PATENT SPECIFICATION

(11) 1 590 304

(21) Application No. 38819/77 (22) Filed 16 Sep. 1977 (19)
(31) Convention Application No's 51/111573 (32) Filed 16 Sep. 1976
51/120142 5 Oct. 1976 in
(33) Japan
(44) Complete Specification Published 28 May 1981
(51) INT. CL.^{3} H01J 17/49
(52) Index at Acceptance
H1D 12B47Y 12B4 35 5C1 5C2 5C3 5D
5E 5J 5M1A 5M1D 5M1Y 5MY 9A 9CX
9CY 9Y
G5C A310 A315 A333 A350 HB

1 590 304

(54) SELF SHIFT TYPE GAS DISCHARGE PANEL

(71) We, FUJITSU LIMITED, a Japanese Corporation, of No. 1015, Kamikodanaka, Nakahara-ku, Kawasaki, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to gas discharge devices.

There has been previously proposed, as one kind of gas discharge display device, an AC driven plasma display panel having a matrix type electrode arrangement. Such a matrix type plasma display panel can have a disadvantage in that complicated drive circuitry is required for the panel in order that electrodes arranged in horizontal and vertical directions in the panel can be addressed individually. Also, as the size of plasma display panel increases the cost of the drive circuitry increases markedly. Thus, with a view to the simplification of driving circuitry, there has recently been proposed a "self shift" gas discharge panel in which a discharge spot shifting function is provided.

One form of self shift gas discharge device is disclosed in detail, for example, in U.S. Patent No. 3,944,875 entitled "Gas Discharge Device Having a Function of Shifting Discharge Spots" by Owaki et al. This gas discharge device disclosed in this U.S. patent includes common electrodes disposed on one of a pair of substrates of the device to extend in a horizontal (Y) direction and covered with a dielectric layer, and a plurality of shift electrodes disposed on the other substrate to extend in a vertical (X) direction and similarly covered with a dielectric layer. The shift electrodes are sequentially connected with three or more shift buses periodically (i.e. are connected one after another in cyclically repeated manner to respective shift buses of which there are three or more) and thereby along each common electrode a shift channel is set up having a periodic arrangement of the discharge points formed between the common electrode and the shift electrodes which cross the common electrode. At one end of the shift channel, a write electrode is provided for feeding in information to be displayed. A discharge spot, which is generated by applying a write pulse to a write electrode, can be shifted from one discharge point to an adjacent discharge point along the shift channel by sequentially switching shift driving voltages applied to the shift buses, by making use of the priming effect due to plasma coupling.

In such an intersecting, or crossing, electrode type self shift gas discharge panel, a plurality of shift electrodes must be connected with at least three buses on one of the two substrates. In the provision of connections of the buses with the shift electrodes, it is necessary that at least one bus and the shift electrodes connected to the other buses cross one another on the substrate, and they must be insulated from each at the crossing points thereof. Formation of insulation can be achieved by the use of cross-over techniques but the formation of cross-over areas nevertheless involves troublesome operations, the production yield of non-defective panels may be low and enhancement of reliability of the panel is hindered. Further, if it is desired to reduce the pitch of the shift electrodes in order to provide a display with high resolution, the pitch of the cross-over parts is also required to be decreased. This makes the fabrication of the panel more difficult, and can seriously hinder the realization of a high-resolution display panel.

Further, U.S. Patent No. 3,775,764 entitled "Multi-Line Plasma Shift Register Display" (J.P. Gaur) discloses a panel structure in which respective pluralities of parallel shift electrodes are disposed in zigzags on the insides of respective substrates of a pair of substrates of the panel, and in which the shift electrodes on each substrate are divided into two groups. This parallel electrode type self shift gas discharge panel can avoid the abovesaid defect attendant upon the necessity for the formation of cross-over areas, but a new problem relating to the separation of discharge spots in the direction of the shift electrodes arises, which can make it difficult to realize a structure capable of providing a high resolution display.

Moreover, U.S. Patent No. 3,704,389, entitled "Method and Apparatus for Memory and Display" (W.B. McCleland) sets forth a panel structure which employs shift electrodes of special patterns such that a discharge spot can be shifted from a discharge point by making use of the phenomenon whereby wall charges spread to the wall surfaces of adjoining discharge points. The shift electrodes of the special patterns provide a meandering or sinuous shift channel. However, this structure can be impractical in that no consideration is taken of plasma coupling between adjacent discharge points, and it can be difficult to obtain an operation margin which makes the structure viable in practice.

Now, panel structures which do not involve the provision of cross-over areas and which can provide for excellent separation of discharge spots have lately been proposed. In one such proposal a type of self shift gas discharge panel having a shift channel in which a discharge spot follows a meander-form shift path has been proposed. In such a panel row electrodes are connected to buses of two different phases on one of a pair of substrates of the panel and column electrodes are connected to buses of two different phases on the other substrate of the pair. The row and column electrodes are disposed opposite each other with a discharge gas space defined therebetween so that the electrodes on the two substrates extend across each other at right angles. A discharge spot is shifted along a shift channel along a meander form route. In another such proposal a type of self shift gas discharge panel having a shift channel in which a discharge spot follows a linear route has been proposed, the shift channel being formed with sinuous electrodes for example. These self shift gas discharge panel structures are described in detail in West German Offenlegungsschrifts Nos. 2,729,659 and 2,731,008 respectively.

The two latter mentioned panel structures will now be described briefly with reference to Figures 1, 2 and 3 of the accompanying drawings.

Figure 1 is a schematic diagram explanatory of the configuration of a self shift gas discharge panel of the type providing a meander-form shift path,

Figure 2 is a waveform diagram, and

Figure 3 is a schematic diagram explanatory of the configuration of a self shift gas discharge panel of the type providing a linear shift path in a shift channel formed with sinuous electrodes.

In the self shift gas discharge panel of Figure 1, a meander channel type, column electrodes xai and xbi (i = 1, 2, 3, ...) are respectively connected to column electrode buses Xa and Xb on one of a pair of substrates of the panel, and row electrodes yaj and ybj (j = 1, 2, 3, ...) are respectively connected to row electrode buses Ya and Yb on the other substrate of the panel. The row and column electrodes are covered by respective dielectric layers and are disposed opposite one another with a discharge gas space defined therebetween so that the column and row electrodes extend across each other at right angles. Further, write electrodes wj (j = 1, 2, 3, ...) are disposed opposite one end of each row electrode yaj. A discharge spot is shifted along a meander-form shift path in each shift channel, for example, in the order of discharge points *a-b-c-d-...* .For the formation of the shift channel, barriers BR are provided between the column electrodes xbi and xa(i + 1) disposed opposite the row electrodes yaj and between the column electrodes xai and xbi disposed opposite the row electrodes ybj.

Figure 2 illustrates an example of drive waveforms which can be applied for shifting a discharge spot in the gas discharge panel of Figure 1. The buses Xa, Xb, Ya and Yb of Figure 1 are supplied with pulse voltage waveforms Vxa, Vxb, Vya, and Vyb, respectively. The pulse interval t1 of the pulse voltage waveform Vxa, the pulse width t2 of a shift pulse Vsh and the pulse width t3 of an erase pulse Ve are selected to be, for instance, 15μS, 5 to 10 μS and 1 to 2 μS, respectively. Waveforms Vaa, Vab, Vbb and Vba show voltages which are applied, as a result of the application of pulse voltage waveforms Vxa, Vxb, Vya and Vyb, to discharge points formed at respective electrode intersections of the panel.

For example, when a write pulse is applied to the write electrode wl to produce a discharge spot at the write discharge point *a* and shift pulses Vsh are applied to each of the buses Xa and Ya, the voltage waveform indicated by the first portion of waveform Vaa is fed to the discharge point *b*, so that the discharge spot shifts to the discharge point *b*. Next, upon application of shift pulses Vsh to the buses Xa and Xb, the voltage Vab is fed to the discharge point *c* to generate a discharge spot at the discharge point *c*, due to plasma coupling, and then the erase pulse Ve is applied to the discharge point *b* to erase the discharge spot thereat, thus shifting the discharge spot from the discharge point *b* to the point *c* as indicated in Figure 2. Thereafter, the discharge spot is similarly shifted to the discharge points *d, e, f,* ... one after another.

In the discharge panel of Figure 3, a meander electrode type, two buses XA and XB, electrode connecting conductors xAi and xBi (i=1, 2, 3, ...), alternately connected to the buses XA and XB, and write electrodes W1, W2 ... are formed on one of a pair of substrates of the panel, and two buses YA and YB, and electrode connecting conductors yAj and yBj (j = 1, 2, 3, ...), alternately connected to the buses YA and YB, are formed on the other substrate of the pair. The electrode connecting conductors on the two substrates are disposed opposite each other with a discharge gas space defined therebetween. The electrode connecting conductors connect electrode portions xa, xb and ya, yb, formed on the opposed substrates, respectively, and opposed parts of adjacent electrode portions form unit discharge regions, *i.e.* discharge points. Dielectric layer material is formed at least on each electrode portion.

For shifting a discharge spot, waveforms as shown in Figure 2 can be used and when they are discharge spots can be shifted along row direction shift channels, that is, in shift channels which extend in the direction in which electrode portions xa and xb are arranged.

The above described meander channel type and meander electrode type self shift gas discharge panels eliminate the necessity for the formation of cross-over areas, as referred to above, but have the structures which provide for shifting of a discharge spot only in one direction.

According to the present invention there is provided a self shift gas discharge device, of the kind having first and second arrays of electrode members, with layers of dielectric material thereover, on respective surfaces of first and second substrates of the device, which surfaces confront one another across a discharge gas space defined therebetween, so that respective discharge points of the device are defined where respective electrode members of the first and second arrays face one another across the said discharge gas space, wherein first and second pluralities of supply buses are provided respectively on the said surfaces, buses of the first and second pluralities respectively and the electrode members of the first and second arrays respectively being connected, on the said respective surfaces, in repetitive regularly-ordered manner, a regularly ordered connection pattern which is repeated on such a surface including no cross-over areas, and wherein a first plurality of shift channels are provided in the device each extending in a first general direction and each being such that a discharge spot can be caused, by the application of driving signals to the supply buses, to follow a shift path, along the shift channel, constituted by a series of the discharge points of the device, and a second plurality of shift channels are provided in the device each extending in a second general direction, transverse to the said first general direction and each being such that a discharge spot can be caused, by the application of driving signals to the supply buses, to follow a shift path, along the shift channel, constituted by a series of the discharge points of the device, and wherein the shift channels of the first plurality thereof intersect the shift channels of the second plurality thereof (i.e. the shift path along a shift channel of the first plurality thereof has a discharge point in common with a shift path along a shift channel of the second plurality thereof) so that a discharge spot in the device at the intersection of two shift channels can be caused, by the application of appropriate driving signals to the supply buses, subsequently to shift along either of the two shift channels.

Embodiments of the present invention can be provided in which easy shifting of a discharge spot is facilitated.

Embodiments of the present invention provide self shift type discharge panels of a construction which eliminates the necessity for intersections of electrodes with buses on a substrate thereby to remove the necessity of the formation of cross-over areas and hence permit simplification of the manufacture of the panel structure.

Embodiments of the present invention provide self shift type gas discharge panels of construction which enables the shifting of a discharge spot in two directions.

A self shift type gas discharge panel embodying the present invention can be constructed so as to ensure correct shifting of a discharge spot when a row or column shifting of the discharge spot is switched over to column or row shifting.

Further, a gas discharge panel embodying the present invention can perform a stable discharge spot shift operation and a stationary display operation.

Thus, in embodiments of the present invention, a plurality of buses and a plurality of electrodes respectively connected thereto are formed on one of a pair of substrates of the device, and a plurality of buses and a plurality of electrodes respectively connected thereto are similarly formed on the other substrate of the device. A zig-zag or meander-form shift channel may be formed by means of barriers in the device, in at least one or row and column directions in the device, and a discharge spot can then shift in the row or column direction in accordance with the combination of shift pulses which are fed to the buses. Further, electrodes may be connected in zigzags to set up linear shift channels in the row and column directions and the discharge spot can then be shifted in the row or column direction in accordance with the combination of shift pulses which are applied to the buses.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example to the remainder of the accompanying drawings, in which:

Figure 4 is a schematic diagram showing the configuration, and particularly the electrode arrangement, of an embodiment of this invention;

Figure 5 is a waveform diagram, showing an example of drive waveforms for use in shifting a discharge spot;

Figure 6 is a waveform diagram, showing an example of further drive waveforms for use in shifting a discharge spot;

Figure 7 is a schematic diagram showing the configuration, and particularly the electrode arrangement, of another embodiment of this invention;

Figure 8 is a waveform diagram showing, in the form of envelopes, drive waveforms for use in shifting operations;

Figure 9 is a schematic diagram showing the configuration, and particularly the electrode arrangement, of another embodiment of this invention;

Figure 10 is a waveform diagram showing an example of drive waveforms for use in shifting operation;

Figure 11 is a waveform diagram showing an example of drive waveforms for use in shifting operation;

Figures 12 and *13* are schematic diagrams showing the configurations, and particularly the electrode arrangements, of respective further embodiments of this invention;

Figure 14 is a schematic diagram, illustrating the electrode arrangement of Figure 9 in a simplified form for use in explanation of shifting operations;

Figure 15 is a schematic diagram showing the configuration, and in particular the electrode arrangement, of yet another embodiment of this invention;

Figure 16 is a schematic diagram illustrating the electrode arrangement of Figure 15 in a simplified form;

Figure 17 is a waveform diagram showing an example of drive waveforms for use in shifting operations;

Figure 18 is a waveform diagram showing an example of drive waveforms for use in shifting operations;

Figure 19 is a schematic diagram showing the configuration, and particularly the electrode arrangement, of still another embodiment of this invention.

Figure 20 is a schematic diagram showing the electrode arrangement of Figure 19 in a simplified form;

Figure 21 is a block diagram showing an example of a drive circuit;

Figure 22 is a schematic diagram showing another embodiment of this invention;

Figure 23 is a cross-sectional view of principal parts of the embodiment of Figure 15,

Figure 24 is another cross-sectional view of the principal parts of the embodiment of Figure 15;

Figure 25 is a simplified schematic diagram showing the configuration and the electrode arrangement of yet a further embodiment of this invention;

Figures 26 and *27* are respective waveform diagrams showing drive waveforms for use with the embodiment of Figure 25; and

Figure 28 is a block diagram illustrating an example of a drive circuit for generating drive waveforms as depicted in Figures 26 and 27.

Figure 4 shows schematically the configuration and the electrode arrangement of an embodiment of this invention, which is of the meander channel type. On one of a pair of substrates of the panel, buses X1 to X3 and electrodes x1i to x3i (j = 1, 2, 3, ...) are formed, as indicated by solid lines in the Figure, and, on the other substrate of the pair, buses Y1 to Y3 and electrodes y1j to y3j (j = 1, 2, 3, ...) are formed, as indicated by broken lines in the Figure. The electrodes formed on the two substrates are respectively covered with dielectric layers, and are disposed opposite each other with a discharge gas space defined therebetween. Though not shown, write electrodes are provided on one of the two substrates.

The electrodes x1i and x3i are connected to the buses X1 and X3 to opposite sides of the panel, respectively, and the electrodes x2i are connected to extend in a zigzag manner between the electrodes x1i and x3i as shown, and are connected to the bus X2. The electrodes y1j and y3j are connected to the buses Y1 and Y3 to opposite sides of the panel, respectively, and the electrodes y2j are connected to extend in a zigzag manner between the electrodes y1j and y3j as shown, and are connected to the bus Y2. Further, barriers BR are provided in the form of islands so that shift channels may be set up in both row and column directions. That is, shift channels are formed in which discharge spots can be shifted along respective shift paths which extend in a zigzag or meander-form manner, in row and in column direction. Those parts of the barriers BR which are indicated by AZ may be omitted.

