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(54) DISPLAY DEVICE

(71) We, N.V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organised and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, the Netherlands, 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:—

The present invention relates to a display device.

Generally display devices comprise a matrix of gas discharge display elements each having a first and a second supply electrode which display elements have a bistable current-voltage characteristic, a control circuit having a plurality of row conductors and a plurality of column conductors, the first supply electrode of each display element being connected to one of the row conductors and the second supply electrode to one of the column conductors in such a way that each display element couples a different combination of a row conductor and a column conductor, a row scanning circuit for successively periodically activating each of the row conductors and a plurality of column selection circuits for selecting those display elements which must be energized with a display current in a period in which a row conductor is activated, which column selection circuits effect at the beginning of the activation of a row conductor the excitation of all of the display elements connected to the activated row conductor.

United Kingdom Patent Specification 1,414,340 discloses a display device of the above-mentioned type wherein all display elements which are connected to an activated row conductor are excited with a voltage which exceeds the ignition-voltage of those display elements and start carrying a current the value of which is at least equal to the display current which is required for a selected display element. By means of a plurality of selection circuits the selection is made of those display elements which should be excited for obtain-

ing a desired display pattern. In these display elements the display current is maintained during the entire period in which a row conductor is activated. The remaining display elements which are connected to this row conductor are extinguished shortly after starting by means of a plurality of erase driver circuits. For the display elements, devices are chosen which have a bistable characteristic so that excitation after ignition can be maintained with an operating voltage which is lower than the ignition-voltage, in which manner it is ensured that non-selected display elements would be unable to restart after extinguishing. The ignition time has been chosen such that the slowest display element still ignites reliably. This results in the faster display elements attaining the display current value within the starting time chosen or even exceeding this value owing to the higher ignition-voltage still present. These currents are also carried by non-selected display elements so that the contrast obtained with the display element between the selected and non-selected display elements is low.

Igniting the display elements requires a high ignition-voltage which, together with the high ignition-current of the display element, causes a high energy loss. Furthermore the circuits used must be able to withstand the high voltages.

According to the present invention there is provided a display device comprising a matrix of gas discharge display elements disposed together in a gas filled space, which display elements have a bistable current-voltage characteristic and have a first and a second electrode, a control circuit having a plurality of row conductors and a plurality of column conductors, the first electrode of each display element being connected to one of the row conductors and the second electrode to one of the column conductors in such a way that each display element couples a different combination of a row conductor and a column conductor, a row scanning circuit for successively periodically activating each of the row con-

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ductors and a plurality of column selection circuits for selecting those display elements which must be energized with a display current in a period in which a row conductor is activated, which column selection circuits effect at the beginning of the activation of a row conductor the excitation of all display elements connected to the activated row conductor, wherein each column selection circuit also comprises a quiescent current supply circuit which couples a column conductor to a d.c. voltage source for supplying a quiescent current so that a quiescent current is supplied during the period wherein the row conductor is activated to those non-selected display elements which are connected to the activated row conductor which quiescent current has such a low value that the display level of the non-selected display elements has a negligible influence on the observation of a formed display pattern.

The provision of this quiescent current circuit enables all display elements which are connected to an activated row conductor to be ignited during the entire activation period. The gas discharge comprises both ionized atoms and metastable atoms. The metastable atoms, that is to say atoms which are excited to a higher energy level are not (electrically) charged and diffuse to nearby display elements. If, during the sequential activation of row conductors the current through a row of display elements is interrupted a plurality of ionized atoms will furthermore be attracted by the activating voltage of the following row of display elements. These movements of atoms and ions are possible because the display elements are disposed together in a gas-filled chamber. The ionized and excited atoms present at this following row cause for this row a lower ignition-voltage to suffice than that which would have been required if the display elements of the preceding row had already been extinguished.

