June 18, 1957 H. J. GEISLER 2,796,557

GLOW DISCHARGE TUBE

Original Filed May 22, 1952 2 Sheets-Sheet 1

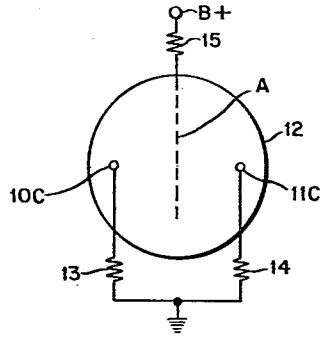


FIG. 1

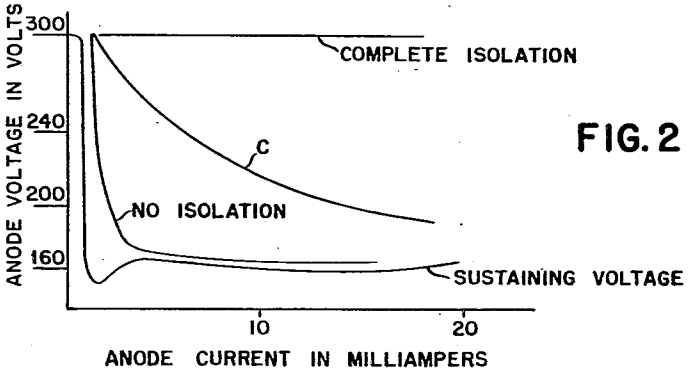


FIG. 2

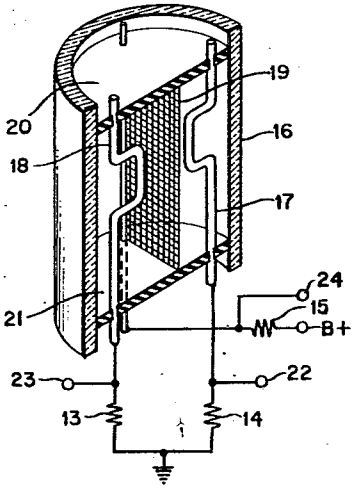


FIG. 3

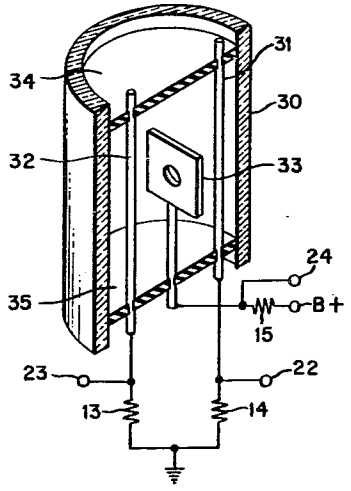


FIG. 4

INVENTOR.
HELMUT J. GEISLER

BY
William V. Schelling
AGENT

June 18, 1957 H. J. GEISLER 2,796,557

GLOW DISCHARGE TUBE

Original Filed May 22, 1952 2 Sheets-Sheet 2

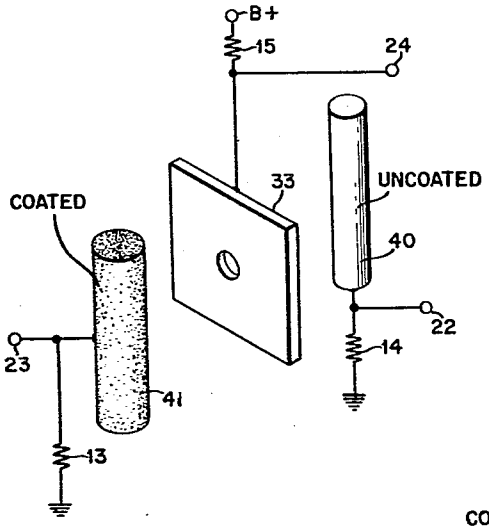


FIG. 5

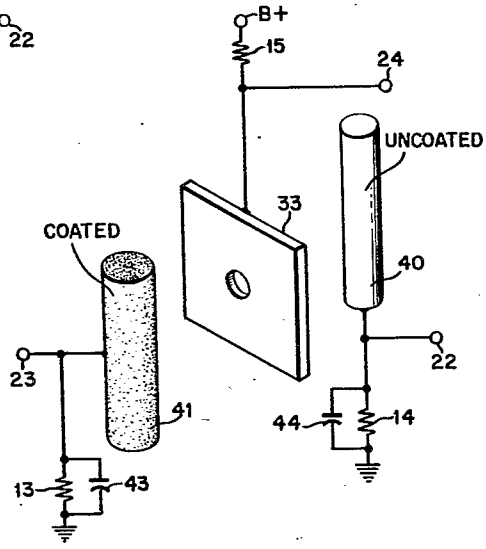


FIG. 5a

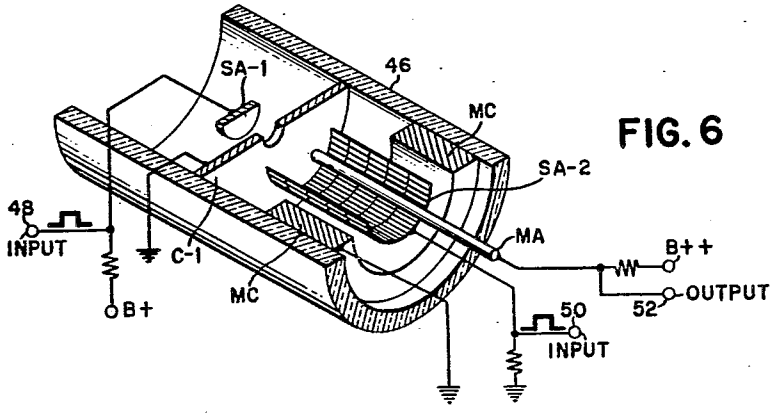


FIG. 6

United States Patent Office

2,796,557

Patented June 18, 1957

2,796,557

GLOW DISCHARGE TUBE

Helmut J. Geisler, Wappingers Falls, N. Y., assignor to International Business Machines Corporation, New York, N. Y., a corporation of New York

Original application May 22, 1952, Serial No. 289,304. Divided and this application June 14, 1956, Serial No. 591,398

4 Claims. (Cl. 315—168)

This invention relates to gaseous discharge tubes and more particularly to switches or triggers of the gaseous glow discharge type as described in the copending United States application, Serial Number 289,304, filed May 22, 1952, to which this application is related as a division.

Such tubes are generally of two types, both employ two cathodes and a single anode common thereto. One type employs intermediate or glow transfer means between the two cathodes of the tube to provide a fast and positive glow transfer from each cathode to the other. The other type tube employs no internal coupling between the cathodes and depends upon external circuitry, such as a condenser connected between the cathodes, to effect actual transfer of the glow discharge.

Accordingly, a principal object of this invention is to provide a novel trigger tube of the glow transfer wherein the above enumerated elements are not required to effect reliable glow transfer within the tube.

Another object is to provide a trigger tube of the gaseous glow transfer type wherein a single anode, intermediate two cathodes, serves both as an anode and an ionic coupling between the cathodes.

