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GLOW TRANSFER STORAGE DEVICE

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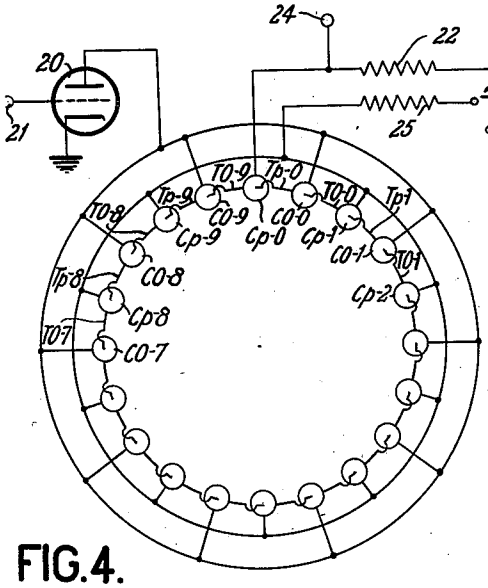



FIG. 4.

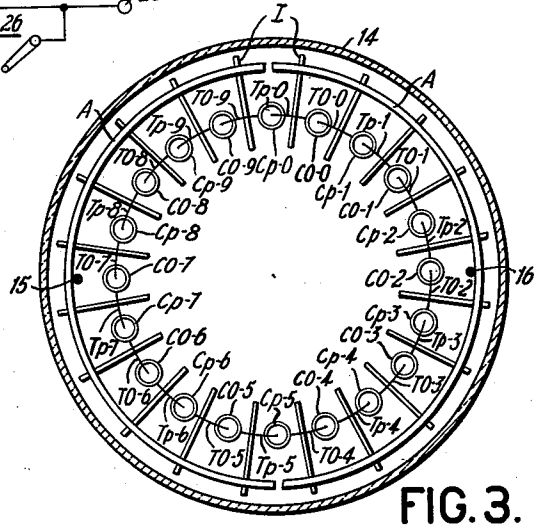
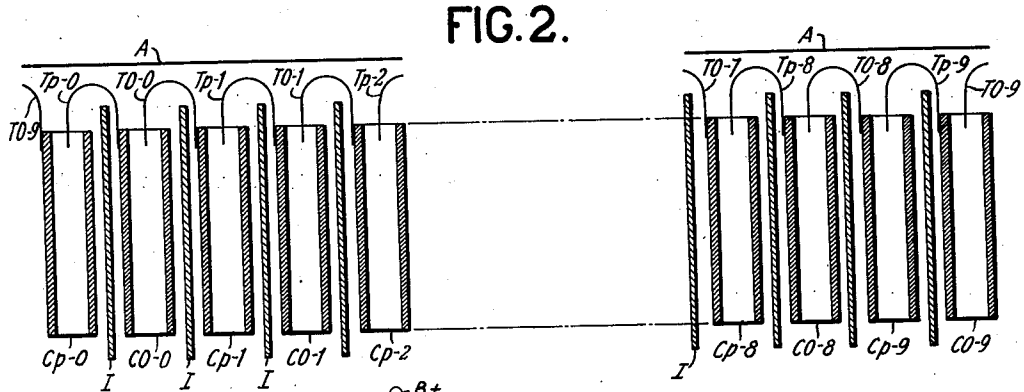



FIG. 3.

FIG. 2.



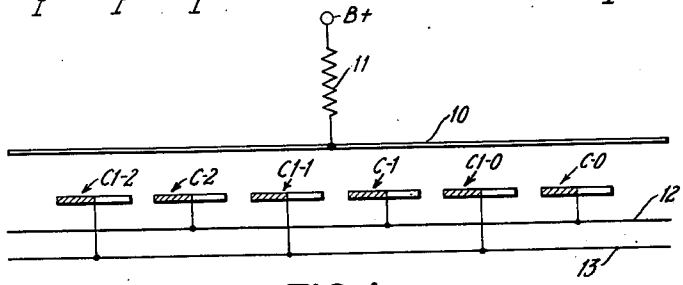




FIG. 1.