Owing to this reduction in ignition-voltage, which is greatest for the two row conductors which are situated next to an activated row conductor in a matrix of display elements, use can be made of the self-scanning principle without the necessity of providing the display elements with auxiliary electrodes, if the next scanning pulse is not supplied to the row conductor which has just been activated or to the preceding one but only to the next one.

The quiescent energy which a non-selected display element absorbs and gives off again partly in the form of visible radiation can be set to a very low value by choosing a high resistance value for the quiescent current supply circuit and, in addition, owing to the low quiescent current, a lower operating voltage is established than the

operating voltage which is required for the display current. It appears that the quiescent current which is required to attain a sufficient pre-ionization is so low that a contrast of approximately 50:1 can be achieved between selected and non-selected display elements without the necessity that, as in the prior art, an ignition period must be much longer than the ignition-time of the slowest display elements so that with an ignition-time of, for example, 8 to 10 microseconds a row activation time of, for example, 64 microseconds can be used as required for the display of television pictures. With prior art circuits the activation time has to be at least 50 times as long as the ignition-time to achieve the same contrast, and often a period of time which is 100 to 400 times longer is used.

The invention will now be described, by way of example, with reference to the accompanying drawings. In the drawings:

Fig. 1 shows a simplified circuit diagram of a display device in accordance with the invention wherein an additional supply voltage for igniting display elements is supplied through a plurality of column conductors;

Fig. 2 shows by means of a simplified circuit diagram a similar display device as in Fig. 1 but with row conductors which are interconnected in groups for using the self-scanning principle;

Fig. 3 shows by means of a simplified circuit diagram a display device in accordance with the invention wherein an additional supply voltage for the ignition is supplied to display elements through a plurality of row conductors, and

Fig. 4 shows by means of a simplified circuit diagram a display device as in Fig. 3 with a different means for exciting the column conductors.

In these Figures corresponding components have always been given the same reference numerals.

In Fig. 1 the display device comprises a matrix 1 of display elements 2 having  $k$  rows and  $l$  columns, only a part of which is shown, which display elements have a first electrode 3 and a second electrode 4 which electrodes 3, 4 are respectively connected to one of a plurality of row conductors 5 and to one of a plurality of column conductors 6 respectively, such that all first electrodes 3 of the display elements  $2_{i,j}$  ( $i = 1, 2, 3, \dots k$ ) are connected to the row conductor  $5_i$  and all second electrodes 4 of the display elements  $2_{i,j}$  ( $j = 1, 2, 3, \dots l$ ) to the column conductor  $6_j$ .

In the Figures the display elements are shown diagrammatically, in general the row conductors and the column conductors constitute at the same time the electrodes of the display elements. To this end the conductors are placed in a closed space

which is filled with a gas or a gas mixture which is suitable for generating gas discharges. At the intersections of row conductors and column conductors gas discharges can be produced at a sufficient excitation, for which purpose the conductors are fed through the wall of the closed space in an insulating manner. This wall is transparent on at least one side to enable visual observation of a display pattern. The column conductors form the anodes of the display element and the row conductors form the cathodes.

Each row conductor can be activated by coupling it through one of a plurality of low scanning switches 10, for example semiconductor switching amplifiers, to a supply input 11 of the display device to which a supply voltage  $V_4$  can be supplied. Each column conductor 6 can be excited by means of one out of a plurality of column selection circuits 20, only one of which is shown. Each column selection circuit 20 comprises a quiescent current supply circuit consisting of a resistor 21 which couples the associated column conductor 6 to a conductor 22 which is coupled through a switch 23, for example a semiconductor switch, to a supply input 24 of the display device to which a supply voltage  $V_3 > V_4$  can be supplied. In addition, the conductor 22 is connected to the cathode 25 of a diode 26 whose anode 27 is connected to a conductor to which a supply voltage  $V_1 < V_3$  can be supplied through a supply input 29 of the display device. If the switch 23 is closed the conductor 22 carries the voltage  $V_3$  so that the diode 26 is blocked. If the switch 23 is non-conducting and the column selection circuits carry current passing through an activated row conductor and the display elements connected thereto, the diode is conducting and the conductor 22 carries a voltage approximately equal to  $V_1$ . The switch 23 is periodically closed during a duty cycle  $T_{i, 1}$  of each activation  $T_i$  ( $i = 1, 2, 3, \dots, 11$  as shown) and opened during a duty cycle  $T_{i, 2} = T_i - T_{i, 1}$ .

