

Nov. 8, 1949

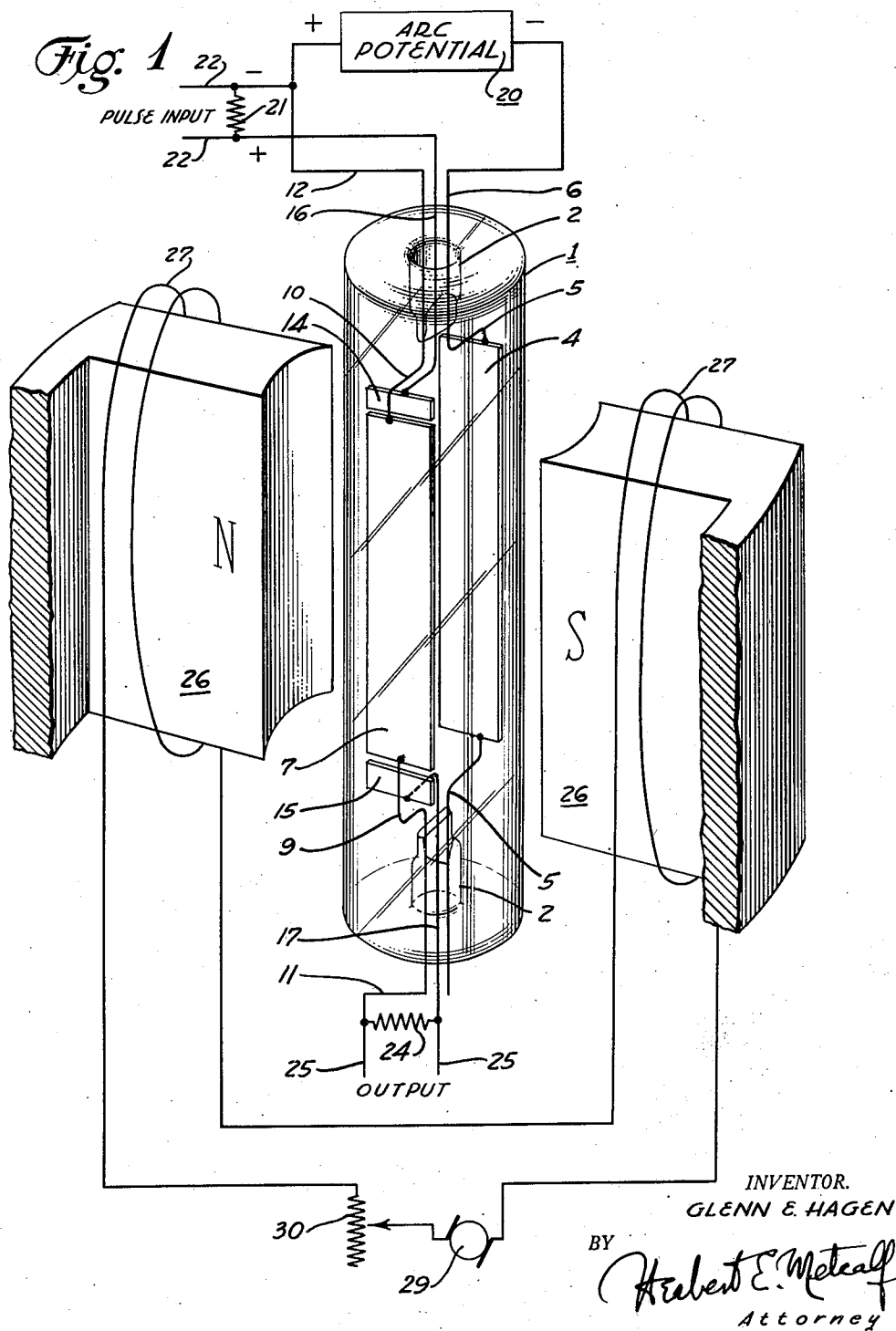
G. E. HAGEN

2,487,332

DELAY DEVICE

Filed March 15, 1949

2 Sheets-Sheet 1



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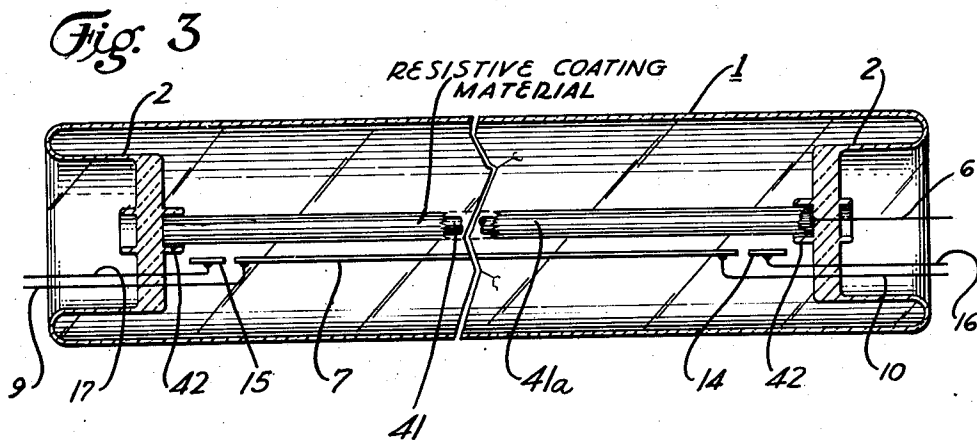
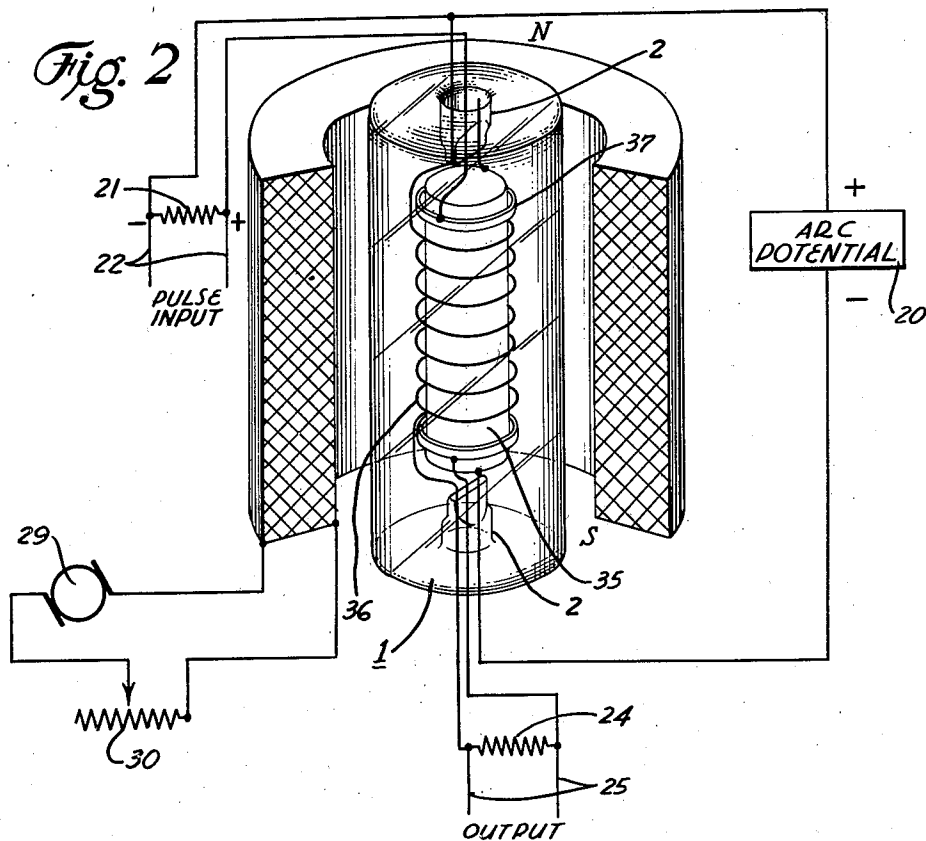
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Filed March 15, 1949

2 Sheets-Sheet 2



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2,487,332

DELAY DEVICE

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Application March 15, 1949, Serial No. 81,529

9 Claims. (Cl. 315-344)

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My invention relates to time delay lines and more particularly to a time delay line suitable for use in electronic computers.

It is well known that time delay lines or "electronic memories" are vitally important for use in electronic, digital computing machines used for intricate mathematical calculations. One of the best known memories is a mercury tube in which pulses travel as shock pulses imparted to and detected in the mercury column by crystal transponders. Such electro-mechanical devices are however subject to temperature effects and the like and require delicate handling.

Among the objects of the invention are:

To provide a means and method of obtaining a controlled time delay in an electrical circuit.

To provide a simple and easily adjusted time delay device.

To provide a time delay device in which transit time can be varied.

To provide a time delay device in which a number of signals can be simultaneously delayed.

And to provide a simple electro-magnetic time delay device.

The present invention relates to an electro-magnetic time delay line in which transit time of an electric arc over a predetermined path is controlled by a magnetic field. The invention is primarily based on the fact that an electric arc that has been struck between two electrodes immersed in a gaseous medium and a magnetic field, will tend to move in a direction perpendicular to both the field and the direction of arc discharge.

