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Owaki et al.

[11] **3,886,403**

[45] **May 27, 1975**

[54] **BRIGHTNESS MODULATION SYSTEM FOR A PLASMA DISPLAY DEVICE**

[75] Inventors: **Kenichi Owaki**, Kobe; **Shozo Umeda**, Kakogawa; **Hiroshi Furuta**, Akashi; **Tadatsugu Hirose**, Akashi; **Michihiro Shimuzi**, Akashi, all of Japan

[73] Assignee: **Fujitsu Limited**, Japan

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Dec. 30, 1971 Japan 47-1464

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

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

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

[56] **References Cited**

UNITED STATES PATENTS

3,603,731	9/1971	Weimer	315/169 TV X
3,627,924	12/1971	Fleming et al.	315/169 TV X
3,665,455	5/1972	Schmersal et al.	315/169 TV X

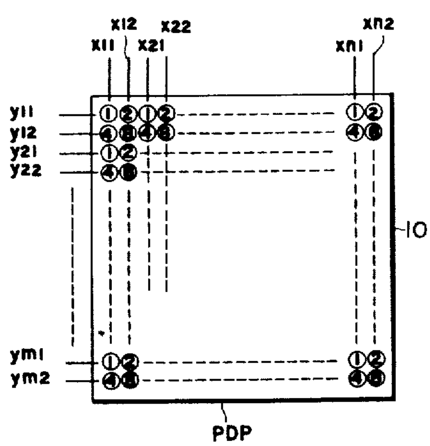
Primary Examiner—Nathan Kaufman

Attorney, Agent, or Firm—Staas & Halsey

[57] **ABSTRACT**

A brightness modulation system for a plasma display panel device in which one picture element is made up of a plurality of discharge cells, the brightness levels of the plurality of discharge cells are made different from each other by impression of voltages of different phases or repetitive frequencies and the discharge cells are selectively combined, thereby to achieve a display composed of a plurality of graded tones.

11 Claims, 21 Drawing Figures



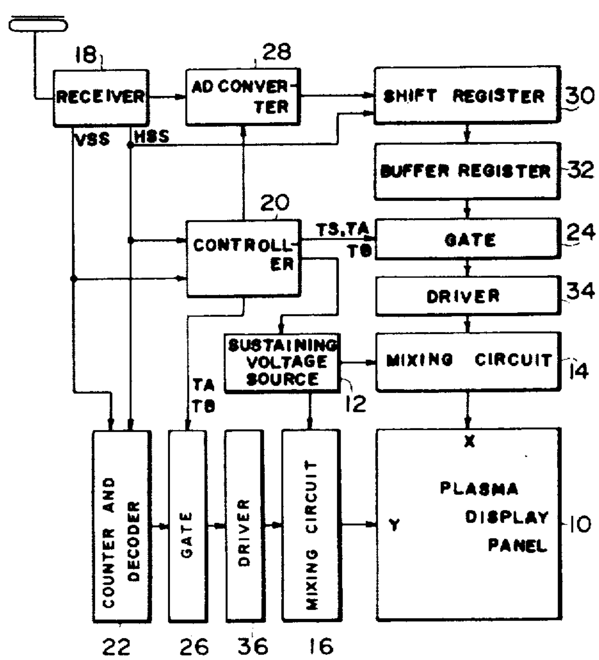


FIG. 1

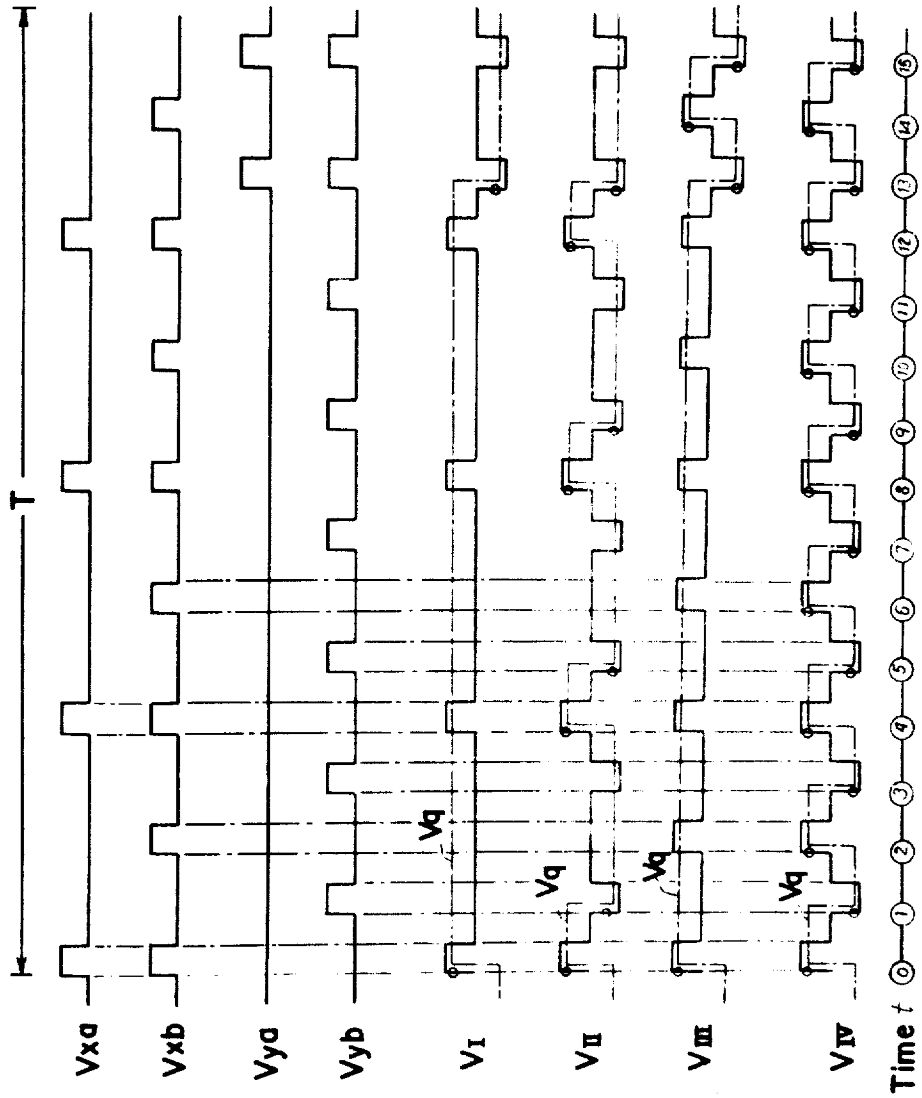
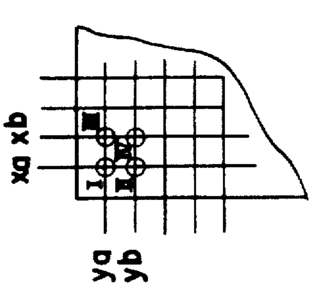

