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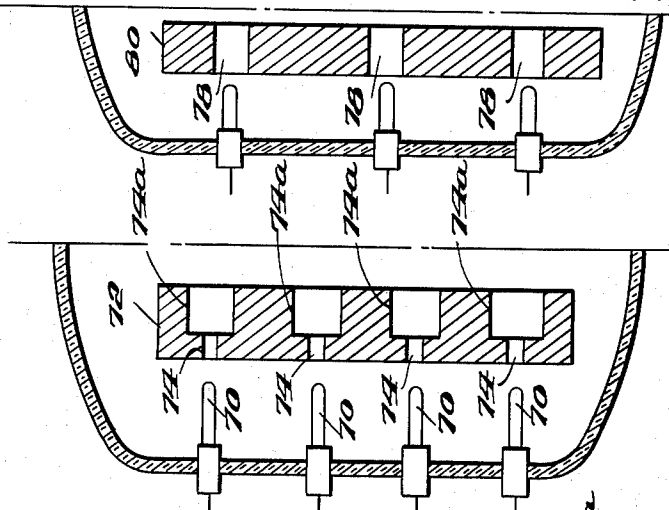
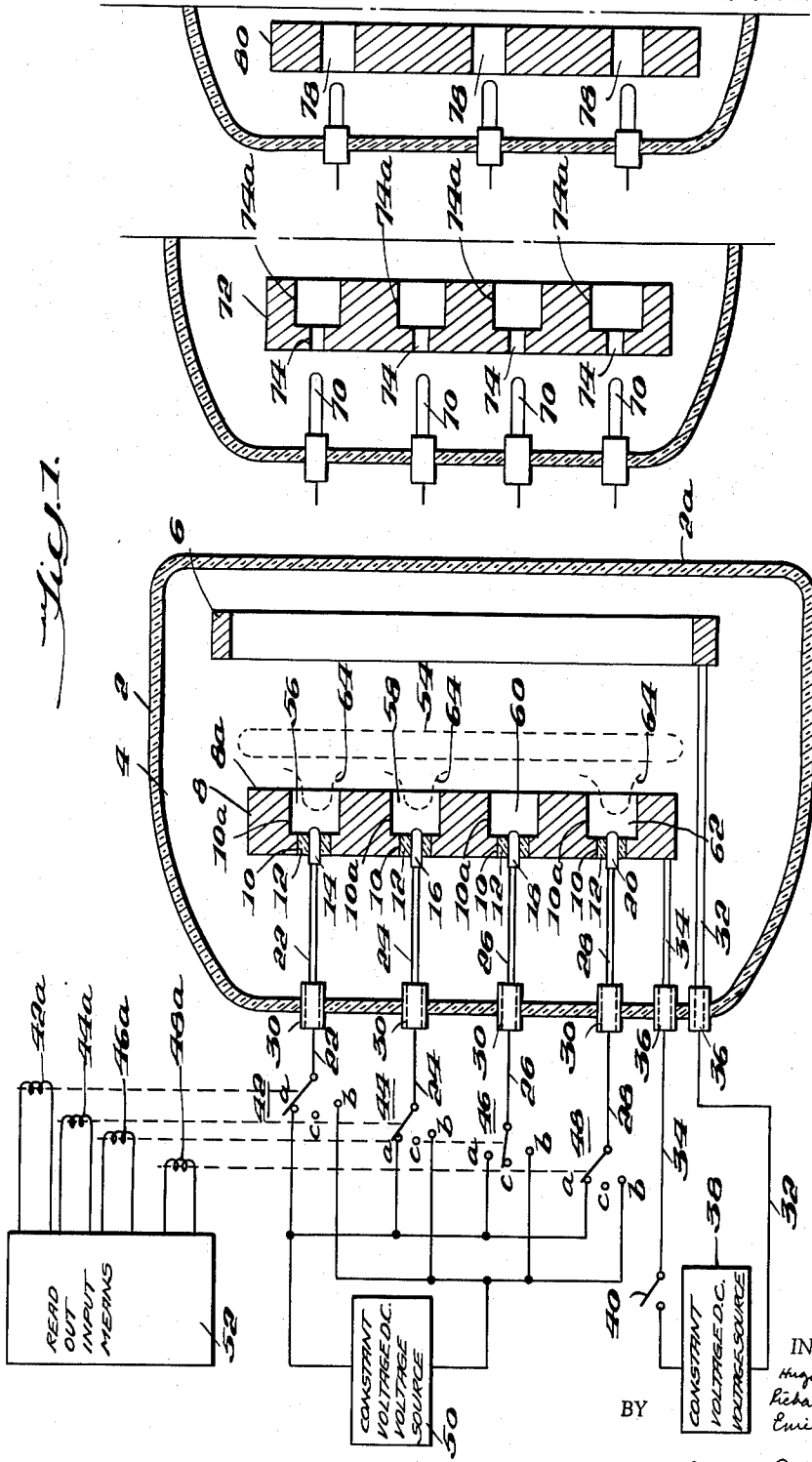
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CATHODE GLOW DISPLAY USING A SINGLE CATHODE ELECTRODE