In broad terms, the present invention comprises a tube having two extended and adjacent electrodes surrounded by a gaseous medium, together with means for producing a magnetic field perpendicular to the extent of the electrodes and to all of the arc paths between the electrodes. The two electrodes are energized to a potential just below that at which an arc between them can occur, and a starting electrode is positioned at one end of the arc electrodes. At the other end of the arc electrodes is positioned a sensing or output electrode.

When a sharp potential pulse is applied to the starting electrode, an arc is struck and moves, under the influence of the magnetic field to the opposite end of the arc electrodes, where it energizes the sensing electrode and is then blown out by the magnetic field. The sensing electrode is connected to a detecting circuit in which a pulse is reconstructed and this pulse thereafter used in the computer as desired.

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As the velocity of the arc along the electrodes is completely dependent upon the strength of the magnetic field, the effective transit time of the pulse through the tube is dependent on the field strength and length of the arc electrodes. When the latter electrodes are of fixed length, the pulse transit time is readily and accurately controlled by variation of the magnetic field strength.

In one preferred form, one of the arc electrodes is coated with resistive material, thereby making it possible for a plurality of pulses to traverse the arc electrodes simultaneously and serially.

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

Figure 1 is a schematic perspective diagram of one preferred form of my invention.

Figure 2 is a similar diagram of a modification of the invention.

Figure 3 is a diagrammatic sectional view, partly in elevation, of a time delay tube having a resistive electrode.

Referring first to the device shown in Figure 1, a glass envelope 1 is provided at each end with reentrant stems 2 on which are mounted four electrodes. On one side of the tube is a longer arc electrode 4, extending the full length of the tube between the stems 2. In this particular embodiment, the electrode 4 may be of sheet metal, and flat. The longer arc electrode 4 is supported from the stems 2 by lead wires 5 one of which is continued to form an outside arc connection 6.

Positioned opposite the longer arc electrode 6 is a shorter arc electrode 7 also flat, and extending parallel and close to longer arc electrode 4. Shorter arc electrode 7 is supported by lead wires 9 and 10 from stems 2 and both of these lead wires 9 and 10 are continued to form outside arc connections 11 and 12 respectively on the outside of the tube.

Positioned at each end of shorter arc electrode 7 and in the plane thereof are two additional electrodes, a starting electrode 14 and an output electrode 15 supported from opposite stems on leads 16 and 17 respectively, both of which are extended for outside connection. The tube, after the usual baking and evacuation, is filled with an inert gas at a pressure of 50-200 mm. of mercury dependent on the size of the tube.

Outside of the tube, the two arc electrodes 4 and 7 are respectively connected through leads 6 and 12 to opposite ends of a source of arc potential 20 as for example, with the longer arc elec-

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trode 4 connected to the negative pole of the potential source 20 and with the shorter arc electrode 7 connected to the positive pole of the source 20. The potential of source 20 is of such a value that an arc between the two arc electrodes 4 and 7 just will not strike.

The starting electrode 14 is connected to the shorter arc electrode lead 12 through a starting resistance 21, the opposite ends of which are continued as input leads 22.

The output electrode 15 is connected to shorter arc electrode lead 11 through an output resistance 24 the opposite ends of which are connected to output leads 25.

A strong magnetic field is produced by magnet poles 26 energized by windings 27 connected to a generator 29 through a variable resistance 30. Poles 26 are positioned on the outside of the tube so that the magnetic field passes the longer and shorter arc electrodes and normal to perpendiculars connecting these two arc electrodes.

In the operation of the system, advantage is taken of the fact that an arc when struck, has a running voltage lower than the starting voltage, and that an arc tends to move at right angles to an applied magnetic field.

Thus when a pulse, such as might be generated in a mathematical counter or computer of electrical type, is applied to the starting electrode 14, the potential of the pulse, added to the potential of the arc potential source 20, is sufficient to start an arc between the starting electrode 14 and the longer arc electrode 4. The magnetic field immediately acts to move the arc lengthwise of the tube and the arc will be transferred to the shorter arc electrode 7, and will then act between the shorter and the longer arc electrodes. The arc will be maintained after the pulse was ceased because the running voltage is less than the potential of arc source 20. The arc will then be moved by the magnetic field along the arc electrodes 7 and 4 until the output electrode 15 is reached. The arc will then be transferred to that electrode, but will then go out. It is extinguished by two effects. It is blown out by the effect of the magnetic field, and the current flowing through output resistor 24 causes a voltage drop which reduces the voltage across the tube. Thus one input pulse has caused an arc to be struck and progressed along the tube to cause a pulse in an output circuit. This latter pulse can then be shaped and passed back into the computer. The time taken by the arc to move along the tube is the delay time between the input and output pulses, and this time is under the full control of the magnetic field. Thus by varying the applied field by use of the variable resistor 30, the same tube can be used for varying delay periods. As the length of the arc electrodes can be made large, time delay periods over a very considerable range can be obtained in a single system.