T
Vxa
Vxb
Vya
Vyb
VI
VII
VIII
VIV
Vq
Vq
Vq
Vq
Time t
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 2


xa xb
ya
yb
I
II
III
IV

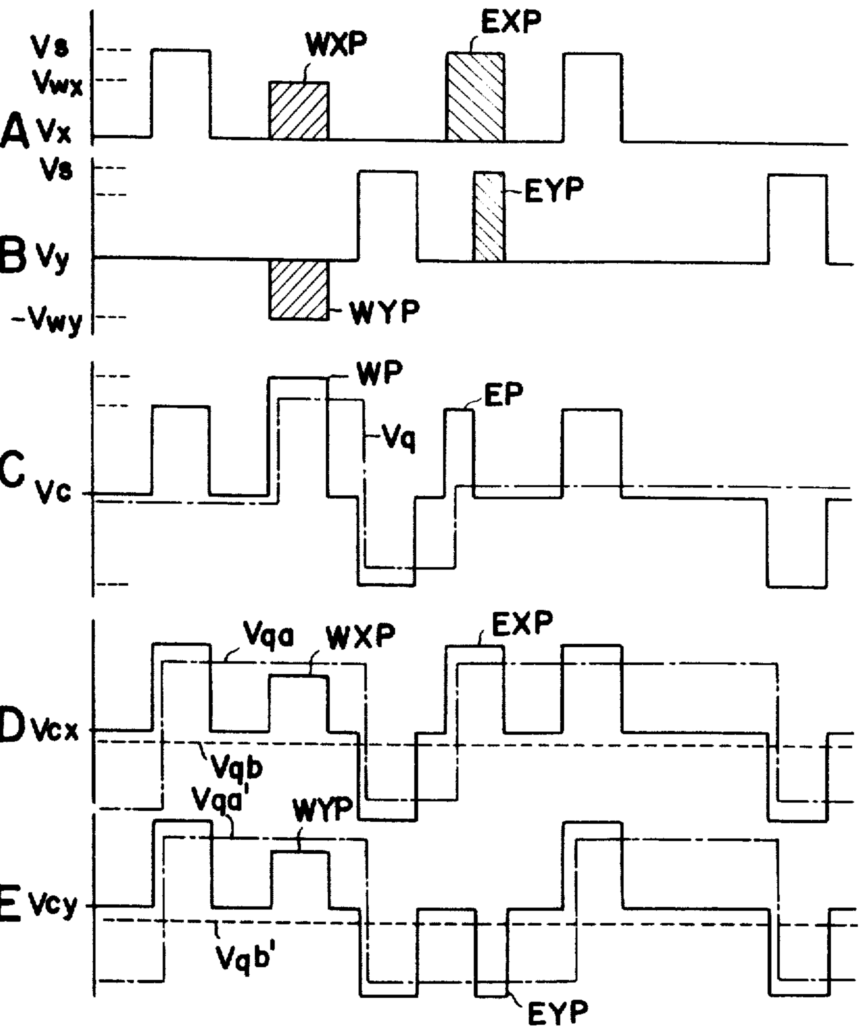


FIG.3A

FIG.3B

FIG.3C

FIG.3D

FIG.3E

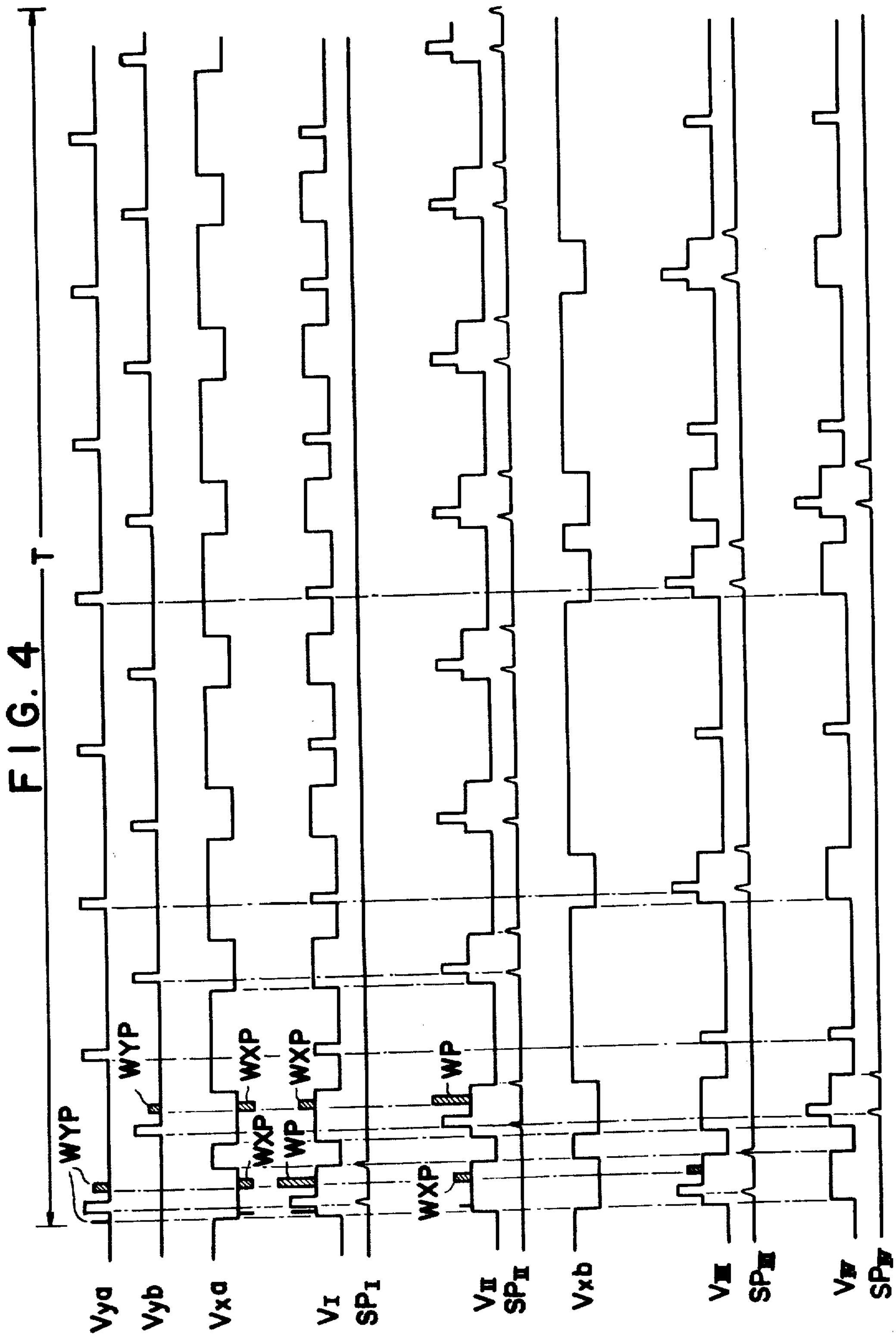

T
WYP
WYP
WXP
WXP
WXP
WP
WP
WXP
Vya
Vyb
Vxa
V_I
SP_I
V_{II}
SP_{II}
Vxb
V_{III}
SP_{III}
V_{IV}
SP_{IV}

FIG. 4

FIG. 5

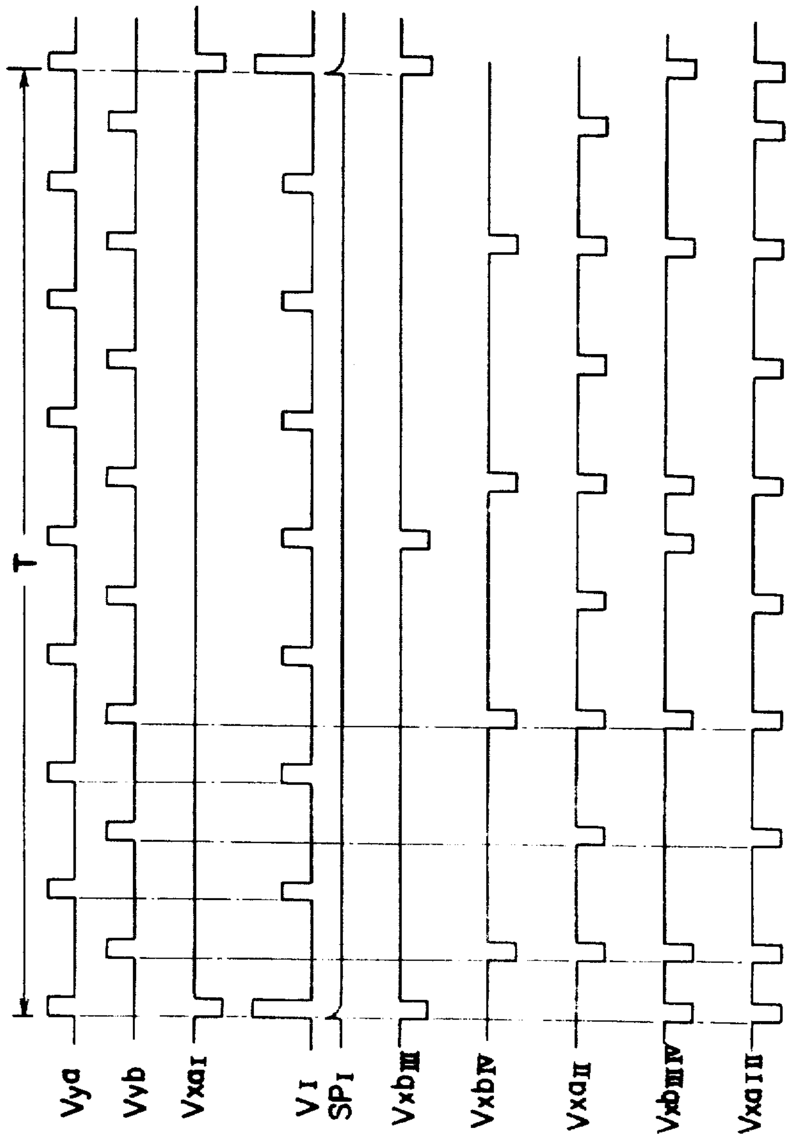


FIG. 6

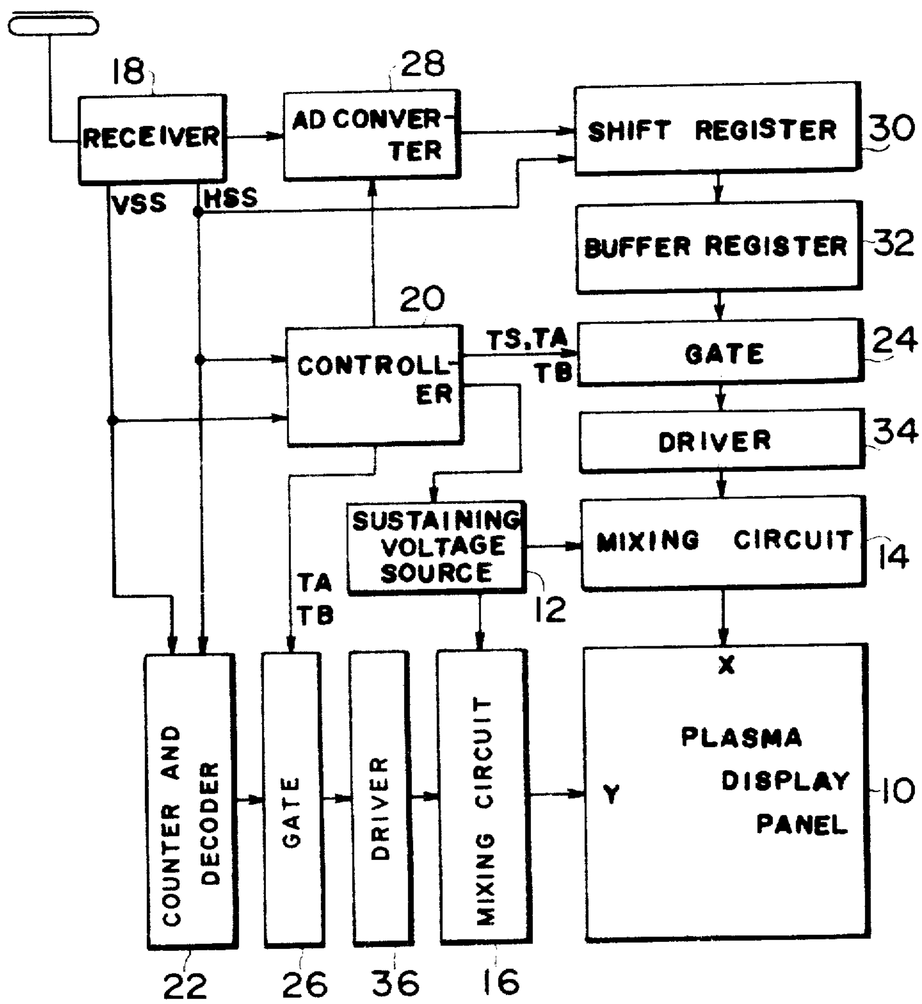

18
RECEIVER
28
AD CONVERTER
30
SHIFT REGISTER