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## GLOW TRANSFER STORAGE DEVICE

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14 Claims. (Cl. 315—168)

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This invention relates to gaseous storage tubes and more particularly to such tubes of the glow transfer type, wherein the position of the glow discharge and the direction of the glow transfer is determined by the physical characteristics of certain electrodes.

In a conventional glow transfer tube of the driven type, the glow discharge is transferred from one electrode to another preselected electrode in response to certain voltages applied to the tube. Obviously, the application of these voltages to the tube and the characteristics of the voltages employed must conform to certain predetermined minimum requirements to insure proper directional transfer of the glow discharge.

In another type glow transfer tube the direction of the glow transfer is determined by the unequal spacing of each electrode from a common anode. A glow discharge initiated at one point on a cathode moves to another point on the cathode thereby decreasing the breakdown of voltage across a gap of an adjacent cathode to create a path of preferential glow transfer thereto. The unequal spacing of different portions of the same cathode from the anode may involve a positioning of each cathode such that a glow discharge thereon will migrate to a preselected position under the influence of a voltage gradient. Likewise, the positioning of the cathode may be such as to enable the lowering of the breakdown voltage across a preselected adjacent glow discharge gap in response to a certain expansion of an existing glow discharge on a cathode, which expansion is caused by the application of a certain voltage to the tube. A common feature of tubes of this type resides in the fact that each position of transfer of the glow discharge is determined by the relative positioning of certain preselected electrodes and is not determined by the physical characteristics of the electrodes per se.

A principal object of this invention is to provide a gaseous storage tube of the glow transfer type, wherein the position of the glow discharge on a given electrode is determined solely by the physical characteristics of that electrode.

Another object is to provide a storage device of the sequential glow transfer type wherein the direction of transfer of the glow discharge is determined by the physical characteristics of the electrodes.

Another object is to provide a novel gaseous discharge counting tube of the glow transfer type having a plurality of cathodes equally spaced from a common anode and having a region of most intense ionization in the vicinity of each cathode, each cathode having a glow transfer wire extending therefrom to a region of most intense ionization to effect sequential glow transfer to the cathode.

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Still another object is to provide a novel arrangement within a gaseous discharge tube wherein glow transfer means are positioned intermediate a region of intense ionization adjacent each cathode and another preselected cathode to establish a path of preferential glow transfer therebetween.

A further object is to provide a novel electrode structure for a gaseous discharge device wherein the composition of certain electrodes is such that a glow discharge occupies a certain predetermined space thereof in preference to any other space.

A still further object is to provide a novel electrode structure for a gaseous discharge device, wherein certain electrodes are composed of two different materials, so that the voltage drop across a glow discharge to each material is different from that across the glow discharge to the other material thereby causing a glow discharge to shift automatically from the material to which the voltage drop is higher to the material to which the voltage drop is lower.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a diagrammatic representation illustrating the principles of the invention.

Fig. 2 shows in rolled-out cross-section a portion of the electrode structure of one embodiment of the invention.

Fig. 3 is a top view of a tube of the invention with the envelope cut away.

Fig. 4 is a circuit diagram illustrating the operation of the embodiment of the invention shown in Figs. 2 and 3.

Briefly, the invention includes a gaseous discharge tube of the glow transfer type wherein a glow discharge is sequentially transferred in response to predetermined electrical manifestations to effect a storage of those manifestations. The tube uses a single anode and a number of cathodes depending upon the storage capacity of the tube. Each cathode is composed of a plurality of materials of different surface characteristics and is so formed or arranged that a re-

gion of preferential glow transfer is established between each cathode and one other cathode. When a glow discharge is present between any one of the cathodes and the anode, that glow discharge will always include only a preselected area of that cathode. A transfer wire projects within the region of intense ionization created by the glow discharge and effects a transfer of the glow discharge to another preselected cathode, in response to the receipt of a predetermined electrical manifestation by the tube. The transfer wire and proper insulation of the cathodes from each other insure certain transfer of the glow discharge. Simplified circuit means are employed to effect the sequential operation of the tube in response to successive electrical manifestations to be stored.