A modification of the invention to obtain a long arc travel without unduly lengthening the tube, is shown in Figure 2. Here, one of the arc electrodes is a central cylinder 35 surrounded by a spiral wire arc electrode 36 spaced from the cylinder 35. As in the previously described embodiment, the two arc electrodes are supported by reentrant stems 2.

As in the previous embodiment, a starting electrode, here in the form of a starting ring 37 is positioned at one end of spiral 36 and an output ring 39 is positioned at the other end of the spiral 36. The exterior connections are the same as described for Figure 1, except that in this case the

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magnetic field is axial and created by a solenoid 40 surrounding the tube. The arc in this case travels along the spiral electrode 36, between the spiral electrode and cylinder 35.

The modifications shown in Figures 1 and 2 are best adapted to handle only one arc at a time between the two arc electrodes, and in consequence the pulse transmission rate is limited by the delay period of the tube. In some instances it may be desirable to have both a relatively high pulse rate and a relatively long delay time. This type of operation can be attained by the use of the tube shown in Figure 3.

In this instance, the longer arc electrode is in the form of a conductor 41 coated with resistive material 41a, this conductor being held on stems 2 by glass tubing inserts 42, so that the input lead 6 connection to the conductor can be shielded from any possibility of direct arcing thereto inside the tube, as of course this lead connection is of higher potential than the electrode surface.

Parallel to the extent of the conductor 41 is the shorter arc electrode 7, with starting and output electrodes 14 and 15 respectively in the plane thereof, as in the embodiment of Figure 1. The exterior connections and magnetic field elements are the same as shown in Figure 1.

In the device of Figure 3 by coating the conductor 41 with a resistive coating material 41a a means is provided whereby a continuous progression of independent arcs along the tube can be maintained without any tendency of one arc interfering with the others. If a series of arcs were attempted to be maintained therebetween the electrodes without a resistive material coating on one of the electrodes the several arcs existing at one time would be unstable since the resistance in the paths of the ions creating the arcs all tend to vary, and hence all or some of the arcs would tend to combine to form a single arc at the discharge point and path giving the least resistance. By adding the resistive material coating 41a to the conductor 41, the potential drop of the current from the conductor through the resistive material stabilizes each particular arc discharge path so as to prevent any tendency of one arc interfering with the others as they move therebetween along the electrodes. Thus a high pulse rate can be maintained even though the delay periods are greater than the time spacing of the pulses.

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 several modes 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 time delay device comprising an envelope, a pair of parallel arc electrodes in said envelope, a filling of conductive gas in said envelope, means

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for starting an arc between said electrodes adjacent one end thereof, means for producing a magnetic field directed to move said arc along said electrodes, and means positioned adjacent the other end of said electrodes for detecting the arrival of the arc.

2. A time delay device comprising an envelope, a pair of parallel arc electrodes in said envelope, a filling of conductive gas in said envelope, means for starting an arc between said electrodes adjacent one end thereof, means for producing a magnetic field directed to move said arc along said electrodes, and means positioned adjacent the other end of said electrodes for detecting the arrival of the arc and means for varying the strength of said magnetic field to vary the transit time of said arc over said electrodes.

3. Apparatus in accordance with claim 1 wherein one of said electrodes is coated with resistive material.

4. A time delay device comprising an envelope, a pair of coextensive adjacent arc electrodes in said envelope, a filling of conductive gas in said envelope, a starting electrode adjacent one end of said arc electrodes, an output electrode adjacent the other end of said arc electrodes, means for energizing said arc electrodes to a potential just below the arc starting potential between said arc electrodes, means for applying a pulse to said starting electrode to start an arc between said arc electrodes, means for producing a magnetic

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field directed to move said arc along said arc electrodes and means connected to said output electrode for creating an indication of the arrival of said arc at said output electrode.

5. Apparatus in accordance with claim 4 wherein one of said arc electrodes is a cylinder and the other of said arc electrodes is a conductive member describing a spiral around said cylinder.

6. Apparatus in accordance with claim 4 wherein means are provided to vary the strength of said magnetic field to vary the transit time of said arc between starting and output electrodes.

7. Apparatus in accordance with claim 4 wherein one of said arc electrodes is coated with resistive material.

8. Apparatus in accordance with claim 4 wherein one of said arc electrodes is coated with resistive material and wherein said energizing means is connected to the resistive coated arc electrode at an end thereof.

9. Apparatus in accordance with claim 4 wherein one of said arc electrodes is coated with resistive material and wherein said energizing means is connected to the resistive coated arc electrode at an end thereof by a lead passing through said envelope, and wherein means are provided to prevent said arc from contacting said lead.

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No references cited.