32
BUFFER REGISTER
VSS
HSS
20
CONTROLLER
TS,TA
TB
24
GATE
34
DRIVER
SUSTAINING VOLTAGE SOURCE
12
MIXING CIRCUIT
14
TA
TB
X
Y
PLASMA DISPLAY PANEL
10
COUNTER AND DECODER
GATE
DRIVER
MIXING CIRCUIT
22
26
36
16

FIG. 7

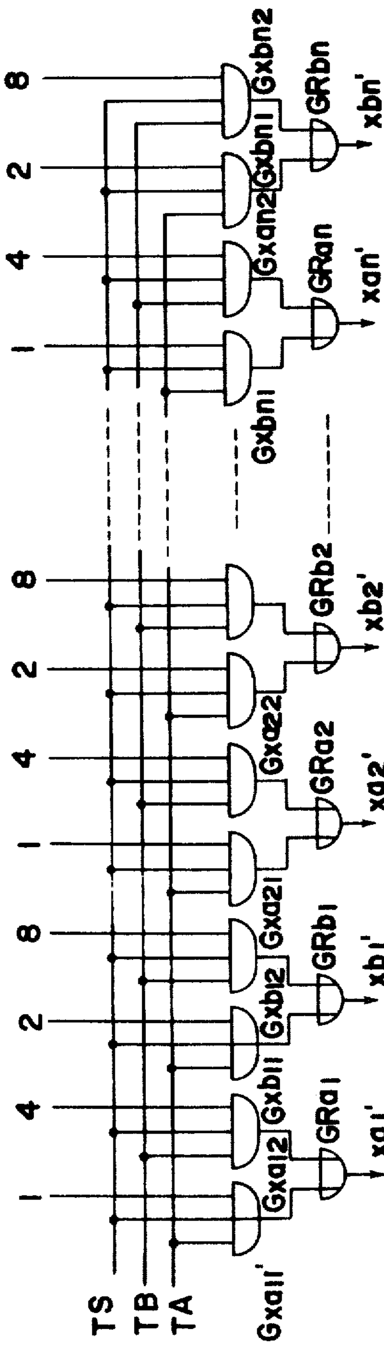

TS
TB
TA
1
4
2
8
Gxa11'
Gxa12
Gxb11
Gxb12
Gxa21
Gxa22
GRa1
GRb1
GRa2
GRb2
xa1'
xb1'
xa2'
xb2'
Gxbn1
Gxan2
Gxbn1
Gxbn2
GRan
GRbn
xan'
xbn'

FIG. 8

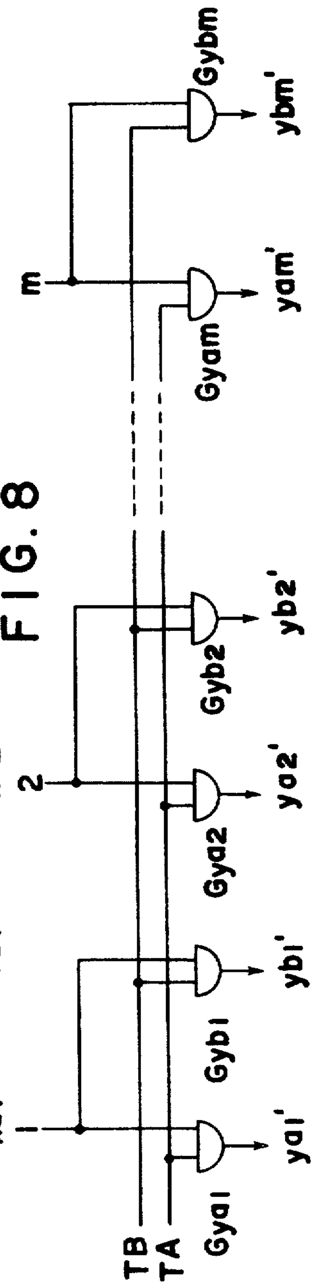

TB
TA
1
2
m
Gya1
Gyb1
Gya2
Gyb2
Gyam
Gybm
ya1'
yb1'
ya2'
yb2'
yam'
ybm'