As described above, three-phase buses X1 to X3 and Y1 to Y3 are provided but no cross-over areas need be formed on either substrate.

Figure 5 illustrates an example of a series of drive wave-forms for use in providing for shift operation in a row direction in the panel of Figure 4. Reference characters Vx1 to Vx3 indicate pulse voltage waveforms applied to the buses X1 to X3, respectively; Vy1 to Vy3 indicate pulse voltage wave-forms applied to the buses Y1 to Y3, respectively, Vsh indicates shift pulses; and Ve indicates erase pulses.

In Figure 4, assuming that a discharge spot, generated by applying a write pulse to a write electrode (not shown), has shifted to a discharge point *a* at the timing of application of shift pulses to the buses X1 and Y1, then the discharge spot next shifts to a discharge point *b* with the application of shift pulses Vsh to the buses X2 and Y1. Then, upon application of the shift pulses Vsh to the buses X3 and Y1, the discharge spot shifts to a discharge point *c*. The sequence of discharge points through which the discharge spot shifts, together with the sequence of combinations of buses supplied with the shift pulses is as follows: a(X1, Y1), b(X2, Y1), c(X3, Y1), d(X3, Y2), e(X2, Y2), f(X1, Y2), g(X1, Y1), h(X2, Y1), i(X3, Y1) and j(X3, Y2). The arrows in Figure 5 indicate the timings and directions of shifting of the discharge spot through the discharge points. In this case, the pulse width of the erase pulse Ve of the timing indicated by the arrow can be selected to range 1 to 5 μS. This pulse is referred to as an overlap pulse.

In such row direction shifting, use is made of the three buses X1 to X3 (of three phases) and the two buses Y1 and Y2 (of two phases) and, in a period of application of shift pulses to the bus Y1, shift pulses are fed to the three buses X1, X2, X3, in the order X1-X2-X3 and, in a period of application of shift pulses to the bus Y2, shift pulses are fed to the three buses X1, X2, X3 in the order X3-X2-X1. Such orders of application of the shift pulses Vsh can be easily set by the employment of a logical circuit. Further, since an erase pulse Ve is fed to a discharge point from which a discharge spot has just been shifted, wall charge at that discharge point will immediately disappear.

Figure 6 illustrates an example of a series of drive waveforms for use in providing shift operation in a column direction in the panel of Figure 4; and the same reference characters as those used in Figure 5 indicate similar items. When a discharge spot has been shifted to the discharge point *f* by the application of shift pulses Vsh to the buses X1 and Y2, if shift pulses Vsh are fed to the buses X1 and Y1, the discharge spot shifts to the discharge point *q* in the same manner as in the case of the abovesaid row shift operation. But, if shift pulses Vsh are applied to the buses X1 and Y3, the discharge spot shifts to a discharge point *q*'. Then, upon application of shift pulses Vsh to the buses X2 and Y3, the discharge spot shifts to a discharge point *h*';

The sequence of discharge points through which the discharge spot shifts, together with the sequence of combinations of buses supplied with shift pulses in column shift operation, is as follows: f(X1, Y2), g'(X1, Y3) h'(X2, Y3), i'(X2, Y2), j'(X2, Y1), k'(X1, Y1) and ℓ'(X1, Y2). Thus, as in row shift operations, in column shift operation a discharge spot shifts along a zigzag or meander form shift path, and at the moment when the discharge spot has reached the discharge point *j*', column shift operation can be changed over to row shift operation. Thus column shift is performed by means of the two buses X1 and X2 (of two phases) and the three buses Y1 to Y3 (of three phases). A discharge spot can be shifted in an oblique direction (i.e. a direction oblique to the row and column directions) in the following manner. That is, when the discharge spot has shifted to the aforesaid discharge point j', column shift operation is switched to row shift operation to shift the discharge spot to discharge point k″ and then to ℓ″ and when the discharge spot has reached the discharge point at the intersection of the electrodes x13 and y23, row shift operation is changed over to column shift operation and, thereafter, by performing the row and column shift operations alternately with each other in the abovesaid manner, the discharge spot can be shifted in an oblique direction.

By continuously applying pulses of a sustain voltage level to any one of the buses X1 to X3 and any one of the buses Y1 to Y3, a stationary display can be provided, with picture elements having a one-to-one correspondence with discharge points. Also, if pulses of sustain voltage level are continuously fed to a selected one of the buses of one of the two substrates and to two selected buses of the other substrate, a stationary display can be provided, with one picture element corresponding to two discharge points. In this case, it is also possible to supply the pulses to the two buses alternately, a predetermined number of pulses being supplied to one bus, then the same number of pulses being supplied to the other bus. Since the abovesaid sustain voltage level is similar to the shift pulse level, a stationary display can be provided by continuous application of shift pulses.

The above embodiment has been described in connection with a case in which a combination of two sets of three-phase buses is employed but it is also possible, of course, to adopt structures having many buses such as, for example, a set of three-phase buses and a set of four-phase buses or two sets of four-phase buses. In such a case, a plurality of electrodes, which are formed to extend between electrodes which are alternately connected to the buses on opposite sides of the panel, are interconnected in a manner to extend in zigzag or in meander form so that they may not cross one another.

Figure 7 shows the configuration and electrode arrangement of the present invention, which embodiment employs two sets of two-phase buses. Row electrodes yaj and ybj are straight as is the case with the previous proposal of Figure 1 but column electrodes xai and xbi are each formed having portions which are displaced with respect to the rest of the electrode, the displaced portions of an electrode being displaced in the direction of the row electrodes so as to be aligned with undisplaced portions of another column electrode. The displaced portions are displaced by an odd number of electrodes (i.e. in the illustrated example the displaced portions of an electrode are displaced by one electrode so that they are aligned with undisplaced portions of an immediate neighbour electrode. Further, write electrodes wℓ ($\ell = 1, 2, 3, ..$) are provided opposite odd-numbered ones of the electrodes connected to the bus Ya. Barriers BR are formed so as to have a pattern similar to that of the previous proposal of Figure 1 in the row direction but, in comparison with the barriers of Figure 1, selected portions of the barriers are removed in Figure 7 to provide straight column shift channels and, further, the barriers are formed so that the even-numbered ones of the electrodes yaj and ybj connected to the buses Ya and Yb cross over the barriers in areas where no column shift channels are formed.

In row shift operation in the embodiment of Figure 7, a discharge spot is shifted over a zigzag or meander-form path to discharge points *a, b, c, d, e, f,* ... by drive waveforms as shown in Figure 2. Assuming, for instance, that a discharge spot is produced at the discharge point *e* by the application of the shift pulses Vsh to the buses Xb and Ya, the discharge spot will be shifted to a discharge point *c'* by the application of shift pulses Vsh next to the buses Xa and Yb. Then, if the shift pulses Vsh are fed to the buses Xa and Ya, the discharge spot shifts to a discharge point *b'*. That is, the discharge spot is shifted in a column direction.

In such column operation, a shift of the discharge spot, for example, from the discharge point *e* to *c'* or from *b'* to *d'*, can be readily achieved by extending one portion of each of the electrodes xa1 and xb1 since there does not exist any electrode acting in common to the row and column directions. In Figure 7 it will be seen that those portions of electrodes xa1, xb1 overlying a column shift channel extend in column directions slightly beyond the start of the oblique portions of those electrodes. After the discharge spot has been shifted by the column shift to the discharge point *d'*, if the column shift operation is switched back to the row shift operation, the discharge spot written by the write electrode w1 is shifted to the line of the write electrode w2 and if the column shift operation is continued, the discharge spot can be further shifted to a desired write electrode line. That is to say, for example, after characters on one write electrode line have been written, all character lines can also be shifted in the column direction.

Figure 8 illustrates, in the form of envelopes, the application of the shift pulses for the abovesaid row and column shift operations, reference characters *b, c, d,* ... indicating the timings at which a discharge spot is shifted to the discharge points similarly referenced in Figure 7. Thus, shift pulses are applied to the buses in the order (Xa, Ya)-(Xa, Yb)-(Xb, Yb)-(Xb, Ya) in row shift operation and in the order (Xb, Ya)-(Xa, Yb)-(Xa, Ya)-(Xb-Yb)-(Xb, Ya) in column shift operation.

For a stationary display, pulse voltages are supplied to selected ones of the buses depending upon whether one picture element is to correspond to one or more discharge points. In the case of displaying one picture element with one corresponding discharge point, pulse voltages are continuously fed to either one of the buses Xa and Xb and either one of the buses Ya and Yb. In the case of displaying one picture element with a corresponding plurality of discharge points, for instance, two discharge points, pulse voltages are successively applied to the buses Xa and Xb and the buses Ya and Yb, or the pulse voltages are supplied to the two buses Xa and Xb (Ya and Yb) alternately for every predetermined number of pulses. This pulse voltage may be the same as the shift pulse voltage.

The same is true in a case of displaying one picture element with four discharge points, and voltages are applied to selected ones of the buses so that discharge spots may be produced at the discharge points, for instance, *b, c, d,* and *e* in Figure 7.

With the construction of the present embodiment, the discharge points *c'* and *b'* discharge to form a path for the vertical shift, but do not positively serve as discharge points for display. Accordingly, the distance between discharge points for use in display tends to increase.

For preventing degradation of display quality resulting from the increased distance between the discharge points, it may be desirable to display one picture element with a plurality of discharge points, as described above. In the present embodiment, it may be appropriate to display one picture element by means of four discharge points.

Figure 9 shows the configuration and electrode arrangement of another panel embodying this invention, which is of the above mentioned meander electrode type. On one substrate of the panel, there are disposed electrodes x1 ℓi; x2ℓi; and x3ℓi and x2aj to x2nj connected respectively to buses X1; X2; and X3, and write electrodes wℓ (ℓ, *i, j,* = 1, 2, 3, ...), as indicated by full lines in the Figure. On the other substrate of the panel, there are disposed electrodes y1ℓk; y2ℓk and y2am to y2am to y2nm; and y3am to y3nm; (*k, m* = 1, 2, 3, ...) connected respectively to buses Y1; Y2; and Y3, as indicated by broken lines in the Figure. The abovesaid electrodes on the two substrates are respectively covered with dielectric layers, and disposed opposite each other with a discharge gas space defined therebetween.

The order of arrangement of the electrodes in a row direction is x1ℓ1, x2ℓ1, x3ℓ1, x2ℓ2, x1ℓ2, x2ℓ3, x3ℓ2, ... on one substrate, and y1ℓ1, y2ℓ1, y1ℓ2, y2ℓ2, ... on the other substrate. The order of arrangement of the electrodes in the column direction is, for example, x111, x2a1, x121, x2a2, ... on one substrate, and y111, y2a1, y3a1, y2a2, y121, y2a3, y3a2, y2a4, ... on the other substrate. The buses X1 and X3 are respectively connected to the electrodes x1ℓi and x3ℓi through conductors arranged in column directions but the bus X2 is connected the electrode x2ℓi in a zigzag or meander-form pattern of connecting conductors, which also connect electrodes x2aj to x2nj. Accordingly, although three buses X1 to X3 are provided, no cross-over areas are formed. Further, the buses Y1 to Y3 and the electrodes y1ℓk; y2ℓk and y2am to y2nm; and y3am to y3nm are interconnected in a manner similar to the manner of connection of the buses X1 to X3 to the electrodes x1ℓi to x3ℓi and x2aj to x2nj, though the connection pattern is in effect rotated through 90°, providing a structure with no cross-over areas once more. Two shift channels extending in one general direction (the row direction) are shown in Figure 9, and four shift channels extending in a perpendicular direction (the column direction) are shown.

Figure 10 shows drive waveforms for use in providing row shift operation in the panel of Figure 9. Reference characters Vx1 to Vx3 and Vy1 to Vy3 indicate pulse voltage waveforms which are supplied to the buses X1 to X3 and Y1 to Y3, respectively; Vsh indicates shift pulses; and Ve indicates erase pulses. In this embodiment of the present invention, it is possible to employ such drive waveforms such that an overlap pulse is applied at the timing for shifting a discharge spot, though this is not shown.

For example, in the case of a write pulse being applied to write electrode w1 (at one end of the first row direction shift channel), when shift pulses Vsh are being fed to the buses X1 and Y1, a discharge spot is produced between the electrodes x111 and y111 by the application of the shift pulses to the buses X1 and Y1, and then the discharge spot can be sequentially shifted to discharge points between the electrodes x211 and y111, x3111 and y111, x311 and y211, and x212 and y211 by applying shift pulses Vsh in sequence to the following combinations of buses:- X2 and Y1, X3 and Y1, X3 and Y2, and X2 and Y2. That is, the shift pulses Vsh are supplied to the buses in the order (X1, Y1)-(X2, Y1)-(X3, Y1)-(X3, Y2)-(X2, Y2)-(X1, Y2)-(X1, Y1)- ..., by which means the discharge spot is shifted in a row direction. Since an erase pulse Ve is applied to each discharge point from which a discharge spot has just been shifted, wall charge at that discharge point is erased.

Figure 11 shows drive waveforms for use in providing column shift operation in the panel of Figure 9. Reference characters Vx1 to Vx3 and Vy1 to Vy3 indicate pulse voltage waveforms which are fed to the buses X1 to X3 and Y1 to Y3, respectively. In this case, after a discharge spot has, for example, been shifted to a discharge point between electrodes x1ℓi and y1ℓk, that is, after shift pulses Vsh have been applied to the buses X1 and Y1, shift pulses Vsh are applied to the buses X1 and Y2. For instance, applying the shift pulses Vsh to the buses X1 and Y2 after the discharge spot has shifted to the discharge point between the electrodes x112 and y112, causes the discharge spot to shift to the discharge point between the electrodes x112 and y2b1. Then, if shift pulses Vsh are fed to the buses X1 and Y3, the discharge spot shifts to the discharge point between the electrodes x112 and y3b1.

In such column shift operation, the shift pulses Vsh are applied to the buses in the order (X1. Y1)-(X1, Y2)-(X1, Y3)-(X2, Y3)-(X2, Y2)-(X2, Y1)-(X1, Y1)- ... .

As can be seen from Figures 10 and 11, in the present embodiment of the invention, during row shift operation, shift pulses Vsh are applied to the buses X1 to X3, Y1 and Y2 in a predetermined order, but the bus Y3 is left idle (only erase pulses are applied thereto). Further, during column shift operation, shift pulses Vsh are supplied to the buses X1, X2 and Y1 to Y3, but the bus X3 is left idle (only erase pulses are applied thereto).

In the case of a stationary display, sustain voltage pulses are applied to the buses X1 and X2, for example, alternately with a predetermined period, and to the bus Y1 continuously, by which means discharge spots are produced alternately between the electrodes x1ℓi and y1ℓk and between x2ℓi and y1ℓk, providing a display of content written by means of write electrode wℓ. The sustain voltage pulses may be the same as the shift pulses Vsh, so that a pulse generator circuit can be used in common to the shift operation and the stationary display operation.

The drive waveforms such as are described above may be obtainable by changing the logical structure of a drive circuit for self shift type gas discharge panels of types already proposed, and it is also possible, of course, to employ waveforms other than those shown in Figures 10 and 11. The drive waveforms depicted in Figures 5 and 6 and those in Figures 10 and 11 are substantially identical with each other except that the shift pulses Vsh are supplied in an overlapping reaction in the case of the latter.

In Figure 9, for convenience of illustration, the electrodes on the two substrates are shown to be of different sizes but the electrodes on the two substrates can be formed to be of the same size. Further, connecting conductors, through which the electrodes forming discharge points are connected to the buses, cross each other, but the discharge characteristics at the crossing locations of the connecting conductors differ from those at discharge points formed by opposing electrode areas. Where, in a gas discharge panel, mutually opposing areas of electrical conductors are small operating voltages required to cause discharge thereat tend to become high, and consequently in the embodiment of Figure 9 discharge spots are produced only at the electrode opposing areas, i.e. at discharge points, and no discharge spots are produced at the areas where crossing connecting conductors oppose one another. Operation margin in the panel of Figure 9 can be further increased by employing a construction which makes generation of discharge spots at the opposing areas of crossing connecting conductors even more difficult, for example, by covering each opposing area of connecting conductor with a thicker dielectric layer than that covering other parts. Also, the number of buses used can increased.