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2 Sheets-Sheet 1



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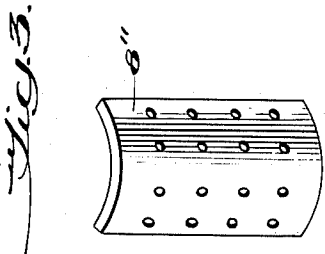
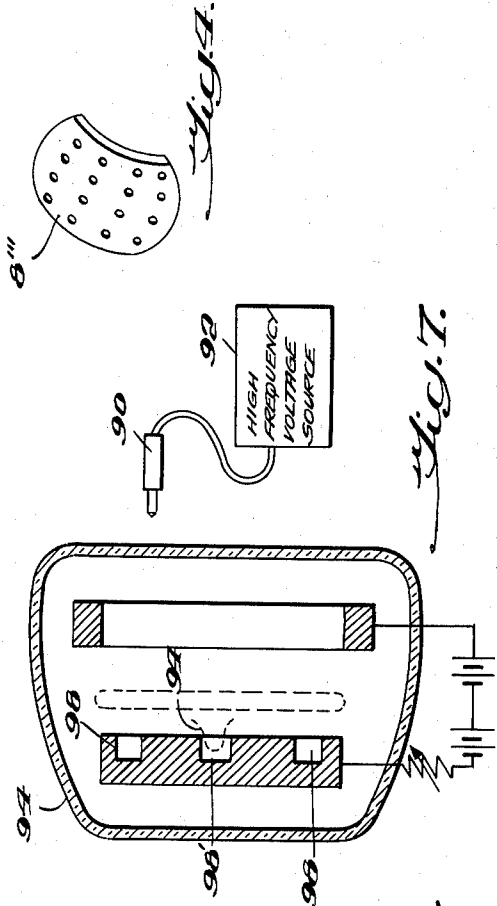
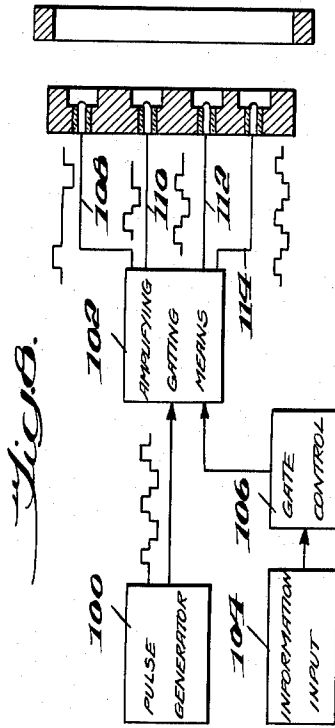
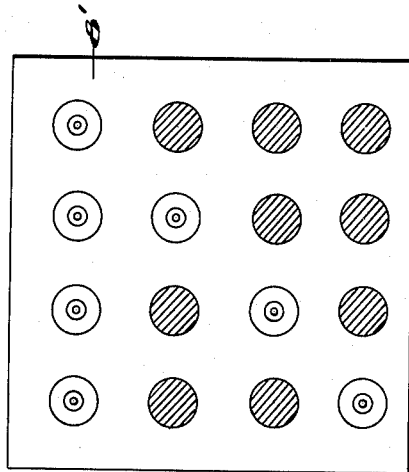


Fig. 2



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CATHODE GLOW DISPLAY USING A SINGLE
CATHODE ELECTRODE

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This invention relates generally to a display and storage device, and more particularly to an information display and storage device including means for initiating and terminating visible glow discharges in selected ones of a plurality of cavities contained in a single cathode body. The invention is characterized in that the luminous glow discharges are initiated solely by the application of single voltage pulses to the respective cavities. Once initiated, the discharges are automatically maintained, without the application of sustaining voltage signals, until single terminating voltage pulses are applied to the respective cathode cavities.

