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GLOW TUBE SWITCH

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Fig. 1

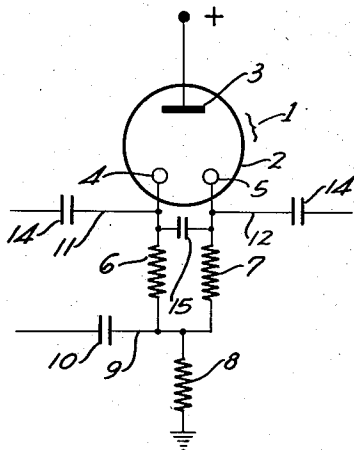


Fig. 3

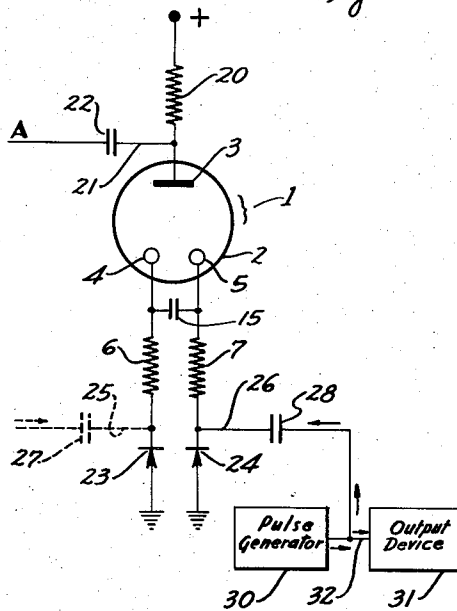


Fig. 4

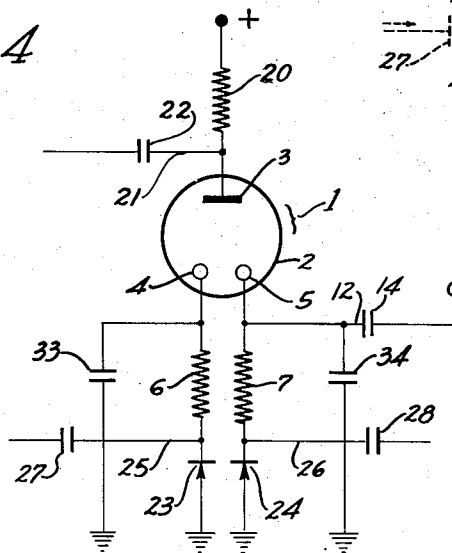


Fig. 2

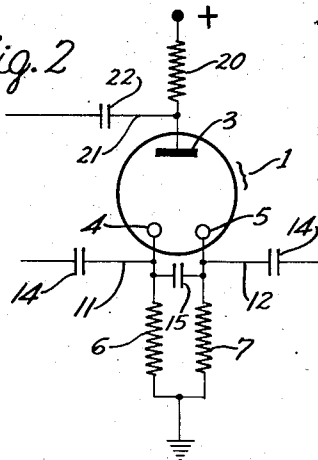
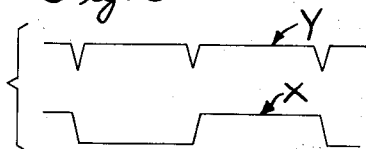


Fig. 5



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## UNITED STATES PATENT OFFICE

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## GLOW TUBE SWITCH

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11 Claims. (Cl. 315-229)

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My invention relates to gaseous discharge tubes, and more particularly to glow tubes that can be utilized as switches for use, for example, in computing machines as gates or the like.

It is an object of the invention to provide a glow tube that can act as a single pole double throw switch.

It is still another object of the invention to provide an ionic switch tube requiring no cathode heating current.

It is a further object of the invention to provide a simple, and physically small glow tube switch and circuit suitable for use in computers.

In brief, the present invention comprises an envelope containing a gas at glow discharge pressure, and having three electrodes immersed therein, i. e., two cathodes and one anode. The cathodes are connected to the anode so that applied input pulses cause a glow discharge to switch from one cathode to the other. Output circuits connected to the cathodes are energized by the discharges to the respective cathodes.

The invention will be more fully understood by reference to the drawings, in which:

Figure 1 is a circuit diagram of a glow tube switch according to the present invention, connected to be operated by positive pulses.

Figure 2 is a circuit diagram of an embodiment of the invention operated by negative pulses.

Figure 3 is a circuit diagram of an embodiment of the invention operated by negative pulses, and used to operate a gating circuit.

Figure 4 is a circuit diagram of a modification of the circuit shown in Figure 3.

