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Nakayama et al.

[11] **3,881,129**

[45] **Apr. 29, 1975**

[54] **GAS DISCHARGE DEVICE HAVING A LOGIC FUNCTION**

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Dec. 15, 1971 Japan 46-10167

[52] **U.S. Cl.** ..... **315/169 TV**; 315/169 R

[51] **Int. Cl.** **H05b 37/00**

[58] **Field of Search** ..... 315/169 R, 169 TV

[56] **References Cited**

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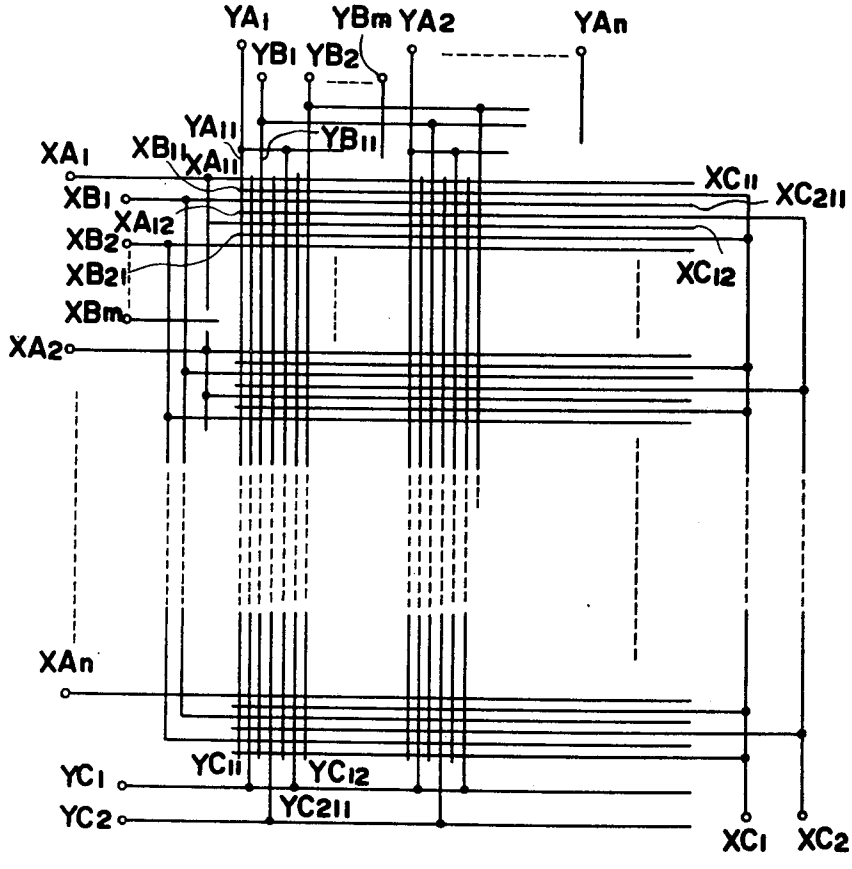
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Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Lawrence J. Dahl
Attorney, Agent, or Firm—Staas & Halsey

[57] **ABSTRACT**

A gas discharge device which has less external terminals than discharge cells formed by intersections of electrodes and which is driven to achieve a logical multiplying or like logical operation between the external terminals and the electrodes forming the discharge cells.