In the prior art, visual display devices have been disclosed which utilize a plurality of cathodes of various sizes and forms mounted in a gas filled tube. Upon the application of suitable control potentials to the various cathodes (which may be in the form of letters, numbers, symbols, and the like), they are caused to glow and present a visible read-out display. In the known devices, sustaining voltages must be applied to the cathodes to maintain them in a luminous condition.

A primary object of the present invention is to provide a read-out device which utilizes a single cathode body for producing a visible display of intelligence. In accordance with the invention the read-out device is operable—without the use of sustaining voltage means—to visibly store one or more signal pulses for an indefinite period of time. The single cathode body is mounted, together with an anode, in a chamber containing an ionizable gas at subatmospheric pressure. The cathode plate contains a plurality of hollow cavities each defining a hollow cathode. Direct current potentials are applied to the anode and cathode electrodes to establish a dull glow discharge on the face of the cathode. In accordance with the invention, pulse means are provided for initiating self-sustaining luminous hollow cathode glow discharges in selected ones of the cathode cavities. The discharge pattern established on the face of the cathode affords a visible indication of pulse intelligence applied to the read-out device.

Another object of the invention is to provide a pulse-responsive display and storage device including a single cathode containing a plurality of cavities, and means for initiating and terminating discharges in selected ones of said cavities.

A more specific object of the invention is to provide a display and storage device including a housing having a chamber containing an ionizable gas, a single anode and a single cathode in said chamber, said cathode including a plurality of cavities, means establishing a potential difference between said anode and cathode to establish a glow discharge in said cavity, and means for applying positive pulses to selected ones of said cavities to develop self-sustaining narrow beam discharges therein. The invention further includes means for applying negative pulses to certain cavities to extinguish the hollow cathode glow discharges therein. According to the preferred embodiment of the invention, the cavities comprise bores extending through the cathode plate, said bores having counterbored portions in the plate surface adjacent the anode, whereby the isolation of the various hollow

cathode discharges is improved. In one embodiment of the invention, the means for applying the pulses to the cavities include control electrodes that extend into the cavity bores. Insulation means may be provided for insulating the electrodes from the cathode. According to another modification of the invention, the pulses are selectively applied to the cavity by an electrode or probe that is movable relative to the cathode. In one embodiment, the probe is arranged externally of the housing and is adapted to supply high frequency, high voltage energy to selected cavities to initiate luminous hollow cathode discharges therein.

The display and storage device offers the advantage that visual read-out patterns may be selectively produced with a constant gas pressure and with a constant anode to cathode potential. Since sustaining voltage signals for maintaining the pulse-produced patterns are not required, the electronic circuitry and control of the device is quite simple and inexpensive. Rapid response to the initiating and terminating pulses is achieved as a result of the substantially instantaneous (on the order of 200 microsecond) switching of the discharges between the surface glow and hollow cathode discharge glow modes.

Other objects and advantages of the invention will become apparent from a study of the following specification when considered in conjunction with the accompanying drawing, in which:

FIG. 1 is a generally diagrammatic illustration of the information read-out and storage device of the present invention;

FIG. 2 is a detailed view of a cathode plate containing a plurality of cathode cavities a selected number of which are operated in the hollow cathode discharge mode;

FIGS. 3 and 4 are perspective views of cathode plates that are formed as sectors of a cylinder and a sphere, respectively;

FIG. 5 is a detailed view of the cathode cavity and control electrode arrangement of another embodiment of the invention;

FIG. 6 is a detailed view of a further modification of the invention;

FIG. 7 illustrates an embodiment of the invention wherein selective initiation of hollow cathode glow discharges is achieved with the use of a high frequency probe arranged externally of the apparatus housing; and

FIG. 8 is a block diagram of another type of electronic circuit means for selectively operating the various cathode cavities in the hollow cathode discharge mode.

