

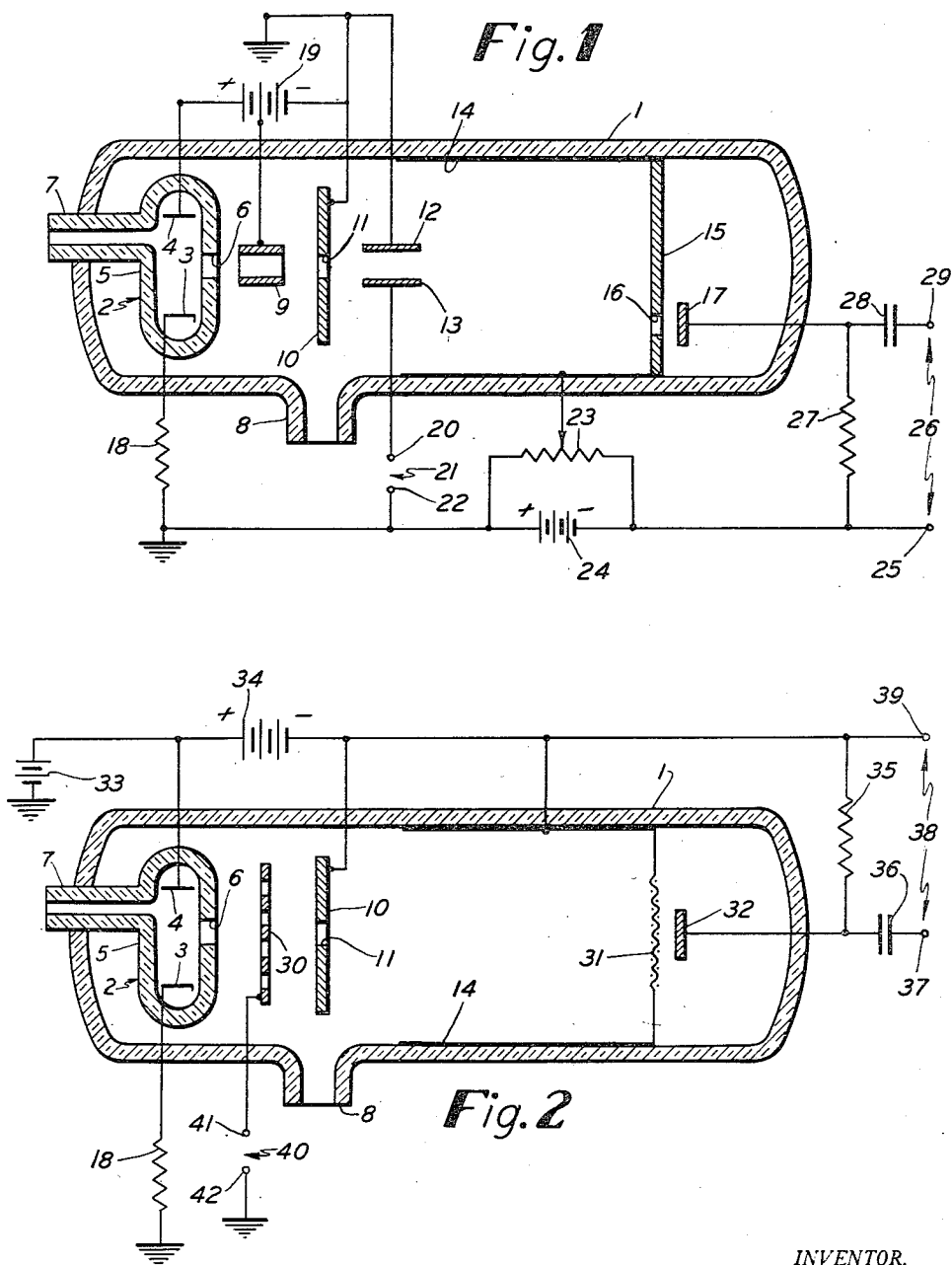
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TIME DELAY SPACE CHARGE DEVICE

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TIME DELAY SPACE CHARGE DEVICE

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The present invention relates to a time delay space charge device, and more particularly to a device for achieving relatively long delay times in electrical circuits, the order of such delay times being in the range of 10 to 50 microseconds.

