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Janning

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[54] **PLASMA SHIFT REGISTER WITH OVERLAPPING GLOW**

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[51] **Int. Cl.** **H03k 23/38**

[58] **Field of Search** 315/84.5, 84.6, 169 R; 328/37; 313/307

[56] **References Cited**

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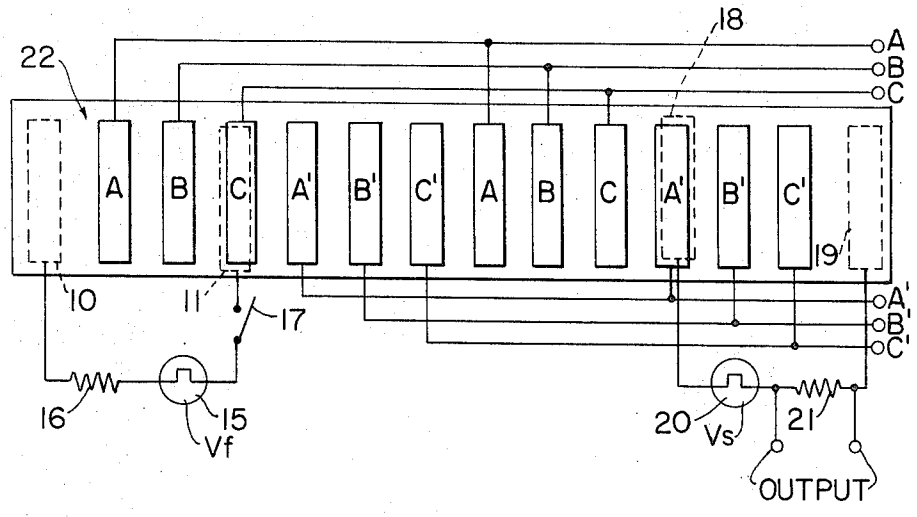
[57] **ABSTRACT**

A plasma gas shift register is provided wherein pairs of electrodes overlapping in space are affixed to an insulating substrate and are overcoated with a dielectric layer. A plasma gas is sealed into contact with the dielectric layer. Clocked signals connected to the electrode pairs cause a shift of any discharge existing between one pair of electrodes to the next pair of electrodes overlapping the discharge pair. Input electrode means for causing a discharge in response to one state of input signal and no discharge in response to another state of an input signal are placed opposite the first pair of overlapping in space electrodes. Output electrode means are positioned opposite the last pair of overlapping in space electrodes to detect the presence or absence of a discharge between the last pair of overlapping electrodes.

