of the invention, the slalom structure may comprise only a single loop.

It is a feature of other specific illustrative embodiments of my invention that the deflection plates be utilized with a high density electron beam characterized by strip beam instability, the space charge of the beam itself being used as the control parameter for the deflection system as the beam is reflected back to the electron gun to impinge on specific deflection plates of possible pairs of deflection plates spaced across the width of the electron beam.

A complete understanding of this invention and of these and other features thereof may be gained from the following detailed description, together with the accompanying drawing, in which:

Fig. 1 is a sectional view of a counting and switching device utilizing a single loop slalom focusing structure in accordance with one illustrative embodiment of my invention;

Fig. 2 is a sectional view of a counting and switching device utilizing a multiloop slalom focusing structure illustrative of another specific embodiment of my invention;

Fig. 3 is a sectional view, along the line 3—3 of Fig. 4, of a counting and switching device in accordance with a further illustrative embodiment of my invention utilizing strip beam instability phenomena;

Fig. 4 is a plan view, along the line 4—4 of Fig. 3, of the device depicted in Fig. 3;

Figs. 5 and 6 are plots of the dynamics of the beam breakup in accordance with strip beam instability phenomena and the field patterns which result therefrom; and

Fig. 7 is a perspective view partially depicting a strip beam deflection system which may be utilized in the device depicted in Figs. 3 and 4 and which includes an electrode interceptor which tends to stabilize sideward drifting of the strip beam.

Referring now more particularly to the drawing, Fig. 1 illustrates one preferred embodiment of my invention and comprises a beam type counting and switching device including an envelope 11 which may be of glass or other suitable material known in the art. At one end of the envelope 11 is positioned an electron gun assembly including a cathode 12, a beam forming electrode 13 including a control grid portion 14 extending across the face of the cathode 12, and an accelerating anode 15. A first pair of deflection electrodes includes an inner wedge shaped electrode 17 and an outer electrode 18. A second set of deflection electrodes includes the floating electrodes 20 and 21, described in further detail below. A circular electrostatic focusing structure includes an inner cylindrical electrode 23 and a concentric grid structure 24. Also concentric with the cylindrical electrode 23 but to the other side of the grid structure 24 are a pair of output electrodes 25 and 26; in most applications only a single output electrode need be employed but, as will be apparent from the discussion below, an output and an alternate output may readily be attained.

The arrangement of the cylindrical electrode 23 and the concentric grid structure 24 may be considered to be a single turn slalom focusing system. Suitable potentials are advantageously applied to the cathode 12, accelerating anode 15, deflecting electrodes 17 and 18, electrostatic focusing electrodes 23 and 24, and output electrodes 25 and 26 as by voltage sources 28, as is known in the art.

In accordance with an aspect of my invention the deflection electrodes 20 and 21 are advantageously treated or otherwise processed so that the outer surfaces 31 are secondary emissive, whereas the inner surfaces 30 are not secondary emissive. In the illustrative embodiment depicted the outer surfaces may comprise a secondary

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emissive coating, not shown, whereas the inner surfaces may be treated, as by a carbonizing technique, or covered by a mesh, as shown in the drawing, to inhibit secondary emission.

In the operation of this specific illustrative embodiment pulses applied from a pulse source 33 to the focusing electrode 13 are counted by causing an output signal to appear at output terminal 35 connected to output electrode 25 in response to every other input pulse. When the beam electrode 13 is pulsed, a relatively thick electron beam is emitted from the gun and is divided by the first deflection electrodes 17 and 18, half being deflected to each side of the electrodes 17 by the deflecting field between the electrodes 17 and 18. The deflection is made just a little more than will allow the current to circumnavigate electrode 23, so that only a small fraction makes the complete circuit. Current moving at too large a radius to circumnavigate the electrode 23 passes through the grid structure 24 and is attracted to the collector or output electrodes 25 and 26. Accordingly, it should be noted that the apertured or slotted structure of grid 24 serves two functions. In addition to permitting current moving at too large a radius to pass through and be attracted to the output electrodes, the apertures in the grid structure 24 also break up the deflecting field between electrostatic focusing electrodes 23 and 24 so that it is periodic, the potential near the beam going from near cathode potential to a large positive potential periodically as it makes the circuit around the electrode 23. This periodic potential variation serves effectively to double the focusing strength and thus the amount of current that can be focused in the system.