Various electronic and circuit expedients have been proposed for the purpose of obtaining controlled delay in the conduction of a signal, such expedients being used for innumerable purposes as will readily occur to a person skilled in the art.

It is an object of this invention to provide a time delay space charge device which will produce a signal occurring a predetermined period of time later than the occurrence of an initiating control signal.

It is another object to utilize the transit time of a moving space charge in a space discharge device for the purpose of delaying a signal by a controllable period of time.

It is still another object of this invention to provide a space discharge device which produces a stream of commonly charged ions of relatively low velocity, this velocity being utilized for the purpose of creating apparent delay in the conduction of a signal from one point to another in a given electrical circuit.

It is still another object of this invention to provide a space discharge device capable of generating an ion discharge and transforming this discharge into a beam of low velocity ions which may be controlled in such a manner as to produce a delay in the transmission of a signal from one point to another in a given circuit.

In accordance with features of this invention, it is proposed to use a space discharge device comprising a source of commonly charged low velocity ions which are formed into a beam by a suitable accelerating electrode. Beam-deflecting means associated with the accelerating electrode is operative to deflect the beam from its normal unidirectional path into a second unidirectional path angularly related to the first, and a collector electrode is mounted in spaced relationship with respect to the beam-deflecting means so as to intercept the beam only during the time it is deflected along its second path whereby the charge of said beam will be collected by the collector electrode only after a period of time after a control signal has been applied to the beam-deflecting means, this period of time being dependent upon the velocity of the ions as they travel from the beam-deflecting means to the collector electrode.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawing, the scope of the invention being defined by the appended claims.

In the accompanying drawing:

Fig. 1 is a diagrammatic, sectional illustration of one embodiment of this invention; and

Fig. 2 is a similar illustration of another embodiment of this invention.

With reference first to Fig. 1, a space discharge device

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is shown as being comprised of a cylindrical envelope 1, made of any suitable material such as glass, which encloses a suitable arrangement of electrodes for generating a beam of charges of a common polarity. While it is to be understood that these charges may have either a positive or negative polarity, ion charges having a positive polarity are herein used in explaining the present embodiments. An ion generator 2, comprising a conventional electron-emissive cathode 3 and anode 4 suitably supported inside a suitable container or envelope 5, is mounted in position in the rear of the envelope 1. The generator envelope 5 is provided with a forwardly opening source aperture 6 and a rearwardly directed nipple 7 which is suitably arranged for connection to a source of mercury vapor or the like. An exhaust port 8 is provided in the wall of the envelope 1 to provide an outlet for gases or vapors introduced into the ion generator tube by means of the inlet nipple 7.

A tubular accelerating electrode 9 made of a suitable conducting material is coaxially supported inside the envelope 1 in registry with and adjacent to the ion source aperture 6. Adjacent the accelerating electrode 9 is a masking electrode 10 in the form of a disk having a centrally located beam aperture 11, the electrode 10 being supported in a position substantially normal to the axis of the envelope 1. Electro-static deflection plates 12 and 13 of conventional design are mounted in operative position adjacent the opening 11 in the masking electrode 10 so as to control the deflection of a beam of ions flowing from the source aperture 6, through the electrode 9 and the masked opening 11.

Another electrode 14 is constituted by a coating of electrically conductive material of conventional composition applied to the inner peripheral surface of the envelope 1 which extends from a point adjacent the deflecting plates 12, 13 to a point adjacent the front end of the envelope. This electrode 14 is terminated on its front or right-hand end by a conducting plate 15 having an off-center beam-passing aperture 16. To the right of the plate 15 but in registry with the opening 16 is mounted a collector electrode 17 also made of some suitable conducting material.