Referring more particularly to Fig. 1, the diagrammatically represented device includes an anode 10 connected to a suitable source of positive voltage B+ through a resistor 11. One group of cathodes comprises the cathodes designated C–0, C–1, and C–2 which are commonly connected to a lead 12. Another group of cathodes comprises the cathodes C1—0, C1—1, and C1—2 which are commonly connected to a lead 13. The cathodes of this group are arranged intermediate the cathodes of the first group as shown.

The portion of each cathode shown on the left (shaded) in Fig. 2 is made of material different from that comprising the right portion of the cathodes, so that the surface characteristics with respect to glow discharges of the right and left portions of each cathode are different. It is assumed that the surface characteristics of the left and right portions of each cathode are such that the voltage drop caused by glow discharge between the anode 10 and one of the cathodes is less when the discharge occurs between the left portion and the anode than when it occurs between the right portion and the anode. The cathodes may be composed of any suitable material, for example, the left portion of each may be composed of nickel and the right portion of carbon. Because the voltage drop is less when the glow is to the nickel portion of the cathode, a glow discharge between any cathode and the anode will always occur between the left portion of the cathode and the anode. If the glow discharge initially exists between the anode and the right portion of a cathode or that portion for which the voltage drop is higher, it will automatically shift along the cathode until it exists in a state of stable discharge between the anode and the left portion of the cathode, or that portion for which the voltage drop is less.

As is well known, the presence of the resistor 11 between the anode 10 and its source of voltage supply B+ insures that at no time does more than one single glow discharge exist between a cathode or cathodes and the anode. Proper voltages are applied to the leads 12 and 13 to cause a glow discharge to exist between one cathode and the anode. If the voltage applied to the lead 12 is less than that applied to the lead 13, the discharge will occur between the anode 10 and one of the cathodes C–0, C–1, and C–2 because the voltage drop from those cathodes to the anode is greater than that from the cathodes C1—0, C1—1, and C1—2 to the anode. With the circuit arrangement as shown, chance will determine which of the cathodes C–0, C–1, and C–2 captures the glow discharge to the anode. For convenience, it is assumed that a glow exists in a stable condition of discharge between the left portion (portion for which the voltage drop is less) of the cathode C–0 and the anode. The existence of a glow discharge at the left portion of C–0 causes increased ionization of the gaseous volume adjacent the right portion of cathode C1—0.

Hence, if the voltage applied to the leads are now interchanged so that the voltage applied to the lead 12 is greater than that applied to the lead 13, the glow discharge will be transferred from the left portion of cathode C–0 to the right portion of the cathode C1—0 adjacent the cathode C–0. However, because of the difference in voltage drops to the cathode which occur when the glow discharge is on different portions of the cathode, the glow discharge automatically migrates to the left portion of the cathode until it attains a condition of stable glow discharge thereat. The glow discharge continues to this portion of the cathode producing the lower voltage drop and the voltage drop thereacross is less than when the glow discharge is to the portion of the cathode producing the higher voltage drop. Once a glow discharge migrates to the portion of the cathode producing the lower voltage drop, the cathode to anode voltage drop is insufficient to sustain a glow discharge to the portion of the cathode producing (i. e., requiring) the higher voltage drop.

When the glow discharge is between the left portion of the cathode C1—0 and the anode, the ionization of the gaseous volume between the cathode C1—0 and C–1 is increased. Hence, a preferential path of glow transfer is established. As a result, when the voltage on the leads 12 and 13 is again interchanged, so that the voltage applied to the cathodes C–0, C–1, and C-2 is less than that applied to the cathodes C1—0, C1—1, and C1—2, the glow discharge is transferred to the right portion of the cathode C–1 in preference to any other place. Again, the glow discharge migrates toward the portion of the cathode which produces the lower voltage drop. Accordingly, the glow reaches a condition of stable discharge on the left portion of the cathode C–1.