Of the current that does complete the circuit around the electrode 23, some strikes the floating deflection electrodes 20 and 21. The part of the current going counterclockwise will partly land at a glancing angle on the outer surface 31 of electrode 20 and by secondary emission will charge it more positively and will partly land on the inner surface 30 of electrode 31, which is covered by a mesh or otherwise treated so that most of the secondary electrons are restrained, and charge it negatively with respect to the average potential of the electron beam. The clockwise current around the electrode 23 will serve to do the opposite, part of the current striking the secondary emissive surface 31 of electrode 21 and part striking the non-secondary electron emissive surface 30 of electrode 20.

If there is not an exact balance in the potentials on the floating electrodes 20 and 21, the deflection given to the beam by these electrodes will be unbalanced, which reverses the unbalance in the beam, giving a larger unbalance in the opposite direction. In the operation of this embodiment of my invention upon pulsing of the electrode 13 there will always be a residual unbalance, one way or the other, of the charge on the electrodes 20 and 21 or an unbalance in the beam itself, due to shot noise or for other causes. As our primary concern is to count the appearance of alternate pulses, for most applications it is not of importance whether the beam initially primarily traverses the electrode 23 in a clockwise or a counterclockwise direction due to the initial unbalance between the beam and the deflecting electrodes 20 and 21. However, if desired, initial voltages may be applied to the deflecting electrodes 20 and 21 by external pulse or voltage sources, not shown.

Let us assume that at a start of a cycle, when the beam electrode 13 is pulsed by an input pulse from source 33, the electrode 20 is somewhat positive and the electrode 21 is somewhat negative with respect to the average potential of the electron beam, so that the half of the beam entering the upper branch between electrodes 23 and 24 has less than the average outward deflection and is focused, by the electrodes 23 and 24, around the circuit. When it has completed a circuit it strikes the

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secondary emissive surface 31 of electrode 21 charging it more positively and the gridded or meshed surface 30 of electrode 20 charging it more negatively. In this manner the initial configuration is reversed, so that subsequently the deflection is in the opposite direction, i.e., the portion of the beam entering the lower branch has less than the average outward deflection and is focused. In the meantime, however, under the initial configuration the portion of the beam in the lower branch receives an additional outward deflection, having more than the average outward deflection, and so most of the beam current is collected on the output electrode 26 and does not circumnavigate the electrode 23. When the potential conditions on the electrodes 20 and 21 are reversed, then most of the beam current in the upper branch is similarly collected by the output electrode 25 and an output pulse can be obtained at terminal 35. It is obvious that an alternate output pulse can also be obtained at output 37.

As just described above, the tube is, in effect, a free running oscillator or multivibrator. However, if the electron beam is pulsed by activating input pulses, applied from source 33 to the electrode 13, of short duration compared to the time of beam transit around the electrode 23 but of long enough duration to allow passage of sufficient current to charge the deflecting plates 20 and 21, then the tube will switch the direction of the electron beam around the electrode 23 only when pulsed. Under these conditions an output pulse will appear at terminal 35 or 37 only on occurrence of every other input pulse, thereby satisfying the requirements for counting. If desired, the input pulses could be applied to electrode 17 rather than to electrode 13.

In Fig. 2 there is depicted another embodiment of my invention wherein a slalom focusing structure employs four rod elements 40, 41, 42, and 43 maintained at a positive potential with respect to the boundary plate elements 45 and 46, as by source 47, to attain slalom focusing of an electron beam along a sinusoidal equipotential surface, in accordance with the principles of slalom focusing, as set forth in R. Kompfner-W. H. Yocom U.S. Patent 2,857,548, issued October 21, 1958. A thin strip beam of electrons is projected from the electron gun by a pair of deflection electrodes. Specifically, the embodiment of Fig. 2 comprises a cathode 50 having adjacent thereto a beam forming electrode 51 including a control grid portion 52 extending across the face of the cathode 50. Input pulses to be counted are applied to the beam forming electrode 51 and specifically to the control grid 52 thereof from a source 53 of input pulses. The strip electron beam is projected through an accelerating anode 54 and between a pair of deflection electrodes including plates 56, electrically connected together, and a projecting strip 57 on the first slalom rod electrode 40.

