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COLD CATHODE SWITCH TUBE

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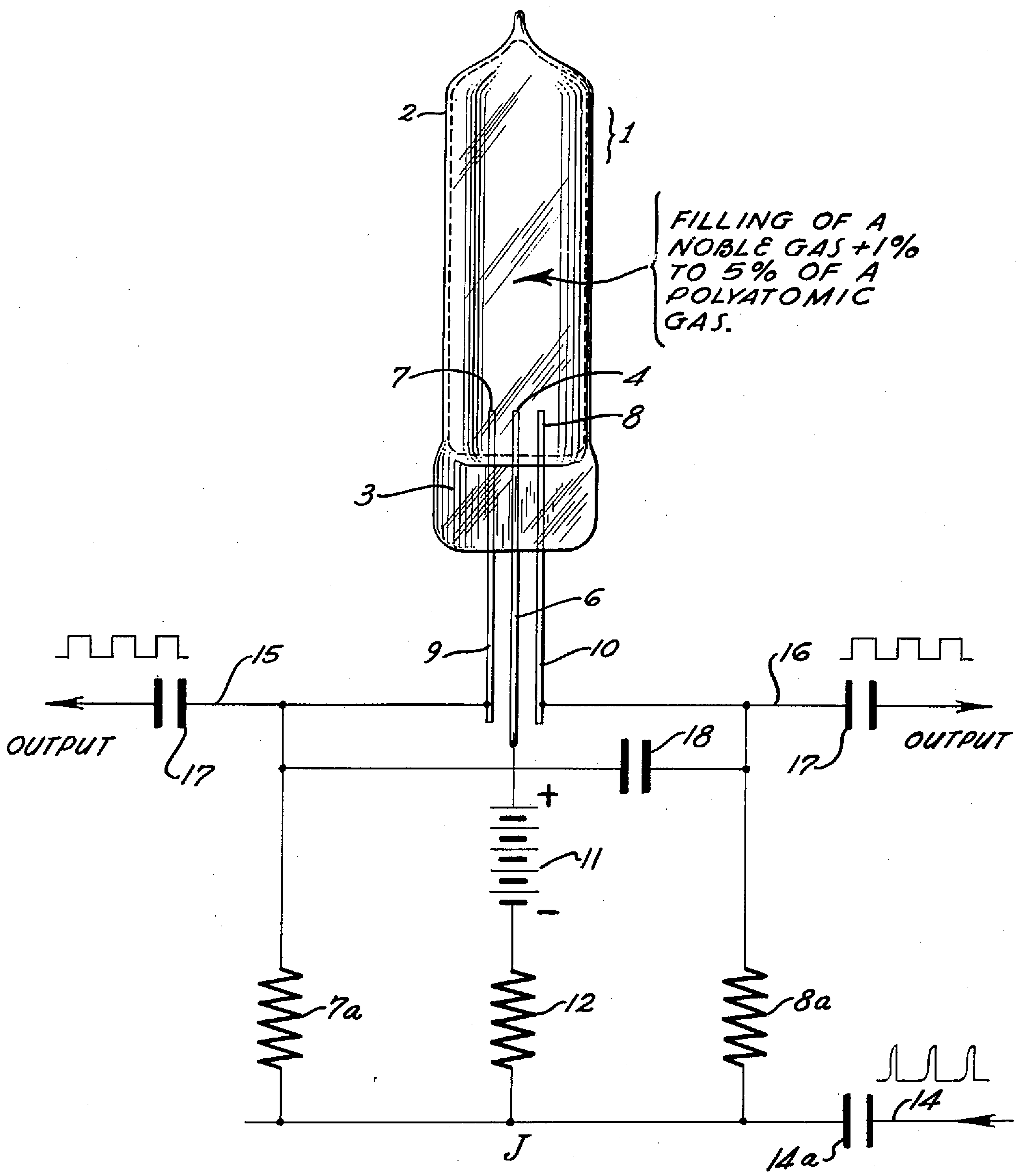


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# COLD CATHODE SWITCH TUBE

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The present invention relates to cold cathode glow tubes and more particularly to a glow tube switch or flip-flop suitable for use in mathematical counters and computers.