Further interchanges of the voltages on the leads 12 and 13 cause a stepped transfer of the glow discharge to the cathodes C1—1, C–2, C1—2, in turn. Obviously, as many cathodes may be employed as is desired, and the sequence of the glow transfer is determined by the relative position of the cathodes.

A practical and novel application of the general principles illustrated by Fig. 1 is shown in Figs. 2 and 4. These figures illustrate an embodiment of the invention suitable for use where absolute accuracy is required and such is advantageous over the illustration of Fig. 1 in that each of the cathodes is substantially ionically insulated from the others and glow transfer wires are provided to insure a certain preselected transfer of the glow discharge, and thereby eliminate the possibility of a spurious glow transfer upon the occurrence of some critical operational change.

Referring to Figs. 2 and 3, the particular tube is enclosed within the envelope 14 and has a storage capacity of ten manifestations. Ten storage position cathodes Cp–0 to Cp–9, inclusive, and ten glow transfer cathodes C0—0 to C0—9, inclusive, are positioned as indicated equidistant from a common anode A. The anode A is formed in two sections to prevent the overheating thereof when processing, and a suitable voltage is applied to each from leads 15 and

16 commonly connected at their other end (not shown) to the voltage supply. An insulating plate I is positioned between successive cathodes, so that each cathode is ionically insulated from the cathodes adjacent to it, thereby dividing the tube into twenty ionic compartments, each having an ionization substantially independent from the others. Glow transfer wires Tp–0 to Tp–9, inclusive, and T0—0 to T0—9, inclusive, are used to transfer the glow discharge from one cathode to another preselected cathode.

Each novel cathode is formed as a hollow cylinder. When a glow discharge occurs between any cathode and the anode, the glow is confined to the inside of the cylindrical cathode and is excluded from its outside. To confine the glow discharge to the inside of each cathode, the inside and outside portions of each cathode are coated with different materials, the inside portion being coated with a material requiring a lesser voltage drop to sustain a glow than the material coating the outside portion of the cathode. Hence, there is a minimum voltage drop across the glow discharge when it occurs from the inside of a cathode to the anode. Any suitable material may be used for the coatings, the use of a nickel coating on the inside of the cathodes and a carbon coating on the outside of the cathodes has been found to be very satisfactory.

The fact that the use of materials of different surface characteristics is necessary for confining the glow to the inside of the cathode is demonstrated by the fact that glow discharge often occurs to the outside of a cathode at the places where a coating in accordance with the invention is not present.

It is advantageous to make the cathodes relatively long or deep as compared to the diameter of the hollow for this permits relatively large currents to be employed in the operation of the tube. As the magnitude of the current increases, the glow discharge extends deeper into the hollow portion of the cathode. As a result, accurate operation is substantially insensitive to changes of the magnitude of the current and the supply voltages employed.

The anode A may be located directly in line with the longitudinal axes of the cathodes or may be offset from the longitudinal axes. Either arrangement will provide a device operable in accordance with the invention, the latter is shown because such facilitates illustration of the invention.

It is seen that the confinement of the glow discharge between the anode and the hollow portion of the cathodes substantially prevents an increase of the ionization of the gaseous volume in the vicinity of other cathodes. Further, the insulating plate I on each side of each cathode intermediate the cathodes adjacent thereto furnishes an additional ionic insulation between the cathodes, so that the danger of a spurious glow discharge during the operation of the tube is completely eliminated.

The transfer wire is connected at one end to the wall of each cathode and is extended over the insulating plate as shown in Fig. 2, or may be extended through a slit or puncture in the insulating plate, to a point in direct line with and intermediate the anode and another one of the cathodes. The physically free end of one of the wires is intermediate each one of the cathodes and the anode, there being provided a number of wires equal to the number of cathodes



used. The glow transfer wires attached to the position cathodes (Cp–0 to Cp–9, inclusive) are designated T0—0 to T0—9, inclusive, and the wires attached to the glow transfer cathodes (C0—0 to C0—9, inclusive) are designated Tp–0 to Tp–9, inclusive. The wires designated by the prefix T0 effect glow transfer from the transfer cathodes, and those designated by the prefix Tp effect a glow transfer from the glow position cathodes. The free end of each glow transfer wire is preferably, but not necessarily, extended downward within the hollow portion of the cathode from which it is to transfer a glow discharge. The improved operation resulting from the extension of the transfer wires within the hollow portions of the cathodes or the vicinity thereof is attributed to the fact that the most intense region of ionization occurs very close to the inner cathode surface (glow is to inner surface) to which a glow discharge exists.

