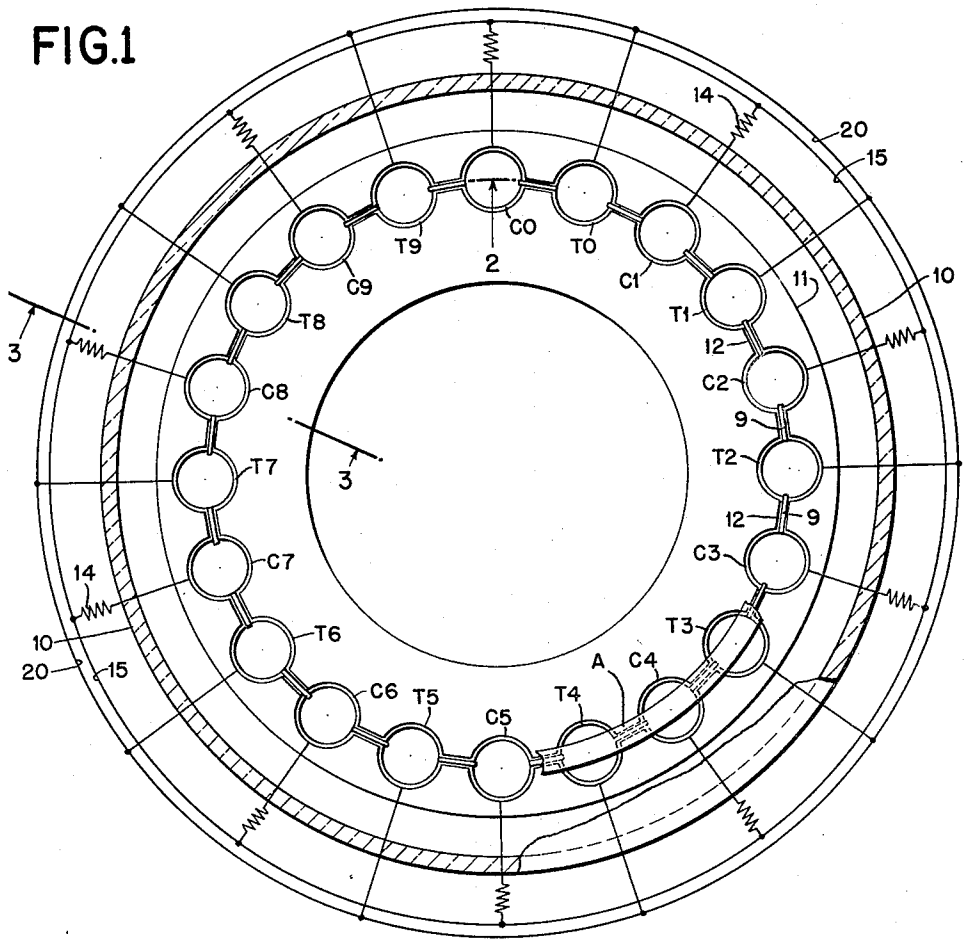
Nov. 1, 1960 R. K. STEINBERG 2,958,807

MULTI-CATHODE GLOW TRANSFER TUBE

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FIG.1



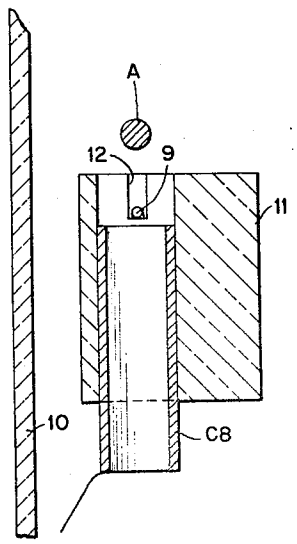


FIG.3

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MULTI-CATHODE GLOW TRANSFER TUBE