7 Claims, 21 Drawing Figures



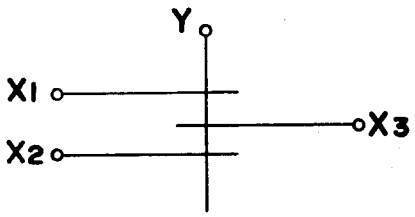


FIG. 1A

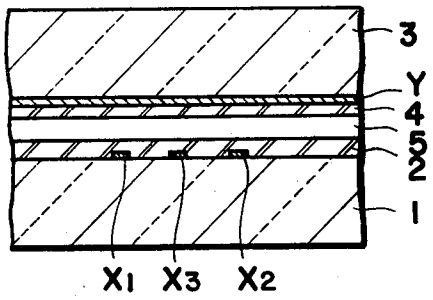


FIG. 1B

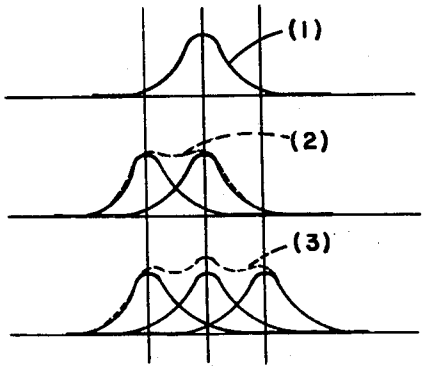
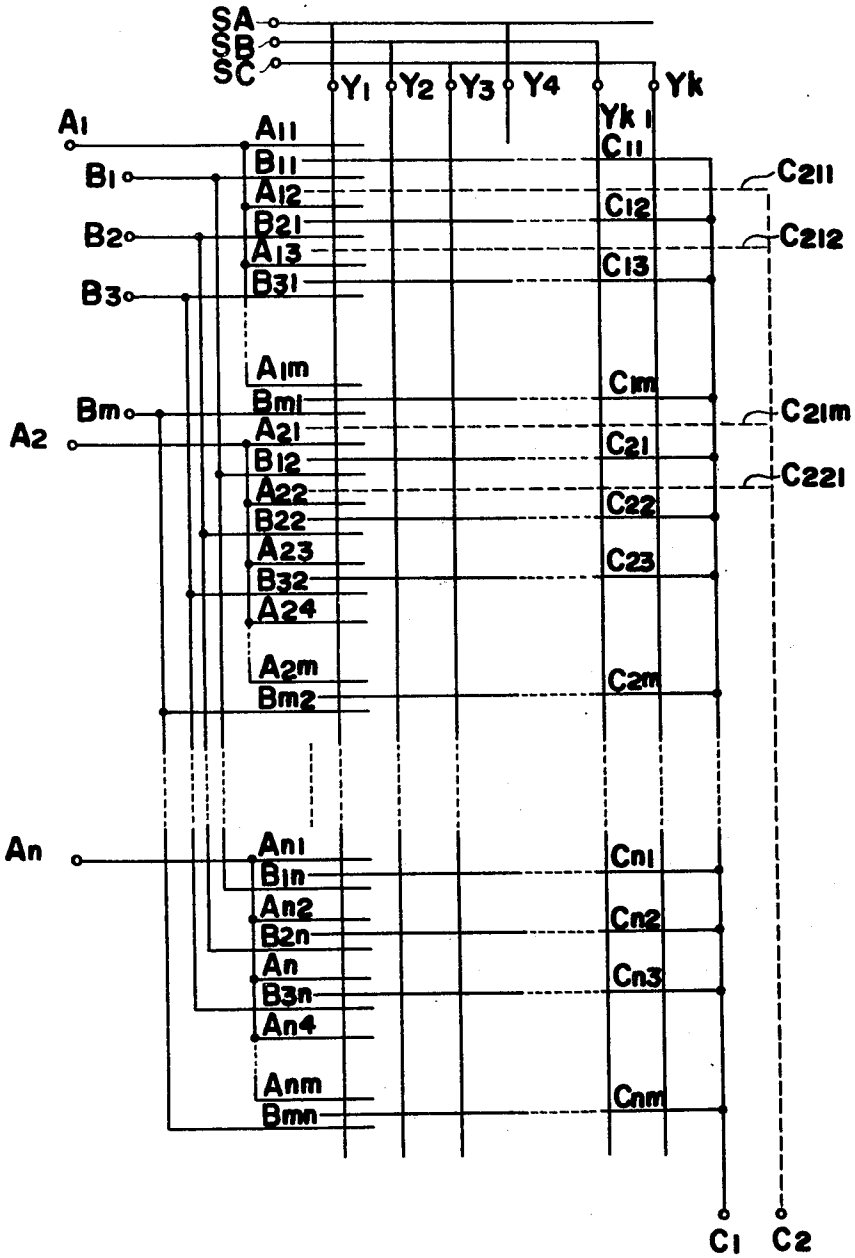


FIG. 1C

FIG. 2


SA
SB
SC
Y1
Y2
Y3
Y4
Yk
Yk+1
A1
B1
B2
B3
Bm
A2
An
A11
B11
A12
B21
A13
B31
A1m
Bm1
A21
B12
A22
B22
A23
B32
A24
A2m
Bm2
An1
B1n
An2
B2n
An
B3n
An4
Anm
Bmn
C11
C12
C13
Cm
C21
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Cn1
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Cnm
C211
C212
C21m
C221
C1
C2