Figure 12 illustrates the configuration and electrode arrangement of another embodiment of this invention, in which row shift operation in the row direction shift channels (along the lines of electrodes w, a, b, c, d etc) is an ordinary shift operation but column shift operation in the column direction shift channels (along the lines of electrodes a′, d′ b′ etc.) is a combination of hopping shift with the ordinary shift operation (explained in more detail below). Reference characters X1 and X2 indicate buses on one substrate of the panel of Figure 12; Y1 and Y2 designate buses on the other substrate of the panel; *w* identifies write electrodes; and *a*, *b*, *c*, *d*, *e*, *f*, *g*, ... *e′*, *f′*, and *g′* denote discharge points formed where electrode portions on the respective substrates oppose one another, that is to say, unit discharge regions.

The ordinary shift operation mentioned above is one in which adjacent discharge points in a direction of shifting of a discharge spot are formed by means of a common electrode extending in the direction of shift of the discharge spot and respective discrete electrodes disposed opposite the common electrode, and in such shift operation a discharge spot is shifted by applying shift pulses to the discrete electrodes one after another. The shifting of the discharge spots in each of the above described embodiments is generally achieved by an ordinary shift operation. The hopping shift herein mentioned relates to a case in which adjacent discharge points in the direction of shift of a discharge spot are respectively formed at the intersections or crossing points of opposed discrete electrodes, and in which a discharge spot is shifted by applying shift pulses to successive pairs of opposed discrete electrodes one after another. In such hopping shift, since no common electrode is provided between adjacent discharge points in the direction of shift of a discharge spot, plasma coupling may be loose in some cases. However, coupling can be made tighter by extending an end portion of each electrode in the direction of shift of a discharge spot.

The correspondence of the sequence of discharge points through which a discharge spot can be shifted to the sequence of combinations of buses supplied with shift pulses in row shift operation is as follows: a(X1, Y1), b(X1, Y2), c(X2, Y2), d(X2, Y1), e(X1, Y1), f(X1, Y2), g(X2, Y2), ... Thus, in row shift operation, shift pulses are respectively applied in the order such that they are fed to the four discharge points *a* to *d*.

In column shift operation, after a discharge spot has been shifted to the discharge point *c* (*g*) for example, shift pulses are fed to the buses in the order a′(X1, Y1) -d′(X2, Y1)-b′(X1, Y2)-c(X2, Y2)- ... . The shifts of a discharge spot from discharge point *c* to *a′* and from *d′* and *b′* are hopping shifts and the shifts from *a′* to *d′* and *b′* to *c* are the ordinary shift.

In column shift operation, assuming that when it was desired to shift a discharge spot from, for example, discharge point *c* to *a'*, the discharge spot is inadvertently shifted for some reason to discharge point *a* to *e*, which are supplied with shift pulses in the same manner as is the discharge point *a'*, since shift pulses are next applied to the discharge points *d'* and *d'*, the discharge spot would normally shift from the discharge point *a'* to *d'* in the column direction but where such inadvertent shift has taken place to discharge point *e* the discharge spot is shifted reversely from the discharge point *e* to *d* in the row direction. Further, where a discharge spot has been inadvertently shifted to the discharge point *a* this spot now disappears. Then, since the next shift pulses are supplied to the discharge points *b'* and *b*, a discharge spot would normally shift from the discharge point *d'* to *b'* in the column direction but, in the row direction, since the discharge point *c* is interposed between point *d* and *b*, an inadvertently shifted discharge spot is difficult to shift, and should disappear. Thus, even if a discharge spot is shifted inadvertently in an incorrect direction, the resulting faulty discharge spot will disappear in the course of subsequent shift operations, so that the shift operation margin of the panel can be increased.

Figure 13 shows another embodiment of this invention in which the row and column shifts in row and column shift channels are achieved by means of a combination of hopping shift and ordinary shift. The electrodes connected to buses X1 and X2 on the one of the two substrates of the panel of Figure 13 are each short in the row direction but long in the column direction and the hatched electrodes connected to buses Y1 and Y2 on the other substrate of the panel are long in the row direction but short in the column direction. Reference character *w* indicates write electrodes.

In row shift operation, a discharge spot can be shifted through the sequence of discharge points *a*, *b*, *c* and *d*, and in relation thereto the sequence of combinations of buses supplied with shift pulses is a(X1, Y2), b(X2, Y1), c(X1 Y1) and d(X2, Y2). In column shift operation, the sequence is b(X2, Y1), d'(X2, Y2), c'(X1, Y1) and a'(X1, Y2) for example. The shifts of a discharge spot from the discharge point *a* to *b*, *c* to *d* and *d'* to *c'*, *a'* to *b* are hopping shifts.

In the above embodiments of the present invention shown in Figures 12 and 13, two buses are provided on each of the two substrates of the panel and a two-dimensional shift (shift in both column end row directions) is made possible without forming any cross-over areas, between buses and electrodes for example. This invention is also applicable, however, to cases where three or more buses are provided on one or both of the two substrates of a panel and the order of application of the shift pulses can in each case be relatively easily set by means of a logical circuit. Further, though the electrode configuration of embodiments of the present invention described above have been shown so that the electrodes on each substrate may be distinguished from those on the other substrate, it is possible, of course, to employ various electrode configurations other than the illustrated ones.

Figure 14 illustrates, in a simplified form, the electrode arrangement of Figure 9, discharge points formed in a row direction being identified by A to F and those formed in a column direction by *b* to *f*. In this simplified form the electrode arrangement has the appearance of the meander channel type. The shift path in a shift channel has the appearance of extending in a zigzag or meander-form pattern as indicated by the arrows in Figure 14. Turning points from row to the column shift and vice versa are located at discharge points A.

The discharge points A are respectively formed between the electrodes connected to the buses X1 and Y1 (see Figure 9). The discharge points B and *b* adjacent A are each formed between respective electrodes connected to the buses X2 and Y1, and the discharge points F and *f* are each formed between respective electrodes connected to the buses X1 and Y2 (see Figure 9). Accordingly, when shifted from a discharge point A, a discharge spot is shifted to the discharge points B and *b* or F and *f* at the same time. In this case, since the two discharge points B and *b* or F and *f* are close to each other, the discharge spots at these discharge points greatly repel each other and either one of them may be erased due to a slight difference between the characteristics of the respective discharge points in some cases. In such cases, if a discharge spot at the discharge point in the shift direction is erased, one portion of the written content is lost.

Figure 15 shows an electrode arrangement used in another embodiment of this invention which is designed to ensure accurate shifting of a discharge spot from a turning discharge point at which row shift operation can be changed to column shift operation as described above. (i.e. at which a row shift channel intersects a column shift channel). The electrodes connected to the buses X1 to X3 and connecting conductors therefor are indicated by broken lines in the Figure, and the electrodes connected to the buses Y1 to Y3 and connecting conductors therefor are indicated by full lines in the Figure. In the present embodiment, the discharge points A, which are the abovesaid turning points, are formed respectively between electrodes connected to the buses X2 and Y2, i.e. those buses for which connecting conductors of zigzag or meander form are provided. The discharge points B, *b*, F and *f* respectively adjoining A are formed between the electrodes connected to different combinations of buses. The combinations of buses for the respective discharge points is as follows: B(X3, Y2), b(X2, Y1), F(X1, Y2) and f(X2, Y3).

Accordingly, when shifting a discharge spot in a row direction shift channel through the discharge points E, F, A, B, C and D one after another, if it is assumed that a discharge spot is produced at the discharge point F by the application of shift pulses to the buses X1 and Y2, the discharge spot is shifted to the discharge point A by the application of shift pulses next to the buses X2 and Y2, and then shifted only to the discharge point B by the subsequent application of shift pulses to the buses X3 and Y2. In other words, there is no possibility of the discharge spot simultaneously shifting to two different discharge points, as described previously in connection with Figure 14.

In a case of shifting a discharge spot in the column direction through the discharge points *e, f,* A *b*, *c* and *d* one after another, if it is assumed that the discharge spot is produced at the discharge point *f* by the application of shift pulses to the buses X2 and Y3, the discharge spot is shifted to the discharge point A by the next application of shift pulses to the buses X2 and Y2, and then shifted only to the discharge point *b* by the subsequent application of shift pulses to the buses X2 and Y1.

Figure 16 is a schematic diagram, similar to Figure 14, illustrating in a simplified form the electrode arrangement depicted in Figure 15. The discharge points A, at which discharge spot shifting operation can be switched from row shift operation to column shift operation and vice versa, are formed at the intersections of the meandering electrodes, i.e. the buses X2 and Y2.

Figure 17 is a waveform diagram showing an example of drive waveforms for use with the panel of Figure 15. In the case of row shift operation the buses X1 to X3 and Y1 to Y3 are respectively supplied with pulse voltages waveforms Vx1 to Vx3 and Vy1 to Vy3, each composed of shift pulses SP, overlap pulses VP and erase pulses EP. At this time, the Y3 is supplied with erase pulses EP only. Reference character Vw indicates a voltage waveform which is applied to a write electrode. At a timing when a discharge spot is shifted to the discharge point F, a write pulse WP is applied and then an overlap pulse VP is applied to shift the discharge spot to the discharge point A and, thereafter, an erase pulse EP is applied.

Reference characters VA to VF and VW show pulse voltage waveforms which are fed to the discharge points A to F and a write discharge point, respectively. The arrows indicate the shift timings of a discharge spot. Reference characters A to F at the top of Figure 17 indicate the periods in which the discharge spot is present at the discharge points A to F, respectively.

In Figure 18, Vx1′ to Vx3′ and Vy1′ to Vy3′ show pulse voltage waveforms which are fed to the buses X1 to X3 and Y1 to Y3, respectively, in a case of column shift operation. The bus X3 is supplied with erase pulses EP only. A and *b* to *f* indicate the periods in which the discharge spot is present at the discharge points A and *b* to *f*, respectively. The pulse voltages which are fed to the discharge points A and *b* to *f* in the above case have waveforms similar to those VA to VF depicted in Figure 17.

In the above embodiment, information is written at a timing at which the discharge spot is shifted to the discharge point F, but it is also possible to write information at a timing of shifting a discharge spot to some other discharge point. For instance, in the case of writing information at the timing of shifting the discharge spot to the discharge point C, the arrangement is made such that the discharge point D may be adjacent a write discharge point W and the above-said turning point is selected to be the discharge point A formed at the intersection of the buses X2 and Y2 of the zigzag configurations, as is the case with the above embodiment.

Figure 19 is a diagram explanatory of an arrangement adopted in another embodiment of this invention, in which four-phase buses X1 to X4 and Y1 to Y4 are provided on each of the two substrates of the panel, respectively. Also, in this embodiment, the intersection of an array of the discharge points A to H in the row direction with an array of the discharge points A and *b* to *h* in the column direction, that is, a turning point as mentioned above, is the discharge point A formed between electrodes connected to zigzag or meander-form buses X2 and Y2, respectively. Although four discharge points B, *b*, H and *h* adjoin a turning point, in a shifting operation a discharge spot is shifted only to the discharge point adjacent A in the selected shift direction.

Figure 20 is a schematic diagram, similar to Figure 14, illustrating, in a simplified form, the electrode arrangement depicted in Figure 19. Adjacent a write discharge point W, a discharge point A is disposed which lies at the intersection of electrodes connected to buses X2 and Y3 respectively, and, by selectively applying shift pulses to buses X1 to X4 and Y1 to Y4, a row or column shift operation can be achieved and the turning point in this case is the discharge point A.

Figure 21 is a block diagram showing a drive circuit for generating pulse voltage waveforms as depicted in Figures 17 and 18. Clock pulses emanating from a clock generator 11 are counted by counters 12 and 13 and the count contents b1 to bn of the counter 12 are decoded by a decoder 14, thereafter being applied as address signals A0 to An to a timing generate circuit 16. The count contents bn+1 and bn+2 of the counter 13 are decoded by a decoder 15 and then applied to the timing generate circuit 16. The timing generate circuit 16 is provided with six read-only memories ROM1 to ROM6 having stored therein drive timings for carrying out six steps of a row shift operation and six read-only memories ROM7 to ROM12 having stored therein drive timings for carrying out six steps of a column shift operation. Reference characters (A) to (F) and (A) to (f) in the read-only memories ROM1 to ROM6 and ROM7 to ROM12 indicate that they have stored therein the timings of pulse voltages to be generated in the periods A to F and A to *f* in Figures 17 and 18.

When a shift instruction or shift command is "1", it is a column shift instruction and when it is "0", the output from an inverter 20 becomes "1" to provide a row shift instruction. A shift driver 19 operates in response to timing signals Ix1 to Ix3 and Iy1 to Iy3 read out of the read-only memories ROM1 to ROM6 and ROM7 to ROM12, supplying the buses X1 to X3 and Y1 to Y3 with the pulse voltages Vx1 to Vx3, Vy1 to Vy3 and Vx1′ to Vx3′, Vy1′ to Vy3′ shown in Figures 17 and 18.

A character generator 17 supplies a write driver 18 with signals IW1 to IW7 corresponding to character address signals, respectively. The signals IW1 to IW7 are output at timings defined by the clock pulses and a timing signal Iwu derived from read-only memory ROM6 or ROM12. A write driver 18 provides write pulses WP indicated at Vw in Figure 17 to write electrodes W1 to W7 at a timing defined by a timing signal Iwd.

In the foregoing embodiments, in the case of row shifting of a discharge spot forming one picture element, the discharge spot is shifted through the discharge points A, B, C, D, ... one after another. This is performed by selecting the buses X1 to X3 in the order X1-X2-X3-X2-X1-X2- ... and the buses Y1 to Y3 in the order Y1-Y2-Y1-Y2- ... . Such a discharge spot drive method will hereinafter be referred to as the single cell scanning method.

On the other hand, there is also a method of shifting a discharge spot for use when generating discharge spots, each forming one picture element, at adjoining discharge points. That is to say, by repeatedly supplying shift pulses to a sequence of combinations of buses such as (X1, X2, X3, Y1), (X3, Y1, X2), (X1, X2, X3, Y2) and (X1, Y1, Y2), a discharge spot is shifted through the discharge points in a repeating cyclic order (A, B, C)-(C, D)-(D, E, F)-(F, A). This method will hereinafter be referred to as the common electrode scanning method because, during a shift operation, discharge spots at mutually adjacent discharge points formed along a common electrode are present at one time.

Such a common electrode scanning method is also applicable to column shift operation and, in embodiments of this invention, both of the abovesaid methods can be employed.

When row shift operation is achieved by a single cell scanning method on a write line (see write line L1 in Figure 22), only one of the buses Y1 and Y2 is selected in a display line (see display lines L2 to Ln in Figure 22). When a display line bus Y1 is selected, the buses X1 to X3 are selected in the order X1-X2-X3-X2-X1-X2- ... as mentioned above, so that a display discharge spot is shifted between discharge points in a repeating cylic order A-B-C-B-A-B ... . That is, since the content already written in the display line is held and displayed while being swayed back and forth through points A, B and C, this method will hereinafter be referred to as the sway method.

Also, with the common electrode scanning method, when a shift operation takes place in a write line, only one of the Y buses is selected in a display line in the same manner as described above. Since the buses X1 to X3 are selected in a repeating cyclic order (X1, X2, X3)-(X3)-(X1,X2,X3)-(X1)-(X1,X2,X3), when the Y bus is selected, display discharge spots are produced at discharge points in the order (A, B, C)-(C)-(A, B, C)-(A)-(A, B, C), so that the content being displayed is held by a sway method in the display line.