The ionization path is present, of course, in the gaseous atmosphere intermediate the anode and the cathode to which a glow discharge occurs, nevertheless, the fact that the most intense region of ionization is very close to the inner surface of the cathode emphasizes the importance of the shape of the cathodes of the invention as well as the use of the insulating plates I intermediate consecutive cathodes. The combined insulating effect of the wall of a cathode and that of the insulating plate I on either side of a cathode substantially confines the ionization resulting from the glow discharge to the region intermediate the insulating plates.

The existence of a glow discharge to any cathode causes the transfer wire having its free end intermediate the hollow of that cathode and the anode to be in a region of intense ionization, so that the voltage difference necessary to initiate a glow to said transfer wire is substantially less than the voltage difference necessary to initiate a glow transfer to any other transfer wire or to any cathode. Then, upon the happening of a subsequent predetermined electrical condition, the glow discharge will be transferred via the transfer wire to exist between the cathode to which the wire is attached and the anode. As a practical matter, it is preferred that the glow discharge cover substantially the entire wire just previous to the time the glow shifts from the transfer wire to the cathode. Hence, the novel transfer wire arrangement provides a preselected ionization at a predetermined place within the tube, which ionization is rendered operably effective in response to a preselected electrical condition.

Referring to Figs. 2 and 3 and more particularly to Fig. 4, the tube 20 which is normally at cut off has its control grid connected to any suitable source of positive pulses (not shown) at the terminal 21. The cathode of the tube 20 is grounded and its plate is connected directly to the commonly connected transfer cathodes C0—0 to C0—9, inclusive. The starting or zero position cathode Cp–0 is connected through a resistor 22 to the terminal 23 connected to a suitable source of positive voltage. An output terminal 24 is connected directly to the cathode Cp–0. The remaining commonly connected position cathodes Cp–1 to Cp–9, inclusive, are connected through a resistor 25 in series with a switch 26 to the terminal 23. The anode A has been omitted from Fig. 4 for the sake of clarity, it being understood that the anode is connected to a suitable source of positive voltage through a

resistor, so that only a single glow discharge exists within the tube of the invention at any one time.

It should be noted that the circuit arrangement (Fig. 4) for operation of the tube differs from that shown in Fig. 1 in that the voltage supplied to one group of cathodes is varied alternating above and below the voltage supplied to the other group of cathodes, while in Fig. 1 the actual voltage applied to each group of cathodes is varied.

To place the tube in the zero or starting position, a glow discharge is caused to exist between the cathode Cp–0 and the anode. When the switch 26 is closed approximately the same voltage is applied to the cathodes Cp–0 to Cp–9, inclusive, and since a glow can exist between only one cathode and the anode at any one time chance will determine which of the cathodes Cp–0 to Cp–9, inclusive, captures the glow discharge. When the switch 26 is opened as shown, the voltage from the terminal 23 is removed from the cathodes Cp–1 to Cp–9, inclusive, so that the voltage drop between the cathode Cp–0 and the anode is the only voltage drop existing within the tube. When the switch 26 is closed the glow discharge between the cathode Cp–0 and the anode is unaffected because the voltage drop across the anode resistor (not shown) causes the voltage between the cathodes Cp–1 to Cp–9, inclusive and the anode to be less than the voltage necessary to initiate a glow discharge.

A glow discharge now exists between the starting cathode Cp–0 and the anode. The shape of the cathode Cp–0 and the insulating plate on either side of it prevent a migration of the ions within the gaseous volume to any appreciable extent, so that there is substantially no tendency to transfer the glow discharge as a result of such migration. The free end of the transfer wire Tp–0 extends into the region of most intense ionization in the vicinity of the cathode Cp–0, thereby establishing a preferential glow transfer path to the cathode C0—0, to which transfer wire Tp–0 is attached.