5 Claims, 7 Drawing Figures



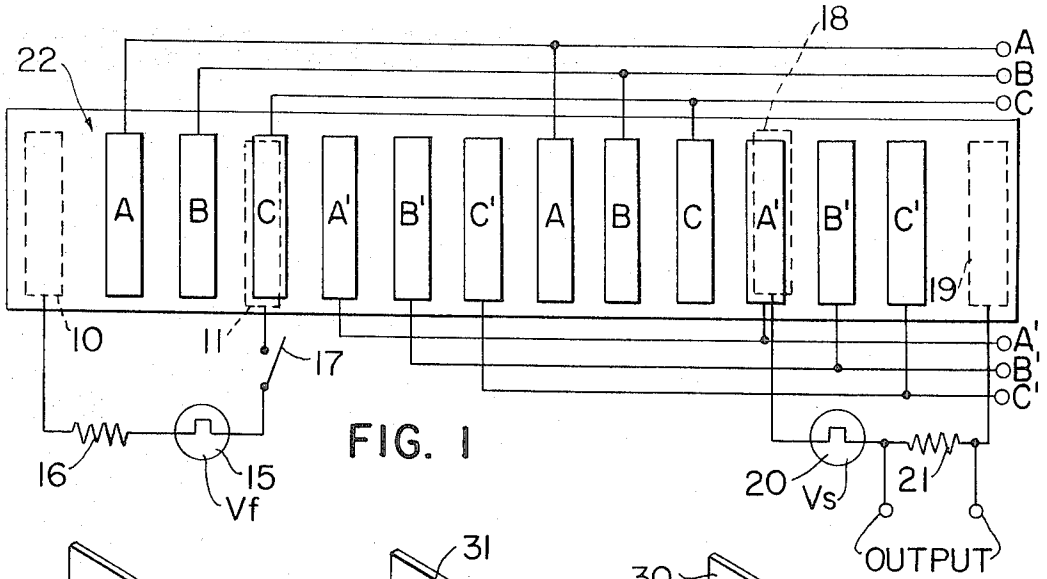


FIG. 1

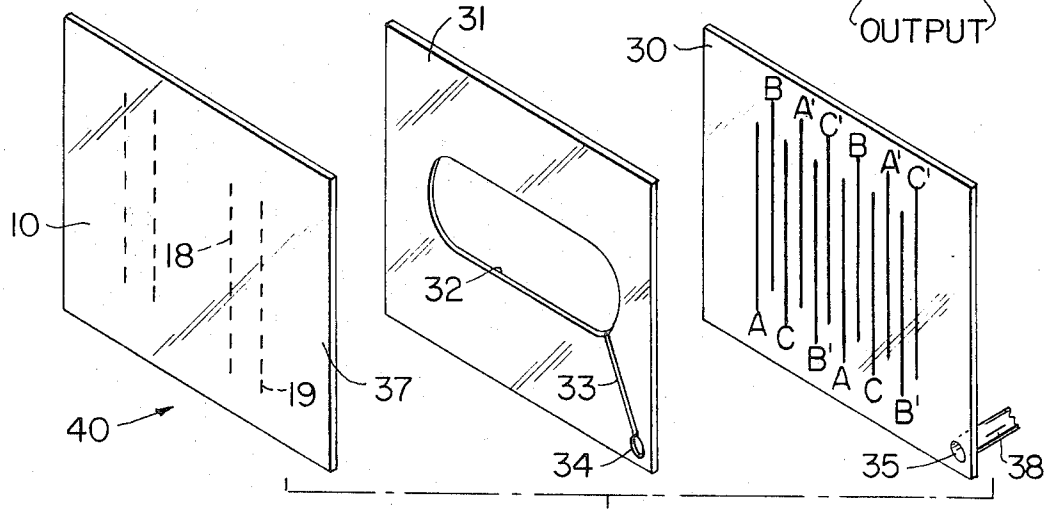


FIG. 2

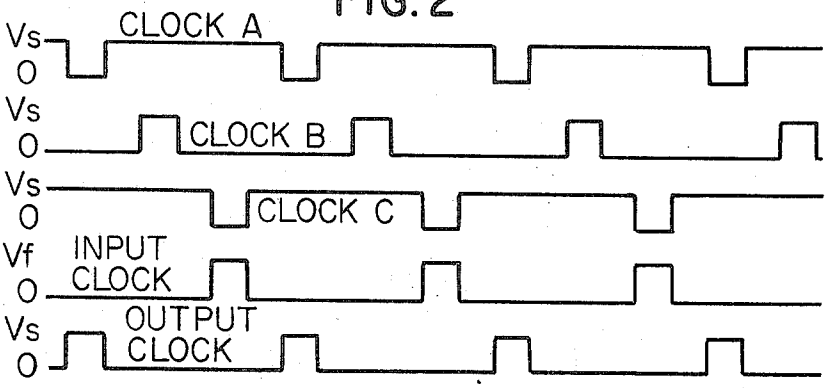


FIG. 3A

FIG. 3B

FIG. 3C

FIG. 3D

FIG. 3E

PLASMA SHIFT REGISTER WITH OVERLAPPING GLOW

BACKGROUND OF THE PRESENT INVENTION

This invention relates to a plasma device in which plasma discharges are moved along the device in shift register fashion.