Suitable connecting leads extend from the foregoing electrodes to external operating circuitry which is comprised of a cathode resistor 18 extending from the cathode 3 to ground and a battery 19 connected between the anode 4 and ground, the positive terminal of the battery 19 being connected to the anode 4. The accelerating electrode 9 is preferably connected to a potential on battery 19 intermediate the ends thereof, and masking electrode 10 is grounded as shown. The deflecting plate 12 is connected to ground, while the plate 13 is connected to a terminal 20 of the control voltage input circuit 21 which has another terminal 22 leading to ground. A potentiometer circuit comprised of a variable resistor 23 and the battery 24 connected in parallel has its positive lead grounded and its negative lead directly connected to a terminal 25 of the system output circuit generally indicated by the reference numeral 26. A signal-forming resistor 27 is interposed between the collector electrode 17, and the line connected to terminal 25, and a suitable signal-coupling capacitor 28 is connected from the collector electrode 17 to the terminal 29 of the output circuit 26. The slider of the potentiometer 23, 24 is connected to the electrode 14, this slider being adjustable to apply the desired velocity control potential to this electrode. Generally, with this arrangement of circuitry and applied potentials, a positive ion existing inside the ion generator 2 will be withdrawn from the generator through the source aperture 6, through the accelerating electrode 9, the masking aperture 11, between the deflect-

ing plates 12 and 13, and coaxially through the electrode 14 after which it impinges against the central portion of the end plate 15. All of the electrodes are so arranged that with no signal applied to the input circuit 21, the normal path of the ion moving from left to right through the tube will terminate near the center of the plate 15, and in any event at a position offset from the deflection aperture 16 in the plate 15.

In the operation, the cathode 3 is caused to emit electrons which flow toward the anode 4. A vapor such as mercury introduced into the container 5 is ionized by bombardment of the electrons therewith, and the ions thereby produced are formed into a suitable beam which traverses to the right to impinge normally against the central portion of the end plate 15. By applying a pulse of signal voltage to the input circuit 21 in such polarity that the plate 12 is made more positive than the plate 13, the beam will deflect downwardly at an angle to the normal beam path and will pass through the deflecting aperture 16 and impinge on the collector electrode 17. Since the ions travel at relatively low velocity, a relatively long period of time will elapse between the instant of applying the signal to the circuit 21 and the instant at which the deflected ion beam reaches the collector 17. Knowing the velocity of the ions comprising the beam, it is possible to compute the period of time elapsed in the beam traveling from the plates 12, 13, to the collector 17.

Since in order to obtain accurate results it is necessary to know the velocity of the beam, a known uniform velocity can be imparted to the beam by the use of the electrode 14 which completely surrounds the beam path from the point of deflection to the point of collection.

Assuming the condition of no signal applied to the input circuit 21, a conducting circuit extending from ion generator 2 to the plate 15 will be established from the plate 15, through the electrode 14, the potentiometer circuit 23, 24, and back to the ion generator 2. However, upon application of a suitable control signal to the input circuit 21, the beam is deflected downwardly through the aperture 16 whereupon the circuit conducting a signal induced by the ion beam now includes, instead of the plate 15, the collector 17, resistor 27, potentiometer battery 24, and the ion generator 2. As the beam strikes the collector electrode 17, the current produced thereby passes through the signal-producing resistor 27 which is coupled to the terminals 25, 29 of the output circuit 26 where it may be observed or utilized. By using known techniques for measuring time between an initiating pulse and an initiated pulse the elapse of time between the application of a signal to the input circuit 21, and the occurrence of the ion beam-produced signal appearing in the output circuit 26 may be measured.