Essentially a flip-flop is a device which has two stable states and is capable of being triggered from one state to the other as by an input pulse. The term flip-flop has assumed independent status in the art. When glow tubes are utilized in flip-flop circuits such as shown, described, and claimed by Hagen in a copending application, Serial No. 100,178, filed June 20, 1949, now Patent 2,575,516 for example, it is desirable that the glow discharge path to one cathode be quickly de-ionized as the path to the other cathode is energized, in order to reduce the possibility of restriking a discharge along the same path when the potential thereon is again raised. Furthermore, fast de-ionization in the tube leads to increased speed of operation and higher accurate counting rates.

It is an object of the present invention to provide a means and method of increasing the accuracy of cold cathode flip-flop tubes by decreasing the de-ionization time in current paths in the tube. It is still another object to provide a glow tube switch or flip-flop having a higher sensitivity, higher voltage swing on the tube, lower input pulse, and a higher frequency of operation than has heretofore been found practical.

In brief, the present invention includes the use, in a switch circuit, of a cold cathode glow discharge tube having an anode symmetrically positioned between two substantially identical cathodes, in which a filling of noble gas such as helium is deliberately contaminated with a polyatomic gas in an amount on the order of from 1% to 5%. Preferred examples are water vapor and pure hydrogen, or combinations thereof.

Our invention will be more fully understood by reference to the drawing which shows a tube embodying the present invention as used in a flip-flop circuit disclosed in the Hagen application cited above.

In the figure, a cold cathode glow tube **1** is provided in accordance with the present invention, having an envelope **2** of glass with an external pinch **3** at one end thereof. A central straight wire anode **4** is held in pinch **3** and extends upwardly only a very short distance into the tube. The anode wire is continued outside of the envelope through the stem as an anode lead **6**.

Two cathode wires **7** and **8** pass through the pinch **3** as continuations of cathode leads **9** and **10**, respectively, and are identical in extent with, parallel to, and one on each side of anode **4**.

In order to obtain maximum sensitivity and counting speed, we fill the envelope **2** with a mixture of noble and polyatomic gases. For example, helium at pressures from 100 to 250 mm. Hg have been found satisfactory, with a deliberate contamination of from 1% to 5% water vapor or pure hydrogen as a preferred impurity used as a quenching gas.



It is believed at the present time, on the basis of experimental evidence, that a polyatomic impurity tends to de-ionize the ionized path of the glow discharge when the energization is withdrawn.

The quenching gas characteristics are as follows:

1. The quenching gas must dissociate on impact with noble gas ions.

2. This dissociation must absorb energy. The absorption of energy is necessary to cause an inelastic collision wherein the speed of the ion is reduced. (As opposed to the elastic collision between noble gas ions or atoms in which they rebound without loss of speed.) Since recombination of ions and electrons (deionization) is roughly inversely proportional to the speed of the ions, prompt deionization results when they are stopped by collision. This qualification excludes the use of endothermic compounds as quenching gases i. e., those that release energy rather than absorb it. For example, nitroglycerine vapor is definitely not suitable.

3. The gas must automatically recombine within the tube so as not to be quickly consumed. This is true of all diatomic elemental gases such as hydrogen, nitrogen, oxygen, etc. It is also true of many compound gases provided proper catalysts are present. Water vapor, ammonia, carbon dioxide, hydrogen chloride, are examples. "Kovar", the most desirable electrode material from the standpoint of manufacturing cost, is a good catalyst for recombination of water vapor. Platinum is good for all those gases mentioned as well as many others. Most of the heavier organic gases, however, will not qualify in this respect. Alcohol vapor, widely used as a quenching gas in commercial Geiger tubes, does not recombine, and thus limits the life of the tube.