In U.S. Patent application Ser. No. 255,547, entitled "Plasma Charge Transfer Device", by William E. Coleman, there is disclosed a shift register device wherein electrodes are alternately staggered on opposite sides of the plasma medium and the electrodes have potentials applied to them so as to cause a discharge to either be stepped along the device or held in place affording a latching action. Once a discharge takes place a wall charge builds on the electrodes with a potential that opposes the applied potential. Within a short period of time the discharge ceases because the sum of the applied potential and wall charge drops below the extinguishing potential of the cell.

The present invention does away with the dependence on wall charge and uses instead the phenomenon of metastable decay. A variable in the potential level required to cause a plasma discharge is the ambient radiation to which the plasma medium is exposed. For example, a plasma discharge can be initiated in a cell at a lower voltage when exposed to light than when placed in darkness. Also, a radio-active source in close proximity can initiate a discharge at a lower voltage. When a cell has been fired and the voltage removed, it can be fired again at a lower voltage if attempted soon enough. Due to a phenomenon of metastable decay, the refiring voltage is a function of how long a time the cell has been off. If the refiring is attempted within a few microseconds, the refiring voltage may be approximately 85% of the initial value required.

SUMMARY OF THE INVENTION

In the preferred embodiment of the present invention there is provided a plasma gas cell which contains a plurality of pairs of electrodes that overlap in space. Voltage means connected to said pairs of electrodes, provides a sequencing voltage to the electrodes for shifting discharges along the length of the device. Input means are provided for initiating a discharge in proximity to the first pair of overlapping electrodes and output means are provided for detecting the presence or absence of a discharge at the last pair of overlapping electrodes. The sequence voltage occurs at a repetition rate which is quick enough to take advantage of the metastable decay occurring after a preceding discharge.

From the foregoing it can therefore be seen that a principal object of the present invention is to provide an improved plasma gas shift register.

It is a further object of the present invention to provide a plasma gas shift register which utilizes the phenomenon of metastable decay.

It is another object of the present invention to provide a plasma gas shift register wherein a discharge is caused to exist in proximity to overlapped in space electrodes so as to provide a metastable state wherein a discharge can be formed between said electrode pair.

These and other objects of the present invention will become more apparent when taken in conjunction with the following description and drawings wherein like characters indicate like parts and which drawings form a part of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an electrical schematic of the preferred embodiment of the invention;

FIG. 2 is an exploded view of the preferred embodiment; and

FIGS. 3*a* to 3*e* are wave forms useful in understanding the operation of the embodiment shown in FIGS. 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a pair of spaced apart input electrodes **10** and **11** are connected to a pulse voltage source **15** through a current limiting resistor **16**. The potential level V_f and repetition rate of pulse source **15** are such that a plasma discharge will take place between electrodes **10** and **11** when the pulse source is connected to the electrodes through switch **17**. A plasma medium **22**, such as a neon gas mixture of 95percent neon and 5percent nitrogen, is maintained in close proximity (or contact) to the electrodes. The electrodes labeled A, B and C are paired with the corresponding electrodes A′, B′ and C′ and are overlapped in space. Two sets of these overlapping paired electrodes are shown in FIG. 1 but any number can be used. For example with a four phase clock signal another set of electrodes could be inserted, one between the C and A′ electrodes and the other between the C′ and A electrodes.

The input electrodes **10** and **11** can be spaced apart further to cover the additional electrodes of a set. A higher potential level V_f is then required for source **15** in order to achieve a discharge between the input electrodes. If the input electrodes are spaced closer together less potential is necessary to cause a discharge but also less metastables are available after the discharge for use by the paired electrodes. A trade-off in design is generally made with the input electrodes overlapping at least the first three electrodes of a three pair as shown in FIG. 1.

A pair of output electrodes **18** and **19** are connected together by means of resistor **21** and a pulsed voltage source **20**. The potential level V_s of voltage source **20** is lower than source **15** so that a discharge will not take place between electrodes **18** and **19** unless a discharge existed previously between the last pairs of electrodes C and C′. When a discharge is initiated between electrodes **18** and **19** a current flows through resistor **21**. The voltage resulting from the current flow is sensed across the terminals labeled output.