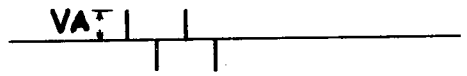


FIG. 3A

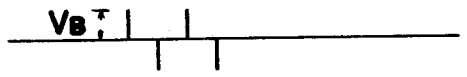


FIG. 3B

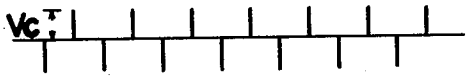


FIG. 3C

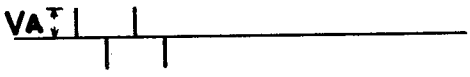


FIG. 4A



FIG. 4B

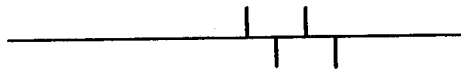


FIG. 4C

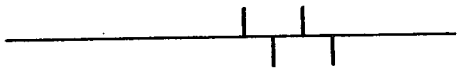


FIG. 4D

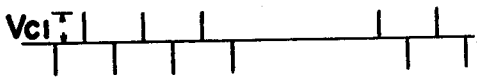


FIG. 4E

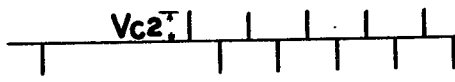


FIG. 4F

FIG. 5

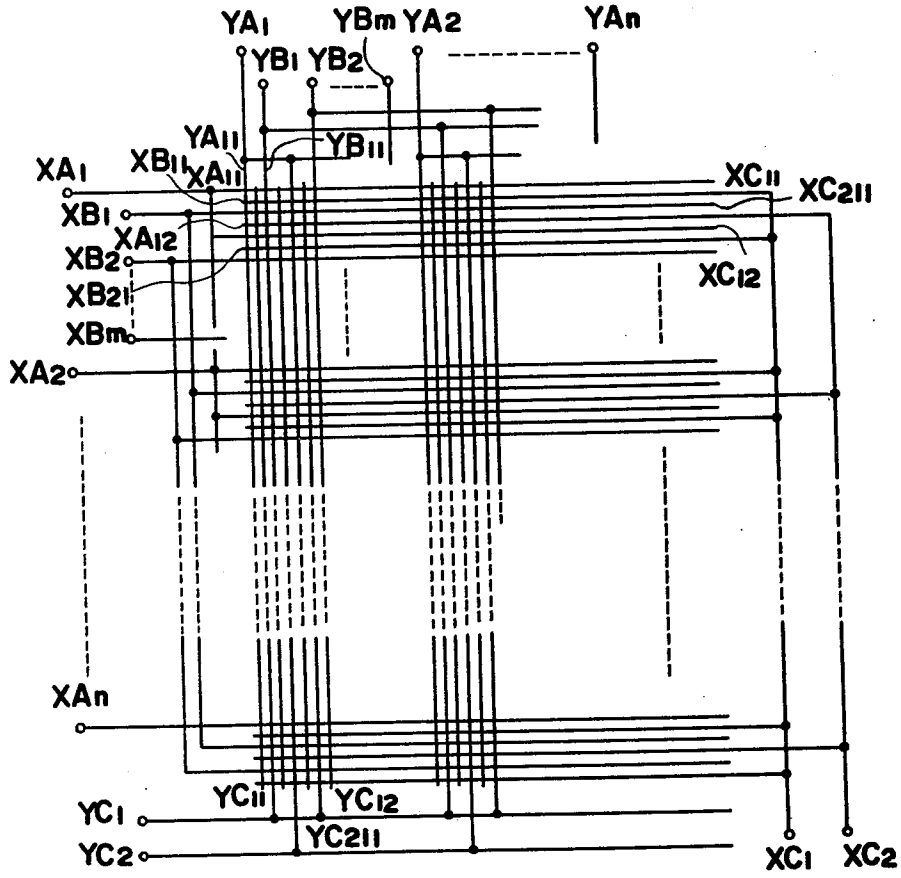

YA1
YBm
YA2
YAn
YB1
YB2
YA11
YB11
XA1
XB11
XA11
XC11
XC211
XB1
XA12
XB2
XC12
XB21
XBm
XA2
XAn
YC1
YC11
YC12
YC2
YC211
XC1
XC2

FIG. 6

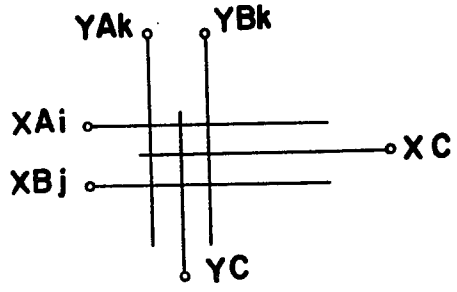

YAk
YBk
XAi
XC
XBj
YC

FIG. 7

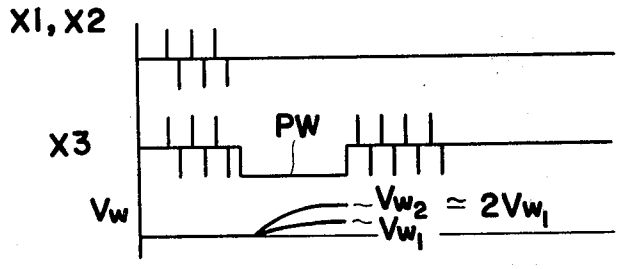


FIG. 8

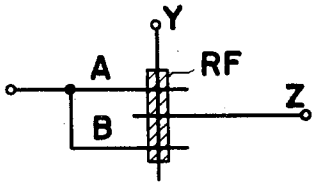


FIG. 9

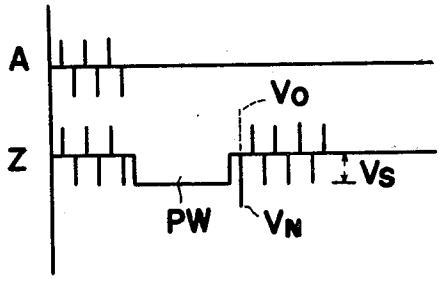


FIG. 10

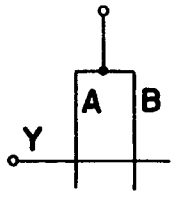


FIG. 11

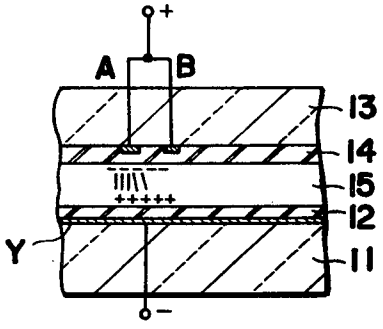
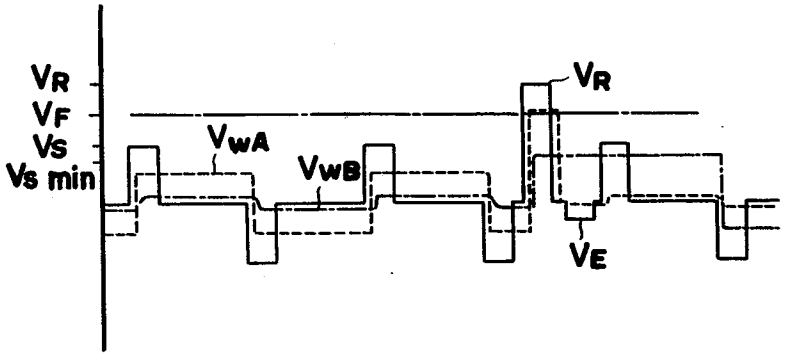


FIG. 12



GAS DISCHARGE DEVICE HAVING A LOGIC FUNCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a gas discharge device having a logical function whose external terminals are less in number than the number of discharge cells.

