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DELAY DEVICE

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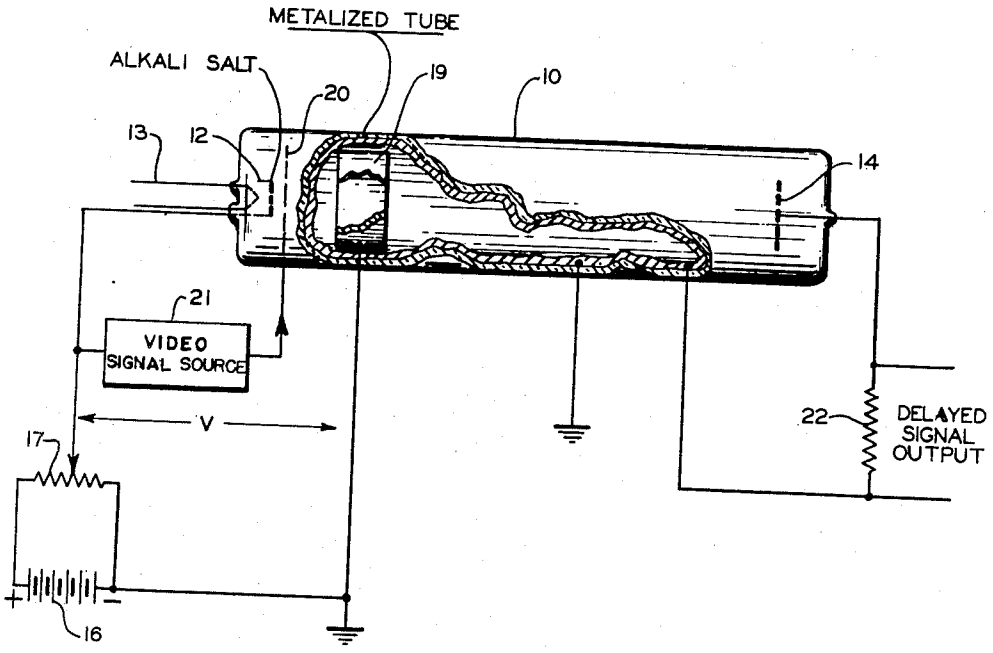

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DELAY DEVICE

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This invention relates to a delay line and more particularly to a variable delay line using a beam of positive ions.

A delay line constructed according to the principles of this invention provides means for electrically varying the delay time. Furthermore, this delay line is advantageous over those heretofore used in that video signals can be applied directly to the line without using a carrier frequency for the video signal.

It is accordingly an object of the present invention to provide a delay line using a beam of positive ions.

A further object of the present invention is to use the transit time of positive ions to delay video signals.

A still further object of the present invention is to provide a delay line having means for electrically varying the delay time.

Another object of the present invention is to provide a delay line such that a video signal can be applied directly to the line without the use of a carrier frequency for the video signal.

These and other objects of the present invention will become apparent from the following specification when taken with the accompanying drawing, the single figure of which is a schematic representation of one embodiment of the invention.

Referring to the figure there is shown an embodiment of the invention suitable for use in a system using the transit time of positive ions to delay signals. This system comprises an evacuated metalized glass tube **10** containing an alkali salt electrode **12** and a collector electrode **14** disposed at opposite ends thereof. Electrode **12**, a source of positive ions, heated by means of a filament **13**, is electrically connected to a source of positive potential **16** through a variable resistance **17**. An accelerating electrode **19**, interposed between electrode **12** and electrode **14** is negatively charged with respect to electrode **12** and is preferably at ground potential. For beneficial results electrode **19** is located in the proximity of electrode **12**. A grid **20** in the vicinity of electrode **12**, and between electrode **12** and electrode **19** is electrically connected to the source of the signal being delayed by the system, as for example a video signal **21**. The delayed signal source output is obtained across a resistance **22** which is electrically connected between electrode **14** and metalized surface of tube **10** which is at ground potential.

The operation of this device is illustrated hereafter as using potassium as the alkali metal of electrode **12**, and a video signal as the signal being delayed. It is to be understood that it is applicable to other alkali metals and other signals. In operation this invention utilizes the transit time of a beam of positive ions to delay video signals. The positive potassium ions are emitted by potassium electrode **12** when heated by filament **13**. Electrode **19** being at a negative potential acts as an accelerating potential for the positive ions. Electrode **14** acts as the collector electrode. The video signal applied to control grid **20**, causes intensity modulation of the ion beam in the evacuated tube. This modulation is reconverted to a delayed video signal upon removal across resistance **22**.

The delay is dependent on the velocity attained by the positive ion. The smaller the velocity of the ion can be made, the greater the delay accomplished by the system. The velocity of the positive ion is given by:

$$v=\left(\frac{2eV}{m}\right)^{\frac{1}{2}} \tag{A}$$

where

e=charge on the ion
V=accelerating potential in e. s. u., and
m=mass of the ion in grams.

Thus it is necessary that the accelerating potential should be small and the mass of the ion large. For example letting the potential $V=25$ volts, and using potassium the mass of whose ion is 6.5×10^{-23} grams, and solving for v in Equation A, the velocity would be approximately 1×10^{6} cm./sec. Thus a delay of approximately one microsecond per centimeter of length of the evacuated tube is attained. By varying the effective accelerating potential by means of variable resistance **17** it can readily be seen that the delay can be varied.