Referring now to FIG. 2, the plasma charge shift register **40** is shown comprised of two end plates **37** and **30** sandwiching a center plate **31**.

The input and output electrodes **10, 11** and **18, 19**, respectively, are deposited on the inner surface of plate **37**. Plate **37** can be a glass or other suitable insulating material. The overlapping electrodes A, B, C, and A′, B′, C′ are formed on the inner surface of the plate **30**. Although not specifically shown in the drawing, it is understood that lead conductors connect the respective electrodes to other conductors external to the device. The thin dielectric coating can be deposited over the electrodes if desired. The coating will extend the life of the electrodes by insulating them from the plasma gas. The center plate **31** has a large opening **32** defined

therein. The opening is of a sufficient size to expose all of the electrodes to the space defined by the opening. A small channel **33** extends from the opening **32** to the hole **34.** Hole **34** aligns with hole **35** in plate **30** when the plates are sandwiched together. A tube **38** connected to plate **30** and aligned with opening **35** is used to evacuate the space formed when the sandwich plates are sealed along their edges. The plates may be sealed using a glass frit mixture coupled with sufficient heat to make the mixture cure. When the space is evacuated a plasma gas mixture (neon mixture) can be inserted into the evacuated space and tube **38** sealed.

Referring now to the waveforms of FIGS. *3a* to *3e*, in combination with the schematic of FIG. **1**: The signal clock A is applied across the electrodes labeled A and A' by any well known source of clock pulses not shown for purposes of clarity. The signal clock B is applied across the electrodes labeled B and B'. The signal clock C is applied across the electrodes labeled C and C'. These clock signals are applied sequentially to the respective electrodes not simultaneously. The input generator **15** provides the input clock signal shown in FIG. *3d* which has a potential level of V_f. The output generator **20** provides the output clock signal shown in FIG. *3e* which has a potential level of V_s. To function it is only necessary that the clock signals provide a differential potential of V_s across the electrode pairs. Clocks A, B and C switch between potential levels V_s and ground. The signal clock B is maintained at zero potential and switched to the potential V_s only when it is desired to acheive a discharge between the B and B' electrodes.

In operation when the input clock pulse (FIG. *3d*) reaches the value V_f a discharge takes place between electrodes **10** and **11,** which discharge overlaps the A and B electrodes of the first set. Electrodes A and B may be at some other potential or ground, but this will not influence the discharge between electrodes **10** and **11** noticably. Shortly after the occurrence of the input clock pulse a pulse of magnitude V_s is applied across electrodes A and A'. The discharge will then appear between the A and A' electrodes. Shortly after the occurrence of the A pulse there is a B pulse of magntidue V_s which starts the discharge between the B and B' electrodes. Similarly when the C pulse occurs across the electrodes C and C' a discharge takes place between these electrodes. Because a discharge existed between the overlapped electrodes there occurred a metastable decay phenomenon when the discharge ceased. Be applying the potential V_s to the overlapping pair of electrodes in the vicinity of the metastable decay before the decay reached a low level, it is possible to cause a new discharge with a potential that is lower than V_f. The fact that a discharge will not take place at the potential V_s unless there has been a recent discharge occurring in the vicinity of the overlapped electrodes permits the device to be used as a shift register.

A new input can be fed into the device simultaneously with the application of the C clock pulses to the C and C' electrodes. Shortly thereafter the output clock (FIG. *3e*) is applied across electrodes **18** and **19.** If a high enough metastable state exists in the overlapped electrodes between **18** and **19** a discharge will occur and the current caused by this discharge will flow through resistor **21** and be detected as an output voltage.

In the preferred embodiment of the invention the electrode plates are silver deposited on a glass substrate. The electrodes are approximately 0.020inches to 0.030inches in width and are spaced approximately 0.010inches apart on the glass substrate.

The voltage pulses applied to the electrodes are of an amplitude of approximately 250 volts and a width of approximately 2 microseconds occurring at a rate of approximately 30 K Hz.