2. Description of the Prior Art.

In a gas discharge device known under the name of a plasma display panel, electrodes covered with dielectric layers are disposed in opposing relation and Neon or like discharge gas is sealed between the opposed electrodes. A voltage higher than a firing voltage is applied between the opposed electrodes to produce a discharge spot, after which, by impression of an alternating sustain voltage lower than a discharge voltage, the potential difference between the sustain voltage applied and a wall voltage produced by the discharge spot exceeds the discharge voltage and the discharge spot is produced each time the polarity of the sustain voltage is reversed. Namely, the sustain voltage is impressed to the opposed electrodes and a write-in voltage is applied between selected ones of the electrodes, by which the discharge spot is produced at the intersection of the selected electrodes, thus enabling a display. However, when the plasma display panel becomes large-sized, the number of electrodes increases and connection with external circuits becomes difficult and a drive circuit becomes complicated and expensive.

Further, there has also been proposed a panel structure such that the discharge spot is shifted by sequential impression of a voltage to the electrodes of the one group to provide a display in the manner of an electric sign. Also in this case, however, the number of write-in electrodes for producing a first discharge spot increases with an increase in the display area and connection with external circuits is not easy as described previously.

SUMMARY OF THE INVENTION

One object of this invention is to provide a gas discharge device which is provided with less external terminals than electrodes forming discharge cells and a simplified drive circuit.

Another object of this invention is to provide a gas discharge device which is adapted so that a logical operation is achieved with a plurality of electrodes forming discharge cells.

Briefly stated, the gas discharge device according to this invention is such that either row or column electrodes are used as first and second electrodes and third electrodes are each disposed between the first and second electrodes. The first electrodes are connected to a common terminal for each electrode group; the second electrodes are connected to terminals common to those of all the electrode groups; and the third electrodes are connected to a common terminal. Only when a voltage is impressed to selected ones of the first and second electrodes and a voltage is impressed to the third electrode disposed therebetween, a discharge spot is produced on the third electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A to 1C are diagrams for explaining the principle of the operation of this invention;

FIG. 2 is a diagram for explaining electrode arrangements in one example of this invention;

FIGS. 3A to 3C and FIGS. 4A to 4F are diagrams for explaining an impression voltage;

FIG. 5 is a diagram for explaining the electrode arrangements in another example of this invention;

FIG. 6 is a diagram for explaining the principle of the operation of the electrode arrangement of FIG. 5;

FIG. 7 is a diagram for explaining an impression voltage for a logical multiply operation of resistance channel coupling;

FIG. 8 is a diagram for explaining electrode arrangements of a NOT circuit of resistance channel coupling;

FIG. 9 is a diagram for explaining an impression voltage upon the electrode arrangement of FIG. 8;

FIG. 10 is a diagram for explaining an electrode arrangement of a flip-flop circuit;

FIG. 11 is a detailed, cross-sectional view of the electrode arrangement of FIG. 10; and

FIG. 12 is a diagram for explaining an impression of voltage upon the electrode arrangement of FIGS. 10 and 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows diagrams for explaining the principle of this invention. FIG. 1A is a top plan view showing the electrode arrangements; FIG. 1B shows its cross-sectional view; and FIG. 1C shows an electric field distribution diagram. Reference character X1 indicates a first electrode, X2 a second electrode, X3 a third electrode and Y an electrode disposed to cross them at right angles thereto in opposing relation. The electrodes X1, X2 and X3 are formed by printed wiring techniques or the like on a base plate 1 as of glass and the electrodes X1, X2 and X3 are covered with a dielectric layer 2 of low-melting-point glass or the like. The electrode Y is similarly formed on a base plate 3 as of glass and covered with a dielectric layer 4. A mixed discharge gas, composed of for example Ne 95 percent, and N_2 5 percent, is sealed within the space 5 defined between the opposing dielectric layers 2 and 4.

Upon impression of a voltage to the third electrode X3, an electric field such as shown at line (1) of FIG. 1C is established and the impression voltage is set lower than a discharge voltage. Impressing voltages to the third and first electrodes X3 and X1, the resulting electric field distribution becomes such as shown at line (2) of FIG. 1C and the voltages are set so that a composite maximum value may not reach the discharge voltage. Further, impressing voltages to the electrodes X1, X2 and X3, the resulting electric field distribution becomes such as depicted at line (3) of FIG. 1C and, in this case, the voltages are set so that a composite value on the third electrode X3 may reach the discharge voltage. Supposing that a discharge voltage between the electrodes Y and X3 in the case of neither electrodes X1 nor X2 is set at a voltage, in the case of either electrodes X1 or X2 is set at a voltage and in the case of both electrodes X1 and X2 are set at voltages respectively taken as V_{f0}, V_{F1} and V_{F2}, they bear such a relation as $V_{f0}>V_{F1}>V_{F2}$. Accordingly, it is possible to achieve a logical multiplying operation X1.X2=X3.

In the foregoing, the logical multiplying operation is effected in the non-discharge mode of the first and third electrodes X1 and X3, but the same operation can also be achieved in the discharge mode of them.

Namely, a discharge voltage between the electrodes X3 and Y in the case of a discharge spot being produced at the intersection of the electrodes X1 and Y, or X2 and Y is taken as V_{f1}; if a discharge voltage between the electrodes X3 and Y in the case of no discharge spot being produced at the both intersections is taken as V_{f0}; and if a discharge voltage in the case of discharge spots being produced at the both intersections is taken as V_{f2}, they bear such a relation as $V_{f0}>V_{f1}>V_{f2}$. This is a phenomenon resulting from plasma coupling due to the discharge spot. Therefore, if a voltage V3 impressed between the electrodes X3 and Y is selected so that $V_{f1}>V_3>V_{f2}$, it is possible to achieve the same operation as the aforesaid logical multiplying operation of non-discharge mode.