When the first positive pulse is applied to the terminal 21, the leading edge of the positive pulse renders the normally non-conductive tube conductive. As a result, the voltage at the anode of the tube 20 is decreased and the voltage at the cathodes C0—0 to C0—9, inclusive, connected to the anode of the tube 20 are accordingly decreased. Hence, the voltage drop between each of the cathodes C0—0 to C0—9, inclusive, and the anode is greater than the voltage drop between the cathode Cp–0 and the anode. This fact along with the symmetrical geometry of the tube would mean that chance would substantially determine the one of the cathodes C0—0 to C0—9, inclusive, which would finally capture the glow discharge. However, the existence of a glow discharge in the region surrounding the transfer wire Tp–0 and the absence of any substantial ionic migration to the vicinity of any of the cathodes C0—0 to C0—9, inclusive, from the cathode Cp–0 establishes a controlled ionization from the cathode Cp–0 to the cathode C0—0. Consequently, the leading edge of the first pulse applied to the tube 20 effects a transfer of the glow discharge from the cathode Cp–0 to the transfer cathode C0—0. The glow discharge continues between the cathode C0—0 and the anode and in the region surrounding the transfer wire T0—0 until the negative going trailing edge of the pulse applied to the terminal 21 renders the tube 20 non-conductive. When the tube 20 is rendered non-conductive, the voltage at its anode and at the cathodes C0—0 to C0—9, inclusive, is increased so that it is more positive than the voltage applied to the cathodes Cp–0 to Cp–9, inclusive, from the terminal 23.

As a result, the glow discharge is transferred from the cathode C0—0 to the cathode Cp–1 and exists between Cp–1 and the anode until the voltage relationships of the electrodes are again changed. The existence of the glow discharge at the cathode Cp–1 is indicative of the fact that one electrical manifestation has been stored.

In a similar manner, the next positive pulse applied to the terminal 21 causes the glow discharge to transfer to the transfer cathode C0—1 and then to the position cathode Cp–2 to indicate that a total of two electrical manifestations have been stored. Subsequent positive pulses applied to the terminal 21 cause a similar sequential transfer of the glow discharge around the tube. Finally, the tenth pulse applied to the terminal 21 causes the glow discharge to return to its place of starting, i. e., between the starting cathode Cp–0 and the anode. When this occurs, the voltage drop across the resistor 22 increases. Consequently, an increased voltage appears at the output terminal 24 which may be used to effect any desired operation or utilized to drive a similar storage tube of a higher order.

Obviously, timed or random storage may be effected in the tube of the invention by any suitable or well known means. Also, the tube may be used as a ring type counter and provide an electrical manifestation in response to each count. One way of providing such a counter is accomplished by replacing the resistor 25 in Fig. 4 by a separate resistor connected at its other end to each of the cathodes Cp–1 to Cp–9, inclusive. Then an increased voltage will appear across the resistor connected to each cathode when the glow discharge is on that cathode, thereby providing an electrical manifestation from the counting tube by each count applied thereto.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a gaseous discharge device for sequentially transferring a glow discharge along a preselected path in response to predetermined electrical manifestations; a plurality of electrodes each constituting a terminal of glow discharge along said path, each of said electrodes including materials having different surface characteristics to insure stable glow discharge at only one preselected region of each electrode; and first circuit means connected to render said device operable.

2. The device set forth in claim 1 wherein each of said electrodes is in the form of an open-ended cylinder having an inside surface of predetermined surface characteristics and an outside surface of different predetermined surface characteristics such that a glow discharge to any one of said cylinders is excluded from the outside

surface thereof because of the physical and surface characteristics of the cylinder.