Referring to FIG. 1, the information read-out and storage device includes a housing 2 defining a chamber 4 which contains an ionizable gas (for example, argon, neon, helium or the like) at a subatmospheric pressure (on the order of 100 microns of mercury). Mounted in spaced relationship in chamber 4 are an anode 6 and a cathode 8. Anode 6 may be of annular, hollow rectangular or other configuration, as desired. Cathode 8 consists of a metal plate having a uniform surface 8a relative to the anode. Bores 10 extend through the cathode plate and are provided with counterbore portions 10a adjacent surface 8a.

Mounted, respectively, in bores 10, and insulated from the wall thereof by ceramic insulating sleeves 12, are control electrodes 14, 16, 18 and 20. For the sake of simplicity, only four cavities and their associated control electrodes have been illustrated in FIG. 1. As shown in FIG. 2, however, the cathode plate normally includes a plurality of rows or arrays of cavities for presenting desired visual displays. Conductor leads 22, 24, 26 and 28 extend from electrodes 14, 16, 18 and 20, respectively, outwardly of the housing wall through insulating sleeves 30. Similarly conductor leads 32 and 34 extend from the

anode and cathode, respectively, outwardly of the housing through insulating sleeves 36.

Conductors 32 and 34 connect anode 6 and cathode 8 with the positive and negative terminals, respectively, of a constant voltage D.-C. voltage source 38. Start switch 40 is connected in series in conductor 34.

Conductors 22, 24, 26 and 28 connect electrodes 14, 16, 18 and 20 with the movable contacts of solenoid-controlled switches 42, 44, 46 and 48, respectively. Solenoids 42a, 44a, 46a and 48a are operable to shift the movable contacts of the switches between switch positions "a" and "b." When the solenoids are de-energized, the movable switch contacts are biased toward open positions "c" by spring means, not shown. Stationary switch contacts "a" and "b" are connected with the positive and negative terminals, respectively, of a constant voltage D.-C. voltage source 50. Solenoids 42a, 44a, 46a and 48a are operated in accordance with the polarity of actuating signals produced by read-out input means 52.

The cathode surface 8a is visible through a transparent window portion 2a of housing 2. If desired, the entire housing may be formed of glass.

In operation, switch 40 is closed to establish a potential difference (on the order of 500-1000 volts D.-C. depending on the subatmospheric pressure and composition of the ionizable gas) between the anode and cathode, whereby a dull glow discharge 54 is created in chamber 4 adjacent cathode surface 8a. The glow discharge substantially covers the cathode surface.

Assume that solenoids 42a, 44a and 48a are momentarily energized by read-out input means 52 to cause the movable contacts of switches 42, 44 and 48 to momentarily engage the respective stationary contacts "a." Assuming that source 50 establishes a firing potential (for example, 500 volts D.-C.) appropriate for the attendant pressure and voltage conditions, positive voltage pulses are applied to the control electrodes 14, 16 and 20 associated with cathode cavities 56, 58 and 62, respectively, to perturb the electric fields therein and thereby initiate the generation of funnel-shaped hollow cathode discharges 64. These hollow cathode discharges appear as intense luminous spots which are readily visible through window 2a. It is important to note that once the hollow cathode modes have been established, the discharges are continuously maintained even after removal of the positive pulses from the control electrodes. Because of the pulse storage capabilities of the device, de-energization of solenoids 42a, 44a and 48a, and the attendant movement of switches 42, 44 and 48 to the open positions "c," has no effect on the hollow cathode discharges generated in the cathode cavities. Owing to the cylindrical configuration of the cavities the hollow cathode discharges 64 are isolated in their respective cavities 56, 58 and 62 and have no effect on cavity 60 which is in a non-generating condition. The hollow cathode discharges 64 are visible through transparent window 2a for an indefinite period of time. In accordance with those control electrodes to which the positive initiating pulses are applied, a visual intelligence pattern of the narrow beam spots is developed on the cathode plate as shown in FIG. 2.

