United States Patent

Grier

[15] **3,701,184**

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[54] **METHOD OF INCREASING LIGHT TRANSMISSION EFFICIENCY OF GAS DISCHARGE DEVICE**

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[73] Assignee: **Owens-Illinois, Inc.**

[22] Filed: **May 4, 1971**

[21] Appl. No.: **140,223**

Related U.S. Application Data

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[52] **U.S. Cl.** **29/25.16,** 29/25.11, 29/624

[51] **Int. Cl.**.....**H01j 9/18,** H01j 9/36

[58] **Field of Search.**29/624, 625, 25.1, 25.11, 25.13, 29/25.15, 25.16; 313/201, 210, 234

[56] **References Cited**

UNITED STATES PATENTS

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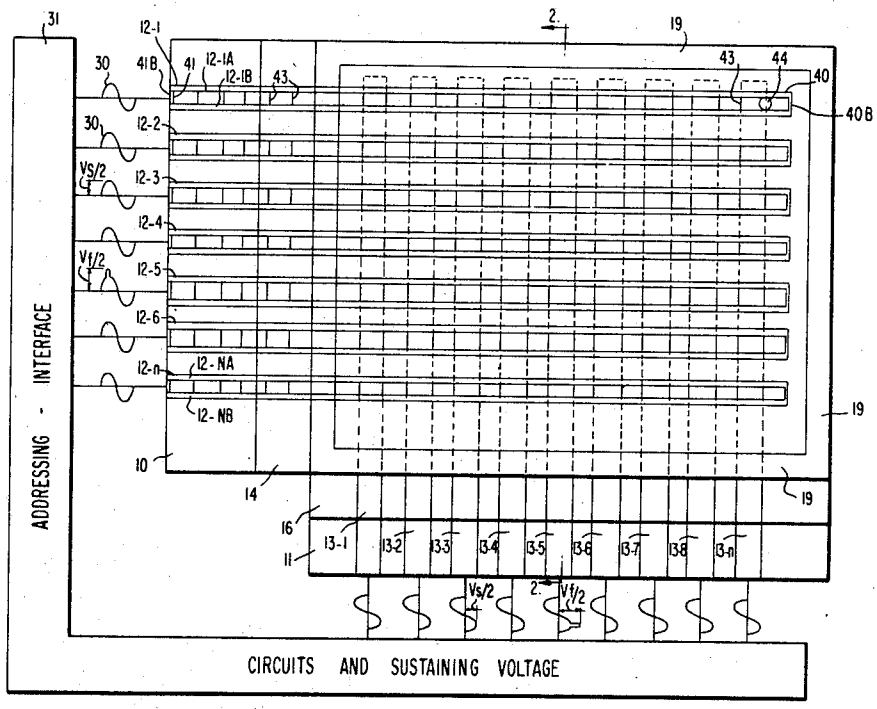
[57] **ABSTRACT**

There is disclosed a method of increasing the light transmission efficiency of a gas discharge device and assuring the electrical continuity of non-transparent printed conductors in the device, the conductors comprising transversely oriented row and column conductor arrays. The conductors of a conductor array on a plate forming the viewing side of the device are formed by sets of coplanar conductor elements spaced apart so that when a discharge occurs, an observer sees more of the center of the discharge which would ordinarily be partially hidden by a solid conductive line on the viewing side of the device. Likewise the conductor elements of a set may be connected at regular intervals to provide a plurality of electrically parallel routes for conduction in case a section of a conductor element of a set is discontinuous. The gas discharge is more visible since the applied field between selected conductor elements is across two conductors which are not congruent as seen by the observer.