A further object is to provide a trigger tube having two cathodes and a single anode wherein the voltage drop between the anode and each cathode is of a different value because of the inherent structure of the cathodes.

A still further object is to provide a novel cold cathode switch-trigger tube wherein one input pulse must be applied to produce an auxiliary glow discharge and a second input pulse must be applied to a second input to produce a main glow discharge which provides an output.

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 showing of a gaseous discharge trigger tube.

Fig. 2 shows characteristic curves representing the operation of a gaseous discharge trigger tube under different conditions of ionic migration.

Fig. 3 shows one embodiment of the trigger tube of the invention.

Fig. 4 shows another embodiment of the trigger tube of the invention.

Fig. 5 shows diagrammatically a further embodiment of the trigger tube of the invention.

Fig. 5*a* shows a variation of the embodiment shown in Fig. 5; and

Fig. 6 shows an embodiment of the switch-trigger tube of the invention.

Briefly, one embodiment of the gaseous trigger tube of the invention includes two cathodes and a single anode functionally common to and located intermediate

the two cathodes. Triggering action is obtained by applying input pulses to the cathodes or the anode. In operation the glow discharge can exist between the anode and only one cathode. Each input pulse causes the glow discharge to be transferred to exist between the anode and the other cathode. The anode is in the form of either a plate having one or more holes connecting its planar faces or a screen wire. The holes through the plate or between the wires of the screen wire, as the case may be, provide for preselected ionic migration or leakage therethrough from the vicinity of the cathode to which the glow discharge exists to the vicinity of the other cathode. In this manner the breakdown voltage of the gaseous atmosphere in the vicinity of the latter cathode is lowered and a more positive glow transfer thereto is accordingly facilitated.

