The invention relates to the digital computer art, and, more particularly, to stored-charge memory systems used in such art. The present application is a continuation in part of my copending applications:

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<th>Serial No.</th>
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<tr>
<td>621,550</td>
<td>July 12, 1956</td>
<td>Electric Discharge Device.</td>
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<td>628,921</td>
<td>May 20, 1958</td>
<td>Electric Discharge Device.</td>
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<td>628,922</td>
<td>May 20, 1958</td>
<td>Electric Discharge Device.</td>
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<td>624,997</td>
<td>November 28, 1959</td>
<td>Electric Controlled Information-Bearing Device.</td>
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<td>624,000</td>
<td>do.</td>
<td>Glowing Discharge Device.</td>
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An object of the present invention is to provide a memory device of the character described which will afford, in a comparatively simple and reliable structure, a memory system of the gaseous electronic type using high frequency glow discharges, and which is compatible with, and may be used in conjunction with, the serial shifting register of the multiple position glow discharge type, as more particularly set out in my copending applications above.

Another object of the present invention is to provide a memory device of the above character which, while being relatively small and compact, is yet capable of storing and making instantly available large numbers of information items.

A further object of the present invention is to provide a memory device of the character described, which is composed of a minimum number of sturdy formed parts which may be fabricated and assembled by relatively low cost mass production techniques.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the preferred form of the invention which is illustrated in the drawing accompanying and forming part of the specification. It is understood, however, that variations in the showing made by said drawing and description may be adopted within the scope of the invention as set forth in the claims.

Referring to said drawings:

Figure 2 is a cross-sectional view of the device taken substantially on the plane of the line 2—2 of Figure 1.

Figure 3 is a perspective view of parts of the device opened up for viewing the interior of the device.

Figure 4 is a cross-sectional view of the device taken substantially on the plane of line 4—4 of Figure 2.

Figure 5 is a cross-sectional view of the device taken substantially on the plane of line 5—5 of Figure 4.

Figure 6 is a simplified schematic drawing showing one of the electrical equivalent circuits.

Figure 7 is a further simplified schematic diagram showing the electrical equivalent circuits for the whole device.

It can be shown that the diffusion processes in the gaseous discharge cell are such as to bring all of the bounding surfaces of the discharge into the relative equilibrium potentials, and that space currents will always flow to these bounding surfaces during discharge so as to bring the surfaces to, and maintain them at, their equilibrium value. Advantage is taken of this phenomena in the present invention by forming one of the dielectric surfaces of the discharge region of the cell as a thin film or coating over a conducting surface, so as to provide a relatively large capacitance, per unit area, between the gas exposed surface of the dielectric coating and the conducting surface. The charge stored by this capacitance is held fixed when a discharge is not present within the vessel, but will change to bring the dielectric surface to its equilibrium value whenever a discharge is initiated. The resulting charge displacement will thus contain the information as to what relative potential change had taken place since the termination of the last discharge.

The present invention then consists briefly of a gaseous discharge cell, a conductor which is mounted in a capacitance coupled relation to a dielectric boundary of a gaseous discharge region of the cell, and which is shielded from contact with the gas in the region, and some means electrically coupled to the dielectric boundary through the gaseous discharge in the cell. The capacitor thus formed is used for storing a charge representing the information to be held and connection to this capacitor is made by effecting electrical discharge in the cell, the electrical discharge thus operating as a selector switch.

The equivalent electric circuit is illustrated in Figure 6 of the drawing. The gaseous discharge cell is represented by switch S1, capacitor C, battery E representing the constant equilibrium potential, and resistance R. One side of switch S1 is connected to one plate 21 of capacitor C and the other side of switch S1 is connected through battery E and resistance R to a common ground 16. The information to be stored is represented by a potential derived from an information source, generally depicted by numeral 15, which is connected by conductor 12 to plate 21 of capacitor C opposite plate 21. Information source 15 is here, for simplicity, shown composed of a battery 13 having one side 14 connected to the common ground 16, and its opposite side 17 connected by conductor 18 through switch S2 to conductor 42. Other information is here represented by a zero or ground voltage connected to conductor 12 through switch S2. Of course, it will be understood that the information potential emanating from source 15 may, in normal practice, assume any value within reasonable operating limits, and the charge-establishing potential here depicted as impressed on capacitor C by effecting an electrical discharge in the cell. After the charge, representing the information to be held, is thus established in capacitor C, the electrical discharge in the cell is discontinued thus, in effect, opening switch S2. This leaves the desired
of the channels may be accomplished by connecting the ends 71, 72, 73, 74, 75, 76, 77 and 78 of channels 32 and 51-57 with the interconnecting channel 79 of a serial shifting register of the multiple position glow discharge type capable of sustaining and selectively shifting a discrete glow discharge into registration with the ends 71-78. This type of register is more fully disclosed and claimed in my pending application of September 10, 1961.