4. The dissociation products of the quenching gas must not form undesirable sludges or films on tube elements. In general, any gas satisfying (3) will also satisfy this requirement.

5. The quenching gas must not react chemically or physically with electrodes in an undesirable manner. Hydrogen polishes the electrodes clean by chemical reduction; water vapor oxidizes them heavily; yet both clean and oxidized electrodes perform satisfactorily in these cases.

6. The quenching gas must not rapidly disappear by adsorption or absorption into electrodes or glass walls.

Hydrogen has been found to be the best possible gas with respect to requirements 5 and 6. Water vapor has also been used because it is very good from the standpoint of requirements 1 and 2. We prefer the water vapor to hydrogen.

In any event the addition of any polyatomic gas has been found to stabilize the tube, prevent refiring of an immediately extinguished path, and to greatly increase sensitivity speed and accuracy over tubes using a noble gas alone. It has also been found that the addition of measured quantities of the impurity results in tubes with reproducible characteristics. Tubes so filled have been accurately operated at pulse input speeds of 10 kc.

The tube as above described is ideal for use in high speed counters when used as a flip-flop device, such as can be accomplished by the circuits of the Hagen application cited above.

As shown in the figure, in one of such circuits, anode **4** is connected to a source of positive potential **11**, such as 300 v. to 1000 v., for example. The cathodes **7** and **8** are grounded to the negative side of the source **11** through respective cathode resistors $7_a$ and $8_a$, and then through a common resistor **12**. An input line **14** is connected to the junction J of cathode resistors $7_a$ and $8_a$, and the common resistor **12**, through an input capacity $14_a$. Output circuits **15** and **16** are respectively connected through cathode leads **9** and **10** to cathodes **7** and **8**. Each output line contains a blocking condenser **17**. A cathode condenser **18** connects both the cathode circuits.

In operation, it will be assumed that an initial discharge will take place between anode **4** and the cathode **7**. Since this will cause current to flow through common resistor **12**, the basic voltage of both cathodes **7** and **8** with respect to the anode **4** will be less than that of the anode supply voltage. In addition, due to the current flowing in cathode resistor **7a**, the voltage on cathode **7** will be more positive than that on cathode **8**, so that condenser **18** will charge.

When a positive pulse is applied to the input line **14**, i. e., to both cathodes, the potential of this pulse is sufficient to raise the potential of the cathode **7** involved in the glow discharge to a value where the glow discharge to cathode **7** is extinguished.

Current then ceases to flow through common resistor **12** and the voltage between anode **4** and the two cathodes **7** and **8** tends to rise quickly to the potential of the anode source. However, the two cathodes **7** and **8** are not now at the same potential, due to the charge on condenser **18**, so that the greatest drop across the tube is now between the anode **4** and cathode **8**. The discharge thereupon strikes between anode **4** and cathode **8**, and condenser **18** charges in the opposite direction, so that when the next positive input pulse arrives, the discharge will be switched back to cathode **7**. Thus each positive pulse will switch the glow discharge from one cathode to the other.

The output lines **15** and **16**, 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 alternately occur in the output circuits, following a succession of positive input pulses in the single input line **14**. 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, because of the particular embodiment of the invention shown in the figure, the output voltages momentarily swing too far to the negative direction as the circuit is flipped. Thus a clean, true, square wave is not generated directly with this particular circuit, but the output is useful, nevertheless, for circuits such as frequency dividers, for example. However, the circuit shown is representative of the action of the tube.

Thus, the dual cathode gas tube flip-flop of the present invention has two conducting stable states; either one cathode is conducting or the other cathode is conducting. The tube is non-conducting only during relatively short transition times and sufficient supply voltage is utilized to guarantee reignition. Thus the usual difficulty of an "on-off" bi-stable gas tube, i. e., that of maintaining consistent ionization during the "off" or non-conducting state to stabilize firing voltage, is avoided.