The time delay occurring between the signal appearing at the input and output circuits 21 and 26, respectively, may be calculated mathematically as follows: For ions, the velocity v_i is given by the equation

$$v_i = 6 \times 10^7 \frac{V(M_e)^{\frac{1}{2}}}{(M_i)}$$

centimeters per second where "V" is expressed in volts, and M_e and M_i are electron and ion masses, respectively. Now if the distance between the deflection plates 12, 13 and the collector 17 is represented by the letter "L," the output pulses appearing at the output circuit 26 will be delayed by

$$t = \frac{L}{v_i} = \frac{L}{6 \times 10^7 V^{\frac{1}{2}} \left(\frac{M_i}{M_e} \right)^{\frac{1}{2}}}$$

To obtain large delay times with reasonable length dimension "L," "V" should be small, and " M_i " large. Therefore, mercury ions are contemplated, for which

$$\left(\frac{M_i}{M_e} \right)^{\frac{1}{2}} = 605$$

Thus, approximately,

$$"t" = \frac{10L}{V^{\frac{1}{2}}}$$

microseconds. (L is in centimeters, V in volts.) Assuming for example a value of 100 volts for V, and 30 centimeters for the length L, a delay time "t" of 30 microseconds will be achieved. The exact value of delay can be regulated by adjusting the D. C. voltage "V" on electrode 14, which, in the preferred embodiment should be fairly stable and supplied by a regulated voltage supply.

With reference to Fig. 2, a similar embodiment is illustrated wherein like numerals represent like parts. Instead of using the accelerating electrode 9, a grid 30 of suitable mesh size and of conventional construction is mounted adjacent the ion source aperture 6. The masking electrode 10 is spaced from the grid 30 but is in registry with the source aperture 6, and the velocity control electrode 14, instead of being terminated in a solid plate, is terminated in a conducting screen 31 which may be similar in construction to the grid 30. The collector 32 in this embodiment is centrally mounted in the envelope 1 in registry with the line extending from the source aperture 6 and the masking opening 11. A battery 33 is connected with its positive terminal leading to the anode 4 and its negative terminal to the ground. Another battery 34 is connected with its positive terminal leading to the masking electrode 10 and its negative terminal leading to the masking electrode 10. A connection is also made between the electrode 10 and the velocity electrode 14. A resistor 35 is conductively connected between the collector 32 and the electrode 14, and a coupling capacitor 36 leads from the upper end of the resistor 35 to a terminal 37 of the output circuit 38. The other terminal 39 of this output circuit 38 leads to the lower end of the resistor 35. The signal input circuit, generally indicated by the reference numeral 40, is connected with one terminal 41 leading to the control grid 30 and the other terminal 42 leading to ground.

In the operation of this second embodiment, ions are generated as in the previously described embodiment and are formed into a beam by means of the negatively charged masking and accelerating electrode 10, the beam passing through the space surrounded by the electrode 14 to impinge on the collector 32. The screen 31 serves as a shield for the collector 32 and acts similarly to the usual screen grid in conventional vacuum tubes. In the present instance, use of the screen 31 is essential because otherwise a displacement current produced by the moving ions would cause a current to flow in the collector 32 during the entire time of transit. The screen 31 prevents this displacement current so that signal current can be induced in the collector only during the short time it takes the ions to move between the screen 31 and the collector 32.

In the embodiment of Fig. 1, the plate 15 provided the necessary shielding between the collector and the non-deflected beam.

In the operation of this second embodiment, the application of a signal to the input circuit 40 will serve to vary the flow of ions through the grid and consequently the intensity of the beam directed toward the collector 32. The transit time of this variation in the beam as it travels from the control grid to the collector 32 constitutes the measurable time delay.

From the foregoing description and the brief mathematical analysis, it is seen as being possible to obtain a regulated delay by varying the potential applied to the wall coating 14. Further, it is possible to obtain a variance by using a vapor other than mercury which produces ions of different mass.

While there has been described what is at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various

changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A time delay space charge device comprising a source of commonly charged ions, electrode means associated with said source for forming a beam comprised of said ions and for directing said beam along a predetermined path, beam-deflecting means associated with said electrode means and operative to deflect said beam from said predetermined path into a second path, an anode electrode spaced from said beam-deflecting means and having a beam-intercepting surface disposed in said predetermined path and an aperture in said surface in registry with said second path, and a beam-collecting electrode mounted opposite said aperture so as to collect the charge of said beam after it passes through said aperture whereby the charge of said beam will be collected by said beam-collecting electrode only upon deflection of said beam into said second path.