By providing the buses X1 to X3 in common to a write line and a display line and by providing separate buses Y1 to Y3 for the write line and for the display line, respectively, it is possible to display a written content while holding the content of a display line by the sway method in a write line during shift operation in the write line by either the single cell scanning method or the common electrode scanning method.

Figure 22 schematically shows a two-dimensional shift gas discharge panel having write and display lines. Reference character

L1 indicates a write line, L2 to Ln designate display lines; W1 to W7 identify write electrodes for use in providing for character display, for example, by means of 5 × 7 dots for each character; X1 to X3 denote buses common to the write line and the display lines; AY1 to AY3 represent buses of the write line; and BY1 to BY3 show buses of the display lines. The lines L1 to Ln have the electrode arrangement shown, for instance, in Figure 9.

The buses X1 to X3 are sequentially selected in accordance with a single cell scanning method or a common electrode scanning method, and supplied with shift pulses Vsh. During write operation, the write electrodes W1 to W7 are selectively supplied with write pulses in accordance with information to be written, and the resulting discharge spots are sequentially shifted into the write line L1 by the application of the shift pulses Vsh to the buses AY1 and AY2 selected from the buses AY1 to AY3 described above. Also, at this time, for instance, the bus BY1 is selected from the buses BY1 to BY3 as described previously, and supplied with shift pulses Vsh, so that a discharge spot is provided in a display line by the sway method.

Upon application of a write operation, the contents in the write line L1 are shifted to the display line L2. By means of column shift operation as mentioned above, that is, by a selective combination of the buses AY1 to AY3 and BY1 to BY3 with, for example, the buses X1 and X2, the written contents are sequentially shifted. If the buses BY1 to BY3 of the display lines L2 to Ln are led out independently line by line, the content to be displayed can be retained in a desired line by means of the sway method even during column shift operation. Also, in the display lines, column shift can be effected.

Figures 23 and 24 illustrate the cross-sections of principal parts of the self shift type gas discharge panel of Figure 15 taken along a row direction and along a column direction, respectively. In Figures 23 and 24, reference numerals 1 and 2 indicate substrates, for example of glass; 3 and 4 designate dielectric layers, for example of a low-melting-point glass; and 5 identifies a space having sealed therein a discharge gas such as neon, for example. It is customary to cover each of the dielectric layers 3 and 4 with an ion shock-proof protective film for example of MgO.

In a case of shifting a discharge spot in a row direction in the order of discharge points E-F-A-B-C-D, if a discharge spot is produced at the discharge point F by the application of shift pulses to the buses X1 and Y2, the discharge spot is shifted to the discharge point A by the application of shift pulses to the buses X2 and Y2, and then shifted only to the discharge point B by the subsequent application of shift pulses to the buses X3 and Y2.

In a case of shifting a discharge spot in the column direction in the order of discharge points *e*-*f*-A-*b*-*c*-*d*, if a discharge spot is generated at the discharge point *f* by the application of shift pulses to the buses X2 and Y3, the discharge spot is shifted to the discharge point A by the application of shift pulses to the buses X2 and Y2, and then shifted only to the discharge point *B* by the subsequent application of shift pulses to the buses X2 and Y1.

Figures 25 shows, in a simplified form, an electrode arrangement for the embodiment of Figure 15 in a case where separate write and display lines are provided (compare Figure 16). A discharge spot written by a write electrode Wi is shifted by applying pulses to selected combinations of the buses X1 to X3 with AY1 and AY2 to discharge points W, A, B, C, ... one after another. Since the discharge point A is a turning point, the discharge spot can then be shifted by applying pulses to selected combinations of the buses X1 and X2 with AY1 to AY3 and BY1 to BY3, in the column direction, to discharge points A, b, c, d, ... one after another.

Figures 26 and 27 show an example of series of drive waveforms, for a panel having the electrode arrangement of Figure 25, in accordance with the common electrode scanning method. Vx1 to Vx3, Vya1 to Vya3 and Vyb1 to Vyb3, Vw; and VA to VF and VW show pulse voltage waveforms applied to buses and to the discharge points of the write line, respectively; Vb to Vf to show pulse voltage waveforms fed to the discharge points *b* to *f*, respectively and VA′ to VF′ show pulse voltage waveforms applied to the discharge points A to F of the display lines, respectively.

When a discharge spot is produced at the write discharge point W by supplying a selected one of the write electrodes with write pulses of the waveform Vw in a period FAB, since pulse voltages of the waveforms indicated by VF, VA and VB are fed to the discharge points F, A and B at that time, discharge spots are produced at the discharge points A and B adjacent the write discharge point W(and at the discharge points F, A and B adjacent a position to which a discharge spot has previously been shifted). In the next period BC, the discharge spot shifts to the discharge points B and C. Further, in the subsequent period CDE, the discharge spot shifts to the discharge points C, D and E. Thereafter, the discharge spot is similarly shifted in the row direction.

In the abovesaid row shift, the pulse voltages indicated by VA′ to VF′ in Figure

27 are fed to discharge points A to F of a display line and a pulse voltage which is in-phase with those applied to the buses X2 and BY1 is applied to the discharge point D, with the result that no potential difference is produced, putting the discharge point D in a state equivalant to one in which no pulse voltage is applied thereto. Accordingly, the discharge spot is swayed between the discharge points E and C in the order (F, A, B,)→(B, C)→(F, A, B,)→(E, F)→(F,A,B,) ..... Thus, during row shift in the write line, a content to be displayed can be retained in a display line by the sway method.

In a period of column shift, pulse voltages of the same waveforms are supplied to the discharge points A to F of the write and display lines and, in this case, since the pulse voltages are sequentially applied to the discharge points as indicated by Vb to Vf, a discharge spot is shifted in the order of the discharge points (f, A, b)→(b, c,)→(c, d, e,)→(e, f,)→(f, A, b).

In Figures 26 and 27, no reference is made to the application of an erase pulse and in-phase pulse voltages are fed to other buses than the selected X and Y buses and no voltages are applied to the discharge points corresponding to them. In this case, however, if the pulse voltages are phased apart, pulse voltages of small width can be applied as erase pulses to the abovesaid discharge points.

For performing the abovesaid shift operations, it is preferred to employ a drive circuit which is composed of read-only memories having stored therein the order of distribution of drive pulses for performing respective steps of row shift operation and of column shift operation, respectively. For example, in the case of driving a panel of an electrode structure such as that of Figures 22 and 25 in accordance with a common electrode scanning method described with regard to Figures 26 and 27, it is possible to employ such a construction as is illustrated in Figure 28. In Figure 28, read-only memories ROM1 to ROM4 included in a fundamental timing generate circuit 26 have respectively stored therein pulse generation timings corresponding to respective electrodes for four unit steps (B, C), (C, D, E), (E, F) and (F, A, B) of row shift operation. The read-only memories ROM1 to ROM4 are sequentially read out with address signals A0 to An and P1 to P4 derived from decoders 24 and 25 based on outputs b1 to bn, bn+1 and bn+2 from counters 22 and 23 which count clock pulses emanating from a clock generator 21 when a shift instruction signal is "1" thereby to instruct row shift operation, supplying drive timing signals Ix1 to IbY3 to a shift driver connected to the respective electrodes of the panel. Write timing signals Iwu and Iwd are read out of the read-only memory ROM4 corresponding to the phase of (F, A, B) at the same time as the memory ROM4 is addressed, and write information from a character generator 27, selected on the basis of a character address signal applied thereto, is fed to a write driver 28 connected to write electrodes W1 to W7 at predetermined timings. When the shift instruction signal becomes "0", thereby to instruct column shift operation, the output from an inverter 30 becomes "1" and read-only memories ROM5 to ROM8 which have stored therein pulse generation timings corresponding to the respective electrodes for four unit steps (f,A,b), (b,c), (c,d,e) and (e, f) of column shift operation, are addressed with the outputs from the decoders 24 and 25 to read out timing signals for column shift, thereby performing such a column shift operation as is described previously in respect of Figures 26 and 27. In this case, it is possible to employ read-only memories, each having 11 × 24 addresses and drive pulse trains for the respective unit steps can be obtained by a sequentially reading out in parallel the contents of sequences of addresses of the memories, each sequence composed of eleven lines.

As has been described in the foregoing, according to the present invention, buses and electrodes need not cross over each other on either substrate of a panel, so that no cross-over areas are needed. This facilitates reduction of electrode pitch, and hence provides a self shift type gas discharge panel capable of a high-resolution display. Further, since shift channels are formed both in row and column directions, it is possible to shift in a row direction discharge spots indicative of written information while sequentially writing-in information from one end of the panel and to shift the resultant discharge spots in a column direction upon completion of writing the information for one line. Thus, by repeating such row and column shifts, information relating to a plurality of lines can be written and displayed.

Where the shift channels are formed with barriers in the row and column directions, the electrode structure is simplified and, although the shift paths in the shift channels are then of a zigzag or meander-form manufacture of electrodes is easy and the electrode pitch can be reduced. Where no barriers are employed, the shift paths in the shift channels in both the row and column directions can be made linear.

Further, a discharge point which is a turning point at the intersection of the row and column shift channels can be formed with electrodes connected to buses through connecting conductors of zigzag or meander-form configurations, by which an erroneous shift of a discharge spot can be prevented, providing for increased operation margin.

WHAT WE CLAIM IS:-

1. A self shift gas discharge device, of the kind having first and second arrays of electrode members, with layers of dielectric material thereover, on respective surfaces of first and second substrates of the device, which surfaces confront one another across a discharge gas spaced defined therebetween, so that respective discharge points of the device are defined where respective electrode members of the first and second arrays face one another across the said discharge gas space, wherein first and second pluralities of supply buses are provided respectively on the said surfaces, the buses of the first and second pluralities respectively and the electrode members of the first and second arrays respectively being connected, on the said respective surfaces, in repetitive regularly-ordered manner, a regularly ordered connection pattern which is repeated on such a surface including no cross-over areas, and wherein a first plurality of shift channels are provided in the device each extending in a first general direction and each being such that a discharge spot can be caused, by the application of driving signals to the supply buses, to follow a shift path, along the shift channel, constituted by a series of the discharge points of the device, and a second plurality of shift channels are provided in the device each extending in a second general direction, transverse to the said first general direction, and each being such that a discharge spot can be caused, by the application of driving signals to the supply buses, to follow a shift path, along the shift channel, constituted by a series of the discharge points of the device, and wherein the shift channels of the first plurality thereof intersect the shift channels of the second plurality thereof (i.e. the shift path along a shift channel of the first plurality thereof has a discharge point in common with a shift path along a shift channel of the second plurality thereof) so that a discharge spot in the device at the intersection of two shift channels can be caused, by the application of appropriate driving signals to the supply buses, subsequently to shift along either of the two shift channels.

2. A device as claimed in claim 1, wherein each shift channel of the first plurality thereof intersects a shift channel of the second plurality thereof each *n*th discharge point along the shift path of the shift channel of the first plurality, where *n* is equal to the sum of first and second pluralities of supply buses.

3. A device as claimed in claim 1 or 2, wherein each electrode member of the first array crosses all of the electrode members of the second array and each electrode member of the second array crosses all of the electrode members of the first array, there being two supply buses provided on each of the said respective surfaces and the electrodes of each of the said arrays being connected alternately, one after another, to the supply buses on the substrate surface concerned, each electrode member of the second array having first and second electrode portions that cross respective pairs of adjacent electrode members of the first array, each such pair comprising one electrode member connected to each of the two supply buses on the surface of the first substrate, the second electrode portions of each electrode member of the second array being displaced, in the direction of extent of the electrode members of the first array, so that they are aligned with the first electrode portions of another electrode member of the second array that is either next adjacent to the electrode member concerned or is spaced apart therefrom by an even number of further electrode members of the second array, and there being barrier means provided in the device, such that along each pair of electrode members of the first array crossed by first electrode portions of the electrode members of the second array a shift channel is formed along which a discharge spot is constrained to follow a meander-form shift path, when the shift channel is in use, and such that discharge points formed where the electrode members of each pair of electrode members of the first array are crossed by second electrode portions of electrode members of the second array constitute discharge points along shift paths of shift channels transverse to the shift channels formed along electrode members of the first array.

4. A device as claimed in claim 1 or 2, wherein two supply buses are provided on each of the said respective surfaces, wherein the electrode members of the first array comprise first and second pluralities of groups of electrode members, the electrode members of the groups of the first plurality being arranged one after another along respective transversely spaced lines running in one direction across the surface of the first susbstrate, and the electrode members of the groups of the second plurality being arranged one after another along respective transversely spaced lines running in another direction, transverse to the one direction, across the surface of the first substrate, and wherein the electrode members of each of the groups of the first and second pluralities thereof comprise electrode members of first and second sets, that are connected respectively to first and second supply buses on the

substrate surface concerned, the electrode members of the first set alternating with those of the second set in each said group of electrode members, and the electrode members of the groups of the first and second pluralities being arranged so as to face electrode members of the second array in such a manner that mutually transverse shift channels are provided in the device along the lines of the electrode members of the groups of the first and second pluralities respectively.

5. A device as claimed in claim 1, wherein three or more supply buses are formed on each of the said respective surfaces of the first and second substrates, and wherein each electrode member of the first array crosses all of the electrode members of the second array and each electrode member of the second array crosses all of the electrode members of the first array, the electrode members of each of the said arrays comprising a first set of electrode members connected in common to a first supply bus on the surface of the substrate concerned, to one side of the electrode members of the other of the said arrays, a second set of electrode members connected in common to a second supply bus on the surface of the substrate concerned, to the other side of the electrode members of the said other array, and at least one further set of electrode members, the electrode members of the or each further set being connected in common to respective supply buses on the surface of the substrate concerned and electrode members of the or each further set each having one end connected, at a position to one side of the electrode members of the said other array, to the adjacent end of the next adjacent electrode member of that set, to one side of the electrode member concerned, and the electrode member concerned having its other end connected, at a position to the other side of the electrode members of the said other array, to the adjacent end of the next adjacent electrode member of that set, to the other side of the electrode member concerned, and so on, so that the electrode members of the or each further set form successive parts of respective continuous folded-electrode configurations extending between, and around respective free ends of, electrode members of the members of the first and second sets, and there being barrier means provided in the device for forming the mutually transversely directed shift channels.

6. A device as claimed in claim 1 or 2, wherein three or more supply buses are formed on each of the said respective surfaces of the first and second substrates, and wherein the electrode members of each said array comprise first and second pluralities of groups of electrode members, the electrode members of the groups of the first plurality of each said array being arranged one after another along respective lines running in one direction across the substrate surface on which the electrode members of the array concerned are formed, and the electrode members of the groups of the second plurality of each said array being arranged one after another along respective lines running in another direction, transverse to the one direction, across the substrate surface on which the electrode members of the array concerned are formed, the one direction across the substrate surface on which the electrode members of the first array are formed being transverse to the one direction across the substrate surface on which the electrode members of the second array are formed, the electrode members of the first plurality of groups on each substrate surface including first and second sets of electrode members connected respectively to first and second supply buses on the substrate surface concerned by way of connecting conductors extending transversely of the one direction on that substrate, the electrode members of the first set alternating with those of the second set in the one direction in each group of the first plurality of groups on the substrate concerned, and electrode members of the first and second sets in the respective groups of the first plurality occupying similar positions along the lines of the respective groups on the substrate concerned being connected together by such connecting conductors, each group of the first plurality on each substrate including one or more further sets of electrodes, aligned with the electrodes of the first and second sets of the groups concerned, connected to respective further supply terminals on the substrate surface concerned, the electrode members of the or each further set in each group of the first plurality on each substrate surface being connected in series with one another, and the electrode members of the or each further set in all of the groups of the first plurality on the substrate being connected in series with one another and with electrode members of all of the groups of the second plurality on the substrate, by means of connecting conductors on the substrate, in such a manner that the connection pattern of electrode members of the first and second pluralities of groups is of zig-zag or meander form, the electrode members of the first array each at least partly facing at least one electrode member of the second array so that electrode members of the groups of the first and second plurality on one substrate surface face electrode members of the groups of the second and first pluralities, on the other substrate surface, respectively, whereby mutually transverse shift channels

are provided in the device between respective electrodes members, on respective opposed substrate surfaces, of the first and second pluralities of groups, and between respective electrode members of the second and first pluralities of groups.