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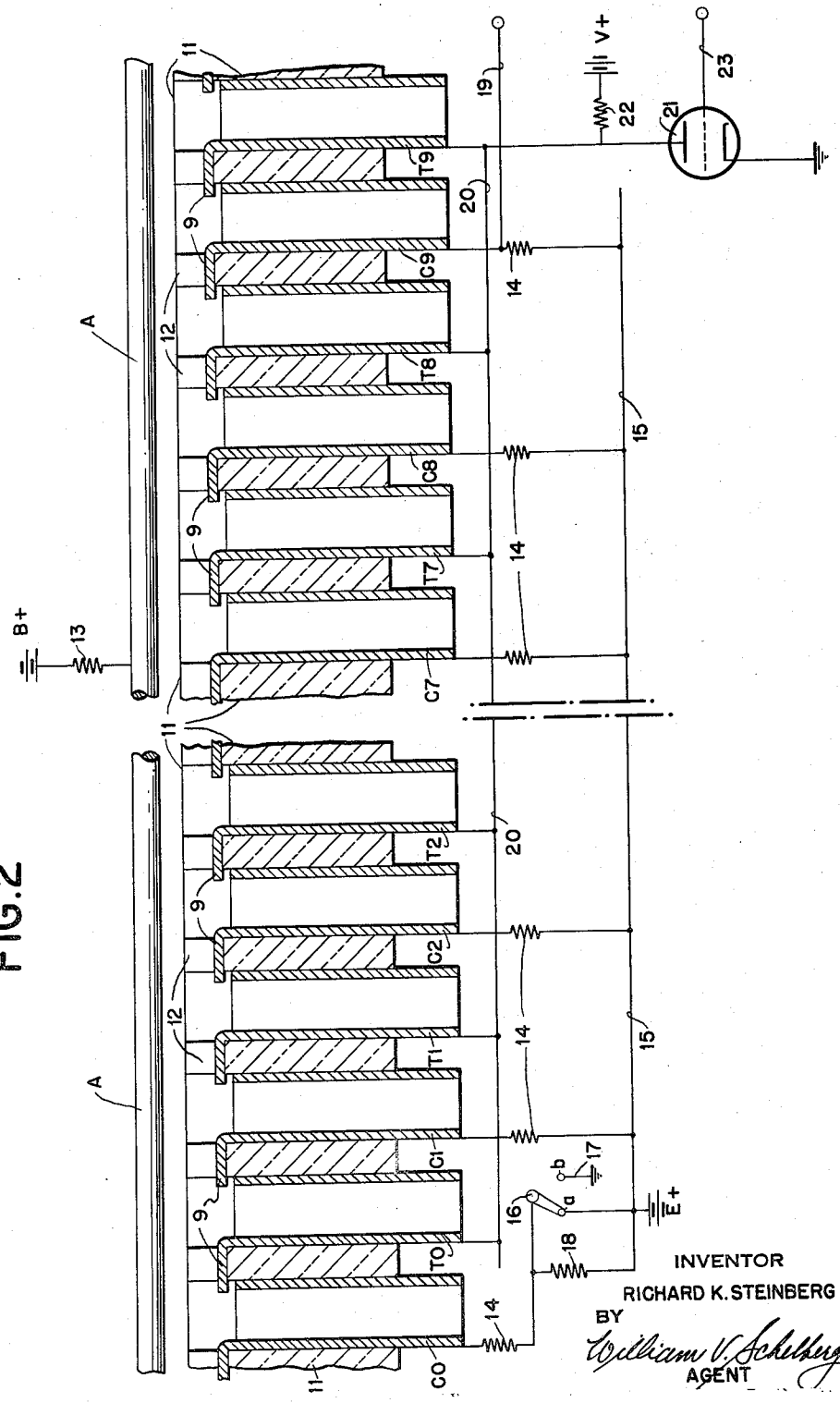


FIG. 2

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2,958,807

MULTI-CATHODE GLOW TRANSFER TUBE

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7 Claims. (Cl. 315—169)

This invention relates to multi-cathode glow discharge devices, and more particularly to a device of the type disclosed in the patent of Richard K. Steinberg, No. 2,621,313, issued December 9, 1952.

Devices of the type disclosed in the above identified patent comprise in general an array of electrodes, at least alternate ones of which are adapted for use as glow cathodes, and a single anode arranged in cooperative relationship with and common to each of the cathode electrodes. Alternate ones of the cathodes are electrically connected in groups, and signal impulses applied to the two groups cause a glow discharge to migrate from one adjacent cathode to another in a preassigned direction. The glow is caused to transfer in the assigned direction by what has been termed a preference mechanism characterized either by the relative physical positioning of the electrodes or by differences in the electrical properties of portions of the electrode surfaces. In one form disclosed in the above mentioned patent, each cathode is composed of different materials so that a region of preferential glow transfer is established in proximity to only one of the two adjacent cathodes.

In accordance with one broad feature of this invention, a preference mechanism is provided whereby glow sustaining ions are caused to be deionized in a region associated with one cathode portion making the voltage necessary to maintain a glow discharge to this portion higher than to other portions of the cathode.