3. The device set forth in claim 2 including insulating plates intermediate each electrode and electrodes adjacent thereto for retarding the migration of ions from the vicinity of the former; a transfer wire for each electrode, the transfer wire having one end affixed thereto and the other end extending freely therefrom adjacent to an open end of one other preselected electrode to establish a preferential glow transfer path to the electrode to which the wire is affixed when a glow discharge exists on said one other preselected electrode.

4. The device set forth in claim 3 wherein each of said electrodes is a cathode and including an anode equidistant from each of said cathodes and connected through an impedance to a source of voltage included in said means so that only a single glow discharge exists to said anode at any one time; and second circuit means connected to preselected non-consecutive ones of said cathodes for applying cyclic voltage changes thereto in response to each voltage pulse applied to said circuit means thereby transferring a glow discharge from a cathode adjacent one of said preselected cathodes to that preselected cathode and then transferring said glow discharge to another cathode adjacent the preselected cathode.

5. In a gaseous discharge storage tube of the glow transfer type; a plurality of electrodes of a first functional type each composed of a plurality of materials so that a glow discharge to any portion of an electrode will automatically proceed to a predetermined region thereon dependent upon the materials used and there exist in a condition of stable discharge to produce a certain region of intense ionization; insulating means arranged intermediate successive electrodes of the first functional type to substantially confine the migration of ions within a compartment formed thereby; an electrode of a second functional type equidistant from each electrode of said first functional type; means connected to establish a glow discharge between one preselected electrode of the first functional type and the electrode of the second functional type; and conductive means positioned within each said region of intense ionization and connected to one other electrode of the first functional type for lowering the breakdown voltage to the latter electrode to a predetermined value.

6. In the tube set forth in claim 5, circuit means for creating a voltage drop between the electrode to which said conductive means is connected and said electrode of the second functional type, said voltage drop being larger in value than the voltage drop between the electrode producing the region of intense ionization and said electrode of the second functional type to cause a transfer of the glow discharge along said conductive means to said latter electrode in preference to any other; and means for rendering said circuit means operable.

7. In a gaseous discharge storage tube of the glow transfer type; a plurality of cathodes arranged in a closed glow transfer path; ionic insulating means separating each cathode from adjacent cathodes to isolate the ionization resulting from the glow discharge to any cathode from the other cathodes; and a glow transfer wire for each cathode, each said wire being attached at one end to a cathode and having its other end extending within a region of stable glow discharge to another cathode to transfer a glow discharge therefrom to the cathode to which it is attached upon the application of a predetermined electrical change to the tube.

8. In a gaseous discharge storage tube of the glow transfer type; a plurality of cathodes arranged in a closed glow transfer path; ionic insulating means separating each cathode from adjacent cathodes to isolate the ionization resulting from the glow discharge to any cathode from the other cathodes; and means for establishing a single region of stable glow discharge to each cathode, said means including a distinct portion of each cathode having different surface characteristics from the remaining portions of the cathode.

9. The gaseous discharge storage tube set forth in claim 8 wherein each cathode is formed as an open-ended cylinder and the material on the inside surface thereof has a surface characteristic different from that of the material on the outside surface; and an anode spaced equidistant from an open end of each cathode, a transfer wire extending intermediate the open end of each cathode closest to the anode and the anode and fastened to another preselected cathode.

10. In a gaseous discharge tube having a plurality of electrodes of one functional type each arranged to serve as a terminal of glow discharge during a cycle of tube operation; ionic insulating means intermediate successive electrodes, one electrode of another functional type positioned to serve as the other terminal of glow discharge; and a conductive member extending intermediate each electrode of said one functional type and said one electrode and connected at one end to a different one of the electrodes of said one functional type for transferring a glow discharge to the electrode to which it is connected.

11. A gaseous discharge storage tube of the glow transfer type wherein a glow discharge is sequentially transferred from one preselected position within the tube to another to store a given manifestation including an even number of cathodes arranged in a closed glow transfer path and formed as open-ended cylinders; an anode arranged equidistant from the open end of each cathode; means for initiating a glow discharge between one preselected cathode and said anode; a first common connection between alternate ones of said cathodes in the closed path and a second common connection between the remaining cathodes, thereby providing for the application of different voltage values to the cathodes joined by said first and second common connections; and conductive means intermediate adjacent cathodes in said path and intermediate the first of those two adjacent cathodes and the anode for establishing a preferential glow transfer path to the second of the two adjacent cathodes when a glow discharge exists between said anode and the first of the two adjacent cathodes.