The switch-trigger tube of the invention provides a first cathode which effectively divides the tube envelope into two ionic compartments. An input pulse is applied to a first starter anode to establish a glow discharge between that anode and the first cathode. During the existence of this discharge ionic leakage occurs into the other compartment to lower the breakdown voltage therein so that when an input pulse is applied to a second starter anode a glow discharge is established between the main anode and main cathode, each located in said other compartment, to produce an output pulse. It is necessary that a glow discharge exist between the first cathode and the first starter anode before the second input pulse can be employed to establish a glow discharge between the main anode and main cathode.

Referring more particularly to Fig. 1 the gaseous discharge tube includes cathodes 10C and 11C and anode A, intermediate the cathodes. All electrodes are enclosed within the envelope 12 filled with any suitable gaseous atmosphere. Cathodes 10C and 11C are connected to ground through resistors 13 and 14 respectively. Anode A is connected through resistor 15 to a suitable source of positive voltage designated B+. If the resistor 15 is of sufficiently high value it will permit a steady glow discharge from the anode A to either of the cathodes 10C and 11C but will not permit a glow discharge between the anode and both cathodes. In operation then a glow exists initially in a state of stable discharge between the anode and one cathode called the fixed cathode. If an appropriate positive pulse is applied to this fired cathode the glow discharge will be transferred to exist in a state of stable discharge between the anode and other cathode. This glow transfer may also be accomplished by applying an appropriate negative pulse to the unfired cathode or to the anode. Obviously, if negative pulses are applied to the anode to effect glow transfer a binary output is present at the cathodes.

Fig. 2 shows a group of characteristic curves illustrating the operation of the tube of Fig. 1. If each fired gap is completely isolated from the unfired gap, for example, if the anode A is a solid metallic sheet, the breakdown voltage of the unfired gap is substantially independent of the current flowing in the fired gap as indicated by the complete isolation curve. If no isolation is effected between the cathodes; i. e., ions are permitted to migrate freely in the entire envelope 12, the no isolation curve approaches the sustaining voltage curve when appreciable anode current flows. It is seen from inspection of the sustaining voltage curve that the operating current value should be sufficiently large to avoid operating at the negative voltage characteristic of the curve. Such operation might produce self-oscillations or spurious glow transfer.

It is seen that ideal tube operation would be along a curve such as the curve C intermediate the no isolation and complete isolation curve. To obtain such operation

it is necessary to control the ionic leakage or migration from the fired gap to the vicinity of the unfired gap.

Referring to Fig. 3 the novel glow transfer trigger tube **16** includes wire cathodes **17** and **18** each having an inwardly extending portion along their length which portions extend toward a wire mesh anode **19**. The cathodes and anode are held in spaced relation by the upper and lower spacers **20** and **21**, respectively. In operation the tube may be connected in circuit as shown. The terminals **22** and **23** connected to the cathodes **17** and **18**, respectively, and the terminal **24** connected to the anode **19** may be employed as input and output terminals.

If a glow discharge exists between the anode **19** and the cathode **17** and a positive pulse is applied to terminal **22** or a negative pulse is applied to terminal **23** or **24** the glow discharge will transfer to exist in a state of stable discharge between the anode **19** and the cathode **18**. Accordingly, the voltage at the cathode **17** will decrease and the voltage at the cathode **18** will increase. If a positive pulse is now applied to the terminal **23** or a negative pulse is applied to the terminal **22** or **24** the glow discharge will be transferred to exist in a state of stable discharge between the anode **19** and the cathode **17**. Because the U-shaped, or inwardly extending portions of the cathodes, are nearest the anode the glow discharge is confined to those portions and does not extend to other parts of the cathode wires.

When a glow discharge exists from the anode to one cathode ions migrate from the vicinity of that glow discharge through the screen wire anode into the vicinity of the other cathode or into the unfired gap. Such migration lowers the breakdown voltage of the unfired gap so that greater speed of glow transfer is possible as well as the use of input pulses of less amplitude. Operation is effected in accordance with the curve C of Fig. 2.

Referring to Fig. 4 the tube **30** includes the wire cathodes **31** and **32** and an anode **33** intermediate the cathodes. The cathodes and anode are held in a preselected spaced relation by the upper and lower spacers **34** and **35** respectively. The anode **33** is formed as a flat sheet and has a hole therethrough as shown to permit ion migration from the fired gap into the unfired gap to permit operation as indicated by curve C of Fig. 2. The number and size of the holes used will vary in accordance with the operating requirements, the electrode spacing and the pressure of the gaseous atmosphere within the envelope of the tube.