FIG. 9

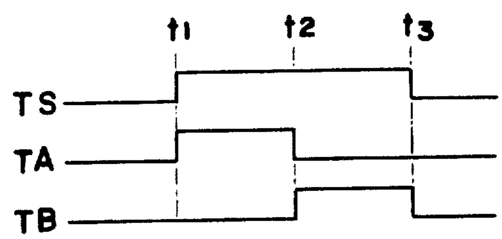

t1
t2
t3
TS
TA
TB

FIG. 10

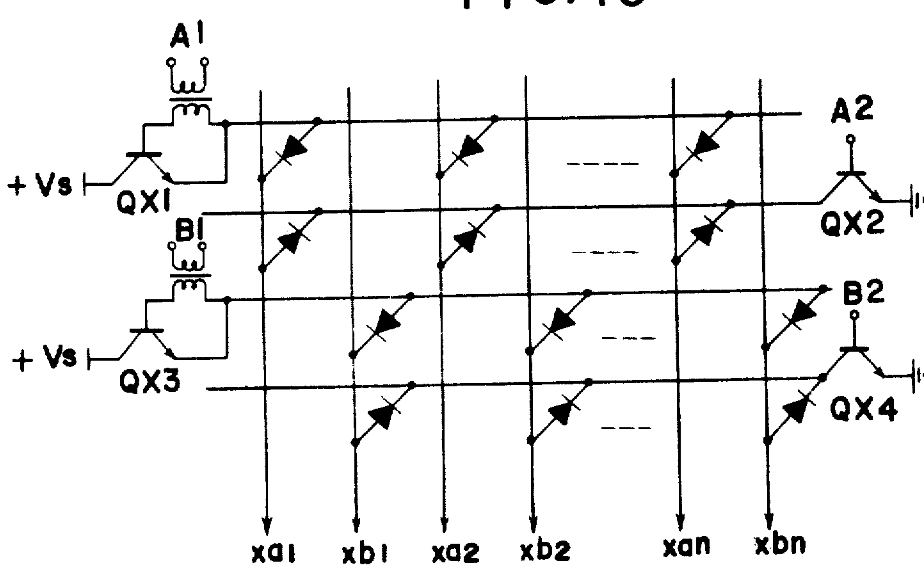

A1
A2
+Vs
QX1
QX2
B1
B2
+Vs
QX3
QX4
xa1
xb1
xa2
xb2
xan
xbn

FIG. 11

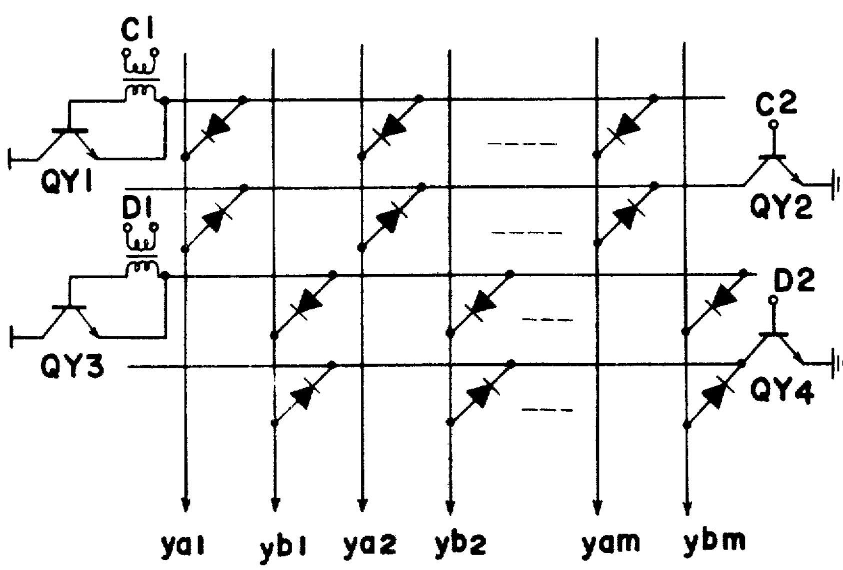


FIG. 12

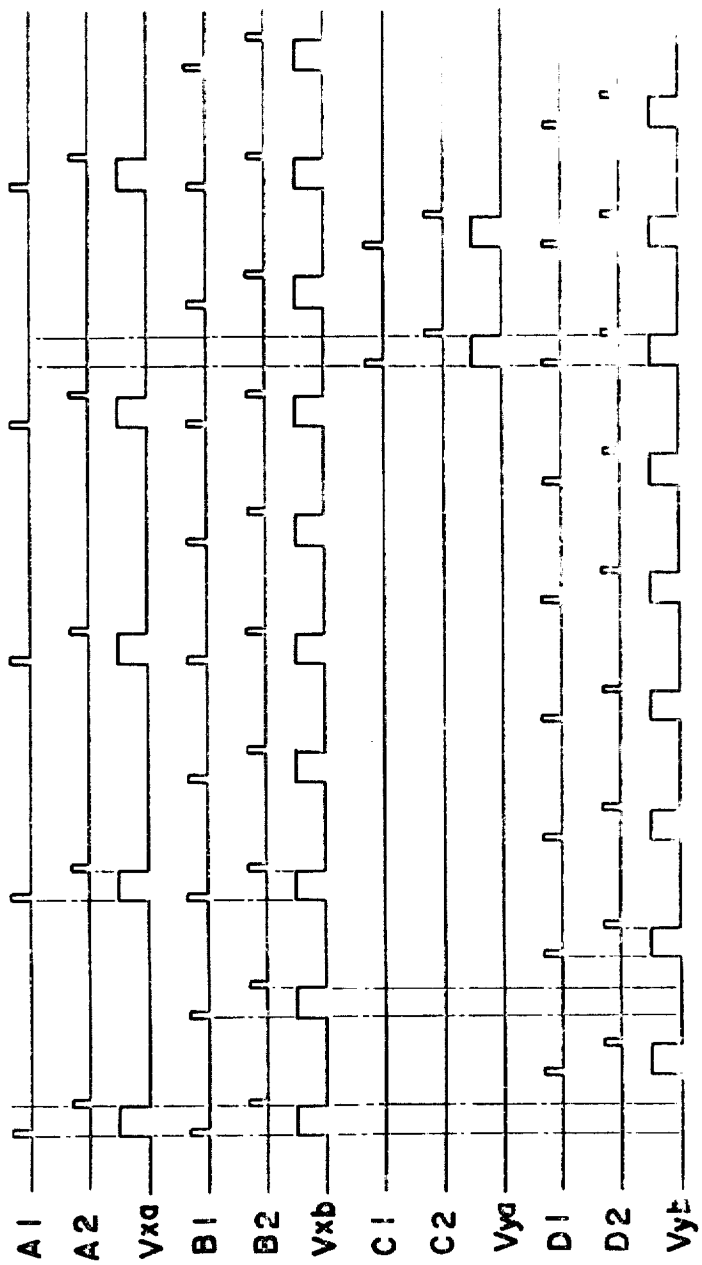


FIG. 13

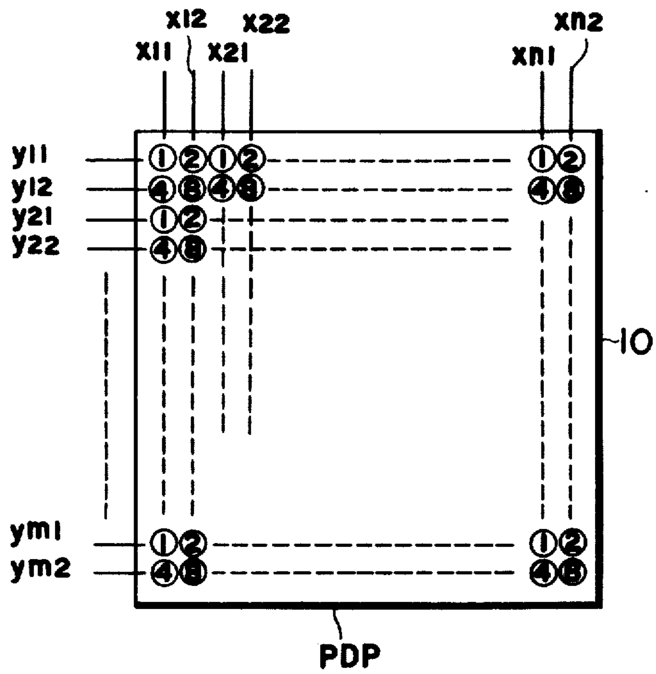

x11
x12
x21
x22
xn1
xn2
y11
y12
y21
y22
ym1
ym2
10
PDP

FIG. 14

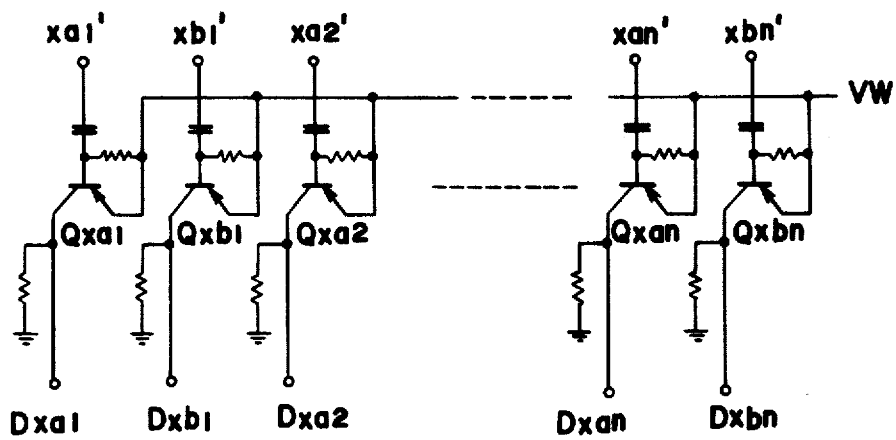

xa1'
xb1'
xa2'
xan'
xbn'
VW
Qxa1
Qxb1
Qxa2
Qxan
Qxbn
Dxa1
Dxb1
Dxa2
Dxan
Dxbn

FIG. 15

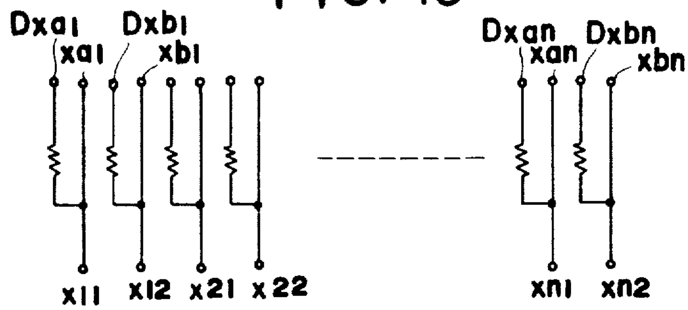


FIG. 16

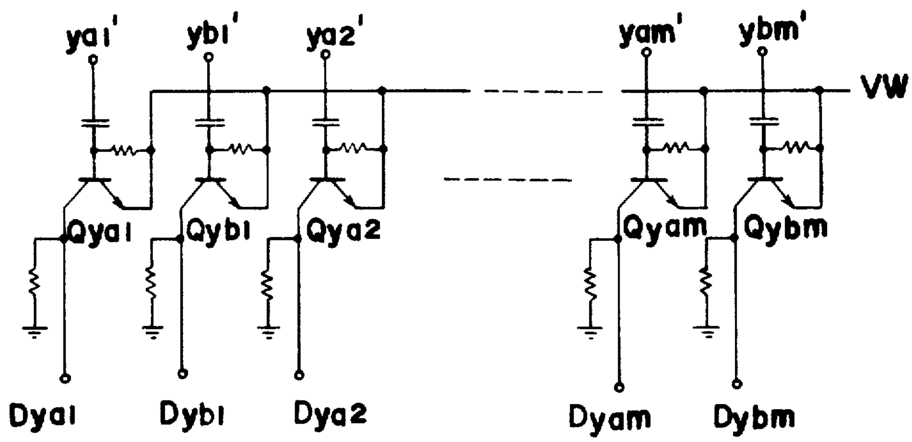
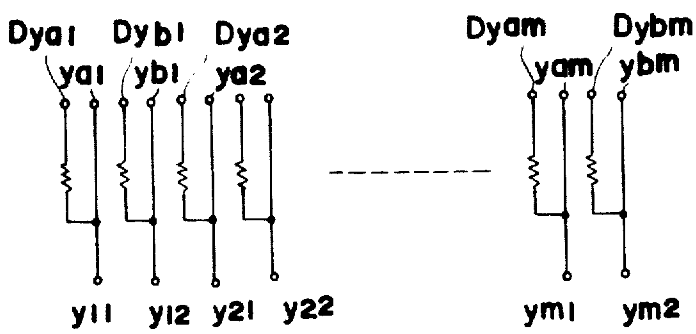


FIG. 17



BRIGHTNESS MODULATION SYSTEM FOR A PLASMA DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a brightness modulation system for a plasma display device in which one picture element is made up of a plurality of cells and the numbers of the cells energized within a certain period of time are made different from each other, thereby to display an image with a plurality of graded tones.

2. Description of the Prior Art

For an image display with the plasma display device, the so-called gray scale display is demanded. To meet the demand, there have heretofore been proposed various systems such, for example, as (1) a system in which cells covered with several kinds of screens having different transmission factors are combined selectively together; (2) a system in which the number of discharges to emit radiation is made different dependent upon the relation between sustain voltage of several voltage values and an initial set level of a wall voltage; (3) a system in which a plurality of stable states of the wall voltage level are selected and the number of discharges to emit radiation is made different dependent upon the impression voltage pulse width and the timing of the voltage impression; and (4) a system in which a plurality of plasma display