An object of this invention is to provide a gaseous storage tube of the glow transfer type, wherein an improved transfer mechanism causes a rapid migration of the glow discharge from cathode to cathode in one direction and allows increased speed of operation.

A more specific object is to provide a storage device of the glow transfer type wherein the preferential portion of each cathode electrode is determined by a shield or baffle member arranged in proximity to the cathode portion.

Still another object of this invention is to provide a storage device of the glow transfer type wherein the preferential portion of each cathode electrode is determined both by a baffle member and by use of materials having different surface characteristics.

A still further object is to provide a glow transfer type gaseous storage tube of simplified and rugged construction.

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:

Figure 1 is a top view of a tube constructed in accordance with the invention and having its envelope cut away.

Figure 2 is an expanded section of a portion of the electrode structure of one embodiment of the invention and includes a circuit diagram illustrating the operation of the embodiment.

Figure 3 is a partial sectioned view of the electrode structure taken along the section line 3—3 of Figure 1.

Referring now to the drawings, the glow discharge device illustrated in Figure 1 comprises an envelope 10 of glass or other suitable material having therein an ionizable atmosphere, for example, a rare gas such as helium, neon, or argon or mixture of such gases. Mounted within the envelope 10 are ten digit representing cathodes designated C0 to C9 and ten transfer cathodes designated T0 to T9 alternately interspersed with one another in a circular array to form a closed glow transfer path having ten stable glow discharge positions. The cathodes are formed as open-ended cylindrical elements, and each of the cathodes has connected to one of its ends at a point adjacent the next lower order cathode, a transfer wire 9. The hollow cylinder cathode design renders the glow tube less sensitive to changes in current as the glow simply reaches more or less deeply within the cylinder and, to permit operation at relatively large current magnitudes, the cylinders may be made proportionately long.

Each of the transfer wires 9 extends from the cathode to which it is connected toward the adjacent cathode and has its opposite end positioned in spaced relationship with the adjacent cathode as shown in Figures 2 and 3. An anode A which may be formed of a plurality of sections electrically connected externally of the envelope, is positioned equidistantly from each of the cathode electrodes.

The hollow cylindrical cathodes and attached transfer wires are supported in a block of glass or other suitable insulating material 11 which may be readily moulded or machined to form a circular arrangement of holes in which the cathode elements are inserted. Grooves or slots 12 are cut between the holes to accommodate the transfer wires 9. The single piece of insulating material employed provides a simply constructed yet rugged supporting member for all the cathodes and gives effective isolation between the individual cathode elements. The insulating member 11 may be formed either as a solid disc or with the center portion removed as in the illustrated structure.

As shown in Figure 3, the anode A is positioned in alignment with the longitudinal axis of the cathode cylinders and the slots 12, however, an operable arrangement may be provided with the anode offset from this position.

The transfer wire 9 attached to each cathode corresponds to a high sustaining voltage portion of its associated cathode, and the interior cylindrical surface of the cathode corresponds to the low sustaining portion. The sides of the slots 12 within which the transfer wires 9 are positioned constitute baffles or shield members and, when a glow discharge exists between the anode A and a transfer wire 9, a substantial number of ions will strike the walls of the slot and be deionized. Photons and metastable atoms will also strike the walls and lose their energy so as to be ineffective in producing additional ions to maintain the glow discharge. The voltage necessary to maintain a glow discharge between closely spaced shields is therefore greater than that necessary in the absence of shields since more energy must be supplied to make up for the energy losses to the shields. The walls of the holes in which the cylindrical cathodes are inserted are relatively widely spaced in comparison with the width of the slots 12 and, although there is a loss of some ions, photons, and metastable atoms, the loss is principally by diffusion and not as great for this portion of the cathode element.

Where a rugged type of construction is not required,

the walls of the slots 12 may be replaced by thin sheets of insulating material placed adjacent the transfer wires 9 to restrict the discharge region and provide deionizing surfaces while other sheets of insulating material may be positioned between adjacent cathode cylinders to isolate them from one another.

As illustrated in Figure 2, the anode A is coupled to a positive source of voltage B+ through a resistor 13 which is provided to assure the existance of but a single glow discharge between the anode A and the cathode elements at any one time. The digit position cathodes C1 to C9 are connected through individual resistances 14 to a lead 15 and though this conductor to a suitable source of voltage E+ which is less positive than the source B+ to which the anode A is connected.