As a basic computer component the cold cathode gas discharge flip-flop tube of the present invention offers many advantages, as follows:

1. Small size, smaller than a dual triode subminiature tube. A satisfactory tube need only be 1 inch long by ⅛ inch in diameter.
2. Simple and extremely rugged electrode construction.
3. Low power consumption. The total heat dissipation can be as little as 0.1 watt per flip-flop stage.
4. Self indicating, due to cathode glow.
5. Fewer components are required to construct a flip-flop stage than with conventional dual triode circuits.
6. Increased reliability—no filament to burn out.
7. High operating speed, on the order of 10 kc.

Complete binary and ring counters, number storage devices, and digital delay lines have been constructed with the tube of the present invention without the aid of vacuum tubes. This versatile three electrode glow tube



can also be used to regulate voltage; as an oscillator; a pulse generator; a pulse amplifier and a one-shot device. As a flip-flop it can control diode gates, operate relays and indicators, as well as self-indicate its state.

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 the preferred form 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 three electrode cold cathrode glow tube switch comprising an envelope containing an anode, and a cathode on each side of said anode, and a filling of a noble gas mixed with from 1% to 5% of water vapor.

2. A three electrode cold cathode glow tube switch comprising an envelope containing an anode, and a cathode on each side of said anode, and a filling of a noble gas mixed with from 1% to 5% of water vapor, said electrodes being formed of a material tending to recombine dissociated water vapor.

3. A three electrode cold cathode glow tube switch comprising an envelope containing an anode, and a cathode on each side of said anode, and a filling of a noble gas mixed with from 1% to 5% of water vapor, said electrodes being formed of platinum.

4. A three electrode cold cathode glow tube switch comprising an envelope containing an anode and a cathode on each side of said anode, said envelope containing a filling of helium at from 100 to 250 mm. of mercury pressure, mixed with from 1% to 5% of water vapor.

5. A three electrode cold cathode glow tube switch comprising an envelope containing an anode and a cathode on each side of said anode, said envelope containing a filling of helium at from 100 to 250 mm. of mercury pressure, mixed with from 1% to 5% of water vapor, said anode and cathodes being of wire of uniform section.

6. An electrical discharge device of the kind having a sealed envelope containing a noble gas mixed with a small amount of a polyatomic gas, including: three electrodes sealed in said envelope and arranged to provide an unobstructed discharge path initiated at the normal striking potential between the two electrodes functioning at any instant as anode and cathode and thereafter maintained between the same two electrodes unaffected by the other electrode until the extinction of said discharge; and circuit means whereby a pulse establishes an uninterrupted discharge path between two of said electrodes and each succeeding pulse extinguishes the discharge between said pair of electrodes and establishes an uninterrupted discharge path between one of said pair of electrodes and the other electrode.

7. An electrical discharge device as set forth in claim 6 comprising a single anode and a cathode arranged at each side of said anode.

8. An electrical discharge device as set forth in claim 7 comprising an anode and two identical cathodes, each of a single length of straight wire extending a small distance into said envelope.

9. An electrical discharge device as set forth in claim 8 comprising an envelope filling of helium at a pressure of 100 to 250 mm. of mercury mixed with from 1% to 5% of a recombinable polyatomic gas.

10. An electrical discharge device device as set forth in claim 9 in which the recombinable polyatomic gas is hydrogen.

11. An electrical discharge device of the kind having a sealed envelope containing a noble gas mixed with a small amount of a polyatomic gas, including: a single anode with a cathode arranged at each side thereof and providing an unobstructed discharge path initiated at the normal striking potential between said anode and one or the other of said cathodes, said anode and two cathodes being each formed of a single length of wire extending a small distance into said envelope.

12. An electrical discharge device as set forth in claim 11 comprising an envelope filling of helium at a pressure of 100 to 250 mm. of mercury with from 1% to 5% of hydrogen.

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