Figure 5 is a graph showing corresponding input and output conditions as existing in the circuit of Figure 4.

In Figure 1 a simple glow tube switch is shown, together with one type of operating circuit therefor. The glow tube 1 comprises an envelope 2 having an anode 3, and two cathodes 4 and 5 therein, and also containing a gas, such as neon, at glow discharge pressure, i. e. 100 m. m. of Hg, for example.

Anode 3 is connected to a source of positive potential such as 300 v. to 1000 v., for example. The cathodes 4 and 5 are grounded through respective cathode resistor 6 and 7, and then through a common resistor 8. An input line 9 is connected to the junction of cathode resistors 6 and 7, and common resistor 8 through an input capacity 10. Output circuits 11 and 12 are respectively connected to cathodes 4 and 5. Each output line contains a blocking condenser 14. A cathode condenser 15 connects both cathodes.

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Preferably the anode 3 is placed between the two cathodes, and all electrodes can be of simple construction, such as small straight wires or rods. As the voltage range over which the gaseous discharge takes place is limited, I prefer to maintain uniform gas pressure on all tubes, when a large number of tubes are to be utilized as in a computer, by placing a plurality of the electrode assemblies 3, 4 and 5 in a single envelope as disclosed in my copending application Serial No. 99,091, filed June 14, 1949, now U. S. Patent No. 2,560,691, granted July 17, 1951.

In operation, it will be assumed that an initial discharge will take place between anode 3 and the cathode 4. Since this will cause current to flow through common resistor 8, the basic voltage of both cathodes 4 and 5 with respect to the anode 3 will be less than that of the anode supply voltage. In addition, due to the current flowing in cathode resistor 6, the voltage on cathode 5 will be more positive than that on cathode 4, so that condenser 15 will charge.

When a positive pulse is applied to the input line 9, i. e., to both cathodes, the potential of this pulse is sufficient to raise the potential of the cathode 4 involved in the glow discharge to a value, where the glow discharge to cathode 4 is extinguished.

Current then ceases to flow through common resistor 8 and the voltage between anode 3 and the two cathodes 4 and 5 tends to rise quickly to the potential of the anode source. However, the two cathodes 4 and 5 are not now at the same potential, due to the charge on condenser 15, so that the greatest drop across the tube is between the anode 3 and cathode 5. The discharge thereupon strikes between anode 3 and cathode 5, and condenser 15 charges in the opposite direction, so that when the next positive input pulse arrives, the discharge will be switched back to cathode 4. Thus each positive pulse will switch the glow discharge from one cathode to the other.

The output lines 11 and 12, being attached to each cathode, will thus carry an output pulse in accordance with which cathode is involved in the glow discharge, so that output pulses will alternatively occur in the output circuits, following a succession of positive input pulses in the single input line 9. Thus the device operates as a flip-flop circuit, useful in computing devices, with two stable states alternating under successive input pulses. The output of the device at the cathodes is essentially a square wave but, in the particular embodiment of the invention

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shown in Figure 1, the output voltage momentarily swings too far to the negative direction as the circuit is flipped. Thus a clean, true, square wave is not generated directly with this circuit but the output is useful, nevertheless, for circuits such as frequency dividers, for example.

In Figure 2, I have shown a glow tube switch, the circuit being slightly modified from that of Figure 1 for operation on negative input pulses. In this case, anode 3 is connected to a positive source of potential through an anode resistor 20, and an input line 21 is connected to anode 3 through an input capacitor 22. The cathode resistors 6 and 7 are connected together and then grounded.

In operation, of this modification, it will be again assumed that the initial discharge will first take place between anode 3 and cathode 4. Since there is no current flowing through cathode resistor 7, cathode 5 will be at ground potential. The current flowing through cathode resistor 6 on the other hand, will cause cathode 4 to be at a more positive potential than ground. This causes condenser 15 to charge. The current flowing through anode resistor 20 causes the anode 3 to be at a somewhat less positive potential than the anode supply voltage.

Thus, when a negative pulse is applied to the anode 3 through input line 21, this negative pulse causes the potential on the anode 3 to decrease sufficiently to extinguish the discharge between anode 3 and cathode 4. At this instant the potential on anode 3 tends to rise quickly toward the potential of the anode potential source, but the potentials on the two cathodes 4 and 5 are not quite the same, due to the charge on condenser 15. When the potential on anode 3 has risen slightly, the discharge will strike between anode 3 and cathode 5, thereby causing the potential on anode 3 to drop to the operating potential, due to the drop across anode resistor 20. The potential on anode 3 does not rise sufficiently to re-strike the discharge between anode 3 and cathode 4. After a short period of operation, condenser 15 will recharge in the opposite polarity from the condition it was in at the time of the first input pulse. When condenser 15 is recharged, the circuit is ready for another input pulse, which will cause the discharge between anode 3 and cathode 5 to be extinguished, and reestablished between anode 3 and cathode 4.