8 Claims, 6 Drawing Figures



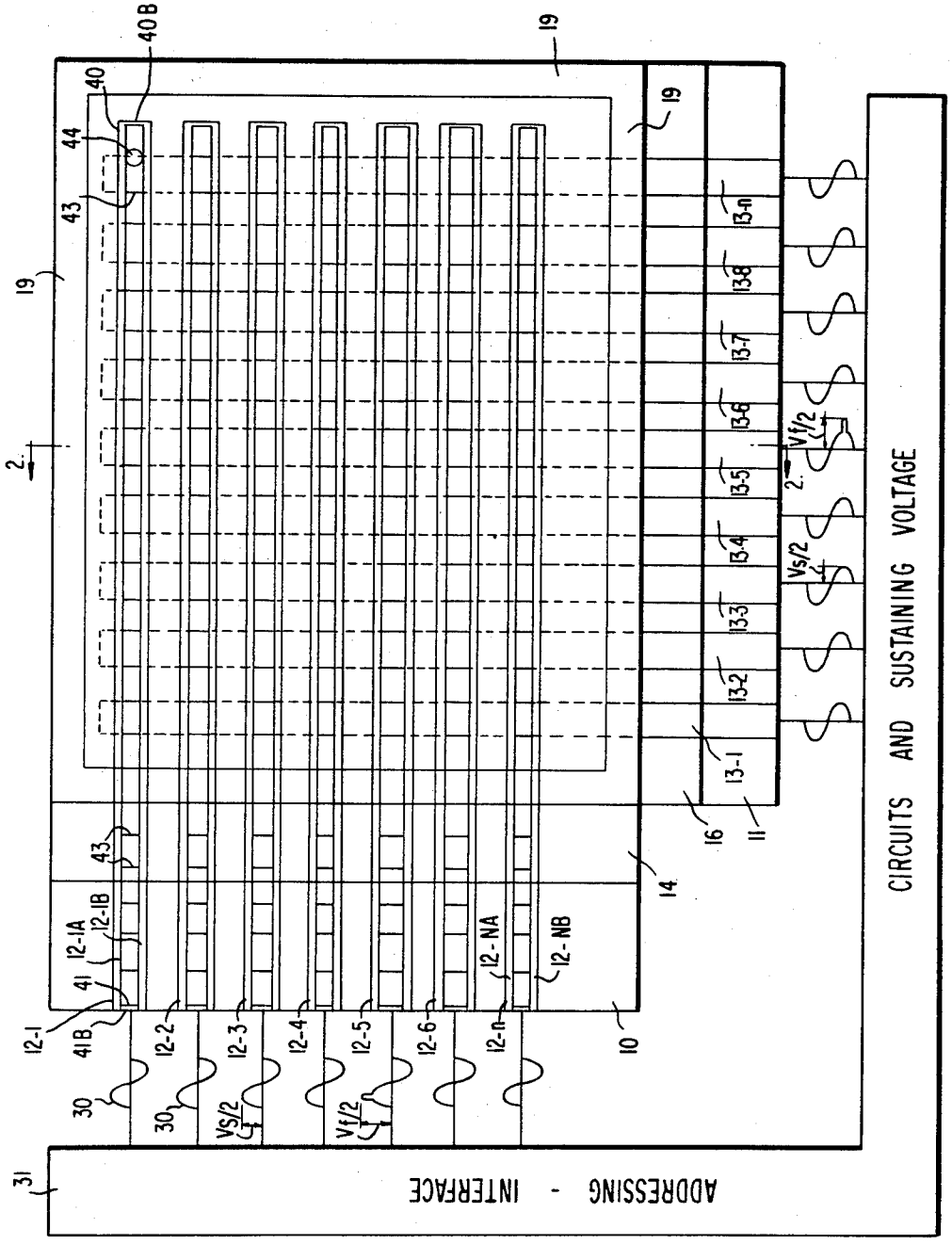


FIG. 1

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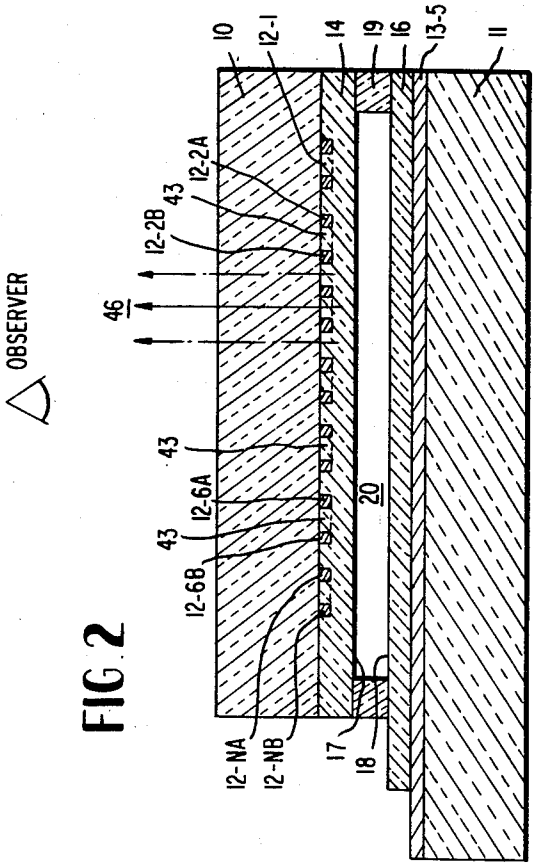