panels are laminated and discharge radiation of the respective stages is superimposed. These systems all utilize the memory function of the plasma display panel and, after once determined, the brightness level is maintained by the sustain voltage until new brightness information is applied; so that it is possible to provide a display with high brightness, as compared with a refresh system.

However, the system (1) requires screens and encounters a difficulty in enhancement of resolution. With the systems (2) and (3), it is possible to set only two to three wall voltage levels, so that the degree of gradation cannot be raised and, further, the required sustain voltage circuit is complicated because of using several kinds of combined voltage waveforms. Moreover, a special address voltage for writing and erasing is required, and the required address circuit is also complicated. The system (4) requires a plurality of panels, and hence is uneconomical.

SUMMARY OF THE INVENTION

One object of this invention is to provide a brightness modulation system with which many gradation degrees can easily be obtained by a plasma display panel.

Another object of this invention is to provide a brightness modulation system in which the construction for producing a sustain voltage for a gradation display is simplified.

To attain the objects, the brightness modulation system of this invention for a plasma display device having a plurality of electrodes disposed in a matrix manner in opposing relation to each other with a discharge gas space therebetween, is characterized in that each picture element is made up of a plurality of cells formed at intersecting points of the electrodes; voltages of different phases or repetitive frequencies are impressed on the cells forming each picture element to make the numbers of times of their radiation different. Further, each picture element is graded by the combination of the cells.