The home position or zero cathode C0 is connected through a resistor 14 to a two position reset switch 16 which, in normal position *a*, connects to the lead 15, and in position *b* connects to a grounded wire 17. A resistance 18 is provided in shunt with the normally closed switch position *a* so that cathode C0 is always connected to the line 15. An output conductor 19 is connected directly to the digit cathode C9.

The transfer cathodes T0 to T9 are connected to a lead 20 which is coupled to the plate of a triode driver tube 21. The cathode of this tube is connected to ground, and the tube is normally biased to cut off. The anode of tube 21 is connected through a resistor 22 to a source of voltage V which is more positive than the source E, and a source of input pulses, not shown, is connected to the control grid through a conductor 23.

In initially applying the potentials B and E to the glow discharge device, a glow will be manifested between the anode A and an indeterminate one of the C0 to C9 cathodes. To insure that the glow is at the C0 cathode and representing a zero condition at the outset of an accumulating function, the reset switch 16 is momentarily operated to position *b* so that a circuit is traceable from ground through the lead 17, the switch 16 and associated resistor 14 to the cathode C0. The greater voltage drop between anode A and cathode C0 establishes a glow therebetween which will remain after the reset switch 16 returns to its normal position *a*. Upon returning switch 16 to position *a*, the cathode C0 is reconnected directly to the wire 15 to maintain the glow established and, during the interval that switch 16 is returning from position *b* to the normal position *a*, the glow is maintained by the connection from cathode C0 to wire 15 through the resistance 18.

When a first positive pulse is initially applied to the input lead 23, the normally nonconductive driver tube 21 is rendered conductive and the voltage at the tube anode decreases to a value less positive than the voltage of the source E. Conductor 20 and the transfer cathodes T0 to T9 connected therewith are each lowered to this potential. The voltage drop between each of the cathodes T0 to T9 and the anode A is greater than the voltage drop between the cathode C0 and the anode A so that the glow discharge at the cathode C0 tends to migrate.

The glow existing intermediate the cylindrical cathode C0 and the anode has a region of intense ionization in the vicinity of the free end of the transfer wire 9 connected with cathode T0 and the glow transfers to a position between this transfer wire 9 and the anode as the potential drop between wire 9 and the anode is greater than that between C0 and the anode. As this glow discharge path is confined between the closely spaced walls of the slot 12 where the glow sustaining ions strike the walls and become deionized, the glow transfers rapidly to the lower sustaining voltage portion of the transfer cathode comprising the interior surface of the cylinder T0 where it remains until the first pulse applied to lead 23 is terminated. At this time, tube 21 becomes nonconductive and each of the transfer cathodes T0–T9 is raised in potential to approximately the value of the source V. The cathodes C0 to C9 however are at the lower potential of source E and, consequently, the voltage drop between the anode A and each of the cathodes C0 to C9 is greater than that between the anode A and cathodes T0 to T9. Under this condition, the glow existing within the cylindrical cathode T0 again tends to migrate and, with the free end of the transfer wire 9 connected to cathode C1 in the vicinity of the intense ionization region of the discharge, it transfers to a position between this transfer wire and the anode. Again the discharge path is confined within the narrow space between the walls of the slot 12 and very quickly migrates to the lower sustaining voltage portion of the cathode C1 where it remains in a stable condition until further pulses are applied to the lead 23.

The existance of the glow discharge at the digit cathode C1 is indicative of storage of one input pulse and, in a similar manner, a second positive pulse applied to lead 23 causes the glow to transfer to the transfer cathode T1 and, on termination of the second pulse, transfers to cathode C2 indicating storage of a second input pulse. Each successive pulse applied to lead 23 causes a similar transfer of the glow discharge and, upon termination of the ninth pulse, the glow discharge is positioned at the ninth digit cathode C9. The tenth input pulse initially causes the glow to leave the cathode C9 and transfer to the associated wire 9 and to cathode T9 from which it transfers on termination of the tenth pulse to the starting position or home cathode C0. When the glow discharge appears on cathode C9, the conductor 19 connected thereto swings more positively than the lead 15 and, when the tenth input pulse causes the glow to leave cathode C9, conductor 19 then swings negatively. Hence, the output conductor 19 goes positive when nine input pulses have been entered in the storage tube and goes negative when storage of the tenth pulse is begun. In this manner, an indication is obtained which may be employed to effect any desired operation or may be utilized to drive a similar gas storage tube representing a higher order of an accumulator device having a plurality of such order tubes.