FIG. 2

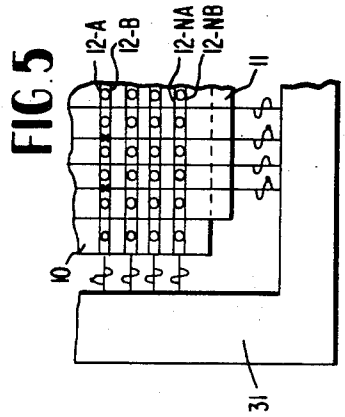

FIG. 5

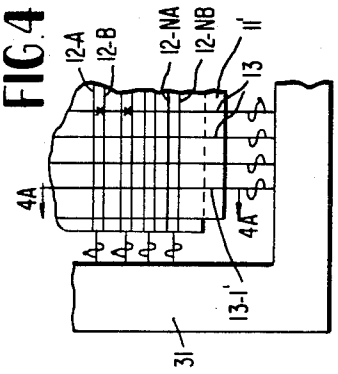

FIG. 4

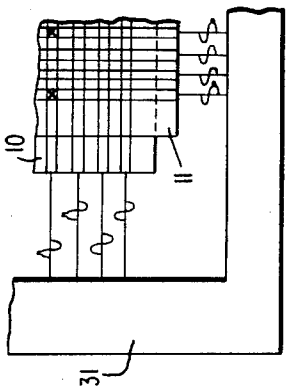

FIG. 3

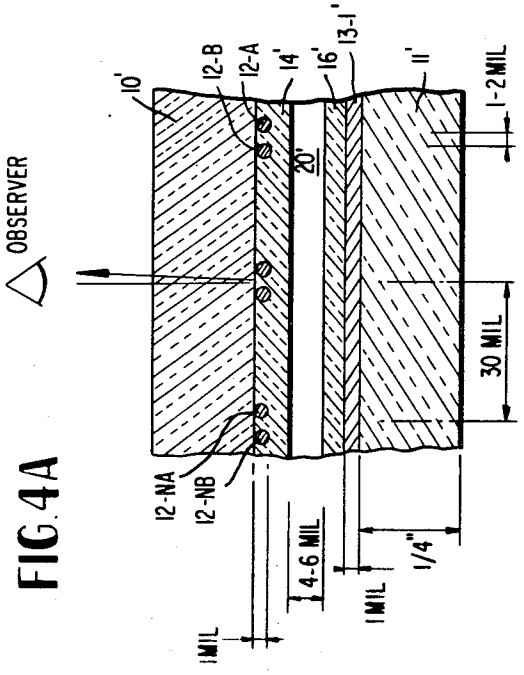

FIG. 4A

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METHOD OF INCREASING LIGHT TRANSMISSION EFFICIENCY OF GAS DISCHARGE DEVICE

RELATED CASE

This is a divisional of copending U.S. Pat. application, Ser. No. 812,801, filed Apr. 2, 1969, **now Patent No.** 3,603,836.

THe present invention is concerned with conductor configurations for display panels and more particularly to conductor configurations for gas discharge display panels.

Objects of this invention are to increase the effective efficiency of light or radiant energy output of a gas discharge panel; the provision of conductor configurations which are substantially more likely to be electrically continuous; the provision of conductor configurations which enable most efficient use of light produced during discharge at selected discharge sites in a discharge panel; and the provision of increased transmission of light or radiant energy from exterior of the panels to the interior of the panel.