The objects and effects of this invention will become more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows waveform diagrams, for explaining the operation of one example of this invention;

FIG. **2** is a diagram for explaining the electrode arrangement of a display panel of this invention;

FIGS. **3A** to **3E**, inclusive, show waveforms for explaining one example of writing and erasing operations of this invention;

FIGS. **4** and **5** show waveforms for explaining the operation of other examples of this invention;

FIG. **6** is a block diagram illustrating another example of this invention as being applied to a TV receiver;

FIG. **7** is a circuit diagram of a gate circuit incorporated in the example of FIG. **6**;

FIG. **8** is a circuit diagram of another gate circuit incorporated in the example of FIG. **6**;

FIG. **9** shows timing pulse waveforms;

FIGS. **10** and **11** are circuit diagrams showing examples of circuits for providing sustain voltages;

FIG. **12** shows waveform diagrams, for explaining the operations of the circuit of FIGS. **10** and **11**;

FIG. **13** is a diagram for showing the electrode arrangement of a plasma display panel;

FIGS. **14** and **15** are, respectively, illustrative circuit diagrams of a driver circuit and a mixer circuit connected to the X electrodes of the panel display of FIG. **6**; and

FIGS. **16** and **17** are, respectively, illustrative circuit diagrams of a driver circuit and a mixer circuit connected to the Y electrodes of the display panel of FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, there are shown waveform diagrams for explaining the operation of one example of this invention, which corresponds to the case where the brightness levels of respective cells I to IV, as depicted in FIG. **2**, are selected at 1, 2, 4 and 8. Voltages Vxa and Vxb are impressed to electrodes xa and xb of a plasma display panel, respectively, and votages Vya and Vyb are impressed to electrodes ya and yb, respectively. Accordingly, the cell I is supplied with a voltage V_I which is the difference between the voltages Vxa and Vya and the cells II, III and IV are supplied similarly with voltages V_{II}, V_{III} and V_{IV}, respectively. When a wall voltage V_Q is set by brightness information at an instant t=0 as indicated by the dotted lines, a discharge is caused in the cell I at instants t=0 and t=13, and a discharge is produced in the cell III at instants t=0, t=13, t=14 and t=15. Namely, discharge radiation is produced at such timing as indicated by small circles within a period T, that is, discharge radiation is caused twice in the cell I, four times in the cell III, eight times in the cell II and 16 times in the cell IV. Since brightness is proportional to the number of radiation discharges within the period T, the brightness levels of the cells I to IV are 1, 2, 4 and 8, respectively. Consequently, 16 gradations can be obtained with combinations of the respective cells.

FIGS. **3A** to **3E** show a series of waveform diagrams, for explaining the operation of one example of writing and erasing operations based on brightness information. Reference character Vx in FIG. **3A** indicates a voltage impressed to the electrodes *xa* or *xb*, and Vy in FIG. 3B refers to a voltage impressed to the electrode *ya* or *yb*, each of which is normally a sustain voltage having a peak value Vs as indicated by a dotted line and whose pulse interval is such as depicted in FIG. **1.** Those electrodes selected by input information are supplied with half-selection write-in voltages WXP and WYP, respectively, and selected cells are supplied with a voltage Vx–Vy, so that a voltage Vc (see FIG. 3C) is impressed and the level of the wall voltage V_Q is raised by a write-in pulse WP and discharge radiation is repeatedly achieved by the subsequent sustain voltage. Since the half-selection write-in voltages WXP and WYP are selected at peak values +Vwx and −Vwy (see FIG. 3A) lower than the peak value Vs of the sustain voltage, voltages Vcx and Vcy (see FIGS. 3D and 3E) are impressed to half-selection cells and it does not matter whether the half-selection cells are in their lighted condition or not. Reference character V_{Qa} designates a wall voltage in the case of the half-selected cells being lighted and V_{Qb} refers to a wall voltage in the case of the cells being not lighted.

For erasing, an erasing voltage EXP is impressed to the selected electrodes *xa* or *xb* and an erasing voltage EYP is impressed to the selected electrode *ya* or *yb*, so that an erasing pulse EP shown in FIG. 3C is impressed to the selected cells, by which the level of the wall voltage V_Q is reduced as shown, thus achieving erasing. The half-selected cells in this case are supplied with the voltage EXP and EYP of the waveforms Vcx and Vcy of FIGS. 3D and 3E. When the cells on the electrodes *xa* or *xb* are lighted, their radiation timing shifts to the timing of the impression of the voltage EXP and no other influence is exerted on the erasing operation.

FIG. **4** shows a series of waveform diagrams, for explaining the operation of another example of this invention, in which the brightness levels of the cells I, II, III and IV shown in FIG. **2** are selected to be 1, 8, 4 and 2, respectively. The electrodes *ya* and *yb* are supplied with the voltages V*ya* and V*yb* of different phases, and the electrodes *xa* and *xb* are supplied with the voltages V*xa* and V*xb* of different pulse intervals, impressing the voltages V_I to V_{IV} to the cells I to IV, respectively. For example, in the case of selecting the cell I for writing, the half-selection write-in voltages WYP and WXP are impressed to the electrodes *ya* and *xa*, respectively. As a result of this, the write-in pulse WP is impressed to the cell I to write therein and discharge radiation takes place twice within the period T as indicated by SPI. Further, since the half-selection cell II is supplied with only the half-selection write-in voltage WXP of the voltage V_{II}, the state of the cell II does not change. The same is true of the half-selection cell III. In the case of selecting the cell II, the half-selection write-in voltages WYP and WXP are impressed, respectively, to the electrodes *yb* and *xa* at the same time, so that the write-in pulse WP is applied to the cell II to produce discharge radiation sixteen times within the period T as indicated by SPII because such a voltage as indicated V_{II} is impressed to the cell II. In the cases of selecting the other cells, writing can be achieved in a similar manner. Since the cells I to IV discharge to emit radiation at such times as indicated by SPI to SPIV, the brightness levels become different from one another and a display with 16 gradations can be achieved by the combination of the cells.

FIG. **5** shows a series of waveform diagrams, for explaining the operation of another example of this invention, in which the brightness levels of the cells I, II, III and IV, shown in FIG. **2** are 1, 8, 2 and 4, respectively. As shown in FIG. **5,** the electrodes ya and yb are always supplied with the voltages V*ya* and V*by* of different phases and the electrodes *xa* and *xb* are supplied selectively with voltages V*xa*I and V*xb*III; V*xb*IV and V*xa*II; and V*xb*III, V*xb*IV, and V*xa*I, V*xa*II, respectively, in accordance with brightness information. In this case, the memory function due to the wall voltage is not used and discharge radiation is repeated at such times that a voltage higher than the discharge voltage is impressed to a selected cell. For example, where the cell I is selected, the voltage V*xa*I is applied to the electrode *xa*, so that the cell I is supplied with the voltage V_I to cause a discharge to radiate at the times indicated by SP. Namely, the cell discharges once in the period T. Impressing the voltage V*xb*III to the electrode *xb*, its timing coincides with that of the voltage V*ya* in the cell III twice in the period T to increase the impressed voltage, causing a discharge twice. Impressing the voltage V*xb*IV to the electrode *xb*, a discharge is caused in the cell IV four times in the period T; while impressing the voltage V*xa*II to the electrode *xa*, a discharge is caused in the cell II eight times in the period T. Consequently, the brightness levels of the cells I, II, III and IV become 1, 8, 2 and 4, respectively. Further, impressing the voltages VxbIII and VxbIV shown in combined form at V*xb*III, IV in FIG. **5,** to the electrode *xb*, a discharge is caused in the cells III and IV twice and four times, respectively, within the period T and the discharge is effected six times in all, so that the brightness level becomes **6.** In the case of impressing the voltages V*xa*I and V*xa*II to the electrode *xa*, a discharge is caused in the cells I and II once and eight times, respectively, within the period T, that is, nine times in all, so that the brightness level becomes 9.