While the preference mechanism described is capable of causing a very rapid transfer of the glow discharge existing between the transfer wire or high sustaining voltage portion of a cathode member, to the interior of the cathode cylinder, it is contemplated that the transfer wire material need not be the same as the cylinder material. Use of different materials such as a nickel coating on the cylinder interior and a carbon coating on the transfer wire has been found satisfactory and combines the effects of both means of producing a sustaining voltage difference between these two cathode portions.

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. 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 number of manifestations, including a plurality of cathodes in a gas filled envelope arranged adjacent one another and formed as open-ended cylinders, conductive members individually interspersed between adjacent ones of said cathodes and secured in conductive relationship to but one of said adjacent cathode cylinders, an anode arranged equidistant from the open end of each of said cylinders, energy absorbing means hugging and substantially surrounding each said

conductive member throughout its length and adapted to confine a glow discharge existing between said members and said anode, and means for initiating a glow discharge between said anode and a selected one of said cathodes.

2. In a gaseous discharge device of the glow transfer type; a sealed envelope containing an anode and a plurality of cathodes arranged in a closed glow transfer path, a glow transfer wire for each cathode, each of said transfer wires being attached at one end to its associated cathode and having its free end extending in proximity to a region of stable glow discharge of an adjacent cathode to transfer the glow from the adjacent cathode to the cathode to which it is attached on application of predetermined signal impulses to said cathodes, and means including energy absorbing members hugging and substantially surrounding each of said transfer wires throughout its length.

3. In a gaseous discharge device for sequentially transferring a glow discharge along a preselected path in response to electrical impulses; said device comprising a sealed envelope containing an anode and a plurality of cathode electrodes each providing a terminal of glow discharge along said path, insulator means adapted to support said electrodes in a closed circular array and electrically isolating said electrodes from one another, slots in said insulator means between said electrodes, portions of each of said electrodes arranged in said slots and extending in proximity to an adjacent one of said electrodes, and means for applying impulses to alternate ones of said electrodes to cause a glow discharge to migrate in a preselected direction from one cathode to another in sequence.

4. In a gaseous discharge device for sequentially transferring a glow discharge along a preselected path in response to electrical impulses; said device comprising a sealed envelope containing an anode and a plurality of cathodes formed as open-ended cylinders each providing a terminal of glow discharge, means including an insulating support member provided with a plurality of holes adapted to accommodate said cylinders and arranged in a closed circular array, slots interconnecting adjacent ones of said holes, a transfer wire attached at one end to each of said cylinders and adapted to be accommodated within said slots with the free end of said wire in proximity to the glow discharge path of an adjacent cylinder, and means for applying electrical impulses to alternate ones of said cylinders to cause a glow discharge to migrate from one cylinder to the transfer wire in proximity therewith and thence to the cylinder to which the transfer wire is attached.

5. In a gaseous discharge device for sequentially transferring a glow discharge along a preselected path in response to electrical impulses; said device comprising a sealed envelope containing an anode and a plurality of cathodes formed as open-ended cylinders each providing

a terminal of glow discharge, means including an insulating support member provided with a plurality of holes for accommodating said cylinders and arranged in a closed circular array, slots interconnecting adjacent ones of said holes, a transfer wire attached at one end to each of said cylinders and adapted to be supported within said slots with the free end of said wire arranged in the glow discharge path to an adjacent cylinder, said transfer wires and said cylinders having different surface characteristics to insure a stable glow discharge only at said cylinder, and means for applying electrical impulses to alternate ones of said cylinders to cause a glow discharge to migrate from one cylinder to the transfer wire in its discharge path and from the transfer wire to the cylinder to which it is attached.

6. A gaseous discharge device for sequentially transferring a glow discharge from one electrode to another in response to a single applied electrical pulse comprising; a plurality of count electrodes, each of which may comprise a terminal for a glow discharge; a plurality of transfer electrodes, each of which is positioned intermediate a pair of count electrodes; each of said count and transfer electrodes comprising a hollow cylinder which is partially enclosed in a block of insulating material; and a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end affixed to said electrodes and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge.

7. A gaseous discharge device for sequentially transferring a glow discharge from one electrode to another in response to a single applied electrical pulse comprising; a plurality of count electrodes, each of which may comprise a terminal for a glow discharge; a plurality of transfer electrodes, each of which is positioned intermediate a pair of count electrodes; each of said count and transfer electrodes comprising a hollow cylinder which is partially enclosed in a block of insulating material; a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end affixed to the inside of said electrodes and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge; and a common electrode which is equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

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