Assume now that after a given period of time, a second intelligence pattern is to be established on the cathode surface. For example, by appropriate energization of solenoids 44a and 46a, the movable contacts of switches 44 and 46 may be momentarily operated to positions "b" and "a," respectively. When switch 44 is in the "b" position, a negative voltage pulse is applied to the electrode 12 associated with cavity 58, said negative pulse being of sufficient magnitude to extinguish the associated narrow beam discharge. Similarly, the application of a positive voltage pulse to the control electrode of cavity 60 establishes a hollow cathode discharge therein. Consequently, hollow cathode discharges occur only in cavities 56, 60 and 62, whereby a new pattern is presented that is observable through window 2a.

It is apparent that a given hollow cathode discharge may be terminated by the application of a negative pulse to the control electrode of the cavity in which the discharge occurs. All of the discharges may be removed by simultaneous operation of the switches to the "b" position, or by opening switch 40.

Although the cathode cavities are generally of the same size, in certain cases it may be desirable to vary the relative dimensions of the cavities in accordance with their respective spacing distances from the anode. Thus when the cathode plate is in the form of a sector of a cylinder (FIG. 3) or a sector of a sphere (FIG. 4) it may be desirable to vary the sizes of the cavities furthest from the anode relative to those cavities which are closest to the anode. In any event, it is desirable that the anode be so arranged relative to the cathode as to provide an electric field distribution that is as uniform as possible.

The control electrodes need not extend into the bores of the cathode cavity. For example, in the embodiment of FIG. 5, the control electrodes 70 are spaced from cathode plate 72 opposite bores 74 on the side thereof remote from counterbore portions 74a. In the cathode embodiment of FIG. 6, the cavities are defined by cylindrical bores 78 that extend uniformly completely through plate 80. While under appropriate operating conditions, and with suitable spacing of the cavities, hollow cathode discharges may be developed in selected ones of the cylindrical cavities 78 as desired, it has been established in practice that the isolation of the discharges is not as complete as in the counterbored cavity embodiments of FIGS. 1 and 5. Since the control electrodes of the FIG. 5 and 6 embodiments do not extend into the cavities, it is somewhat more difficult to extinguish hollow cathode discharges than in the FIG. 1 embodiment.

Since it is not necessary for the control electrodes to extend into the cathode cavity bores, it is possible, in accordance with a further modification of the invention, to provide a single control electrode that is movably mounted in the housing adjacent the cavity bores for initiating hollow cathode discharges in selected ones of the cavities as desired. Furthermore, in the embodiment of FIG. 7 a movable probe 90 supplied with high frequency energy from source 92 may be mounted externally of sealed housing 94 to initiate hollow cathode discharges 96 in selected ones of the cathode cavities 98. In devices utilizing a relatively movable electrode or probe, a desired hollow cathode spot pattern may be established on the cathode surface by a "writing" motion of the movable element. As shown in FIG. 7, the cavities need not extend completely through the cathode plate.

It is apparent that the read-out and storage device of the present invention may be utilized with many types of electronic systems. For example, in the apparatus of FIG. 8, pulse generator 100 continuously supplies amplifying and gating means 102 with an A.-C. voltage having a rectangular wave form. Information received by input means 104 (from perforated tape pick-up means, for example) is applied to gate control 106 for controlling the gating means associated with the respective control electrodes of the cathode cavities. The amplified and gated positive and negative signal pulses transmitted by conductors 108, 110, 112 and 114 selectively control the firing and extinguishing, respectively, of the various hollow cathode discharges.

The cathode plate of the invention may be formed of a suitable conductive material, such as copper, aluminum or the like. In certain cases it may be desirable to line the cavity walls with a layer of tungsten or other metal having low sputtering characteristics.

In addition to the methods described above, perturbation of the electric fields to selectively initiate the hollow cathode discharges may be achieved by other means, such as a wire grid matrix, magnetic probes, or the like.

While in accordance with the provisions of the Patent Statutes the best form and embodiments have been illus-

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trated and described, it will be apparent to those skilled in the art that various modifications may be made in the apparatus described without deviating from the invention set forth in the following claims.