FIG. 2 illustrates the electrode structure of one example of this invention. Of electrodes A11 to Anm and B11 to Bmn (which are row electrodes), first and second electrodes A11 to A1m and B11 to Bm1 constitute a first electrode group; first and second electrodes A21 to A2m and B12 to Bm2 constitute a second electrode group; and, similarly, first and second electrodes An1 to Anm and B1n to Bmn constitute an nth electrode group. The first electrodes A11 to A1m, A21 to A2m and An1 to Anm of the first, second and nth electrode groups are connected to terminals A1, A2 and An, respectively. The second electrodes B11, B12, . . . and B1n of the first, second, . . . and nth electrode groups are connected to a terminal B1; the second electrodes B21, B22, . . . and B2n of the first, second, . . . and nth electrode groups are connected to a terminal B2; and, similarly, the second electrodes Bm1, Bm2, . . . and Bmn of the first, second, . . . and nth electrode groups are connected to a terminal Bm. Further, third electrodes C11 to Cnm, each disposed between the first and second electrodes, are connected to a common terminal C1. Then, electrodes Y1 to Yk, which are column electrodes, are disposed to cross the row electrodes at right angles thereto in opposing relation and only the electrode Y1 is disposed opposite to the first, second and third electrodes. The electrodes Y1 to Yk are sequentially supplied with voltages and, for example, every third ones of them are connected to buses SA, SB and SC respectively and the voltages to be impressed to the buses SA, SB and SC may be such sustain voltages which lap at the beginning and end thereof periodically and in time.

Impressing a voltage to the terminals, for example, A1, B1 and Bm, discharge spots are produced between the electrode Y1 and those A11 to A1m, B11 to B1n and Bm1 to Bmn. At an instant of impressing a voltage to the terminal C1, discharge spots are produced between the electrode Y1 and those C11 and C1m, and upon application of a voltage to the electrode Y2, the discharge spots shift to the intersections of the electrodes C11 and C1m with the electrode Y2. Namely, the first and second electrodes of the respective electrode groups perform the functions of writing electrodes of a self-shift panel. In this case, the number of the terminals is n+m but writing cam be effected at nxm points, so that the number of the terminals is considerably smaller than the number of electrodes employed in the prior art. According to this invention, in a conventional device using, for example, 128 electrodes or terminals, if $n=8$ and $m=16$, addressing can be achieved with such number of terminals as $n+m=24$. Similarly, in the case of 256 electrodes, if $n=16$ and $m=16$, the number of terminals is 32 and in the case of 512 electrodes, if $n=16$ and $m=32$, the number of terminals is 48. Then, it is possible to achieve addressing with a logical multiply that $A_i.B_j=C_{ij}(i,j=1, 2, 3. . .)$.

FIGS. 3A, 3B and 3C are diagrams for explaining impression voltage waveforms. Voltages V_A and V_B shown in FIGS. 3A and 3B which are impressed to the first and second electrodes A_{ij} and B_{ji} are selected substantially equal to each other; in the case of the discharge mode, they are selected such that $V_A=V_B>V_{f0}$, and in the case of the non-discharge mode, they are selected such that $V_{F1}>V_A=V_B\cong V_{F2}$. While, a voltage V_C shown in FIG. 3C which is applied to the third electrode C_{ij} is selected so that $V_{f1}>V_c>V_{f2}$ or $V_{F1}>V_C>V_{F2}$ as described previously. No limitation is imposed on the number of pulses of the voltages V_A and V_B (which may be one or more waves).

In FIG. 2, the spacing, for example, between the first and second electrodes A12 and B11 is shown to be equal to that between the electrodes A11 and B11 but it may also be narrowed. Further, where a third electrode C211 is provided between the electrodes B11 and A12 and connected to a terminal C2 as indicated by a broken line, when the terminals A1 and B1 are selected, either one of the electrodes C11 and C211 can be selected by selecting either one of the terminals C1 and C2. Accordingly, if $n=8$ and if $m=8$, addressing of 128 discharge cells can be achieved with such a number of terminals as $n+m=16$. If $n=16$ and if $m=16$, addressing of 512 discharge cells is possible with 32 terminals.

FIGS. 4A to 4F, inclusive, are diagrams for explaining the voltage waveforms in the case of selecting the terminals C1 and C2. In the case of writing with an electrode C_{ij} selected, the voltage to the terminal C2 is cut off as depicted in FIG. 4F at an instant when a voltage is impressed to the terminals Ai and Bj as shown in FIGS. 4A and 4B. In the case of writing with an electrode C2ij selected, the voltage to the terminal C1 is cut off as depicted in FIG. 4E when the voltage is applied to the terminals Ai and Bj as shown in FIGS. 4C and 4D. The voltages V_A, V_B, V_{C1} and V_{C2} in this case are also selected in the same manner as in the foregoing. In FIGS. 3 and 4, in the case of the discharge mode, it is also possible that a first pulse voltage or a pulse voltage impressed a half cycle thereafter to the terminal Ai and Bj is selected higher than V_{f0}; that a sustain voltage Vs less than V_{f0} is applied thereafter; that, during the impression of the above voltage, in the voltage impressed to the terminal C1 and/or C2, the pulse voltage of desired period is selected higher than V_{f2} and the pulse voltage of other period is selected in the sustain voltage Vs. Further, in the case of the non-discharge mode, it is also possible to achieve writing by impressing the sustain voltage V_S to the terminals Ai and C1 or C2 and impressing a pulse voltage higher than V_{F2} to the terminal C1 or C2 as in the case of a query pulse. This provides an advantage that an erasing operation is easy because the relatively low sustain voltage V_S is impressed after writing.