In the fabrication of the device, the envelope may be formed of glass, and the channels 51-57 are preferably formed in a dielectric member 81 mounted in the envelope. As will be best observed from Figure 2, member 81 is here formed with a plurality of grooves (defining channels 51 and 57) in one side 83 thereof mounted in engagement with the end side 82 of the envelope for closing off the channels. Electrodes 33 and 61-67 are preferably mounted in the base of the channels and extend longitudinally of the channels. At one end of the channels, see Figure 4, electrodes 33 and 61-67 are extended through an end wall portion 86 of member 81 and are connected to a transversely extending conductor 87, see Figure 5, which is taken out of the envelope 31 and connected to an R-F generator 88, see Figures 1 and 5.

The transverse, information reading and writing electrodes 41-48 are preferably mounted on envelope side 64, and may be composed of elongated metallic strips of any convenient form. If desired, these electrode strips may be formed by the vacuum deposition of metal on the surface of printed circuits. The dielectric coating 49 covering the conducting surfaces representing electrodes 41-48 may be made very thin as by depositing the dielectric material, as by evaporation, over the conductive coatings 41-48. A surface to conductor capacitance may thus be readily obtained of substantial magnitude for very satisfactory voltage ratings. Good quality dielectrics are capable of holding a charge on the capacitance practically indefinitely, so that the memory system of the present invention may be considered, for practical purposes, as a permanent one, and not in the volatile class requiring frequent inspection for the purposes of reinstanting charges decaying towards ambiguous values.

The member 81 may be formed of any good quality plastic or ceramic material of high dielectric strength. Many of such materials are available commercially which may be manufactured by molding or machining. To supply an example, a machinable ceramic material known as Al-Si-Mg 222 sold by American Luna Corporation is noted. This material is a porous Al-Si-Mg having a physical strength comparable to dry press porcelain and may be machined to desired shapes and forms.

The reading and writing electrodes 41-48 are connected to conductors 101-108 which are brought through the envelope 31 for connection to a plurality of information sources 111-118 of the general type offering electric potentials representing information to be stored and as generally characterized as information source 15 hereinbefore described.

The serial shifting register for selectively shifting a glow discharge into the several channels 32 and 51-57 here includes the elongated transversely extending channel 79 which has, at one end thereof, a pair of glow starting electrodes 121 and 122 which are connected to conductors 123 and 124 brought through the envelope for connection to a suitable voltage source capable of initiating or setting a localized glow discharge in what may be considered a localized cell here adjacent the entrance of the channel 78. The glow discharge thus entered in the channel may be shifted longitudinally of the channel by means of a plurality of electrodes 131, 132, 133, 134, 135, 136, 137 and 138 which are arranged along the length of channel 79 and located at the ends of the intersecting channels 71-78. Electrodes 131-138 may be connected as here depicted, to three R-F voltages a, b and c as by conductors 141, 142 and 143. In keeping with the teach-

As a feature of the present invention, selective priming
ings of my copending applications, voltages $a$, $b$ and $c$ are sufficient to sustain a discrete glow discharge in the channel and to transfer such glow discharge if primed by an adjacent glow discharge, but which are insufficient to initiate a glow discharge without such priming. R.-F. excitation in the order of 20 to 25 volts per second and a magnitude of 60 to 120 volts R. M. S. is suggested. Accordingly, by phasing voltages $a$, $b$ and $c$, the single glow discharge entered in the channel 79 may be shifted at very high speed, and very precisely, into registration with any of the channels 71–78. Electrodes 131–138 may be made of electrically conductive materials, as here illustrated, and cooperate with a common ground electrode 144 at the opposite side of the envelope so as to effect selective localized energization of channel 79 at each of the connections of channels 71–78. Electrode 144 may consist of a simple strip of metal mounted on what is here depicted as the underside of the envelope in the common vertical plane of the channel 78 and the plurality of electrodes 131–138 mounted on what is here depicted as the upper side of the envelope. Electrodes 131–138 may similarly be of any desired metal conducting form suitably attached to the envelope.