The only difference between the circuits of Figures 1 and 2 is the position of the resistor in the anode cathode circuit with respect to the anode potential source, and the position of the input line. The change of position of this resistor changes the operation of the device from operation by positive pulses in the circuit of Figure 1 to operation by negative pulses in the circuit of Figure 2. In each case the outputs are taken from the cathodes and these outputs again, as stated for the circuit of Figure 1 will have essentially square wave form, deviating therefrom only by slight overshooting of the voltages in a positive direction, as shown.

In Figure 3, I have shown the switching circuit of Figure 2 connected to operate a gate circuit.

In Figure 3, the two cathodes 4 and 5 are each connected to ground through the cathode resistors 6 and 7 respectively, and through respective diodes 23 and 24. The cathodes 4 and 5 also have output lines 25 and 26 respectively connected between the cathode resistors and the diodes, these output lines having isolation ca-

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pacities 27 and 28 respectively therein. The cathodes 4 and 5 are connected together through the cathode condenser 15 as in the circuit of Figures 1 and 2.

While both cathodes can be used in the circuit of Figure 3 to control circuits to be gated, only one such circuit is shown. A pulse generator 30 used as a source of pulses is connected to an output device 31 through connection line 32, and connection line 32 is connected to output line 26 through the isolation capacity 28.

In the circuit just described, when there is a discharge between anode 3 and cathode 5, a current will flow through diode 24, hence when a negative pulse from pulse generator 30 is applied to the anode of the diode 24 it will be passed to ground. However, the potential of the negative pulses from pulse generator 30 must not be of so great amplitude as to destroy the conducting condition of diode 24, since, a negative pulse of a greater magnitude than the tube current will not be absorbed by the tube current and thus an undesired pulse will pass to the output device.

When a pulse from pulse generator 30 is passed to ground through diode 24, this pulse cannot operate the output device 31. If however, there is no discharge between anode 3 and cathode 5, the diode 24 is not in conducting condition, and the voltage of a negative pulse applied to the anode of diode 24 will not be passed to ground, but will become available to operate the output device 31. Thus, the condition of the switch tube 1 determines the action taken when negative pulses are applied to diode 24. Diode 23 can also be used to control other negative pulses applied through the dotted output line 25. As for positive pulses applied to either diode, these are always passed by the diode, and hence cannot operate an output device.

Referring next to Figure 4, it will be noted that the single condenser 15 positioned between the cathodes 4 and 5 in Figures 1 and 2 has been replaced by separate condensers 33 and 34. It is this modification of the circuit that results in a clean square wave being generated at the cathode output 12, as shown by curve X in Figure 5 in response to input pulses as shown in curve Y of the same figure. In operation, the device of Figure 4 depends upon the individual charge of condensers 33 and 34 to maintain a difference of potential between the two cathodes 4 and 5 during a switching period. Since the two cathode resistors 6 and 7 are bypassed by the condensers 33 and 34 respectively, a larger percentage of the negative switching pulse potential will be across the electrodes of the tube rather than across the cathode resistors. A more slightly stable operation and a clean square wave output is obtained, but at the expense of the use of the additional condenser. Thus this circuit is most desirable for use when a square wave output is desired. In none of the circuits disclosed herein, however, it is necessary to have evenly spaced input pulses for proper operation.

The present invention has the distinct advantage that it utilizes a simple tube and associated circuit wherein a single pole double throw, highly reliable, electronic switch action is obtained. Since the tube used is of the glow discharge type, the current necessary for operation is appreciably less than that required for conventional vacuum tube circuits of similar capabilities. This also results in less heat radiation by equipment utilizing a plurality of such circuits, which is highly desirable. In prior devices of this type,

it is the usual practice to employ neon bulbs for visually indicating to the operator which stable position the switch is in at any given time. However, by exposing the glow tube of the present invention to the operator, the switching position is visually indicated by the location of the glow discharge which is clearly distinguishable as being associated with either one or the other of the cathodes.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise several preferred forms of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

What is claimed is:

1. A glow tube switch comprising an envelope containing a filling of gas at non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a capacity between said cathodes, a cathode resistor connected at one end to a cathode, a second cathode resistor connected at one end to the other cathode, the other ends of said cathode resistors being connected together to form a cathode lead, a single resistor directly connected to one of said leads, a potential source connected to the other of said leads, said single resistor and said source being connected together in series to place said anode at a positive potential, a pulse input line connected to the lead to which said single resistor is directly connected, and a pulse output line connected to one of said cathodes.