FIG. 5 illustrates the electrode structure of another example of this invention, in which the first and second electrodes are formed to extend with the third electrode therebetween and the electrodes opposite thereto are also similarly constructed. In the present example, when voltages are selectively impressed to electrodes, for example, XA1, XB2 and XC1 and those YA1, YB1

and YC1, a discharge spot is produced at the intersection of the electrodes XC12 and YC11. Namely, in FIG. 6, the peak values of the impressed voltages are selected so that only where electrodes XAi, XBj and YAk, YBh are simultaneously selected and voltages are applied to electrodes XC and YC, a discharge spot is produced at the intersection of the electrodes XC and YC. This is possible in both the cases of the discharge mode and the non-discharge one.

This example corresponds to a conventional plasma display device of the type that, by selecting the X- and Y- direction electrodes, a discharge spot is produced at their intersection. For example, if $n = 8$ and if $m = 8$, the total number of terminals of the X- and Y- direction electrodes is $(n+m) \times 2 = 32$, with which it is possible to address 128^2 discharge cells. On the other hand, the conventional device requires 128×2 terminals and this invention substantially decreases the number of terminals. Namely, the relation between the number of terminals P of a conventional device and the number of terminals Q in the present invention can be expressed by an approximate equation $2\sqrt{P} \cong Q$ and, according to the present invention, the number of terminals can be decreased by geometrical progression.

Further, in the example of FIG. 5, a display can also be provided by connecting the electrodes YA11, YB11, . . . in the manner shown in FIG. 2. In this case, the electrodes connected to the terminals YC1 and YC2 are omitted. Further, condition for producing the discharge spot is such that XAi.XBj.Yk=XC.

With this invention, the number of terminals can be made as much as one order than that of electrodes as described above, so that the connection with external circuit becomes easy and the electrode selection can be achieved by the incorporated logical multiply operation mechanism without using a resistance-diode matrix of the prior art. Accordingly, the space can be saved and the cost of the device can be lowered. Further, the manufacture does not become especially complicated. For example, the electrodes and wires interconnecting the electrodes and the terminals are formed on a base plate as of glass; insulating layers are formed on the parts of the intersections of the wires; and then wire for interconnecting the electrodes and the respective groups are formed on the insulating layers. This invention increases only two manufacturing processes as compared with the prior art, but the device of this invention can easily be manufactured by the application of techniques for producing an integrated circuit.

In the example of FIGS. 1A to 1C, a logical multiply operation can also be achieved by resistance channel coupling such that a resistance film is formed on the dielectric layer 4 covering the electrodes Y in their lengthwise direction and a wall charge produced by discharge scatters along the resistance film and flows into adjacent channel regions.

Also in this case, the firing voltage is selected such that even if a wall charge produced by discharge of either one of the electrodes X1 and X2 flows in the electrode X3, no discharge is caused by the electrode X3 except that when discharge is produced by the electrodes X1 and X2 and a wall charge resulting therefrom flows in the electrodes X3, discharge is caused by the electrode X3. The wall charge flowing into adjacent discharge cell regions reaches its maximum value after a certain period of time and the time therefor becomes shorter with a decrease in the resistance value of the resistance film.

FIG. 7 shows one example of an impression voltage waveform for achieving the logical multiply operation by the above-described resistance channel coupling. When discharge is produced by simultaneous impression of a voltage to the electrodes X1 and X2, the voltage is cut off and then a pulse PW attracting wall charges on the electrodes X1 and X2 is applied to the electrode X3, by which the wall charges are caused to move rapidly, providing a high-speed operation and accuracy of the operation. Where only either one of the electrodes X1 and X2 causes discharge, the resulting wall charge V_W on the electrode X3 becomes V_{W1} and where the both electrodes X1 and X2 cause discharge, the resulting wall charge becomes such that $V_{W2} \cong 2V_{W1}$ and discharge is caused by the potential difference between the wall charge V_{W2} and a subsequent voltage impressed to the electrode X3. The voltage applied to the electrode X3 in this case is the sustain voltage V_S.

Next, an OR circuit will be described. In the case of the discharge mode, if an impression voltage V3 applied to the electrode X3 is selected so that $V_{f0} > V3 > V_{f1}$, a logical summing operation of (X1)+(X2)=X3 can be achieved. In the case of the non-discharge mode, the impression voltage is selected such that a discharge spot may be produced on the electrode X3 with the composite value of the electric field distributions shown in the middle of FIG. 1C. Further, in the case of using the resistance channel coupling, a logical summing operation can be achieved by impressing such a voltage that a discharge spot may be produced due to the potential difference between it and the wall charge V_{W1} or by impressing, subsequent to the pulse PW, a voltage V_O selected higher than the sustain voltage V_S and such that $V_F > V_0 + V_{W1}$ where V_F is a discharge voltage.

Next, a NOT circuit will be described. FIG. 8 shows its electrode arrangements and FIG. 9 one example of impression voltage waveforms. Reference character RF indicates a resistance film. This is the case of employing the resistance channel coupling and either one of electrodes A and B may be left out. An electrode Z is supplied with the pulse PW attracting the wall charge and then with a pulse V_N of the same polarity as the pulse PW. The value of the pulse V_N is selected so that discharge is caused when the wall charge is close to "O". When, discharge is caused at the electrode A and the resulting wall charge is attracted to the electrode Z, the wall voltage V_{W1} of the polarity cancelling the field produced by V_N is produced and if the discharge voltage is taken as V_F, the result is that $V_F > V_N - V_{W1}$ and no discharge is caused. However, if no discharge is caused at the electrodes A, $V_F < V_N$, so that discharge is caused by the pulse V_N. Therefore, a NOT logic operation $\bar{A}$=Z can be carried out. A pulse V_O indicated by a broken line is a pulse for the logical summing operation and it is selected so that $V_F < V_O + V_{W1}$.