FIG. **6** is a block diagram illustrating an example of this invention as being applied to a television receiver, which employs a plasma display panel **10** capable of the diaplay of 16 graded levels, as described above.

To the plasma display panel **10** is impressed a sustain voltage of FIGS. **1** or **4** from a sustain voltage source **12** through mixer circuits **14** and **16.** A television signal is received by a receiver **18** and horizontal and vertical synchronizing signals HSS and VSS separated from a video signal are applied to a controller **20.** In a counter-decoder **22,** the number of the norizontal synchronizing signals HSS appearing between the vertical synchronizing signals VSS is counted and where Y electrodes are 512 and no interlace scanning is achieved, 256 pulses are sequentially provided between the vertical synchronizing signals VSS at equal intervals.

The controller **20** applies write-in timing pulses TS, TA and TB to a gate circuit **24** and the write-in timing pulses TA and TB to a gate circuit **26** with the horizontal and vertical synchronizing signals HSS and VSS. An A/D converter **28** is supplied from the controller **20** with sampling pulses for sampling the video signal of one horizontal line period, at n instants of equal intervals. In this case, where there are 512 X electrodes, it follows that n=256. Thus, the A/D converter **28** converts the brightness level into a 4-bit digital signal, which is stored in a shift register **30.** When the shift register **30** has stored therein the digital signal of one horizontal line period, its stored content is read-out by the horizontal synchronizing signal HSS and applied to a buffer register **32.** In accordance with the content, a write-in pulse is impressed to the X electrodes of the plasma display panel **10** through the gate circuit **24,** a driver **34** and the mixing circuit **14.**

The output from the counter-decoder **22** is applied to the Y electrodes of the plasma display panel **10** through the gate circuit **26,** a driver **36** and the mixing circuit **16** to effect writing in discharge cells formed at the intersecting points of the X and Y electrodes. Namely, the Y electrodes arranged in pairs are supplied with voltages following the timing pulses TA and TB and are scanned in accordance with the output from the counter-decoder **22.** At the same time, the X electrodes, also arranged in pairs, are supplied with a voltage according to the content temporarily stored in the buffer register **32.** The timing pulses TA, TS and TB and the video signal of one horizontal scanning line is written in parallel to display a TV picture of 16 gradations.

The aforementioned receiver **18** corresponds to a typical television receiver including a deflection circuit and the other circuits required for providing a display on a cathode ray tube. The A/D converter **28,** the shift register **30,** the buffer register **32,** etc. may be selected from those types well-known in the art.

The gate circuit **24** is made up of AND gates G*xa***11** to G*xbn***2** and OR gates GR*a***l** to GR*bn*, as shown in FIG. **7,** from which are derived outputs *xa***1**' to *xbn*' in accordance with brightness level signals 1, 2, 4 and 8 stored in the buffer register **32** and the timing signals TS, TA and TB. While the gate circuit **26** is formed with AND gates G*ya***l** to G*ybm*, as depicted in FIG. **8,** from which are derived outputs *ya***1**' to *ybm*' in accordance with outputs **1** to *m* from the counter-decoder **22** and the timing pulses TA and TB.

The timing pulses TS, TA and TB bear a relationship as shown in FIG. **9** and writing in the discharge cells of the brightness levels 1 and 2 is achieved with the timing pulse TA between instants *t*1 and *t*2 and writing in the discharge cells of the brightness levels 4 and 8 is effected with timing pulse TB between the instants *t*2 and *t*3.

The sustain voltage source **12** has a construction as illustrated in FIGS. **10** or **11,** and FIG. 12 shows a series of waveform diagrams for explaining the operation of the sustain voltage source **12.** With a pulse **A1,** a transistor QX1 is turned on to produce a voltage +V*s* in outputs *xa***1** to *xan*, which is applied to the electrodes of the plasma display panel **10.** In the case that no discharge is produced, capacitors are formed between the opposing electrodes, so that a transistor QX2 is turned on by a pulse A2 to discharge the capacitors. Accordingly, the outputs *xa***1** to *xan* become of such a voltage V*xa* as depicted in FIG. **12.**

Further, transistors QX3 and QX4 are turned on by pulses B1 and B2, respectively, so that the outputs *xb***1** to *xbn* become of such a voltage V*xb* as shown in FIG. **12.**

In FIG. **11,** transistors QY1 and QY2 are turned on by pulses C1 and C2, respectively, and outputs *ya***1** to *yam* become of such a voltage V*ya* as depicted in FIG. **12,** and transistors QY3 and QY4 are turned on by pulses D1 and D2, respectively, so that outputs *yb***1** to *ybm* become of such a voltage V*yb* as shown in FIG. **12.** Namely, the sustain voltage described previously with regard to FIG. 1 is obtained.

FIG. **13** is a diagram, for explaining one example of the plasma display panel **10,** in which electrodes *x***11** to *xn***2** and *y***11** to *ym***2** form pairs and four discharge cells formed at the intersecting points of two pairs of the electrodes constitute one picture element **40.** Numerals 1, 2, 4 and 8 in circles represent the brightness levels of the respective discharge cells.

The driver **34** is formed of transistors Q*xa***1** to Q*xbm*, as illustrated in FIG. **14,** and the outputs *xa***1**' to *xbn*' from the gate circuit **24** are applied to the bases of the transistors Q*xa***l** to Q*xbn* to provide outputs D*xa***l** to D*xbn* of a voltage +VW. The outputs D*xa***1** to D*xbn* are applied to the mixing circuit **14** together with the signals *xa***l** to *xbn* from the sustain voltage source **12.** The mixing circuit **14** has a construction as shown in FIG. **15,** comprised of a plurality of resistive elements R**l** to R*n* and its output is applied to the electrodes *x***11** to *xn***2** of the plasma display panel **10.**

The driver **36** comprises transistors Q*ya***1** to Q*ybm* as depicted in FIG. **16,** and the outputs *ya***1**' to *ybm*' from the gate circuit **26** are impressed to the bases of the transistors Q*ya***l** to Q*ybm* to provide outputs D*ya***l** to D*ybm* of a voltage −VW. The outputs D*ya***l** to D*ybm* are applied to the mixing circuit **16** together with those signals *ya***l** to *ybm* from the sustain voltage source **12.** The mixing circuit **16** is of such a construction as shown in FIG. **17** comprising resistors R'1 to R'*m*, and its output is applied to the electrodes *y***11** to *ym***2** of the plasma display panel **10.**

Accordingly, in the plasma display panel **10,** the sustain voltage is impressed to the discharge cells forming picture elements so that their brightness levels may be different from one another and the discharge cells are selected in accordance with the video signal and writing is achieved, thus displaying a TV picture having tone gradations. In the foregoing, the electrodes (*y***11,** *y***12**), (*y***21,** *y***22**), . . . (*ym***l**, *ym***2**) are scanned sequentially for writing. It is also possible to improve picture quality by effecting the first scanning in the manner described above and subsequently scanning the electrodes (*y***12,** *y***21**), (*y***22,** *y***31**), . . . *y*(*m*−1)**2,** (*ym***1**) in pairs. Further, in the case of simultaneously writing the signal of one horizontal scanning line, the capacity of the buffer register increases, so that by dividing the horizontal scanning line into a plurality of sections, the capacity of the buffer register can be reduced down to a fraction of the number of the divided sections.

With the brightness modulation system of this invention, one picture element is formed with a plurality of cells, the numbers of times of discharge radiation of the respective cells are made different from one another to make the brightness levels of the cells different from one another and a plurality of gradations can be obtained by the combination of the respective cells, as has been described in the foregoing. It is also possible that the peak values and pulse widths of the impression voltages therefor are made equal to one another only by selecting them in different phases and at different repetitive frequencies and that only their phases and pulse widths are selected different from one another. Therefore, the sustain voltage circuit can be simplified. Further, if no memory function due to the wall voltage is employed, the impression voltages can be regularly displaced apart in-phase. In the foregoing examples, 16 gradations are obtained with four cells, but if each picture element is made up of six, eight or more cells, 32, 64 or more gradations can be obtained, respectively.