7. A device as claimed in claim 6, wherein mutually transverse shift channels intersect (i.e. the shift paths of the respective shift channels have a discharge point in common) where electrode members of the or of one of the said further sets on one substrate surface face electrode members of the or of one of the said further sets on the other substrate surface.

8. A device as claimed in claim 1 or 4, wherein the shift mechanism by which a discharge spot can be caused to follow a shift path in a shift channel in the device is a combination of ordinary shift mechanism as hereinbefore defined and hopping shift mechanism as hereinbefore defined.

9. A device as claimed in claim 8, read as appended to claim 4, wherein the shift mechanism along shift channels provided along the lines of the groups of one of the first and second pluralities thereof is the ordinary shift mechanism as hereinbefore defined, and the shift mechanism along the lines of the groups of the other of the first and second pluralities thereof is a combination of the ordinary shift mechanism and the hopping shift mechanism.

10. A device as claimed in claim 6, wherein a third array of electrode members, with dielectric material thereover, is formed on the surface of the first substrate on which the electrode members of the first array are formed, so that respective discharge points of the device are formed where respective electrode members of the third and second arrays face one another across the said discharge gas space, there being an additional plurality of supply buses provided on the said surface of the first substrate, and the electrode members of the third array being connected to the supply buses of the additional plurality so that a discharge spot can be caused, by application of driving signals to supply buses of the device to move in either of two mutually transverse general directions across the device.

11. A device as claimed in claim 10, wherein a region of the device where electrodes of the first and second arrays face one another is a write-in region, and a region of the device where electrodes of the third and second arrays face one another is a display region, and wherein, when the device is in use, a discharge spot can be caused to follow a shift channel extending in a first general direction in the write-in region, until it reaches a desired position, and it can then be caused to follow a shift channel extending in a second general direction, transverse to the first general direction, and to move to a desired display position in the display region, whereafter it can be caused to move back and forth, in a swaying mode, in the first general direction, to provide a display.

12. A device as claimed in claim 11, wherein, in such a display, one discharge spot corresponds to one picture element.

13. A device as claimed in claim 11, wherein, in such a display, a plurality of discharge spots are employed in correspondence to each picture element.

14. A device as claimed in any preceding claim, in combination with driving circuitry, connected to the supply buses of the device and operable to apply driving signals thereto.

15. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 4, Figures 4, 5 and 6, Figure 7 or Figures 7, 8 and 9 of the accompanying drawings.

16. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 9, or Figures 9, 10, 11 and 14 of the accompanying drawings.

17. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 12 or Figure 13 of the accompanying drawings.

18. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 15, Figures 15, 23 and 24, Figures 15 to 18, Figures 15 to 18 and 21, or Figures 15 to 18 and 23 and 24, or Figures 15 to 18, 21, 23 and 24 of the accompanying drawings.

19. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 19 or Figures 19 and 20 of the accompanying drawings.

20. A self shift gas discharge device substantially as hereinbefore described with reference to Figure 22, Figures 22 and 25, Figures 22, 25, 26 and 27 or Figures 22, and 25 to 28 of the accompanying drawings.

HASELTINE, LAKE & CO.
Chartered Patent Agents,
Hazlitt House,
28, Southampton Buildings,
Chancery Lane,
London, WC2A 1AT.
-also-
Temple Gate House,
Temple Gate,
Bristol BS1 6PT.
-and-
9, Park Square,
Leeds LS1 2LH,
Yorks.
Agents for the Applicants.

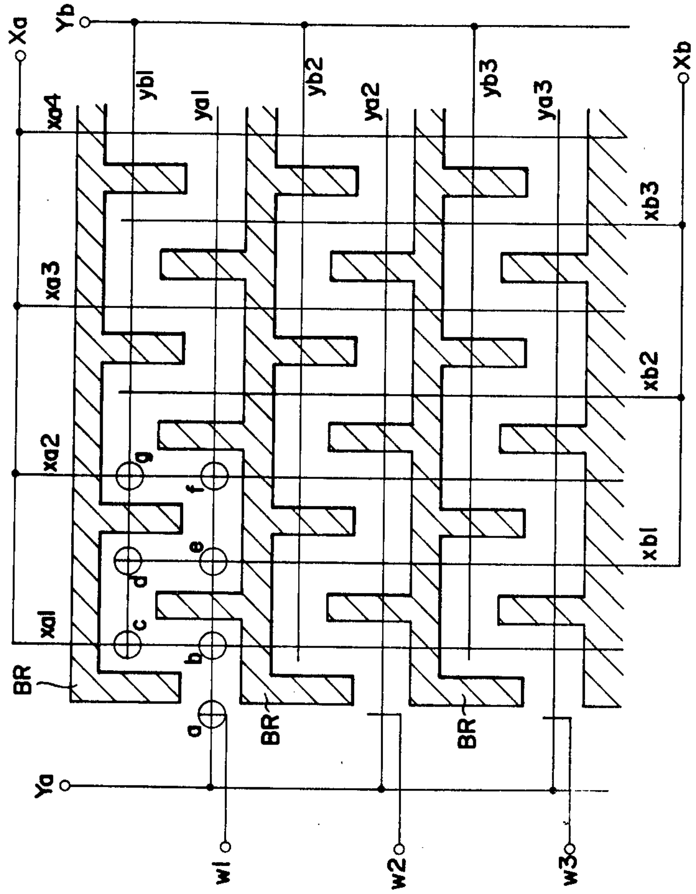
Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. I



1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 2

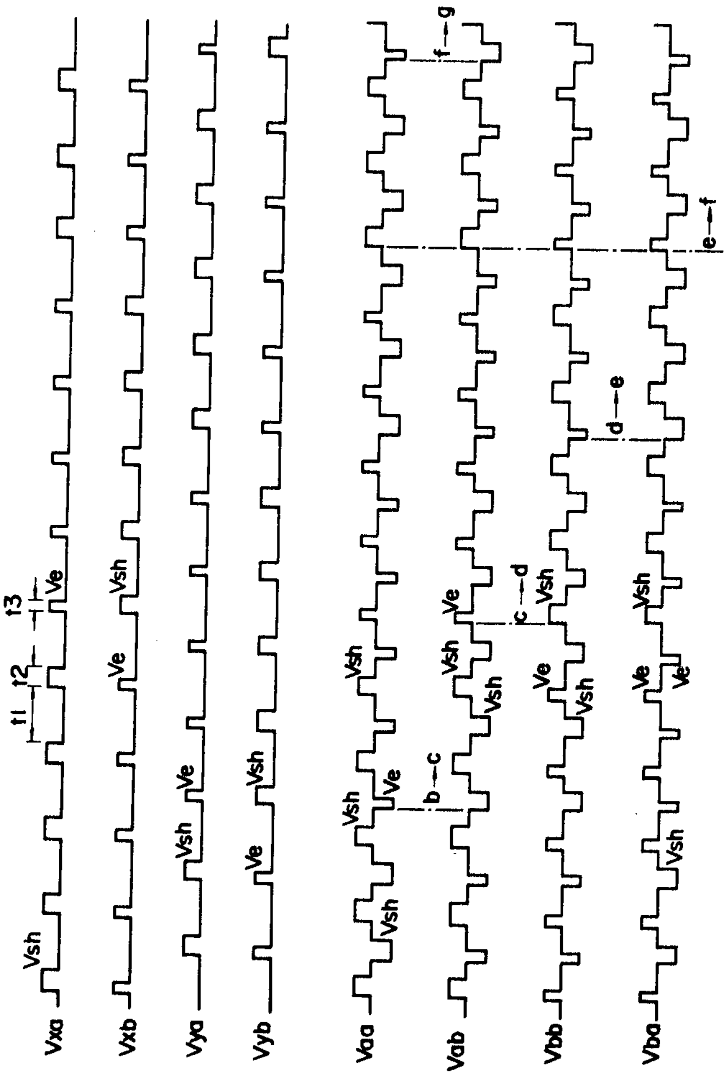


FIG. 3

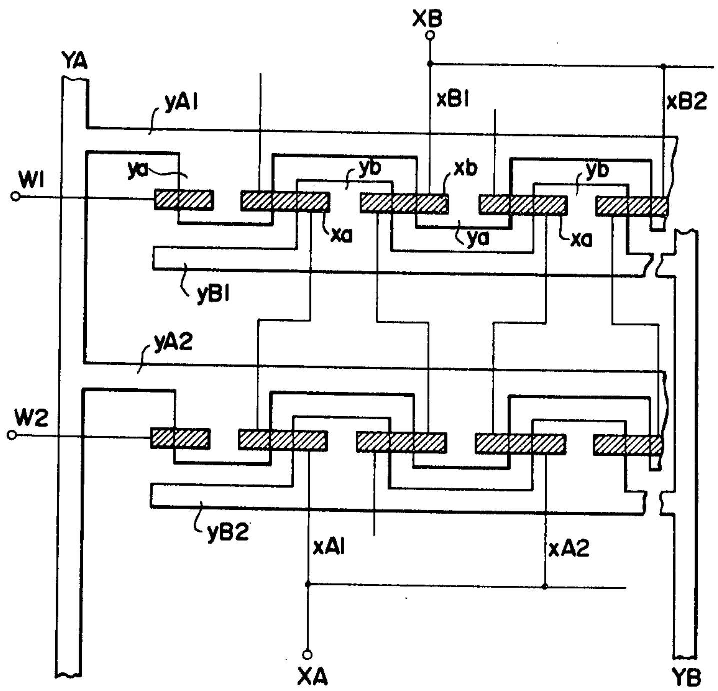

XB
YA
yA1
xB1
xB2
W1
ya
yb
xb
yb
xa
ya
xa
yB1
yA2
W2
yB2
xA1
xA2
XA
YB

FIG. 4

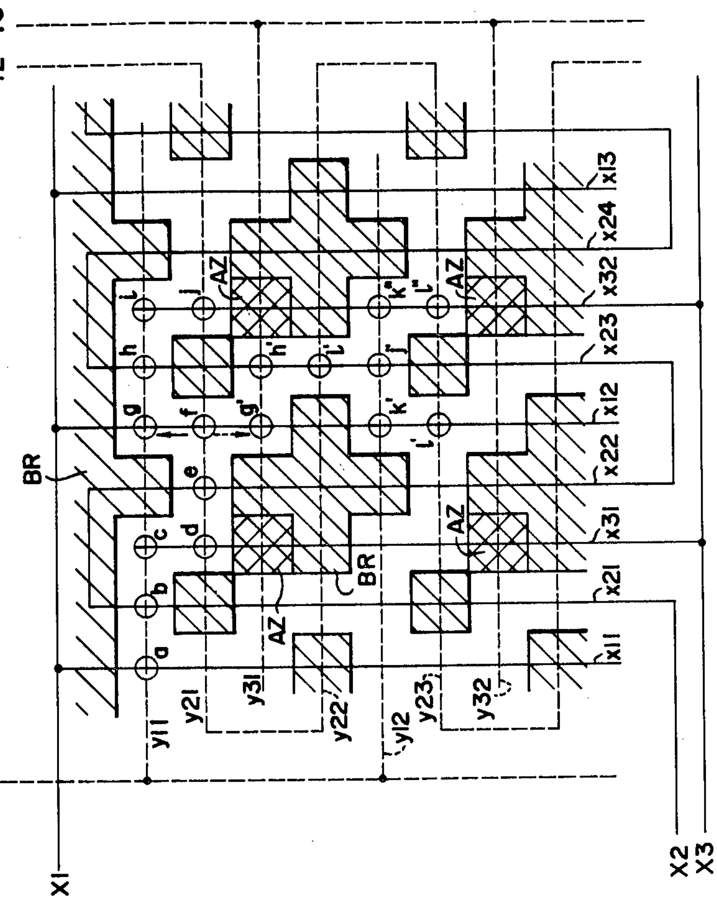
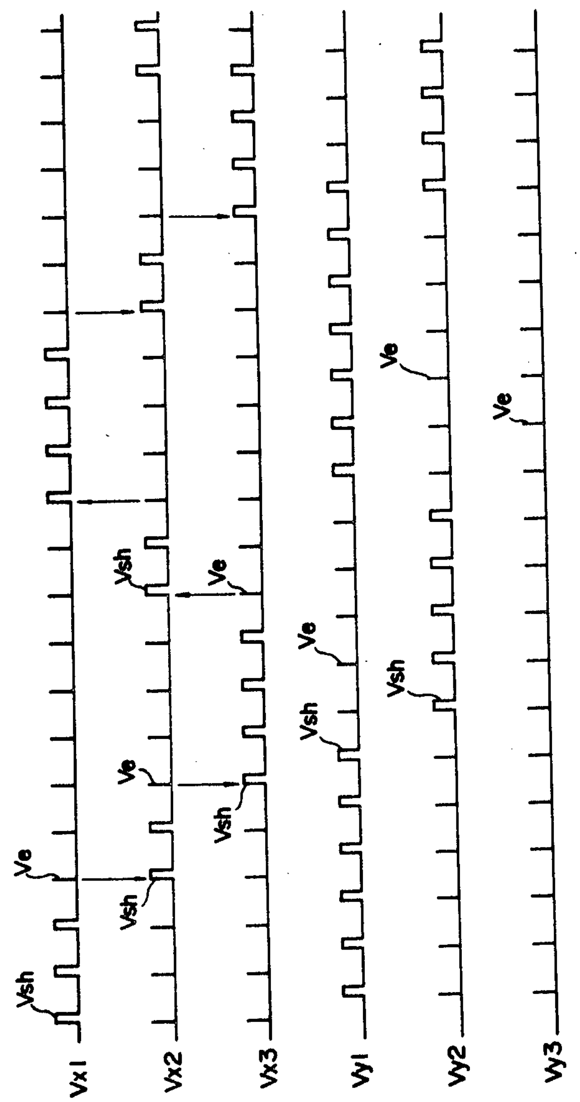

Y1
Y2
Y3
X1
X2
X3
BR
AZ
x11
x12
x13
x21
x22
x23
x24
x31
x32
y11
y12
y21
y22
y23
y31
y32