Where the electrodes A, B and Z are disposed very close to one another, there is a phenomenon that when the same voltage is applied to the electrodes and discharge is produced at one of adjacent electrodes, discharge is difficult to be caused at the other electrode. Such a proximity effect is usually caused where the spacing between the electrodes is less than 400μ or so, although it is different according to the device's dimensions and to the kind of a gas used. Therefore, where

the electrodes A, B and Z are disposed close to one another and connected as shown in FIG. **8**, when discharge is caused at the electrodes A and B, no discharge is produced at the electrode Z and when no discharge is caused at the electrodes A and B, discharge is produced at the electrode Z. Namely, the aforementioned NOT logic operation is performed. This is based on plasma coupling and no resistance channel is required.

In the case of a NOR circuit, a logical operation $\overline{A+B}=Z$ can be achieved by using the electrodes A and B which are separated in FIG. **8** as control electrodes. In the case of a NAND circuit, a logical operation $\overline{A.B}=Z$ can be effected by using the electrodes A and B which are separated as control electrodes and selecting the pulse V_N such that $(V_N-V_{W2})<V_F<(V_N-V_{W1})$.

FIG. **10** illustrates an example of a flip-flop circuit construction and FIG. **11** is a cross-sectional view of its principal parts. Reference numerals **11** and **13** designate base plates as of glass, **14** and **12** dielectric layers, and **15** the space defined between the opposing dielectric layers. Reference characters A, B and Y indicate electrodes. The illustrated flip-flop circuit utilizes the aforementioned proximity effect and the electrodes A and B both serve as control and output electrodes. In FIG. **11**, assuming that a discharge is caused at the electrode A, when a positive voltage is applied to the electrodes A and B and a negative voltage is applied to the electrode Y, negative and positive charges are stored in the dielectric layers **14** and **12** overlying the electrodes A and Y respectively and negative charges are also attracted to the electrode B, so that the negative charges act to cancel the impressed voltage. Consequently, after once produced, the discharge is continuously generated only at the electrode A by continuous impression of the usual sustain voltage V_S. Then, impressing a reverse pulse voltage V_R of the same polarity as the sustain voltage V_S and of high peak value prior to the application of the sustain voltage V_S as shown in FIG. **12**, the discharge at the electrode A is stopped and instead a discharge is generated at the electrode B. The voltage V_R is selected to exceed the discharge voltage V_F. With this voltage V_R, discharges are caused at the both electrodes A and B and a wall charge V_{WA} of the electrode A is thereby greatly increased to cause a discharge, and hence become attenuated. While, the level of a wall charge V_{WB} of the electrode B is raised by the voltage V_R and the discharge is continued by the subsequent sustain voltage V_S as in usual writing operation. Accordingly, each time the voltage V_R is impressed, a discharge is caused alternately at the electrodes A and B to provide the operation of the flip-flop circuit. Reference numeral V_E indicates an erasing pulse, which provides ensured operation, but the flip-flop operation can be carried out by the reverse pulse V_R without using the erasing pulse V_E.

As has been described in the foregoing, the present invention enables various logical operations by selecting the spacing between the electrodes or impression voltages and their polarity, and the output can be derived by a light detector, a discharge current detector or shift of the generated discharge spot. Hence, the device of this invention can be adapted for a wide range of uses.

With the present invention, a logical operation is achieved with one part of the electrodes of a plasma display panel and the number of external terminals can be made smaller than that of the electrodes by the use of the logic circuit as described in the foregoing, so that the number of drive circuits for driving the display device can be reduced to provide for simplified construction.

It will be apparent that this invention is not limited specifically to the foregoing examples and that various modifications and variations may be effected without departing from the scope of the spirits defined in the appended claims.

What is claimed is:

1. A method for controlling a discharge in gas discharge apparatus comprised of first support means for supporting first, second and third electrodes, each disposed in a first direction and covered with a first dielectric layer, said third electrode being disposed between said first and second electrodes; second support means for supporting a fourth electrode spaced from and disposed to traverse said first, second and third electrodes and covered with a second dielectric layer; and envelope means for confining a discharge gas between said first and second dielectric layers; said method comprising the steps of:

applying between said third and fourth electrodes a first control voltage of a magnitude insufficient to produce a discharge in said discharge gas; and

applying a second control voltage selectively to said first and second electrodes, said second control voltage being selected to be of a magnitude higher than the discharge voltage between said first and fourth electrodes and the discharge voltage between the second and fourth electrodes, wherein

said first control voltage impressed between said third and fourth electrodes is selected to be lower than a first lowered discharge voltage established between said third and fourth electrodes when a discharge is produced on only one of said first and second electrodes by said second control voltage, and to be higher than a second, further lowered discharge voltage established between said third and fourth electrodes when a discharge is produced on each of said first and second electrodes by said second control voltage whereby a discharge is produced across said discharge gas between said third and fourth electrodes as a result of the impression of said second control voltage to said first and second electrodes and of said first control voltage between said fourth and third electrodes.

2. A method for controlling a discharge in gas discharge apparatus according to claim **1**, wherein said first control voltage impressed between said third and fourth electrodes is selected to be lower than a discharge voltage therebetween, and said second control voltage is impressed to both of said first and second electrodes and is so selected to be of a magnitude to establish a composite electric field of sufficiently high intensity to produce a discharge across said discharge gas between said third and fourth electrodes in association with said first control voltage, whereby the discharge is produced across said discharge gas between said third and fourth electrodes as a result of a logical multiplying operation by the impression of said second control voltage to said first and second electrodes.