ENVIRONMENT OF THE INVENTION

The invention will be described in connection with a gas discharge display panel of the type disclosed in Baker et al. application, Ser. No. 686,384 filed Nov. 24, 1967, and entitled "Gas Discharge Display-Memory Device and Method" which is assigned to the assignee of the present invention. However, in a broader sense, the invention has utility wherever it is desired to increase the transmission of light in devices requiring conductor arrays for exciting selected electroresponsive sites in an electroresponsive medium. The invention is particularly applicable to multiple gas discharge display and/or memory panels of the type disclosed in the aforementioned Baker et al. application which are characterized by a gaseous medium, usually a mixture of two gasses, at a relatively high gas pressure in a thin gas chamber or space between a pair of opposed dielectric storage members which are backed by conductor arrays, the conductor arrays backing each dielectric member being transversely oriented to define or locate a plurality of discrete discharge volumes, each such volume, conductor crossing and discrete dielectric storage area constituting a discharge unit or site. In some cases, the discharge units may be additionally defined by a physical structure such as a perforated glass plate and the like in registry with the discharge sites. In both cases, charges (electrons and ions) produced upon ionization of the gas at a selected discharge unit or site or conductor crosspoint, when proper alternating operating potentials are applied to selected conductors in the arrays are collected upon the surfaces of the dielectric at the discharge site and constitute an electrical memory.

The present invention, then, is concerned primarily with individual conductors per se, and configurations thereof, which, while the material forming the conductors are normally non-transparent, the unique configurations disclosed herein can effectively render the conductors substantially transparent so as to permit greater quantities of light or radiant energy produced during the discharge to exit through a viewing plate of the panel and/or alternately permit light to pass through the plate to condition the device for discharge or electrophotographic purposes. This is achieved in the present invention by constituting the conductor of at least one conductor array by at least a pair of parallel conductor elements with the discharge being made more visible (that is not hidden behind one of the electrical conductors effecting the discharge) because the electrical field is commonly applied by two spaced conductive elements forming a conductor which are not congruent with a coacting conductor in an opposing conductor array as seen by the observer. Furthermore, by connecting the conduction elements at their ends, and/or regular intervals along the conductors (preferably not at a discharge site), there is an increase in the probability that all of the conductor lines of the arrays will be electrically conductive after fabrication of the panel.

The above and other advantages and features of the invention will become more apparent from he following specification when considered with the attached drawings wherein:

FIG. **1** is a diagrammatic illustration of a gas discharge panel incorporating the invention and associated driving circuit;

FIG. **2** is a cross sectional view taken on lines A—A of FIG. **1**.

FIG. **3** is a modification wherein both conductor arrays of a display panel are formed in accordance with the invention;

FIG **4** is a diagramatic illustration of the invention as applied to the conductor array on the viewing plate of a display device incorporating the invention and FIG. **4** A is a cross sectional view thereof; and

FIG. **5** is a diagramatic illustration of a further modification of the invention.

GAS DISCHARGE PANELS

With reference to the drawings, FIGS. **1** and **2** diagramatically illustrate a gas discharge display/memory panel in which glass support or plate members **10** and **11** have formed on their opposing or facing surfaces conductor arrays **12** and **13**, respectively. Dielectric members or coatings **14** and **16** have gas contacting wall surfaces for storage of charges (electrons and ions) generated upon discharge (ionization) of individual discharge units, respectively.

The surfaces **17** and **18** of dielectric members **14** and **16**, respectively are spaced apart by spacer sealant **20** to form a thin gas chamber **20**. Glass support or plate members **10** and **11** are sufficiently rugged to withstand the pressure of the gas within space **20** and ambient pressure with a minimum deflection. In the disclosed panel there are no physical obstructions or structures in the gas chamber and a plurality of discrete discharges can occur within chamber **20** without detrimental interaction to the display or memory function of individual discharge units even though the conductors of the conductor arrays are spaced no more than about 30 mils center to center spacing. If desired for large panels spacer rods (not shown) may be located parallel to and between a conductor pair of one conductor array.

Individual discharge units or discharge sites may be turned "on" (a sequence of momentary discharges on alternate half cycles of applied alternating potential following an initial discharge) and "off" (termination of the sequence) by many different wave forms the sim-

plest of which is sinusodial voltage waveform. Basically, the only condition other than the voltage wave form is that the discharge unit be conditioned such that it is responsive to the applied voltage and this may be done by flooding the panel with ultra violet light or other conditioning techniques, as disclosed in the aforementioned Baker et al. application, may be used.