Situated between the accelerating anode 54 and the start of the slalom focusing structure are a pair of alternate output electrodes 60 and 61 and a pair of floating deflection plates 62 and 63, advantageously having secondary emissive surfaces 64 facing away from the electron beam.

In operation one of the floating electrodes 62 and 63 is charged more positively than the other with respect to the average potential of the beam, either due to a residual charge, beam instability, or by applying an initiating pulse thereto; let us assume that the electrodes are initially biased so that the upper electrode 62 is more positive than the lower electrode 63. The strip electron beam in passing through the deflection plates 62 and 63 is then turned upward so that most of the beam passes between the upper deflection plate 56 and the projecting strip 57. The electrode 56 is biased more positively than the strip 57 and bends the beam even more, starting it on a stable slalom course. The beam then traverses several bends around the slalom rods 40, 41, 42, and 43, being reversed by a reversing rod 66 to which is applied a negative potential with respect to the boundary plates 45 and 46, as

by source 67; the slalom beam path in this traversal is indicated by the dotted and arrowed lines 68. Upon emerging from the slalom focusing structure and the deflection plates 56, most of the current from the beam is collected on the floating deflection electrodes 62 and 63. The current to the upper electrode 62 is collected on the inside surface 70 where secondary electrons cannot escape, either due to the close geometry and spacing of the electrodes 62 and 63 or due to a secondary electron inhibiting coating on the surface 70. Accordingly, the beam current tends to charge the upper electrode 62 negatively. The beam current striking the lower electrode 63 strikes the secondary emissive outer surface 64 producing secondary electrons in an electric field which draws them away, thereby charging the lower electrode 63 positively. This is just opposite to the initial potential arrangement of the electrodes 62 and 63 and steers subsequently emitted current into the lower path between the electrode 56 and portion 57 where it slaloms around the slalom rods in the opposite direction to that depicted by lines 68 until it emerges from the upper path between electrodes 56 and 57 again reversing the charge on electrodes 62 and 63. The secondaries emitted by the outer surfaces 64 of electrodes 62 and 63 are collected by the output electrodes 60 and 61, respectively, so that output signals may be taken, in alternate cycles of operation, from either output electrode at the output terminals 72 and 73, respectively.

The period of the cycle is determined by the transit time through the slalom structure, which depends upon the number of slalom rod elements employed before the reversing rod element 66, and the switching time depends on the time required for the beam to charge the electrodes 62 and 63. As in the embodiment of Fig. 1, the input pulses are of proper duration and repetition interval so that the tube will switch the direction of the electron beam through the slalom focusing structure only when pulsed. It may be pointed out, in comparing the embodiments of Figs. 1 and 2, that as the rate of switching is dependent on the time of transit for the electron beam, the embodiment of Fig. 1 comprising, in effect, a single turn slalom focusing structure, may be utilized for switching at a faster rate than the embodiment of Fig. 2.

Figs. 3 and 4 depict another specific illustrative embodiment of my invention in which the counting tube utilizes the phenomenon of strip beam amplification, as described in my application Serial No. 560,547, filed January 23, 1956. Turning now to Fig. 3, the device includes an elongated cathode 80 adjacent which is a beam forming electrode 81 having a control grid 82. An accelerating anode 83 completes the electron gun structure. For purposes of clarity the heater element and support elements, which are necessary and are known in the art, are not depicted in the drawing.

Positioned adjacent the accelerating anode 83 are pluralities of pairs of output electrodes 85 and 86 on opposite sides of the electron beam path. As seen in Fig. 4, the alternate electrodes 85 are connected together to a first output terminal 87 and the other alternate electrodes 86 are connected together and to a second output terminal 88. The alternate electrodes above the electron beam are also so connected, each electrode 85 below the beam having opposite thereto an output electrode 86 above the beam, as seen in Fig. 3.

Next to the output electrodes are a plurality of pairs of deflecting electrodes 90, designated in the drawing as 901, 902 . . . etc. After passing through the deflecting electrodes 90 the electron beam enters a drift space in which there is a linear magnetic field, indicated in the drawing by the arrow H. This field may be provided by any of the many magnetic focusing arrangements known in the art, but not shown in the drawing. After passing through the drift space the electrons are reflected by the reflector 93 back toward the deflection plates and output electrodes, as described further below.