2. A time delay space charge device comprising a source of commonly charged ions, electrode means associated with said source for forming a beam comprised of said ions and for directing said beam along a predetermined path, beam-deflecting means associated with said electrode means and operative to deflect said beam from said predetermined path into a second path, an anode electrode spaced from said beam-deflecting means and having a beam-intercepting surface disposed in said predetermined path and an aperture in said surface in registry with said second path, and a beam-collecting electrode mounted opposite said aperture so as to collect the charge of said beam after it passes through said aperture, said anode and beam-collecting electrodes being physically separated so that the former collects the beam charge from the first path only and the latter collects the charge from the second path only.

3. A time delay space charge device comprising a source of commonly charged ions, an accelerating electrode mounted adjacent said source and serving to form a beam composed of moving ions derived from said source, beam-deflecting means positioned adjacent the path of said beam as it emanates from said accelerating electrode and operative to deflect said beam into a second path angularly related to the first path, anode electrode means disposed to obstruct both paths but having an aperture in registry with said second path, and a collector electrode mounted adjacent said aperture to receive said beam as it passes therethrough whereby only said anode means receives the charge of said beam in the first-mentioned path and only said collector electrode receives the charge of said beam in said second path.

4. A time delay space charge device comprising a source of commonly charged ions, an accelerating electrode mounted adjacent said source and serving to form a beam composed of moving ions derived from said source, beam-deflecting means positioned adjacent the path of said beam emanating from said accelerating electrode and operative to deflect said beam into a second path angularly related to the first path, anode electrode means disposed to obstruct both paths but having an aperture in registry with said second path, a collector electrode mounted adjacent said aperture to receive said beam as it passes therethrough whereby only said anode means receives the charge of said beam in the first-mentioned path and only said collector electrode receives the charge of said beam in said second path, and circuit

means for applying a beam-deflecting potential to said beam-deflecting means for switching said beam from its first to its second path.

5. A time delay space charge device comprising a source of ion discharge, said source including spaced anode and cathode electrodes submerged in a vapor which is ionized by bombardment of the electrons flowing from the cathode to the anode, an enclosure for said vapor and said electrodes having a source aperture through which the ion discharge may be attracted, an ion accelerating electrode mounted adjacent said source aperture for forming the ion discharge into a low velocity beam which propagates along a first path, beam-deflecting means positioned adjacent the path of said beam emanating from said accelerating electrode and operative to deflect said beam into a second path angularly related to the first path, anode electrode means disposed to obstruct both paths but having an aperture in registry with said second path, and a collector electrode mounted adjacent said aperture to receive said beam as it passes therethrough whereby only said anode means receives the charge of said beam in the first-mentioned path and only said collector electrode receives the charge of said beam in said second path.

6. A time delay space charge device comprising a source of commonly charged ions, electrode means associated with said source for forming a beam comprised of said ions and for directing said beam along a predetermined path, a beam-intensity control electrode interposed in the path of said beam, an anode electrode spaced from said control electrode and having a beam-intercepting surface disposed in said path for collecting the charge of said beam, a signal input circuit coupled to said control electrode, and circuit means operatively coupled between said control electrode and said anode for determining the travel time of said beam as it passes from said control electrode to said anode.

7. A time delay space charge device comprising a source of commonly charged ions, electrode means associated with said source for forming a beam comprised of said ions and for directing said beam along a predetermined path, a control electrode interposed in the path of said beam, an anode electrode spaced from said control electrode and having a beam-intercepting surface disposed in said path for collecting the charge of said beam, a signal input circuit coupled to said control electrode, and circuit means operatively coupled between said control electrode and said anode for determining the travel time of said beam as it passes from said control electrode to said anode.

8. A time delay space charge device comprising first means for forming an ion beam, second means situated at a first cross-section of said beam to modulate it, third means situated at a second cross-section to detect the modulation, and circuit means operatively coupled to said first means to determine the beam-velocity between both cross-sections.

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