In normal operation each conductor **12-1, 12-2...12-N** of conductor array **12** (which may be considered as row conductors) has applied thereto a sustaining voltage **30** from addressing-interface-sustaining voltage circuits **31** and an opposite phase sustaining voltage **32** is applied to conductors **13-1, 13-2 . . . 13-N** of conductor array **13** (which may be considered as column conductors it being understood that the designations of "row" and "column" conductors being determined by panel orientation) on plate **11**. Opposite phase sustaining voltages **30** and **32** as applied to conductor arrays **12** and **13** are of a magnitude which is insufficient to initiate a discharge at any crosspoint defined or located by conductor crossings of the conductor arrays. As shown on the drawings, the voltage **30** constitutes one-half of the sustaining voltage Vs/2 and the voltage **32** applied to the conductors of conductor array **13** constitute the other half of the sustaining voltage (Vs/2). When a firing voltage pulse is added to the sustaining voltages applied to a selected conductor pair in both arrays the discrete volume of gas between the crossing points of the conductors in each array is ionized or discharged and charges (ions and electrons) produced on such discharge are collected or stored on the surfaces **17** and **18** of dielectric members or coatings **14** and **16**, respectively. Electrons are drawn to and stored on that discrete area of surface **17** under or in the shadow of the crossing of the selected conductors having the positive potential thereon at that instant and ions are collected on the opposing discrete surface area having a negative potential at that instant. As described in the aforementioned Baker et al. application these charges constitute an electric field opposing the applied field which created them and hence terminate the discharge almost immediately and constitute an electric memory. After application of the initial firing voltage, the stored charges constitute an electrical field across the gaseous medium, and aid in initiating the discharge on the next succeeding half cycle of applied potential so that after an initial discharge and formation of charges on the dielectric surfaces at selected discharge sites the sustaining voltages **30** and **32** are sufficient to sustain the discharges thereafter. Light production during the discharge is momentary there being two flashes of light for each cycle of applied potential. "On" and "off" conditions of the discharge units may be selectively controlled by "on" and "off" pulses added to the sustaining voltages. A suitable frequency for the sustaining voltage is about 50 KHz so once a sequence of discharges has been initiated there will be approximately 100,000 flashes of light per second.

CONDUCTOR ARRAYS ACCORDING TO THE INVENTION

The present invention is concerned with improving the transmission of light to and from the discharge site which is the "shadow" area of two crossing conductors on the respective conductor array **12** and **13**. In accordance with the invention, at least one of the conductor arrays has the conductors thereof formed as a plurality of spaced apart coplanar and parallel conductor elements in such a way that when a discharge occurs at a selected crosspoint or discharge site an observer can see more of the center of the discharge which normally would be partially hidden by the conductor line. In FIGS. **1** and **2**, only the conductors in the array **12** on plate **10**, which is designated as the viewing plate, are constituted in this fashion. Thus, conductor **12-1** is constituted by two conductor elements **12-1A** and **12-1B** and each conductor in conductor array **12** is likewise constituted. In addition, the terminal ends **40** and **41** of each conductor element pair in conductor array **12** has a conductive bridges **40** B and **41** B extending between the conductor elements **12-1A** and **12-1B** to provide alternate conductive routes for conduction in case a section of a conductor element is discontinuous. Preferably, a plurality of conductive bridges **43** bridging conductor elements **12-1** A and **12-1** B are provided at regular intervals so as to provide a great variety of routes for conducting in case a section of the conductive elements is discontinuous. Moreover, as illustrated in FIG. **1**, such conductive bridges **43** are preferably located at places or locations not overlying a discharge site. Thus, conductive elements **43** are to the sides of or interspersed between discharge sites.

In this way, conductive bridges **43** may be relatively large circular dots as indicated at **44**. In effect, each conductor **12-1, 12-2,...12-N** is constituted by a ladder-like element in which the spaces between "rungs" (bridges **43**) permit light to pass through the panel more effectively as indicated the the arrow of **46**. At the same time, by constituting the conductors of the conductor arrays by at least a pair of conductive elements connected electrically in parallel radiant energy from exterior of the panel may, if desired, may be passed more efficiently to the interior of the panel as for purposes of conditioning the panel for discharge or writing on the panel with a light pen, for example. As shown in the above mentioned Baker et al. application, such panels may be conditioned for uniform operation by maintaining at one or more discharge units in a "-fired" condition or by directing radiant energy, such as ultra violet, to the gas in the panel which creates a supply of free electrons necessary for initiation of a discharge. Although, only two conductor elements are shown for each conductor in an array, it will be appreciated that there may be more than two conductor elements constituting a single conductor in an array. It should also be noted that the conductor elements of a set are coplanar, although, at each discharge site there may be a discharge between each conductor element and the opposing conductor elements or conductor on the opposite conductor array, particularly where the conductor elements are widely separated, such is deemed to constitute a single discharge for purposes of this invention.