A suitable positive potential is maintained between the cathode 80 and the accelerating electrode 83, as by a battery 95. Similarly, a positive potential is maintained on the output electrodes 85 and 86 from a suitable positive source, as through individual high resistors 96. The deflection plates or electrodes 90 are electrically floating, being connected individually to ground through high resistors 98; in Fig. 4 only the end plate 906 is shown so connected but it is to be understood that each of the other deflection plates there depicted is also similarly connected to ground.

To understand the principles and features of this specific illustrative embodiment of my invention let us consider the operation of the tube. We shall assume that the deflection plates have a charge on them such that alternate plates above the electron beam path are positive and negative, respectively with respect to the average potential of the electron beam, and that the other plate of each pair below the beam has a charge of the opposite polarity. The deflection plates are thus pre-charged due to residual charge remaining on the plates from a prior operating cycle, as herein explained, or due to pulsing of these plates from external circuitry, not shown. The beam, which is a thin, flat electron beam, is projected from the electron gun and through the deflection plates. The initial deflection of the beam is at first sinusoidal, as shown in Fig. 5A, with equal deflections in the plane of, and transverse to the plane of the beam. The illustration of Fig. 5A depicts a part of the cross section of the beam across its width, i.e., looking toward the electron gun and the deflection plates in the plan view of Fig. 4. Of course, only the beam width across a few of the pairs of deflection plates is depicted.

The beam with this initial deflection on it due to the charge on the deflection plates 90, traverses the drift space where the deflection is increased according to the laws governing strip beam instability in a magnetic field. The beam is then reflected back by the negatively biased reflector 93 and collected, mainly, on the output electrodes 85 or 86; in other illustrative embodiments the electron gun anode 83 could be properly segmented and utilized also as the output electrodes.

The deflected beam has distinct bunches of charge which are phased so as properly to excite the fresh electrons emerging from the gun in the same form and thus acts to maintain the deflection. While most of the reflected beam will impinge on the output electrodes, part of the returning beam impinges on the deflecting plates, as best seen and further explained with reference to Fig. 6. The returning beam impinging on the deflection plates leaves a negative charge on these plates. It can readily be seen that the plates 90 on which the beam will impinge are just those plates which priorly had been charged positively and had attracted the beam as it initially passed between the plates. The negative charge on these plates will tend, to a lesser degree, to excite the new electrons from the gun in the opposite sense to the space charge of the returning beam. However, the space charge deflection of the returning beam is controlling.

These conditions will be maintained until the electron beam is interrupted by a negative pulse applied, as from a pulse source 100, to the control grid 82. When this occurs, the space charge, due to the prior deflection of the beam, disappears. Accordingly, when the control grid again allows current to flow from the electron gun, the electrode voltages on the various pairs of deflection plates 90 are reversed, thereby causing a reverse excitation on the new beam and the reverse configuration of the deflection of the beam. Each pulse applied to the control grid 82 therefore reverses the output terminal, 87 or 88, at which an output occurs. This can be seen from the alternate connections to the output electrodes 85 and 86, as discussed above.

In this specific illustrative embodiment of my inven-

tion a new condition is established in a round trip transit time, which may be of the order of millimicroseconds. It is only necessary to have enough charge on the beam to put a few volts on the small deflecting plates 90. To reduce circuit capacitance to the deflection plates 90 they may be so constructed as to have no connecting wires or other circuitry connected thereto; thus, in a particular specific illustrative embodiment the discharging resistances 98 may be part of the insulating support for the deflecting plates 90. The resistance 98 can be very high so that the deflecting plate system has a time constant much longer than the length of the actuating pulses from source 100, since the deflecting field will be of sign determined by the most recent beam configuration, even though the charge from earlier operations is not completely gone.