Although the above description of the present invention may be made in various sizes containing various numbers of reading and writing elements 41–48 and various numbers of glow discharge channels 33 and 51–57. The number of electrodes 41–48 determines the number of information items to be stored, thus determining the length of the word, phrase or number which can at any one time be held by the device. The number of glow channels 33 and 51–57 determines the number of such whole words, phrases, numbers, etc. which may be stored. The total operation of the device is depicted in the simple electrical equivalent diagram, Figure 7. The reading and writing elements are depicted by conductors 101–108 which are, as above noted, connected to information sources 111–118. Each of these information sources is diagrammatically illustrated as containing a two way switch 146, a generalized source 213 representing the information to be stored, a readout device 23 capable of measuring the charge in a selected storage capacitor, and a common ground connection 16, the parts being wired, as depicted, so that on throwing switch 146 to contact 149 voltages will be sent over conductors 101–108, and under appropriate conditions (discharge in one of the glow channels 71–78) the charges on the capacitors in the selected glow channel will be established to correspond to these impressed voltages. Subsequently, after an arbitrary time interval during which the above channel was kept free of any discharge, closure of switches 146 to contacts 147 and reestablishment of the discharge in the same channel allows the readout devices 23 to determine ("read") the value of the voltages which had been impressed upon conductor 101–108 during the above "write" period. The conductor 101 is connected to a set of capacitors 161, 162, 163, 164, 165, 166, 167, and 168 representing the capacitances across the dielectric layer between the conductor 48 and a cell boundary of each of the discharge channels 71–78.

The switches 151, 152, 153, 154, 155, 156, 157 and 158 connect capacitors 161–168 to ground electrodes 171, 172, 173, 174, 175, 176, 177 and 178, and represent in simplified form the conductivity or non-conductivity afforded by the discharge or no-discharge states, respectively, within the channels 33 and 51–57. The ground electrodes 171–178 correspond functionally to the charge-displacement paths provided by R.-F. electrodes 33 and 61–67. In like manner, the remaining conductors 102–108, representing read-write electrodes 42–48, are connected through a plurality of switches and capacitors, each representing a discharge cell at the intersection of the read-write electrode and the gaseous discharge channel, to common ground electrodes 171–178. Since all of the cells in any one channel 71–78 are fired simultaneously, all of the switches in each of the horizontal rows of Figure 7 are shown as ganged for simultaneous opening and closing.

As will be understood, the information sources 111–118 may be constantly sending out their signal, or no signal, as the computing machine, of which the sources are part, does its work. At any instant when it is desired to store the information at sources 111–118, a glow discharge is shifted into registration with one of the channels 71–78, and the R.-F. generator 88 is turned on thus firing the full length of the channel and effectively closing the electrical switch at each of the cells in the channel. This is depicted by a gang closing of a bank of horizontally arranged switches in Figure 7, thus impressing the electrical potentials of the sources 111–118 on one of the horizontal banks of condensers 161–168. The R.-F. excitation provided by generator 88 is then shut off, leaving the condensers correspondingly charged. At other times, the information of sources 111–118 may be similarly stored in the other banks of capacitors in the other discharge channels. Whenever it is desired to retrieve the information so stored in any of the banks of capacitors, switches 146 are thrown to contacts 147 and the appropriate glow discharge channel is fired (by shifting a glow to that channel and turning on R.-F. generator 88), at which time the individual charges contained on the individual capacitors in the horizontal bank of capacitors, as seen in Figure 7, will be reflected and read at the individual readout devices 23 at each of the information sources 111–118, thus recalling the information held by such sources at the previous time.