FIG. 5



1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 6

FIG. 6

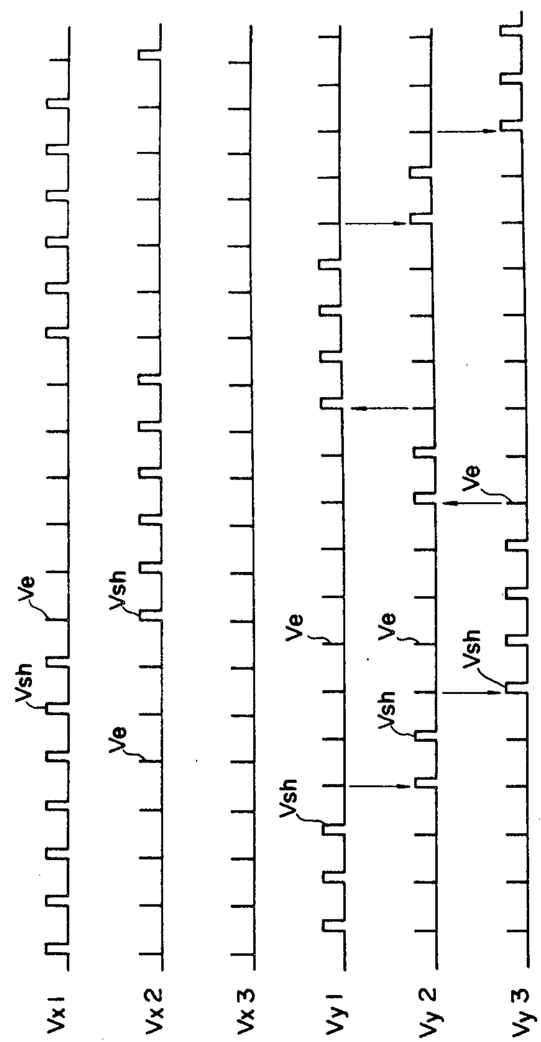


FIG. 7

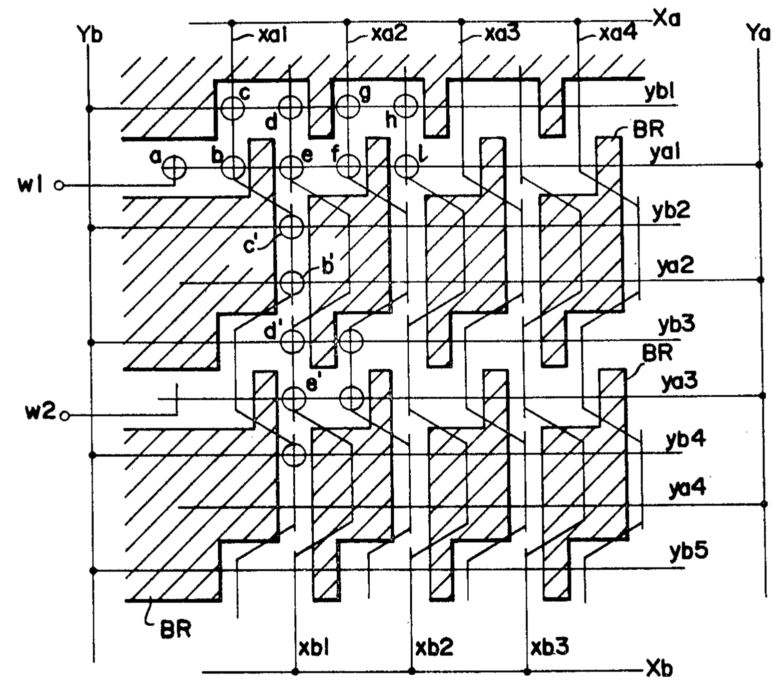

Xa
xa1
xa2
xa3
xa4
Yb
Ya
yb1
ya1
yb2
ya2
yb3
ya3
yb4
ya4
yb5
BR
BR
BR
w1
w2
a
b
c
d
e
f
g
h
i
c'
b'
d'
e'
xb1
xb2
xb3
Xb

FIG. 8

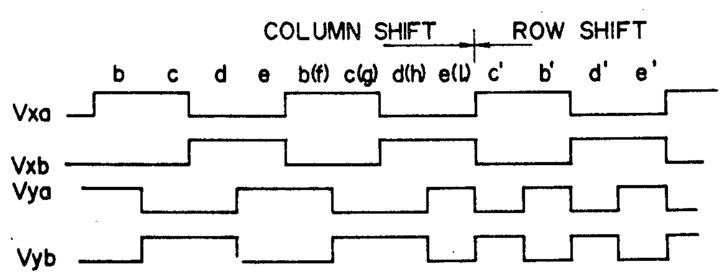

COLUMN SHIFT
ROW SHIFT
b c d e b(f) c(g) d(h) e(i) c' b' d' e'
Vxa
Vxb
Vya
Vyb

FIG. 9

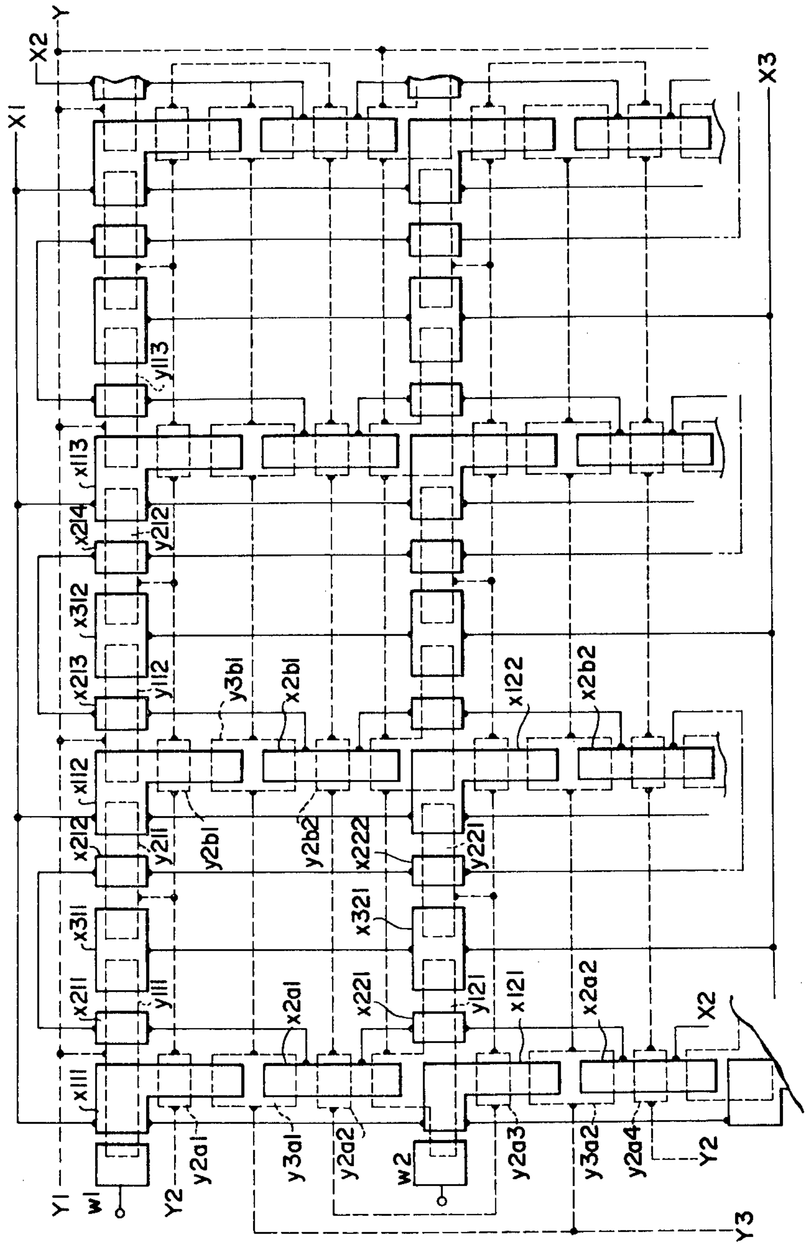

X2
Y
X1
X3
y113
x113
x214
y212
x312
x213
y112
y3b1
x2b1
x122
x2b2
x112
x212
y211
y2b1
y2b2
x222
y221
x311
x321
x211
y111
x2a1
x221
y121
x121
x2a2
X2
x111
Y1
w1
Y2
y2a1
y3a1
y2a2
w2
y2a3
y3a2
y2a4
Y2
Y3

FIG. 10

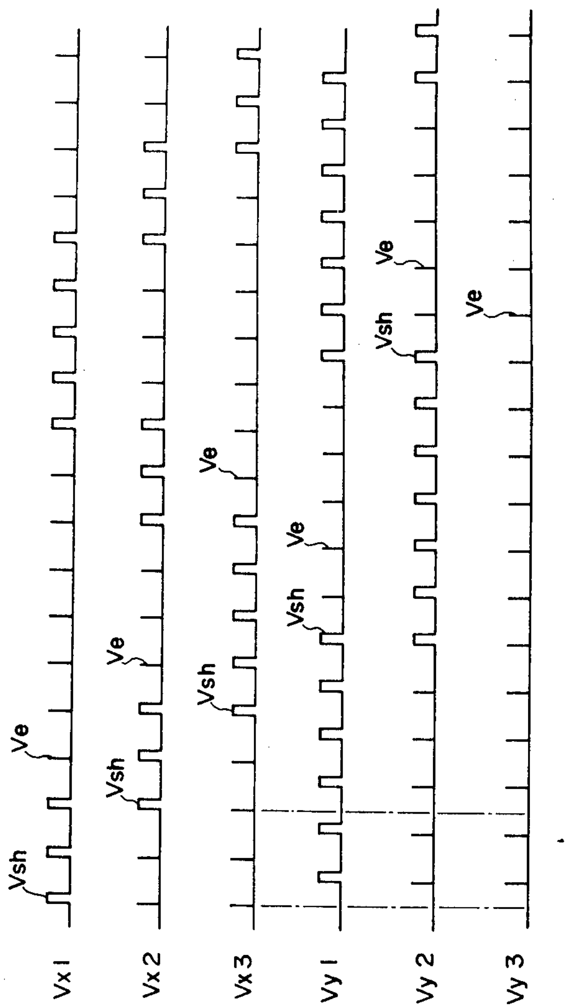


FIG. 11

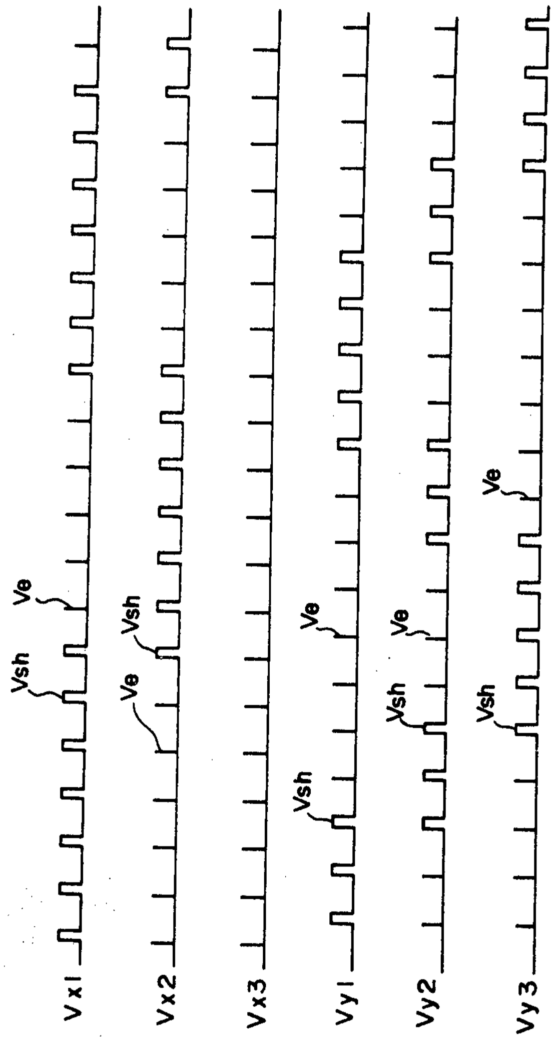


FIG. 12

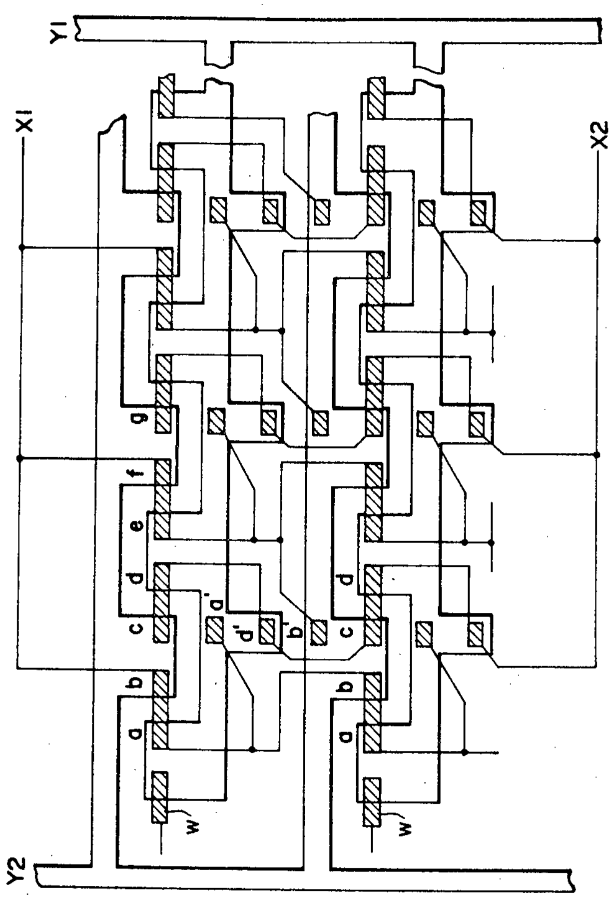
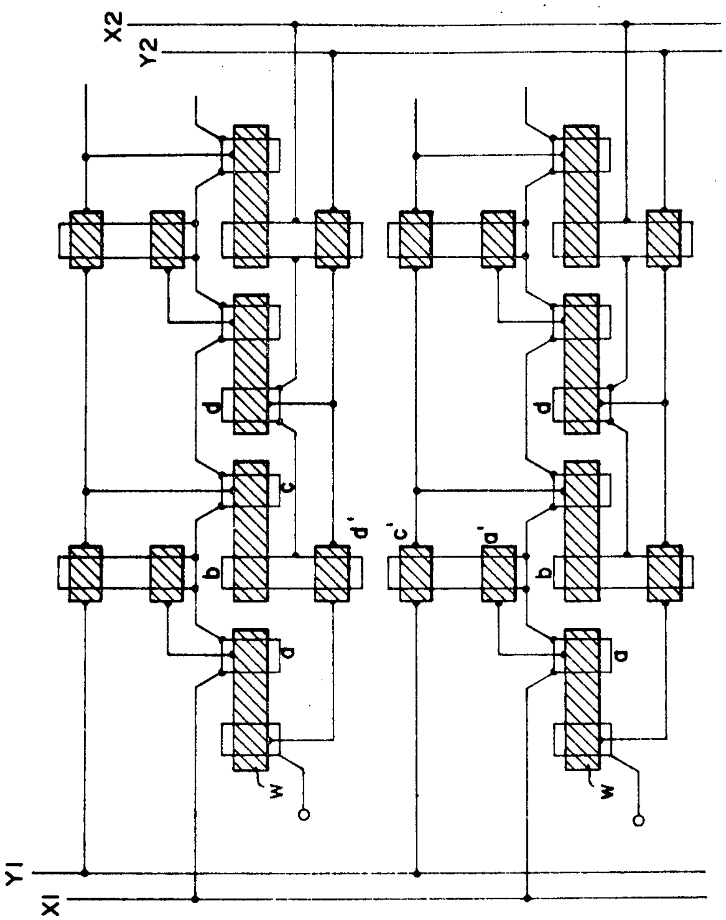