Due to the thermal distribution of velocities of emission of the positive ions from the alkali electrode there will be some spread in delay time. This spread though will be small as shown by: substituting

$$\frac{s}{t}$$

for v in the equation

$$v=\left(\frac{2eV}{m}\right)^{\frac{1}{2}}$$

and differentiating dt/t. This gives the equation

$$dt/t=\left(\frac{dV}{V}\right)\times\tfrac{1}{2} \tag{B}$$

in which dt is the spread in delay time, t the total delay time, dV the variation of accelerating potential and V the accelerating potential. If, for example, the variation of potential is as much as $\frac{1}{10}$ volt, the spread in delay time will be:

$$\frac{dt}{t}=\left(\frac{1}{10}\Big/25\right)\times\tfrac{1}{2}=\frac{1}{500}$$

Thus there is a spread in delay time of only 1 microsecond for a delay of 500 microseconds.

A delay line as contemplated by this invention thus provides a novel system which will produce a variable delay. This delay can be readily regulated and the system is such that a signal can be applied directly to the grid and removed at the collector electrode.

The invention described in the foregoing specification need not be limited to the details shown which are considered illustrative of one form the invention may take.

What is claimed is:

1. A delay line for electrical signals comprising an evacuated tube, a positive ion emitting electrode, means disposed within said tube for accelerating positively charged ions emitted from said first mentioned electrode, means disposed within said tube for collecting positively charged ions emitted by said first-mentioned electrode, a grid disposed within said tube between said first-mentioned electrode and said accelerating means having input signals electrically connected thereto, means for varying the potential on said first mentioned electrode and means electrically connected to said collector means for removing said electrical signals from said collector means.

2. A delay line for electrical signals comprising an evacuated tube, a positive ion emitting electrode, an accelerating electrode within said tube for accelerating positively charged ions emitted from said first-mentioned electrode, means disposed within said tube for collecting positively charged ions emitted by said first-mentioned electrode, a grid disposed within said tube between said first-mentioned electrode and said accelerating electrode having input signals electrically connected thereto, means for varying the potential on said first-mentioned electrode, and means eletcrically connected to said collector means for removing said electrical signals from said collector means.

3. A delay line for electrical signals comprising an evacuated tube, a positive ion emitting electrode, an accelerating electrode within said tube for accelerating positively charged ions emitted from said first-mentioned

electrode, a collector electrode disposed within said tube for collecting positively charged ions emitted by said first-mentioned electrode, a grid disposed within said tube between said first-mentioned electrode and said accelerating electrode, means for varying the potential on said first-mentioned electrode, and means electrically connected to said collector means for removing said electrical signal from said collector means.

4. A delay line for video signals comprising an evacuated tube, a positive ion emitting electrode, an accelerating electrode within said tube for accelerating positively charged ions emitted from said first-mentioned electrode, a collector electrode disposed within said tube for collecting positively charged ions emitted by said first-mentioned electrode, a grid disposed within said tube between said first-mentioned electrode and said accelerating electrode having a source of video signals operatively connected thereto, means for varying the potential on said first-mentioned electrode, and means electrically connected to said collector means for removing said video signal from said collector means.

5. A delay line for video signals comprising an evacuated tube, a positive ion emitting electrode within said tube, an accelerating electrode within said tube negatively charged with respect to said first-mentioned electrode for accelerating positively charged ions emitted from said first-mentioned electrode, a collector electrode disposed within said tube for collecting positively charged ions emitted from said first-mentioned electrode, a grid disposed within said tube between said first-mentioned electrode and said accelerating electrode having a source of video signals operatively connected thereto, means for varying the potential on said first-mentioned electrode, and means electrically connected to said collector electrode for removing said video signal from said collector electrode.

6. A delay line for video signals comprising an evacuated tube, a potassium salt coated electrode within said tube, an accelerating electrode within said tube negatively charged with respect to said potassium salt coated electrode for accelerating potassium ions emitted by said potassium salt coated electrode, a collector electrode disposed within said tube for collecting potassium ions emitted from said potassium salt coated electrode, a grid disposed within said tube between said accelerating electrode and said salt coated electrode having a source of video signals operatively connected thereto, means for varying the potential on said salt coated electrode, and means electrically connected to said collector electrode for removing said video signal from said collector electrode.

7. A delay line for video signals comprising an evacuated tube, a potassium electrode within said tube, an accelerating electrode within said tube negatively charged with respect to said potassium electrode for accelerating potassium ions emitted by said potassium electrode, a collector electrode disposed within said tube for collecting potassium ions emitted from said potassium electrode, a grid disposed within said tube between said potassium electrode and said accelerating electrode having a source of video signals electrically connected thereto, a variable potentiometer for varying the potential on said potassium electrode, and means electrically connected to said collector electrode for removing said video signal from said collector electrode.

8. A delay line for video signals comprising a positive ion emitting anode, a grid electrically connected to a video signal, an accelerating electrode, and a cathode; said anode, said grid, said electrode, and said cathode disposed in a spaced relationship and enclosed in a metalized evacuated glass tube; means for varying the potential on said anode, and means for applying an electrical signal to said grid and removing said signal from said cathode.

9. Apparatus for delaying video signals comprising, a generator of a beam of positive ions, said generator including at least an emitting electrode, a grid, and a collector electrode enclosed in an evacuated envelope having a conductive shield, said emitting electrode being the source of said positive ions, means for applying said video signals between said grid and said emitting electrode for modulating said beam, and means for extracting said video signals across said collector electrode and said conducting shield.

10. Apparatus as in claim 9 including means for varying the voltage gradient between said emitting electrode and said collector electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,629,009	Snook	May 17, 1927
1,767,218	Kunsman	Jan. 24, 1930
2,179,601	Smith	Nov. 13, 1939
2,321,335	Tolson	June 8, 1943
2,456,466	Sunstein	Dec. 14, 1948