I claim:

1. A memory device comprising, an envelope providing a plurality of gaseous discharge channels, a first set of electrodes mounted along said channels, and a second set of electrodes mounted to traverse said channels in longitudinally spaced relation and cofunctioning with said first set of electrodes to define a plurality of cells in each of said channels and when energized to provide glow discharges in said cells, one of said sets of electrodes being mounted in capacitance coupled relation to a dielectric boundary of each of said cells, the other of said sets of electrodes being electrically coupled to said boundaries through the gaseous discharge in said cells.

2. A memory device comprising, an envelope providing a plurality of gaseous discharge channels, a first set of electrodes mounted along said channels, a second set of electrodes mounted to traverse said channels in longitudinally spaced relation and cofunctioning with said first set of electrodes to define a plurality of cells in each of said channels and when energized to sustain and propagate an existing glow discharge in said channels, one of said sets of electrodes being mounted in capacitance coupled relation to a dielectric boundary of each of said cells and capable of storing a charge representing information to be held, the other of said sets of electrodes being electrically coupled to said boundaries through the gaseous discharge in said cells, and means for selectively priming said channels with a glow discharge.

3. A memory device comprising, an envelope providing a plurality of gaseous discharge channels, a second set of electrodes mounted to traverse said channels in longitudinally spaced relation and cofunctioning with said first set of electrodes to define a plurality of cells in each of said channels and when energized to sustain and propagate an existing glow discharge in said channels, one of said sets of electrodes being mounted in capacitance coupled relation to a dielectric boundary of each of said cells, the other of said sets of electrodes being electrically coupled to said boundaries through the gaseous discharge in said cells, and a serial shifting register of the multiple position glow discharge type capable of sustaining and
selectively shifting a discrete glow discharge into said channels.

4. A memory device comprising, an envelope, an ionizable gas therein, a dielectric member mounted in said envelope and formed with a plurality of elongated grooves in one side thereof, a closure member of dielectric material mounted on said side closing said grooves to define a plurality of gaseous discharge channels, a first electrode mounted in and extending longitudinally of each of said grooves and in contact with the gas therein, a plurality of second electrodes of elongated form carried by said closure member and traversing said grooves so as to define with said first electrodes a plurality of longitudinally spaced cells in each of said channels, and a coating of dielectric material separating said second electrodes from said channels and providing a dielectric boundary for each of said cells.

5. A memory device comprising, an envelope, an ionizable gas therein, a dielectric member mounted in said envelope and formed with a plurality of elongated grooves in one side thereof, a closure member of dielectric material mounted on said side closing said grooves to define a plurality of gaseous discharge channels, a first electrode mounted in and extending longitudinally of each of said grooves and in contact with the gas therein, a plurality of second electrodes of elongated form carried by said closure member and traversing said grooves so as to define with said first electrodes a plurality of longitudinally spaced cells in each of said channels, a coating of dielectric material separating said second electrodes from said channels and providing a dielectric boundary for each of said cells, said dielectric boundary and said second electrodes defining a capacitor at each of said cells for storing a charge representing information to be held, an R-F generator connected to each of said first electrodes and furnishing a potential and frequency sufficient to sustain and propagate an existing glow discharge in said channels while being incapable of initiating such glow discharge, and means for selectively priming said channels with a glow discharge.

6. A memory device comprising, an envelope, an ionizable gas therein, a dielectric member mounted in said envelope and formed with a plurality of elongated grooves in one side thereof, a closure member of dielectric material mounted on said side closing said grooves to define a plurality of gaseous discharge channels, a first electrode mounted in and extending longitudinally of each of said grooves and in contact with the gas therein, a plurality of second electrodes of elongated form carried by said closure member and traversing said grooves so as to define with said first electrodes a plurality of longitudinally spaced cells in each of said channels, a coating of dielectric material separating said second electrodes from said channels and providing a dielectric boundary for each of said cells, said dielectric boundary and said second electrodes defining a capacitor at each of said cells for storing a charge representing information to be held, an R-F generator connected to each of said first electrodes and furnishing a potential and frequency sufficient to sustain and propagate an existing glow discharge in said channels while being incapable of initiating such glow discharge, and means for selectively priming said channels with a glow discharge.

References Cited in the file of this patent

UNITED STATES PATENTS

2,012,710 Crosby Aug. 27, 1935
2,051,601 Hobart Aug. 18, 1936
2,123,242 Holmann July 12, 1938