The plasma gas is a mixture of 99.7percent Neon, 0.2percent Nitrogen and 0.1percent Argon at a pressure of approximately 90 Torr.

If a glass insulating material is positioned over the electrodes its thickness should be approximately 0.2 thousandths of an inch.

While there has been shown what is considered to be the preferred embodiment of this invention, it will be manifest that many changes and modifications could be made herein without departing from the spirit and scope of the invention, the scope of the invention being limited only by the scope of the claims.

What is claimed is:

1. A plasma gas shift register comprising in combination:

means including at least one envelope defining an elongated channel containing a plasma gas;

a plurality of substantially evenly spaced pairs of electrodes with an electrode of each pair overlapping into the space between the first pair of evenly spaced electrodes, all of said electrodes mounted along said elongated channel on one inner surface of said envelope;

input means positioned at one end of said channel on the inner surface opposite said one inner surface for causing a plasma discharge in the vicinity of at least one pair of overlapping electrodes;

output means positioned at the opposite end of said channel on the inner surface opposite said one inner surface for detecting the presence of a plasma discharge in the vicinity of the last pair of overlapping electrodes; and

means for applying a sequential stepping potential to said pairs of overlapping electrodes so as to cause the plasma discharge to be advanced along said channel.

2. A plasma gas shift register comprising in combination:

a channel containing a plasma gas;

a plurality of substantially equally spaced electrodes positioned along the length of one surface of said channel in proximity to the plasma gas;

input means positioned on the surface opposite said one surface of said channel for causing plasma discharges adjacent the equally spaced electrodes at one end of said channel;

means for applying periodic potentials across nonadjacent pairs of spaced electrodes so as to initiate a plasma discharge between the nonadjacent pairs of electrodes exposed to a plasma discharge such that plasma discharges occur sequentially along the length of said channel; and

output means positioned on the surface opposite said one surface of said channel for detecting the presence of a discharge between the last pair of nonadjacent electrodes in said channel and for providing an indication of said detection.

3. A plasma gas shift register comprising in combination:

means including at least one envelope defining an elongated channel containing a plasma gas;

input electrode means positioned on one inner surface within said channel for causing a discharge at one end of said channel upon receipt of an input potential:

a plurality of electrode pairs arrayed in an overlapping in space sequence along the surface opposite said one inner surface within said channel and coupled to said gas for transferring a discharge at one end of said channel to the opposite end of said channel by the application of electrical energy across each pair of electrodes in sequence; and

output electrode means positioned on one inner surface within said channel for detecting a discharge existing at the other end of said channel and for providing an output indicative of the detected discharge.

4. A plasma shift register comprising in combination:

means including at least one envelope defining an elongated channel containing plasma medium;

a plurality of substantially envenly spaced pairs of electrodes mounted in proximity to said plasma medium on one surface of said envelope with an electrode of each succeeding pair overlapping onto the space between the preceeding pair of electrodes;

a pair of input electrode means mounted on the surface opposite said one surface and positioned overlapping at least the first electrode at one end of said channel for causing a discharge in the plasma gas;

means for applying a sequential stepping potential across said pairs of overlapping electrodes before the metastable decay of a discharge falls below the level which enables a discharge to take place between an adjacent pair of electrodes so as to effectively step a discharge through said channel; and

a pair of output electrode means mounted on the surface opposite said one surface and positioned overlapping at least the last electrode at the other end of said channel for detecting a discharge in the proximity of the last pair of electrodes.

5. The plasma shift register according to claim 4 wherein said envelope is comprised of:

a first substantially flat insulator upon one surface of which the plurality of evenly spaced pairs of electrodes are placed;

a second substantially flat insulator upon one surface of which the input and output electrode means are placed;

a third substantially flat insulator plate sandwiched between said first and said second substantially flat insulators having an opening defined therein which opening exposes the plurality of evenly spaced pairs of electrodes to said input and output electrode means with said plasma medium contained in the defined opening.

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