3. A method for controlling a discharge in gas discharge apparatus according to claim **1**, wherein the magnitude of said first control voltage is so selected to produce a discharge in cooperation with the effect pro-

duced on said discharge gas by said second control voltage when it is impressed to one of said first and second electrodes, whereby a discharge is produced across said discharge gas between said third and fourth electrodes as a result of a logical multiplying operation by the impression of said second control voltage to one of said first and second electrodes.

4. A method for controlling a discharge in gas discharge apparatus comprised of first support means for supporting first, second and third electrodes, each disposed in a first direction and covered with a first dielectric layer; second support means for supporting a fourth electrode spaced from and disposed to traverse said first, second and third electrodes and covered with a second dielectric layer, said third electrode disposed between said first and second electrodes; and envelope means for confining a discharge gas between said first and second dielectric layers, said method comprising the steps of:

a. impressing a control voltage to at least one of said first and second electrodes to produce a discharge across said discharge gas from said fourth electrode to one of said first and second electrodes; and

b. impressing, to said third electrode, an auxiliary pulse for establishing a wall charge at the portion of the surface of said first dielectric layer corresponding to said third electrode, due to the discharge resulting from the effect of said control voltage on the surface of said first dielectric layer corresponding to at least one of said first and second electrodes; and

c. applying to said third electrode an inquiry pulse selected so that the sum of said inquiry pulse and a wall voltage produced by said attracted wall charge exceeds a discharge voltage, to effect a discharge across said discharge gas between said third and fourth electrodes in response to the impression of said control voltage to at least one of said first and second electrodes.

5. A method for controlling a discharge in gas discharge apparatus comprised of first support means for supporting first, second and third electrodes, each disposed in a first direction and covered with a first dielectric layer; second support means for supporting a fourth electrode spaced from and disposed to traverse said first, second and third electrodes and covered with a second dielectric layer, said third electrode disposed between said first and second electrodes; and envelope means for confining a discharge gas between said first and second dielectric layers, said method comprising the steps of:

a. impressing a control voltage to at least one of said first and second electrodes to produce a discharge across said discharge gas between said fourth electrode and said one electrode;

b. impressing to said third electrode an auxiliary pulse for establishing at the surface of said first dielectric layer corresponding to said third layer, a wall charge due to the discharge resulting from the effect of said control voltage on the surface of said first dielectric layer corresponding to said one electrode; and

c. applying to said third electrode an inquiry pulse of a magnitude selected so that, in the absence of said wall charge, it exceeds a discharge voltage but that, in the presence of said wall charge, the difference between said inquiry pulse and a wall voltage produced by said wall charge is lower than said discharge voltage, whereby the discharge between said third and fourth electrodes is effected as a result of a NOT-logic operation by the impression of said control voltage to at least one of said first and second electrodes when said inquiry pulse is impressed.

6. A method for a controlling a discharge in gas discharge apparatus comprised of first support means for supporting pluralities of each of first, second and third electrodes disposed in a plurality of electrode groups, each of said groups comprising a plurality of pairs of electrodes, each said pair including a first and a second electrode and having a corresponding third electrode disposed between said first and second electrodes of said pair at least one of said first, second and third electrodes, said first electrodes of each electrode group being connected in common to a respectively associated one of first common terminals respectively corresponding to said groups, and said electrodes of the corresponding pairs of said plural electrode groups being connected in common to a respectively associated one of second common terminals, said third electrodes of all said electrode groups being connected to a third common terminal, said first, second and third electrodes being covered with a first dielectric layer, second support means for supporting a fourth electrode spaced from and disposed to traverse said first, second and third electrodes and covered with a second dielectric layer; and envelope means for confining a discharge gas between said first and second dielectric layers, said method comprising the steps of;

a. applying between said fourth electrode and said third electrodes a first control voltage of a magnitude insufficient to produce a discharge across said discharge gas; and

b. applying a second control voltage to a selected one of each of said first and second common terminals for application thereof in turn to the first and second electrodes connected to said selected first and second common terminals, the first and second control voltage being of respective magnitudes selected to produce in cooperation with each other a discharge across said discharge gas between the third electrode disposed between said first and second electrodes of the pair to said first and second electrodes of which said second control voltage is applied, and said fourth electrode.

7. A method for controlling a discharge in gas discharge apparatus according to claim **20,** wherein selected ones of said third electrodes define first output electrodes and the remaining ones of said third electrodes define second output electrodes and there is further included a plurality of said fourth electrodes traversing said first and second electrodes, said method further comprising the step of applying the first control voltage individually and in sequence to said plurality of said fourth electrodes, whereby the discharge produced across said discharge gas between said third electrodes and said one of said fourth electrodes as a result of the impression of said second control voltage to both of said first and second electrodes and of said first control voltage between said fourth and third electrodes and of said first control voltage between said fourth and third electrodes is shifted sequentially to successive ones of said fourth electrodes in accordance with the said application of said first control voltage individually and in sequence to said plurality of said fourth electrodes.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,881,129 Dated April 29, 1975

Inventor(s) Norihiko Nakayama; Hiroshi Furuta; Shizuo Andoh and Toshimori Urade

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the face of the patent at "[73]", change "Fujetsu" to --Fujitsu--.

Column 5, line 32, after "order" insert --of magnitude smaller--.

Column 6, line 36, change "$V_F >$" to --$V_F <$--.

Column 10, line 8, delete "a" (first occurrence).

Column 10, line 16, delete "at least one of said first, second and third electrodes".

Signed and sealed this 15th day of July 1975.

(SEAL)
Attest:

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Attesting Officer

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