FIG. 13

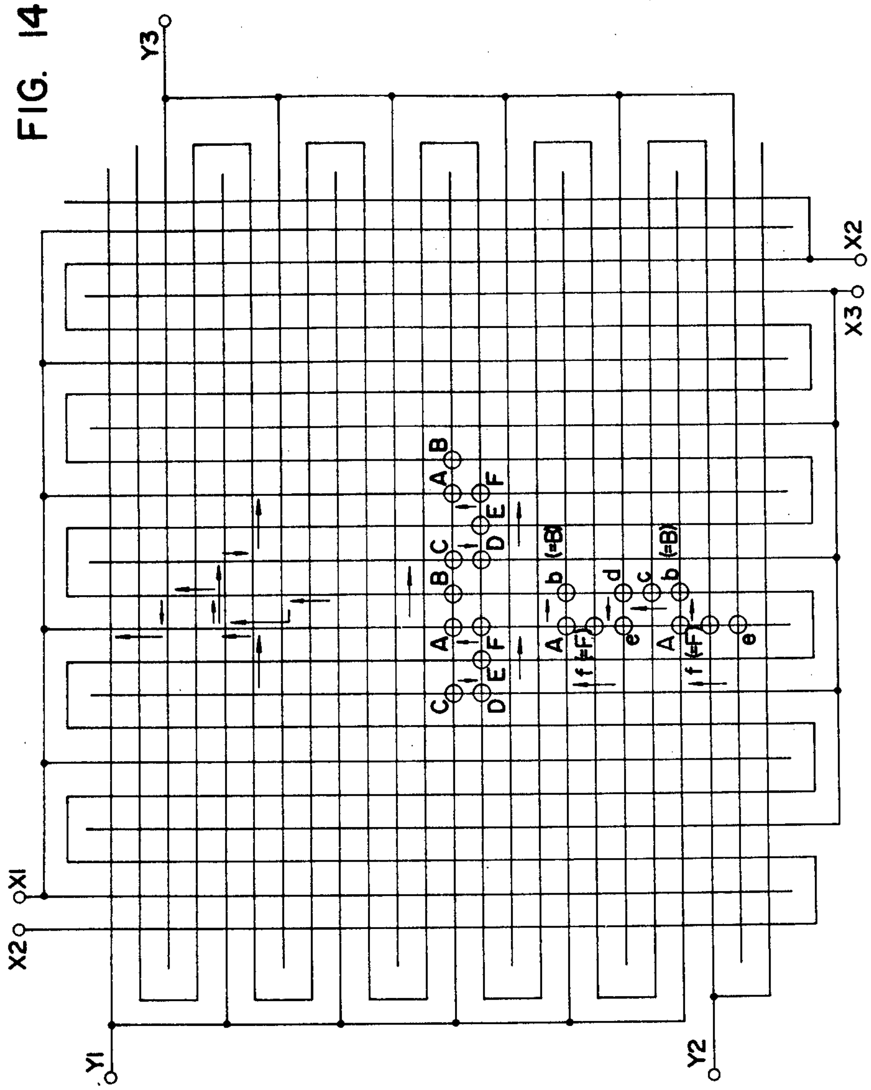


1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 13

FIG. 14



1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 14

FIG. 15

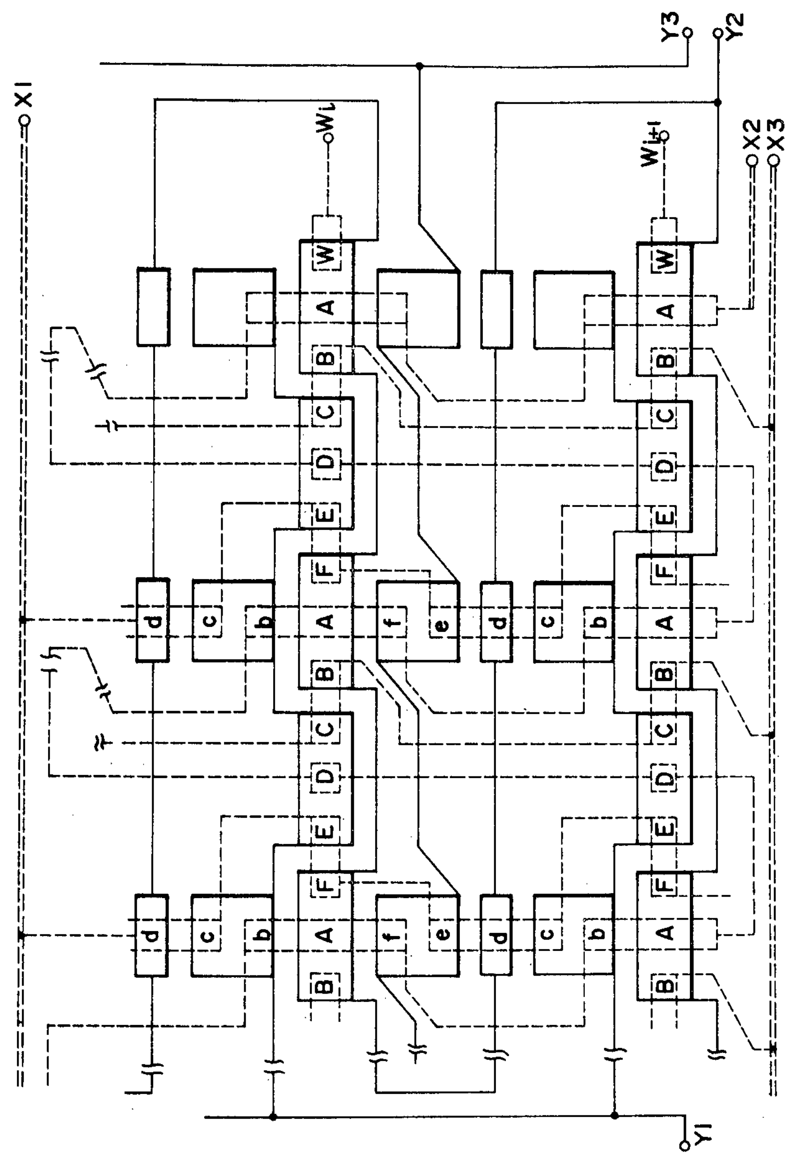
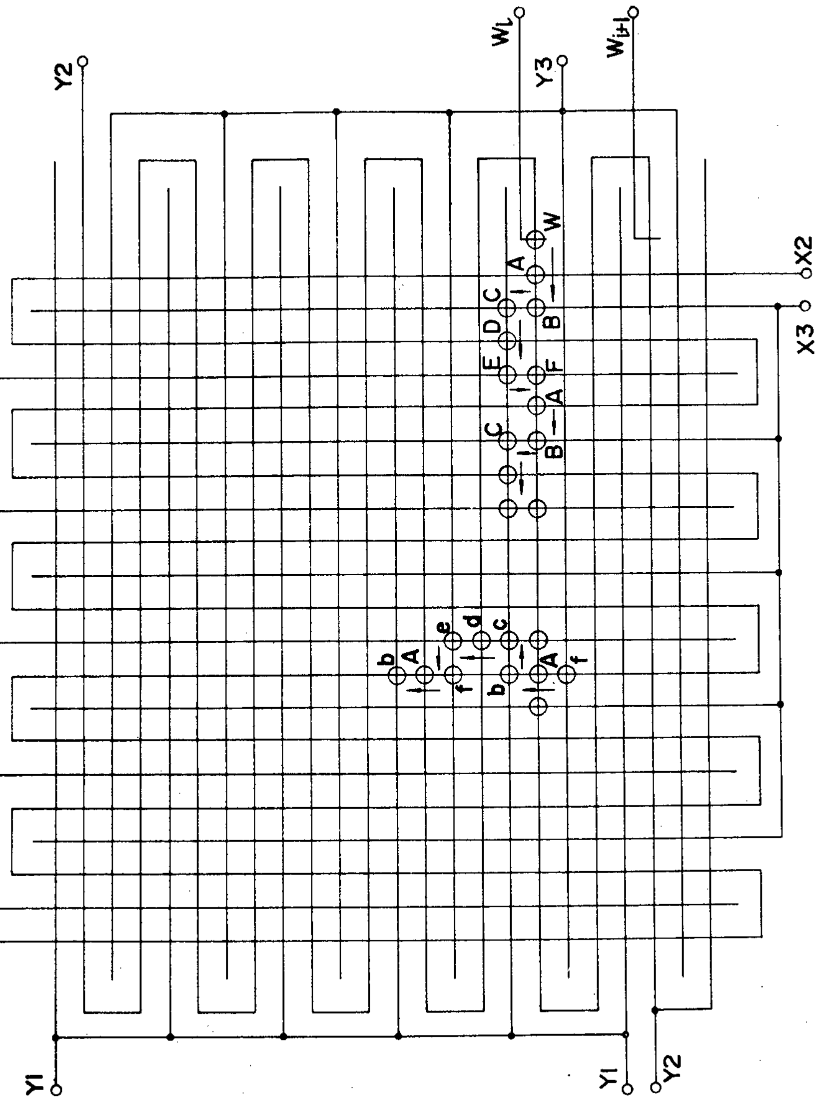


FIG. 16



1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 16

FIG. 17

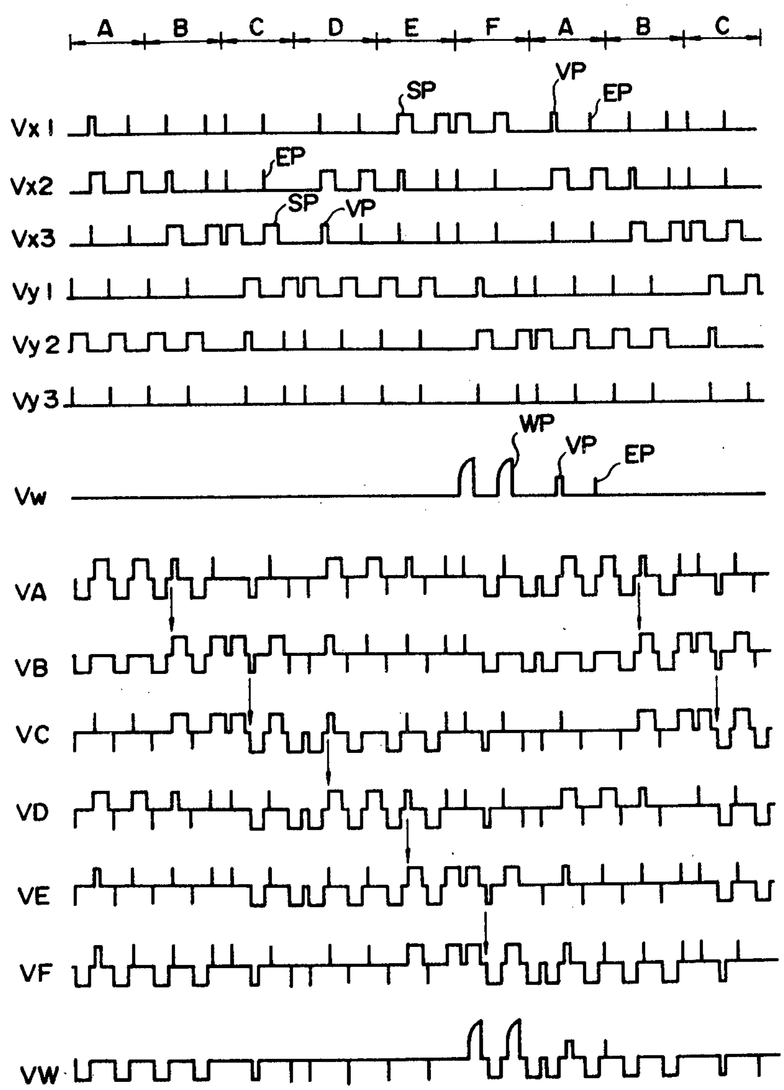
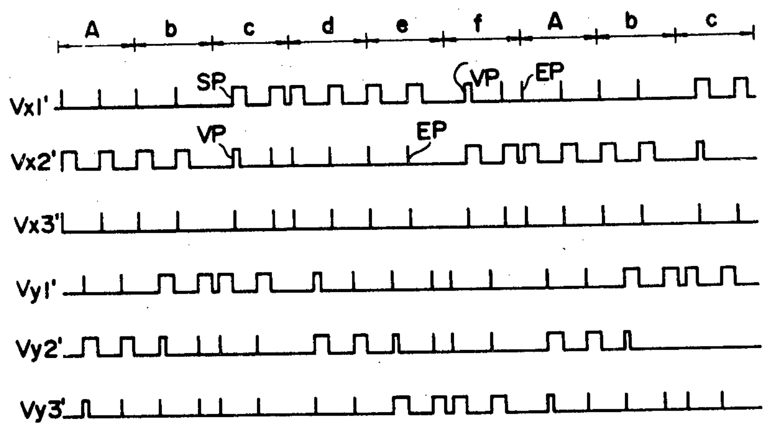