In this tube the beam breakup should advantageously be carried into the overload region. This can be seen from considering for a moment the dynamics of beam breakup and the resulting field pattern. The deflection is at first sinusoidal with equal deflections in the plane of and transverse to the plane of the beam, as depicted in Fig. 5A and discussed above. The space charge forces on the beam due to its own disturbance are as shown in Fig. 5B, and it can be seen that in the presence of the magnetic field these space charge forces would result in a continued growth of the deflection. It is known, however, that in strip beam amplification there are a number of pairs of waves which are developed and that with each growing wave there is also excited a decaying wave. If the deflection were purely sinusoidal, as shown in Fig. 5A, the space charge variations would also excite the accompanying decaying wave. This can be seen in Fig. 5C which depicts the space charge interacting forces on a fresh, undisturbed beam from the electron gun coplanar with that priorly depicted; as can be seen, the transverse fields are reversed and indeed this configuration is just that necessary to excite the decaying disturbance so that no growth would be excited in this new beam.

However, by carrying the beam into the overload region, eventually the growth depicted in Fig. 5A leads to a pattern like that shown in Fig. 6, in which the transverse fields are weak and the fields in the plane are augmented, so that the increasing disturbance is excited. Also depicted in Fig. 6 are possible positions of the deflection plates 90 to show how they, and the corresponding output electrodes positioned behind them, are selectively impinged by the disturbed electron beam.

Since the beam is self excited, the disturbance might be expected to drift sideways. This could be prevented, if such is found desirable, by selectively intercepting part of the returning beam with electrodes 102 and 103, shaped, as depicted in Fig. 7, to have intercept portions 105 positioned in the path of the beam between adjacent deflection plate pairs and apertures 106 to allow passage of the beam to the deflection plates 90. The electrodes 102 and 103 could, of course, be combined with the deflecting electrodes 90 and, in fact, if the electrodes were simply made of a slightly conducting insulator, they would serve both purposes. The part of the returning beam passing the electrodes 102 and 103 will be predominant in certain regions defined by the apertures 106, and if the disturbance tended to drift to one side, the tendency would be blocked by the electrode portions 105 so that the excitation position of the input would not be changed. It is thus apparent that the electrodes 102 and 103 are positioned directly adjacent the deflection plates 90 and between them and the reflecting electrode 93.

For this specific illustrative embodiment one specific set of parameters and operating conditions is as follows: the electron beam is at 200 volts and 20 milliamperes, about 1 centimeter wide and .02 centimeter thick. This calls for a periodicity of about $n=6$ and a magnetic field

H of about 500 gauss. The drift space provides about 4.0 centimeters of equivalent drift length or a transit time of less than 10^{-8} seconds. The deflecting plates in this specific illustrative embodiment pick up of the order of 2 milliamperes and have a capacitance of about 1 micro-microfarad. This results in a deflection voltage of 20 volts in 10^{-8} seconds, which is much more than ample. Ten milliamperes of current may be used in a load impedance of 100 ohms, giving an output voltage of 1 volt. If the gain of the modulating grid was 20,000 micromhos, this would be sufficient to switch another such tube, which is desirable from a circuit standpoint of being able to connect such devices directly in series. It is to be realized, however, that the specific figures just recited are not optimized but merely exemplary and that much better performance is obtainable.

Further, it is to be understood that the above-described arrangements are merely demonstrative of the application of the principles of my invention. 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. An electron discharge device comprising electron gun means for forming an electron beam and projecting said beam along a path, deflection means positioned on opposite sides of said path, means for causing said electron beam to be returned toward said electron gun to impinge on at least one of said deflection means to reverse the charge on said deflection means dependent on an initial charge on said deflection means, and output means conductively isolated from said deflection means for receiving electrons dependent on the charge on said deflection means.
2. An electron discharge counting device comprising means for forming and projecting an electron beam, deflection means positioned on opposite sides of the electron beam, means for causing said electron beam after traversal through said deflection means in one direction to be directed back to said deflection means to impinge thereon, output means conductively isolated from said deflection means for receiving electrons dependent on the charge on said deflection means, and means for pulsing said electron beam.
3. An electron discharge device in accordance with claim 2 wherein said output means are positioned adjacent said deflection means for receiving secondary electrons therefrom, said deflection means having opposing surfaces for the generation and suppression, respectively, of secondary electrons under impingement by said electron beam.
4. An electron discharge device in accordance with claim 2 wherein said output means are positioned adjacent said deflection means and also in the path of the electrons directed back toward said deflection means.
5. An electron discharge device in accordance with claim 2 wherein said deflection means causes said beam to traverse one of two possible paths and wherein said output means are adjacent said paths for receiving electrons directly from said beam.
6. An electron discharge device comprising electron gun means for forming and projecting an electron beam, deflection means for directing said beam upon one of an alternate pair of paths according to the potentials on said deflecting means, means positioned along said path for causing said beam to be returned toward said electron gun means and at least partially impinge on said deflection means to reverse the potentials thereof, thereby causing said beam to be directed to the other of said alternate paths, and collector electrode means conductively isolated from said deflection means for receiving electrons dependent on the charge on said deflection means.