The cell herein mentioned is a single discharge region formed at each intersecting point of the electrodes and adjoining discharge regions need not be mechanically isolated from each other.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of this invention.

What is claimed is:

1. A brightness modulation system for producing an image display with selectively controlled brightness level gradations on a plasma display device, said plasma display device having a plurality of X electrodes and a plurality of Y electrodes disposed to intersect each other with a discharge gas spaced therebetween whereby a plurality of discharge cells is formed at the intersections of the X and Y electrodes, the successive, adjacent electrodes of at least one of said pluralities of X and Y electrodes being arranged in groups and the electrodes of each such group defining corresponding combinations of discharge cells at the intersections thereof with the electrodes of the other of said pluralities of X and Y electrodes, each said combination of discharge cells comprising a display element of the said image display, the corresponding cells of each said combination being selectively and individually controllable to undergo respective, different and predetermined rates of discharge to produce corresponding, different individual brightness levels thereby to provide selective gradations of the brightness level of the display element formed by each such combination of discharge cells, said brightness modulation system comprising:

means for providing a number of different sustain signals corresponding to the number of discharge cells in each said combination thereof and of respectively different repetition rates,

means for supplying said number of different sustain signals to the electrodes of said pluralities of X and Y electrodes corresponding to each said combination of discharge cells, thereby to sustain predetermined, different rates of discharges in the respectively corresponding cells of said combinations of cells,

means for indicating the brightness level gradation to be displayed in each display element of the image display.

means responsive to said indicating means for selecting the cells of the combination thereof corresponding to each display element which, in combination, provide the brightness level gradation for that corresponding display element as indicated by said indicating means,

means for selectively establishing discharges in the cells selected by said selecting means of each said combination thereof, and

said sustaining means sustaining discharges in those cells of each said combination in which discharges are selectively established by said means for selectively establishing discharges in accordance with the said predetermined different rates of discharges sustained by the respective, different sustain signals, thereby to sustain the gradation of brightness level for each said display element as indicated by said indicating means.

2. A brightness modulation system as recited in claim 1 wherein the successive, adjacent electrodes of each of said pluralities of X and Y electrodes are arranged in groups, the intersections of the electrodes of a group of one of said pluralities of X and Y electrodes with the electrodes of a group of the other of said pluralities of X and Y electrodes defining a corresponding combination of discharge cells comprising a display element of the said image display.

3. A brightness modulation system as claimed in claim 2 wherein each said group of X electrodes and each said group of Y electrodes includes n electrodes, defining thereby n discharge cells in the corresponding combination of discharge cells defined by the intersections of the electrodes of each said group of X electrodes with the electrodes of each said group of Y electrodes, whereby the number of brightness level gradations of each display element is 2^n.

4. A brightness modulation system as recited in claim 2 wherein said sustain signal providing means provides sustain signals of different repetitive frequencies to the electrodes of each of said group of X electrodes and said group of Y electrodes associated with a given combination of discharge cells, for all said combinations, whereby each discharge cell of each said combination defined by each group of one of said X and Y electrodes with a group of the other of said X and Y electrodes sustains a discharge at a different rate than the other discharge cells of that said combination.

5. A brightness modulation system as recited in claim 2, wherein said sustain signal providing means provides sustain signals of different pulse intervals to electrodes of each group of one of said pluralities of X and Y electrodes and provides sustain signals of a common repetition rate, but out of phase from one another, respectively, to the electrodes of each group of the other of said X and Y electrodes, whereby each discharge cell of each combination of discharge cells defined by the intersections of the electrodes of each group of one of said pluralities of X and Y electrodes with the electrodes of each group of the other of said pluralities of X and Y electrodes sustains a discharge a different number of times within a given time interval.

6. A brightness modulation system as recited in claim 2 wherein said brightness level gradation indicating means comprises:

means for receiving an analog picture signal to be displayed and converting the analog amplitude levels thereof representing the brightness of the picture to be displayed, to digital amplitude levels for the respectively corresponding display elements, and

said selecting means is responsive to said digital signals for selectively establishing discharges in the cells of each said combination thereof in accordance with the brightness level gradations indicated by the digital signals for the respectively corresponding image display element.

7. A brightness modulation system as claimed in claim 2 for use with a television receiver receiving transmitted video signals and providing a corresponding analog picture signal defining brightness levels of a picture to be displayed, wherein said brightness level gradation indicating means comprises analog-to-digital converter means for converting the amplitude levels of said analog picture signal into corresponding digital signals, and said selecting means is responsive to said digital picture signals for selectively establishing discharges in the cells of each said combination thereof corresponding to each display element of the picture to be

displayed, whereby an image display with brightness level gradations is provided.

8. A brightness modulation system for producing an image display with selectively controlled brightness level gradations on a plasma display device, said display device having a plurality of X electrodes and a plurality of Y electrodes disposed to intersect each other with a discharge gas spaced therebetween whereby a plurality of discharge cells is formed at the intersections of the X and Y electrodes, the successive, adjacent electrodes of each of said pluralities of X and Y electrodes being arranged in groups, and the intersections of the electrodes of each such group of one of said pluralities of X and Y electrodes with the electrodes of each such group of the other of said pluralities of X and Y electrodes defining corresponding combinations of discharge cells, each said combination of discharge cells comprising a display element of the said image display, the cells of each said combination being selectively and individually controllable to undergo respective, different and predetermined rates of discharge to produce corresponding, different and predetermined brightness levels thereby to provide selective gradations of the brightness level of the display element formed by each such combination of display cells, said brightness modulation system comprising:

means for providing a first set of energizing signals of a common repetition rate but displaced in phase, said first set including a number of energizing signals equal in number to the number of electrodes of each said group of one of said pluralities of X and Y electrodes,

means providing at least a second set of energizing signals of respectively different repetition rates, the signals of said second set being in phase with the signals of said first set, and being equal in number to the number of electrodes of each of said group of electrodes of the other of said pluralities of X and Y electrodes.

means for applying the said number of energizing signals of said first set to respectively corresponding electrodes of each said group of said one of said pluralities of X and Y electrodes,

means for indicating the brightness level gradation to be displayed in each display element of the image display, and

means responsive to the indicated brightness level gradation for each display element for selectively applying the signals of said second set to respectively corresponding electrodes of each group of said other of said pluralities of X and Y electrodes corresponding to each said display element, thereby selectively to establish discharges in the cells of each said combination as to which the energizing signals applied to the corresponding X and Y electrodes of the groups associated with each said combination are in phase, and thereby to produce a brightness level gradation for the said combination of discharge cells in accordance with the indicated brightness level gradation for the corresponding display element.

9. A brightness modulation system as recited in claim **8** wherein said providing means provides a third set of energizing signals of respectively different repetition rates, each signal of said third set being in phase with one of said signals of said first set, and

said applying means selects between the signals of said second and third sets for supply of the selected set of signals to the electrodes of each group of the other of said pluralities of X and Y electrodes to establish, selectively, discharges in the respectively corresponding discharge cells of the corresponding combinations thereof for producing respectively corresponding brightness level gradations in the associated picture elements of the display.

10. A brightness modulation system as recited in claim **9** wherein each of said first, second and third sets of energizing signals comprises two energizing signals differing as aforesaid, the signals of said second set being in phase with a first of said signals of said first set and the signals of said third set being in phase with the second of said signals of said first set.

11. A brightness modulation system as recited in claim **9** wherein said applying means is operable to select corresponding first ones of the signals of said second and third sets for supply to the electrodes of each said group of said one of said pluralities of X and Y electrodes and to select the second signals of both of said second and third sets for supply to the electrodes of each said group of said other of said X and Y electrodes.

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