2. Apparatus in accordance with claim 1 wherein said single resistor is connected to said cathode lead and wherein an output lead is connected to at least one of said cathodes.

3. Apparatus in accordance with claim 1 wherein said single resistor is connected to said anode and wherein an output lead is connected to at least one cathode.

4. Apparatus in accordance with claim 1 wherein said single resistor is connected to said anode, wherein a diode is positioned between the end of each cathode resistor and the point where said cathode resistors are connected together, the anodes of said diodes being connected to the respective cathodes through the respective cathode resistors, a pulse generator, an output device connected to be operated by pulses to said generator, and a gating line connected to the output of said pulse generator and to the anode of one of said diodes.

5. A glow tube switch comprising an envelope containing a filling of gas at non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a capacity between said cathodes, a cathode resistor connected at one end to a cathode, a second cathode resistor connected at one end to the other cath-

ode, the other ends of said cathode resistors being connected together to form a cathode lead, a single resistor directly connected to one of said leads, a potential source connected to the other of said leads, said single resistor and said source being connected together in series to place said anode at a positive potential, a pulse input line connected to the lead to which said single resistor is directly connected, and a connection to at least one of said cathodes to sense the existence of a glow discharge between said latter cathode and said anode.

6. A glow tube switch comprising an envelope containing a filling of gas at non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a capacity between said cathodes, a cathode resistor connected at one end to a cathode, a second cathode resistor connected at one end to the other cathode, the other ends of said cathode resistors being connected together to form a cathode lead, a single resistor directly connected to one of said leads, a potential source connected to the other of said leads, said single resistor and said source being connected together in series to place said anode at a positive potential, a pulse input line connected to the lead to which said single resistor is directly connected, and a separate output connection to each of said cathodes.

7. A glow tube switch comprising an envelope containing a filling of gas at non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a cathode resistor connected at one end to a cathode, a second cathode resistor connected at one end to the other cathode, the other ends of said cathode resistors being connected together to form a cathode lead, a single resistor directly connected to one of said leads, a potential source connected to the other of said leads, said single resistor and said source being connected together in series to place said anode at a positive potential, a capacity connecting one of said cathodes to the negative potential of said source, another capacity connecting the other of said cathodes to the negative potential of said source, a pulse input line connected to the lead to which said single resistor is directly connected and a connection to at least one of said cathodes to sense the existence of a glow discharge between said latter cathode and said anode.

8. A glow tube switch comprising an envelope containing a filling of gas at non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a capacity between said cathodes, a first cathode resistance means connected at one end to a cathode, a second cathode resistance means connected at one end to the other cathode, the other ends of said cathode resistance means being connected together to form a cathode lead, a single resistance means directly connected to one of said leads, a potential source connected to the other of said leads, said single resistance means and said source being connected together in series to place said anode at a positive potential, a first pulse carrying line connected to the lead to which said single resistance means is directly connected, a second pulse carrying line connected to at least one of said cathodes, one of said pulse carrying lines serving as a pulse input line, the other of

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said pulse carrying lines serving as a pulse output line, in accordance with which of said leads is directly connected to said single resistance.

9. A glow tube switch comprising an envelope containing a filling of gas at a non-arcing cathode glow discharge pressure, an anode in said envelope, a lead for said anode, two cold cathodes in said envelope adjacent said anode, a capacity between said cathodes, a first cathode resistor connected at one end to a cathode, a second cathode resistor connected at one end to the other cathode, a rectifying diode having the anode thereof connected to the other end of said first cathode resistor, a second rectifying diode having the anode thereof connected to the other end of said second cathode resistor, the cathodes of said rectifying diodes being connected together to form a cathode lead, a single resistor connected to one of said cathode and anode leads, a potential source connected to the other of said cathode and anode leads, said single resistor and said potential source being connected in series to place said anode at a positive potential, a pulse input line connected to the lead to

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which said single resistor is directly connected, and a pulse output line connected to one of said cathodes.

10. A glow tube switch in accordance with claim 1 wherein said anode and cathodes are relatively short, parallel and adjacent wires, with said anode between said cathodes.

11. A glow tube switch in accordance with claim 9 wherein said anode and cathodes are relatively short, parallel and adjacent wires, with said anode between said cathodes.

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