Referring to Fig. 5 the cathodes **40** and **41** are of the wire type. The cathode **40** has a relatively small and uncoated surface area as compared to the surface area of cathode **41** which is coated with any suitable material such as activated barium-strontium compounds. The object in making the area of cathode **41** large relative to that of cathode **40** and of coating cathode **41** is to provide a voltage drop between the anode **33** and cathode **41** which is less than the voltage drop between the cathode **40** and anode **33** when a glow discharge exists across those respective gaps and the values of resistors **13** and **14** are equal.

Since the voltage drop is less across a glow discharge between the cathode **41** and anode **33** than between the cathode **40** and anode **33** it is possible to transfer the glow discharge from the cathode **40** to the cathode **41** by applying a negative pulse of relatively low amplitude and short duration to the terminal **23** or positive pulse to terminal **22** as compared to the amplitude and duration of the negative pulse which must be applied to the terminal **22** or positive pulse to terminal **23** to transfer the glow discharge from the cathode **41** to the cathode **40**. As an example, it has been found that for one given condition of operation a negative pip or spike pulse is sufficient to effect glow transfer when applied to the terminal **23** as compared to a square pulse of approximately 100 microseconds duration which must be applied to the terminal **22** to insure reliable glow transfer. For equal ignition characteristics at starting or equal cathode spacing relative to the anode, the glow discharge to a desired cathode can be accomplished by applying the "cold" or initial striking voltage to the cathode to which it is desired to create a glow discharge. This may be done by allowing that cathode to be more negative than the other cathode until ionization ensues.

Variations in the amplitude of the pulses applied to the terminals **22** and **23** may be obtained by varying the distance of the cathodes **40** and **41** from the anode **33**. For example, if cathode **40** is sufficiently more distant from the anode **33** than the cathode **41** the pulse applied to the terminal **22** will have to be of greater amplitude than that applied to the terminal **23**. In this case the discharge will initiate between cathode **41** and anode **33** provided the cold striking voltage is less than that required to create a glow discharge across **40—33**. The size of the hole in anode **33** or the amount of ionic coupling permitted is dependent upon the spacing of the cathode from the anode, the area of the anode and the area of the cathodes, and the mixture and pressure of the gaseous atmosphere employed. As in the previously described embodiments it is desirable to permit sufficient ionic leakage into the unfired gap region to facilitate rapid glow transfer but not enough ionic leakage to cause instability. In other words, conditions illustrated by curve C (Fig. 2) are most desirable.

Voltage amplification may be effected by employing resistors **13** and **14** of different values. For example, suppose resistor **13** is of larger value than resistor **14** and the voltage drop between anode **33** and cathode **41** is less than that between anode **33** and cathode **40**. Then, when the glow discharge is transferred from the cathode **40** to the cathode **41** there is no increase in the current through anode resistor **15** and a gain in voltage amplification is accordingly effected.

Referring to Fig. 5*a* the embodiment is of particular utility when used as a binary scaler; i. e., input pulses are applied to terminal **24** and an output is derived from either of the terminals **22** or **23**. Resistor **15** is chosen so that it will sustain a glow discharge to only one of the cathodes **40** or **41** and resistor **13** is larger than resistor **14**. Condensers **43** and **44** in parallel with cathode resistors **13** and **14**, respectively, are provided to increase the stability of the glow transfer. Although the value of resistor **15** is too large to permit glow present to both the cathodes **40** and **41** simultaneously the resistor **13** has a larger value than the resistor **14** and the tendency to prevent the existence of glow discharge between anode **33** and cathode **40** by the shorting out effect above referred to is accordingly decreased because the voltage drop across resistor **15** is substantially constant whether the glow discharge be to the cathode **40** or to the cathode **41**. The condensers **43** and **44** ensure that the voltage between each cathode and the anode will be sufficiently high to prevent a spurious glow transfer while de-ionization is effected in the gap from which the glow discharge has just been transferred. If the impedance of **13** and **43** equals the impedance of **14** and **44** and condenser discharge time is matched to repetition rate and width of pulses at **14** such is ensured.

Referring to Fig. 6 the novel switch-trigger tube **46** is shown in cross-section and includes a starter anode SA in spaced glow discharge relation to a disc-shaped cathode C–1, having a hole through its center. This cathode C–1 effectively divides the tube envelope into two ionization chambers linked together by the ionic leakage effected through the hole at the center of cathode C–1. The starter anode SA is situated in the first or left-hand ionic chamber and the main anode MA, starter anode SA–2, and main cathode MC are situated in the second or right-hand ionic chamber. The main anode MA is of the wire type, starter anode SA–2 is of the cylindrical wire mesh type and is positioned intermediate the main anode MA and the annular-shaped main cathode MC.