What is claimed is:

1. An information read-out and storage device, comprising
housing means defining a chamber containing an ionizable gas at a subatmospheric pressure;
a single anode in said chamber;
a single cathode in said chamber and spaced from said anode, said cathode comprising a plate having a uniform surface containing a plurality of cavities, said housing means including a transparent wall portion opposite said cavities;
means biasing said cathode to a constant negative direct-current potential relative to said anode to establish a diffused glow discharge in said chamber;
and means for initiating hollow cathode glow discharges in a selected group of said cathode cavities.
2. Apparatus as defined in claim 1 wherein said hollow cathode discharge initiating means comprises a plurality of control electrodes associated with said cathode cavities, respectively, and means for applying to each of the control electrodes associated with said group of cavities a voltage pulse that is positive relative to said cathode and of a magnitude sufficient to initiate the hollow cathode discharge.
3. Apparatus as defined in claim 2 wherein said cathode cavities are defined by cylindrical bores arranged in and normal to said cathode uniform surface.
4. Apparatus as defined in claim 3 wherein said electrodes are spaced from said cathode plate opposite said bores, respectively.
5. Apparatus as defined in claim 3 wherein said cylindrical bores extend through said cathode plate, and further wherein said cavities include counterbore portions adjacent said cathode uniform surface.
6. Apparatus as defined in claim 5 wherein each of said electrodes is arranged on the side of said cathode plate remote from said counterbore portions, said electrodes extending into said bores in the direction of said counterbore portions.
7. Apparatus as defined in claim 6, and further including means insulating said electrodes from said cathode plate.
8. Apparatus as defined in claim 2, and further including means for applying to a control electrode associated with a cavity which is in a hollow cathode discharge generating condition a voltage pulse that is negative relative to said firing potential, said pulse being of a magnitude to extinguish the hollow cathode glow discharge associated therewith.
9. Apparatus as defined in claim 2 wherein said cathode uniform surface is planar.
10. Apparatus as defined in claim 2 wherein said cathode uniform surface is in the form of a sector of a cylinder.
11. Apparatus as defined in claim 2 wherein said cathode uniform surface is in the form of a sector of a sphere.
12. Apparatus as defined in claim 2 wherein said uniform cathode surface is non-planar and is arranged relative to said anode to establish a uniform electric field,

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and further wherein the cavities are of unequal size in accordance with their relative spacing from said anode.

13. Apparatus as defined in claim 2 wherein said cavities have identical dimensions.

14. Apparatus as defined in claim 1 wherein said hollow cathode glow discharge initiating means comprises probe means movable relative to said cathode.

15. Apparatus as defined in claim 14 wherein said probe means comprises a high frequency voltage probe arranged externally of said housing.

16. A visual display and storage device, comprising housing means defining a chamber containing an ionizable gas at a subatmospheric pressure;
a single anode in said chamber;

a single cathode in said chamber and spaced from said anode, said cathode comprising a plate having a generally uniform surface relative to said anode, said surface containing a plurality of generally cylindrical cavities, said housing having a transparent wall opposite said cathode;

means biasing said cathode to a negative direct-current potential relative to said anode to establish a diffused glow discharge in said cavity;

a plurality of electrode means each of which is associated with one of said cavities, respectively;

means applying to each of a selected number of said electrode means a voltage pulse of a polarity that is positive relative to said cathode, said voltage pulse being of sufficient magnitude to establish a self-sustaining hollow cathode glow discharge in the cavity associated therewith;

and means for subsequently applying to at least one of said selected electrode means a voltage pulse of negative polarity and of sufficient magnitude to terminate the associated hollow cathode discharge.

17. An information display and storage device, comprising

housing means defining a chamber containing an ionizable gas at a subatmospheric pressure;

a single anode in said chamber;

a single cathode in said chamber and spaced from said anode, said cathode comprising a plate having a uniform surface containing a plurality of cavities, said housing means having a transparent wall portion opposite said cavities;

means biasing said cathode to a constant negative direct-current potential relative to said anode to establish a diffused glow discharge in said chamber;

and means for perturbing the electric field in a selected one of said cavities to initiate a self-sustaining hollow cathode glow discharge therein.

18. Apparatus as defined in claim 17 wherein said field perturbing means comprises means for applying to said selected cavity a voltage pulse that is positive relative to the potential of said cathode.

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