7. An electron discharge device in accordance with claim 6 wherein said means for causing said beam to be returned toward said electron gun means includes a slalom focusing structure.

8. An electron discharge device in accordance with claim 7 wherein said slalom focusing structure comprises an inner curved member and an outer curved member having apertures therethrough, said beam being directed between said inner and outer members, and wherein said collector electrodes are positioned to the other side of said members removed from said inner member.

9. An electron discharge device comprising electron gun means for forming and projecting an electron beam, first deflection means for splitting said electron beam onto two alternate paths, second deflection means for directing said electron beam to traverse one of said alternate paths, said second deflection means including a first and a second deflection plate each having a first surface capable of emitting secondary electrons and an opposed second surface from which secondary emission is repressed, and focusing means adjacent said alternate paths for returning said electron beam toward said electron gun to impinge on said first and second surfaces to reverse the potential on said second deflection means, thereby causing said electron beam to be directed to traverse the other of said alternate paths.

10. An electron discharge device in accordance with claim 9 further comprising an output electrode adjacent one of said deflection plates for receiving the secondary electrons emitted therefrom on impingement of said first surface of said plate by said electron beam.

11. An electron discharge device in accordance with claim 9 wherein said focusing means comprises a single turn slalom focusing structure comprising inner and outer curved members, said outer curved member being apertured and further comprising collector electrodes adjacent said alternate paths and to the other side of said outer curved member.

12. An electron discharge device in accordance with claim 11 further comprising means for pulsing said electron beam.

13. An electron discharge device in accordance with claim 9 wherein said focusing means comprises a plural rod slalom focusing structure.

14. An electron discharge device comprising electron gun means for forming and projecting a thin, flat beam of electrons, a plurality of deflection plates to opposite sides of said electron beam to cause said beam initially to assume a substantially sinusoidal cross section, means including means defining a drift space and magnetic field means for causing strip beam amplification of said beam cross section, means for causing said beam to be di-

rected back toward said electron gun to impinge on said deflection plates to reverse the potentials thereof, and means for pulsing said beam.

15. An electron discharge device in accordance with claim 14 further comprising a plurality of output plates each adjacent one of said deflection plates and means electrically connecting alternate of said output plates together, said alternate output plates also being selectively impinged by said electron beam.

16. An electron discharge device in accordance with claim 15 further comprising means interposed in said beam path adjacent said deflection plates for preventing electrons impinging on an incorrect deflection plate due to sidewise drifting of said electrons.

17. An electron discharge device comprising means for forming and projecting an electron beam, deflection means having a charge thereon for deflecting said beam along a first of alternate paths, means for pulsing said beam, and focusing means for causing at least a portion of said beam to impinge on said deflecting means for changing the charge thereon.

18. An electron discharge device comprising means for forming and projecting an electron beam, beam splitting and deflection means in the path of said beam for directing said beam onto two alternate paths, a pair of curved electrodes, said alternate paths being between said curved electrodes in the clockwise and counterclockwise directions and the outer of said curved electrodes being apertured, and a pair of collector electrodes to the other side of said outer curved electrode, said deflecting means causing the portion of said beam traversing one of said paths to pass through said outer electrode to be collected by one of said collector electrodes and causing the portion of said beam traversing the other of said paths to circumnavigate between said curved electrodes and impinge back on said deflecting means to reverse the charge thereon.

19. An electron discharge device in accordance with claim 18 wherein said deflecting means includes a first and a second deflecting plate, each adjacent one of said paths, said deflecting plates being electrically floating and each having one surface which is secondary emissive and one surface from which secondary emission is inhibited.

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