The enumerated electrodes are connected as shown and a positive input pulse is applied to the input terminals 48 and 50 in turn to effect operation of the tube. That is a pulse must first be applied to the input terminal 48 and subsequently a pulse must be applied to input terminal 50 to derive an output from the output terminal 52 connected to the main anode MA. Because of this required sequence of input pulses the tube 46 is termed a switch-trigger tube.

When an input pulse is applied to input terminal 48 and hence to the starter anode SA–1 the voltage difference between the anode SA–1 and the cathode C–1 is increased sufficiently to initiate a glow discharge therebetween. This glow discharge is referred to as an auxiliary glow discharge. Ions and electrons then migrate through the hole in the cathode C–1 into the right-hand ionization chamber and thereby cause a decrease of the breakdown voltage required to effect a glow discharge therein. While a glow discharge exists between the anode SA–1 and cathode C–1 an input pulse is applied to the input terminal 50. This input pulse creates a sufficient voltage difference between the starter anode SA–2 and the main cathode MC to create a glow discharge therebetween. This glow discharge between anode SA–2 and cathode MC effects a further ionization of the gaseous atmosphere within the right-hand chamber. This ionization is sufficient to cause the glow discharge to be extended from anode SA–2 to the more positive main anode MA and thereby exist between the main cathode MC and the main anode MA. This glow discharge is referred to as a main glow discharge. In other words, the glow discharge between the main cathode MC and the starter anode SA–2 provided the transfer current to initiate the glow discharge between the main cathode MC and the main anode MA. When the input pulse applied to input terminal 48 ceases or the voltage across the glow discharge between the starter anode SA–1 and cathode C–1 is caused to decrease below the required sustaining voltage such as by removal of the B+ voltage source that glow discharge is extinguished. Also, when the input pulse applied to input terminal 50 ceases the glow discharge between the main cathode MC and the starter anode SA–2 is extinguished. The glow discharges between the starter anode SA–1 and the cathode C–1 and between SA–2 and MC may be extinguished at any desired time after a glow discharge is created between MA and MC in the right-hand chamber without effecting the operation of the tube. A negative output voltage pulse appears at the output terminal 52 while a glow discharge is present between the main cathode MC and the main anode MA.

The various electrodes are so positioned that the application of an input pulse to either of the input terminals 48 and 50 alone will not produce an output pulse or create a glow discharge in the right-hand chamber. An output is produced only when an input pulse is applied to the input terminal 48 to produce a glow discharge between the starter anode SA–1 and the cathode C–1 and while that glow discharge exists an input pulse is applied to the input terminal 50.

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 switch-trigger tube of the glow discharge type including a first and a second ionic chamber ionically coupled by a preselected ionic migration from the first chamber into the second to lower the breakdown voltage of the gaseous atmosphere in the second chamber; a first starter anode and a first cathode positioned to maintain a glow discharge within said first chamber when a first voltage change is applied therebetween to cause said preselected ionic migration into said second chamber; a main cathode and a second starter anode positioned in glow transfer relation within said second chamber; and input means for applying a second voltage change to said second starter anode to create a glow discharge therebetween only when said glow discharge exists within said first chamber.

2. The invention set forth in claim 1 including a main anode positioned within said second chamber more remote from said main cathode than said second starter anode whereby a glow discharge between said main cathode and said second starter anode provides a transfer current causing initiation of a glow discharge between said main cathode and said main anode; and output means connected to said main anode to derive an output therefrom when a glow discharge exists between said main cathode and main anode.

3. In a switch-trigger tube of the glow transfer type having first and second ionically coupled chambers and requiring the application of two inputs sequentially applied to produce an output; electrode means for creating a first glow discharge within said first chamber; cathode and anode means for creating a second glow discharge within said second chamber in response to an input voltage and said first glow discharge; and anode means for effecting a third glow discharge within said second chamber in response to ionic changes effected by said second glow discharge.

4. A glow transfer type tube for providing an output only in response to the application of two input pulses including; first electrode means for maintaining an initial glow discharge; second electrode means for initiating second and third glow discharges, in turn, for providing an output; ionic transfer means intermediate said first and second electrode means for providing a preselected ionic migration into the vicinity of said second electrode means from the vicinity of said initial glow discharge; and circuit means for rendering said tube operable.

References Cited in the file of this patent

UNITED STATES PATENTS

1,420,824	Dohle	June 27, 1922
1,951,416	Hund	Mar. 20, 1934
1,992,493	Los	Feb. 26, 1935
2,575,516	Hagen	Nov. 20, 1951
2,638,564	Williams	May 12, 1953