FIG. 18

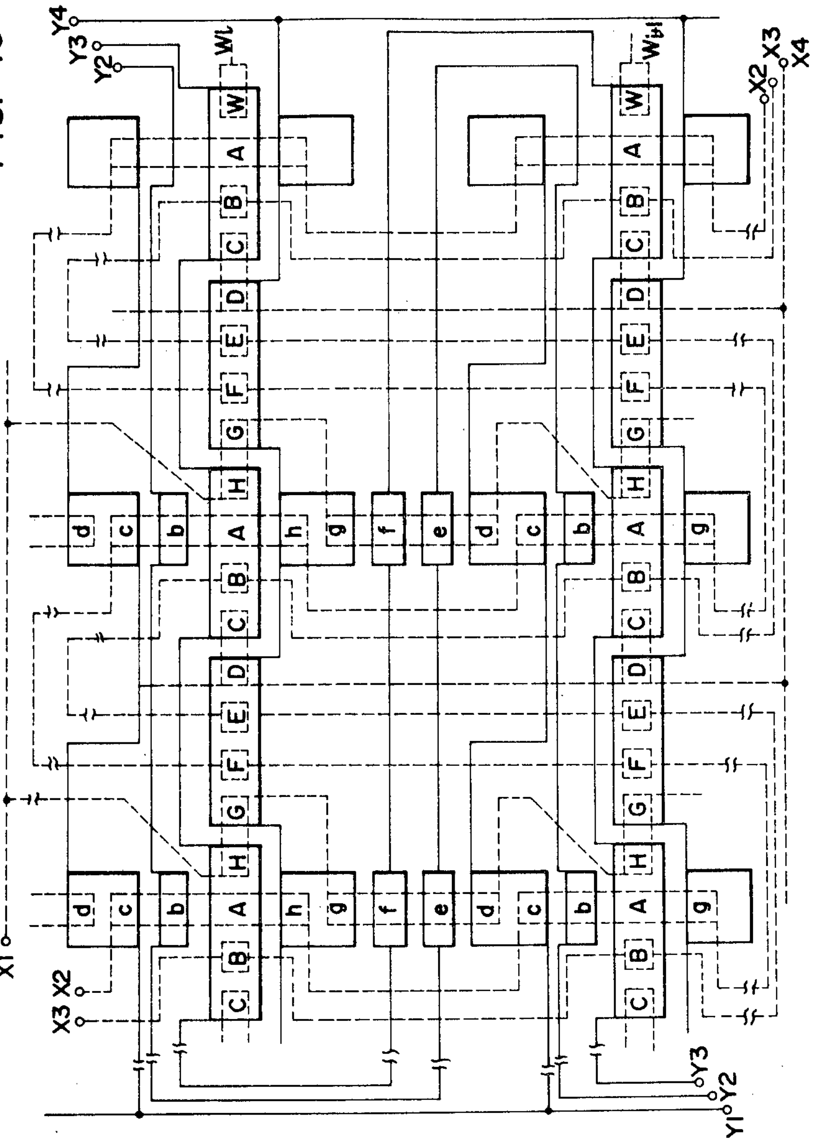


1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 18

FIG. 19



1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 19

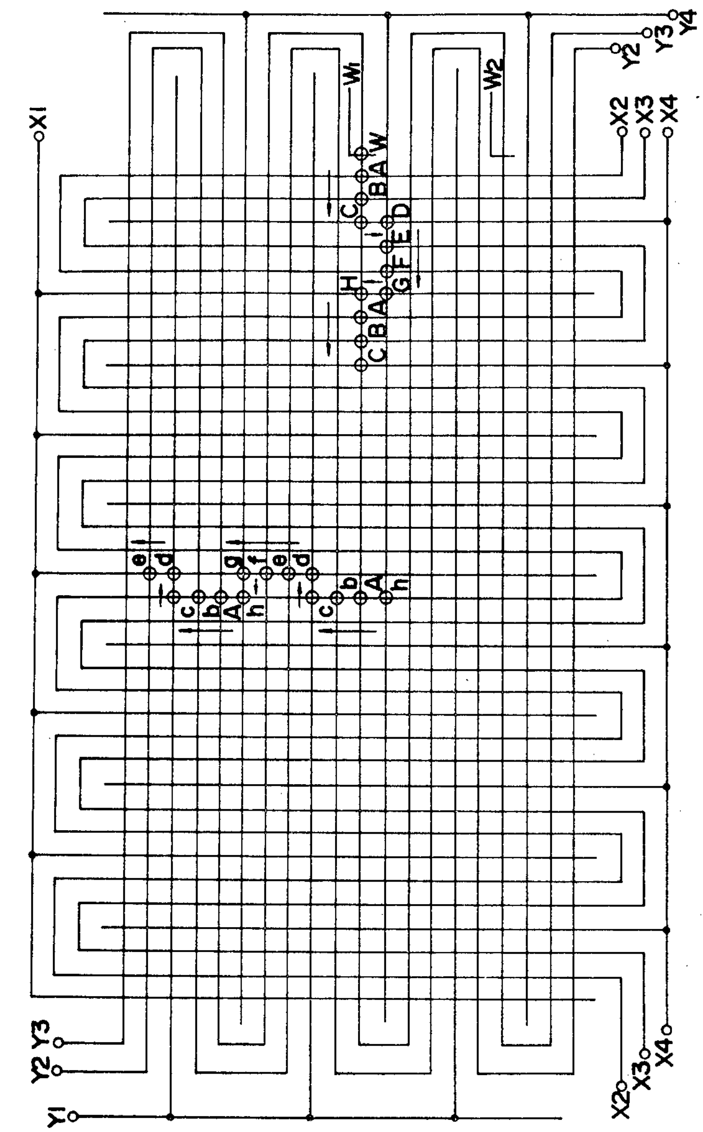


FIG. 20

1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 20

FIG. 21

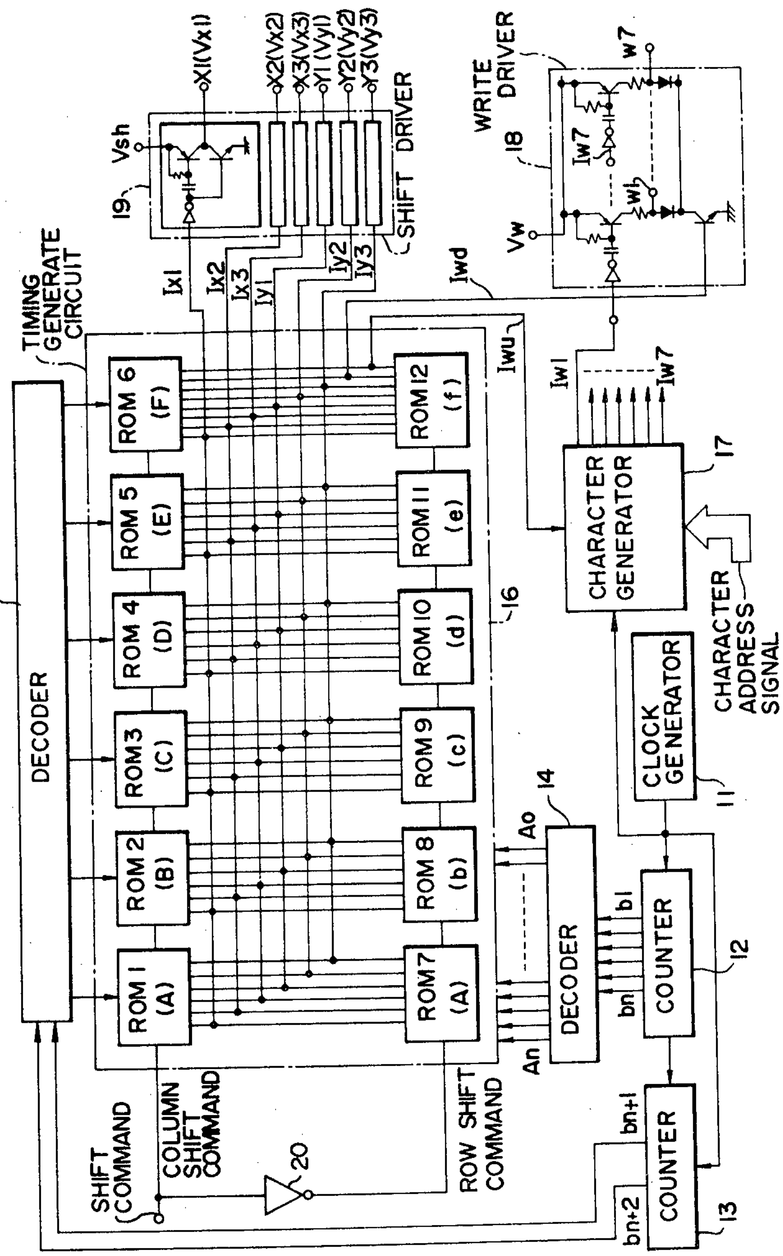


FIG. 22

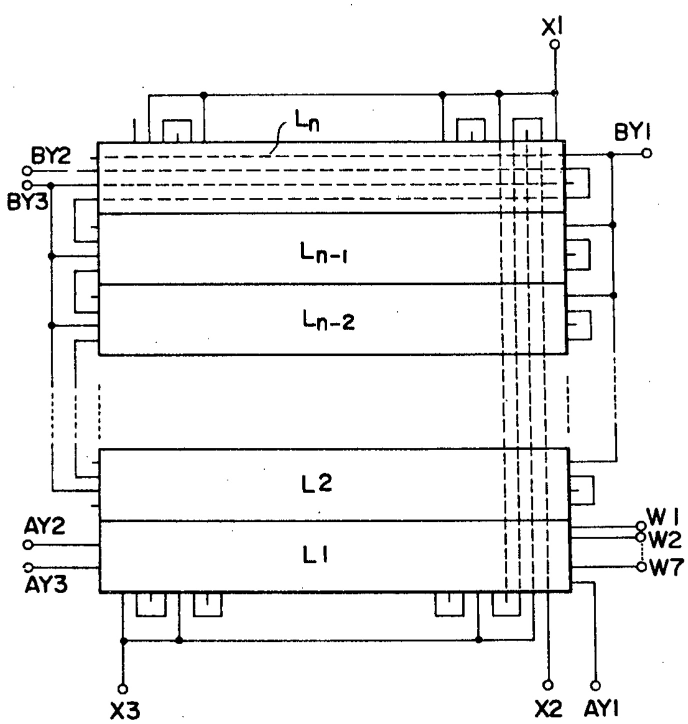


FIG. 23

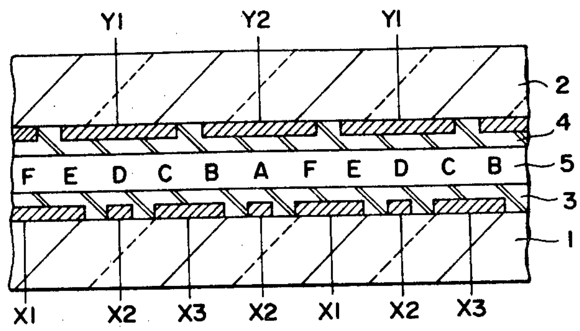
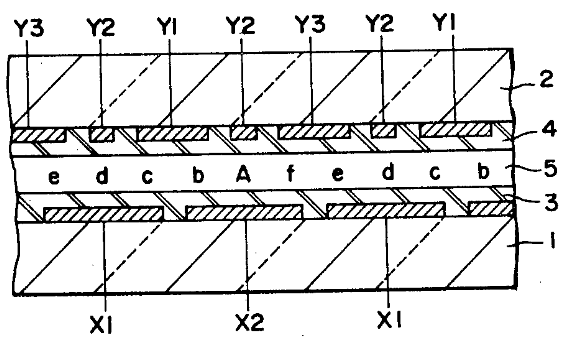

Y1
Y2
Y1
2
4
F E D C B A F E D C B
5
3
1
X1
X2
X3
X2
X1
X2
X3

FIG. 24


Y3
Y2
Y1
Y2
Y3
Y2
Y1
2
4
e d c b A f e d c b
5
3
1
X1
X2
X1

1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 23

FIG. 25

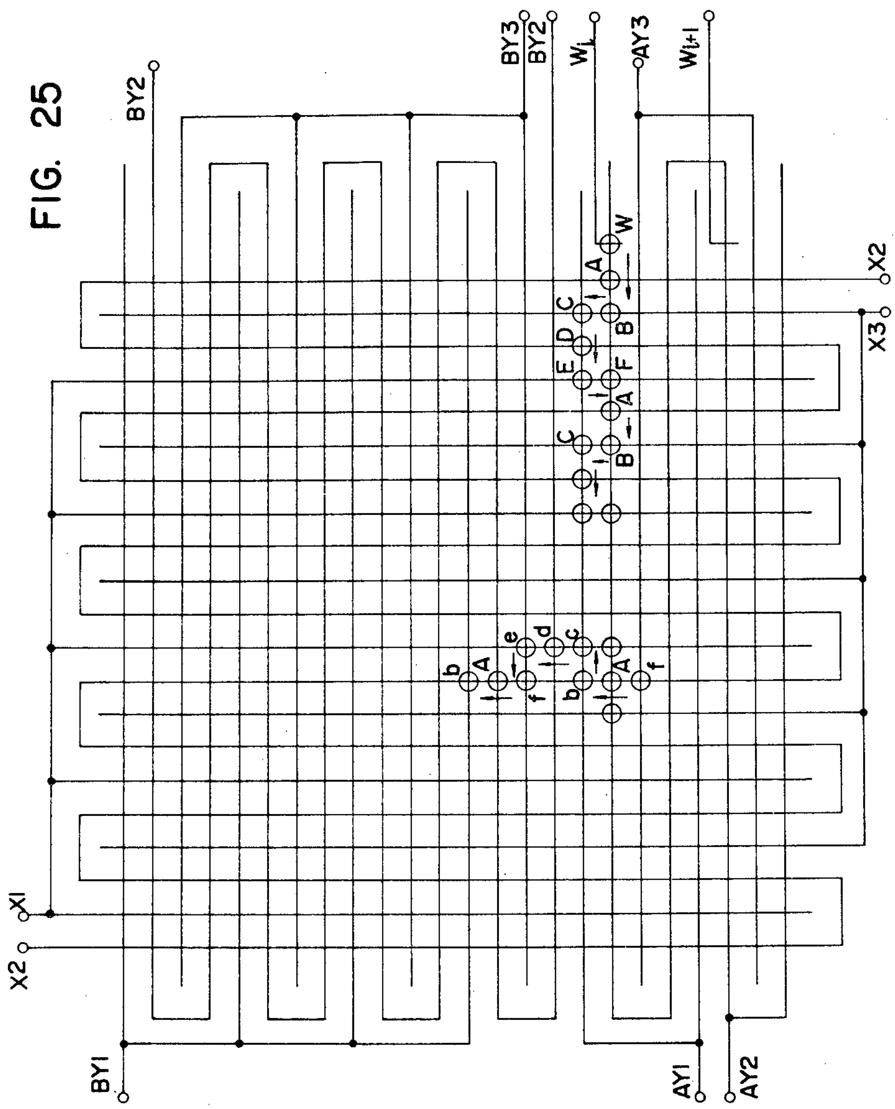


FIG. 26

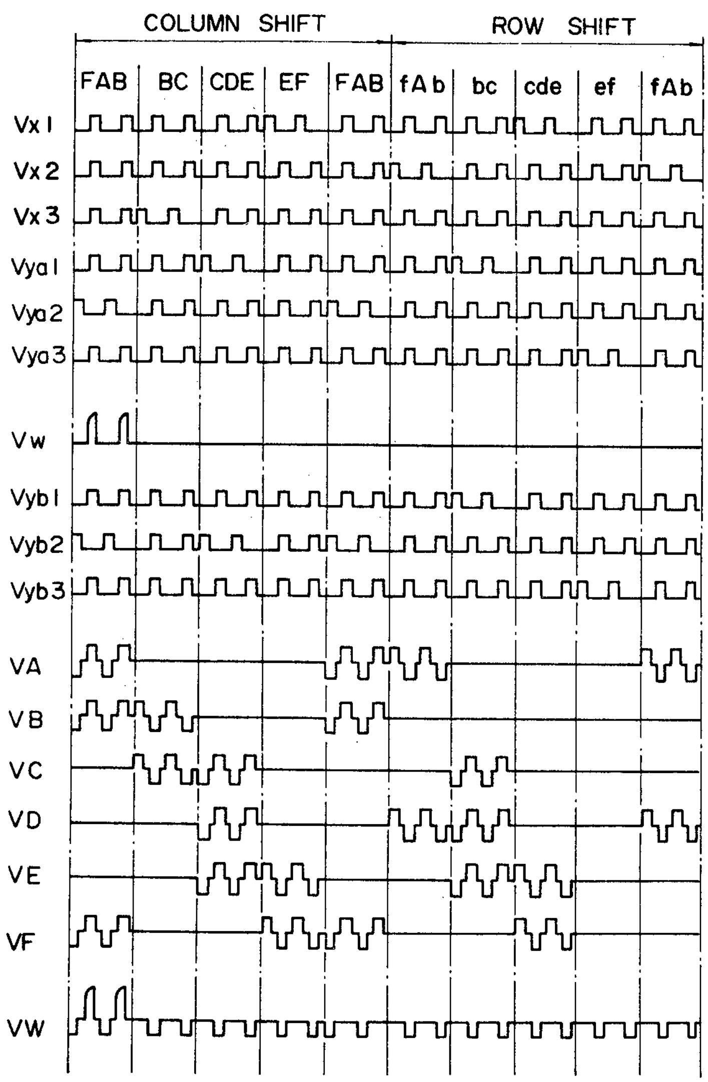
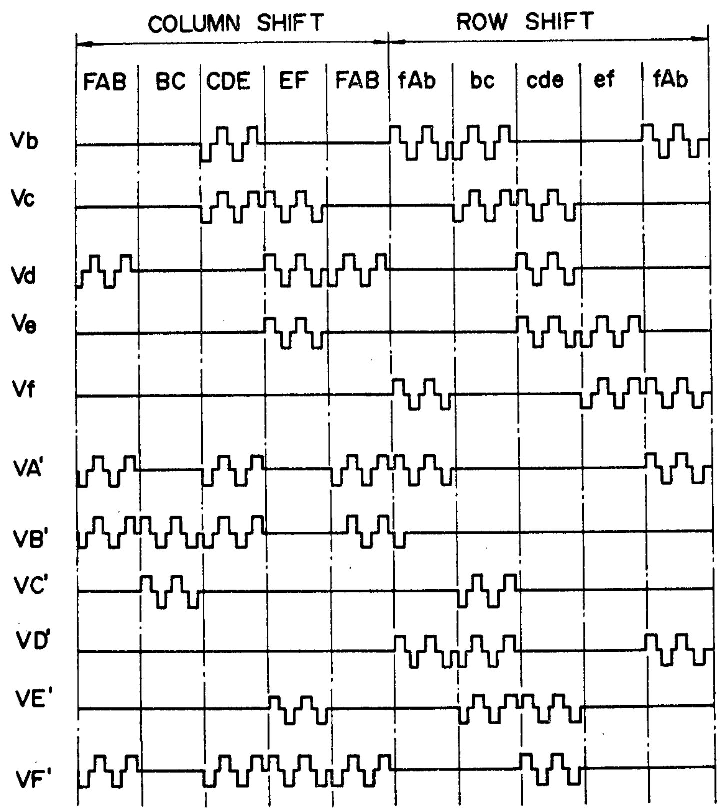

COLUMN SHIFT
ROW SHIFT
FAB
BC
CDE
EF
FAB
fAb
bc
cde
ef
fAb
Vx1
Vx2
Vx3
Vya1
Vya2
Vya3
Vw
Vyb1
Vyb2
Vyb3
VA
VB
VC
VD
VE
VF
VW

FIG. 27


COLUMN SHIFT
ROW SHIFT
FAB
BC
CDE
EF
FAB
fAb
bc
cde
ef
fAb
Vb
Vc
Vd
Ve
Vf
VA'
VB'
VC'
VD'
VE'
VF'

1590304 COMPLETE SPECIFICATION

26 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 26

FIG. 28