12. The gaseous discharge tube set forth in claim 11 wherein the inside surface of each of the cylindrical cathodes is coated with nickel and the outside surface is coated with carbon to insure a stable glow discharge only to the inside surface and including; circuit means connected to one of said common connections for applying two voltage changes, one in a positive and the other in a negative direction, to the common connection to transfer the glow discharge along the preferential glow transfer path to the adjacent cathode connected to the other com-

mon connection and then transfer the glow discharge to the other adjacent cathode of said one of said common connections to thereby indicate the storage of an electrical manifestation; and means for applying an electrical manifestation to said circuit means to render said tube operable.

13. A gaseous discharge storage tube of the glow transfer type wherein a glow discharge is sequentially transferred along a closed path to effect storage including a source of voltage; nine glow storage position indicating cathodes and one starting cathode arranged in spaced relation along a continuous line; current conductive means including an electrical switch commonly connecting said position cathodes to said source; current conductive means connecting said starting cathode to said source; ten transfer cathodes, one arranged intermediate each two adjacent position cathodes; an anode arranged equidistant from each of said cathodes; a source of pulses to be stored; pulse responsive voltage changing means commonly connected to said transfer cathodes for applying two successive voltage changes thereto in response to each pulse to be counted; means coupling said source of pulses and said voltage changing means; a glow transfer wire connected to each transfer cathode and extending intermediate each position cathode and said anode so that each time a glow discharge is present between that position cathode and the anode a glow discharge is present along said wire thereby establishing a preferential glow transfer path from that position cathode to that transfer cathode; a glow transfer wire connected to each position cathode and extending intermediate each transfer cathode and said anode so that each time that a glow discharge is present between that transfer cathode and the anode a glow discharge is present along said wire thereby establishing a preferential glow transfer path from that transfer cathode to that position cathode; and means for rendering said tube operable to sequentially advance the glow discharge from one position cathode to the next in response to each pulse to be stored, said glow discharge first being advanced to the transfer cathode intermediate the position cathodes.

14. In a gaseous discharge storage tube of the glow transfer type wherein a glow discharge is sequentially transferred in the same direction along a closed glow transfer path to effect storage including a source of voltage; nine glow position cathodes commonly connected and one



zero position cathode, each cathode being arranged in a preselected spaced relation along said transfer path; means separately coupling said nine position cathodes and said zero position cathodes to said source of voltage so that only said zero position cathode may be coupled to said voltage; ten transfer cathodes, one being arranged intermediate successive position cathodes along said path so that the position and transfer cathodes are alternately encountered by the glow discharge in moving along said path; a coating on each cathode of at least two materials of different surface characteristics so that a glow discharge to any one of the cathodes is always in a stable glow position within only a certain preselected area of the cathode; an anode arranged equidistant from each of said cathodes; a source of pulses to be stored; pulse responsive voltage changing means commonly connected to said transfer cathodes for applying two successive voltage changes thereto in response to each pulse to be counted; means coupling said source of pulses and said voltage changing means; a glow transfer wire connected to each transfer cathode and extending intermediate each position cathode and said anode so that each time a glow discharge is present between that position cathode and the anode a glow discharge is present along said wire thereby establishing a preferential glow transfer path from that position cathode to that transfer cathode; a glow transfer wire connected to each position cathode and extending intermediate each transfer cathode and said anode so that each time that a glow discharge is present between that transfer cathode and the anode a glow discharge is present along said wire thereby establishing a preferential glow transfer path from that transfer cathode to that position cathode; and means for rendering said tube operable to sequentially advance the glow discharge from one position cathode to the next in response to each pulse to be stored, said glow discharge first being advanced to the transfer cathode intermediate the position cathodes.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,524,213 | Wales | Oct. 3, 1950 |