FIG. **3** illustrates diagramatically a modification wherein conductors **12-1 . . . 12-N** and **13-1 . . . 13-N** in conductor arrays **12** and **13** are constituted by parallel conductive elements, respectively. The embodiment shown in FIG. **4** is similar to the embodiment shown in FIGS. **1** and **2**. However, in this instance, as shown in

the cross sectional view of FIG. 4-A, the conductive elements of a set constituting conductor in a conductor array may be wires **50** (1–2 mil) instead of being printed and fired conductors as is the case with the embodiment shown in FIGS. **1** and **2**. In this case, it is only necessary to apply a conductive bridge to the exposed terminal ends of the conductors.

The conductor elements **12** 1-A, **12**-1B, **12**-2A, **12**-2B as well as conductive bridge elements in **43** may be printed in accordance with the printing methods and apparatus disclosed in my patent application, Ser. No. 796,797 filed Feb. 5, 1969. Thus, the individual conductor elements B after having first translated the printing member with respect to the plate **10** or **11** being printed upon. Finally, the conductive bridges **43** may be printed as dots of conductive material between and touching the conductor elements A and B, it being understood that the conductive bridges may be printed in as many places at regular intervals and in one or more printing steps, as desired.

By use of the printing methods and apparatus disclosed in my aforementioned patent application, conductive lines 1 to 2 mils in width (and larger if desired) may be printed with a spacing between conductive elements A & B of about 1 mil to thus approximately equal a conductor line printed by silk screen processes where the conductor line may have a width of approximately 6 mils. Other dimensional parameters of a typical panel incorporating the invention are plates **10** and **11** being one-quarter-inch plate glass (250 mils); dielectric coatings **14** and **16** being 1 to 2 mils; spacing between surfaces **17** and **18** of dielectric coatings **14** and **16**, respectively being between 4 and 6 mils (and at least under 10 mils) and the effective center to center spacing between conductor elements **12** and **13** being about 30 mils (the "center" of the "conductors" being half the spacing between conductor elements A and conductor elements B). In a 4 inch display area, there will be approximately 33 conductors per lineal inch and hence, approximately 18,000 discharge sites defined by the crossing points of conductor array **12** and **13**.

Since many widely different embodiments of the invention may be made without departing from the spirit thereof, it is to be understood that the invention is not limited to the specific embodiments disclosed herein except as defined in the appended claims.

I claim:

1. A method of increasing efficiency of light transmission and assuring electrical continuity of non-transparent printed conductors in a multiple discharge gas discharge device in which a gas discharge medium is confined between a pair of dielectric coated conductor arrays and selected discharge sites within the gas medium are excited by electrical potentials applied between at least one conductor in one of said arrays and at least one conductor in the other of said arrays, the crossing point of said conductors locating a selected discharge site, comprising

printing each conductor of at least one of said arrays on a viewing plate of the device as a set of narrow, spaced apart, conductor elements and

making a conductive electrical bridge connection at least at the terminal ends of conductor elements constituting a conductor in the array.

2. The invention defined in claim **1** wherein a conductive electrical bridge connection between conductor elements is made at regular intervals along the length thereof.

3. The invention defined in claim **2** wherein said conductive bridges are at least at both ends of the conductive elements of a pair.

4. The invention defined in claim **2** wherein said conductive bridges are at regular intervals along the length of the conductive elements of each said pair, respectively.

5. The invention defined in claim **2** wherein said conductive bridges are at least at both ends of the conductive elements of each said pair and at regular intervals between the ends.

6. The invention defined in claim **5** wherein said regular intervals are between selectable discharge sites defined by said crossing points of said conductor arrays.

7. The invention defined in claim **1** wherein the conductors in one of said arrays are constituted by a single conductor element, said single conductor element having a width which is wider than individual conductor elements in said pair.

8. The invention defined in claim **1** wherein each conductor in the other of said conductor array is constituted by at least a pair of conductor elements, each conductor element of a pair being spaced from the other conductor elements in its pair to permit radiant energy to pass therethrough.

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