The switches 10 are closed in turn during a respective one of successive activation periods  $T_i$  and remain opened thereafter for the remaining periods in the scan.

If the ignition-voltage of a display element with a weak pre-ionisation is  $V_0$  and the nominal operating voltage  $V_n$ , has, owing to the tolerance differences between display elements, the extreme values  $V_{0 \min}$  and  $V_{0 \max}$  and  $V_{n \min}$  and  $V_{n \max}$  respectively then the supply voltages must satisfy the following conditions.

$$V_{0 \max} < V_3 - V_4$$

$$V_{n \max} < V_1 - V_4$$

The circuit operates as follows. During the whole of the activation period  $T_m$  the

switch  $10_m$  is closed and the row conductor  $5_m$  is at the voltage  $V_4$ . During the first part  $T_{1, 1}$  of the period  $T_{1, 2}$ , all resistors 21 are coupled to the voltage  $V_3$ , the switch 23 being closed. As the difference voltage is  $V_3 - V_4 > V_{0 \max} > V_0(m, j)$  all display elements  $2_{m, j}$  will ignite. The current through the display elements is limited to a low value by the choice of the resistors 21 which serve as series resistors for the display elements. During the second part  $T_{1, 2}$  of the period  $T_1$  the display elements  $2_{m, j}$  remain energized through the resistors with a voltage  $V_1 - V_4$ , the switch 23 being opened. As  $V_1 - V_4 > V_{n \max}$  the display element  $2_{m, j}$  consequently remain in the ignited state. At the end of the period  $T_{1, 1}$  and the beginning of the period  $T_{1, 2}$  the switch  $10_m$  opens and switch  $10_{m-1}$  closes, so that the display elements  $2_{m, j}$  extinguish and the display elements  $2_{m-1, j}$  ignite etc.

In the column selection circuits 20 selected column conductors 6 are coupled through series arrangements of a selection switch 30, in this case a pnp-transistor, and a resistor 31 to the conductor 28. The resistor 31 is connected between the conductor 28 and the emitter 32 of the transistor 30 whose collector 33 is connected to the associated column conductor 6. The base 34 of the transistor 30 is controlled by a gate circuit 35, in this case a transistor 36 having a collector resistor 37, the emitter of the transistor being connected to the conductor 28, the base to the input 38 of the gate circuit 35 and the collector to one side of resistor 37 and through the output 39 of the gate circuit 35 to the base 34 of the transistor 30. The other side of resistor 37 is connected to a supply input 40 of the gate circuit to which a supply voltage  $V_2$  can be supplied. A logic control circuit, not shown, supplies a selection signal to the input 38 of the gate circuit 35 the voltage of which is equal, or approximately equal, to  $V_1$  if the associated column conductor is selected and equal, or approximately equal, to  $V_2$  if this column conductor is not selected. If this input voltage is equal to  $V_1$  then the output voltage at the output 39 is approximately equal to  $V_2$  and, consequently, the transistor 30 conducts. The resistor 31 serves as emitter resistor for the transistor 30 so that the voltage at the emitter 32 substantially follows the voltage at the base 34 and becomes approximately equal to  $V_2$ . The difference voltage  $V_1 - V_2$  and the resistance value of the resistor 31 determine the current through the series arrangement 30, 31 substantially independent of the voltage at the collector 33 of the transistor 30 as long as the collector voltage is more negative than the base voltage. Thus the series arrange-

ment operates as current source for the selected display element 2 if

$$V_4 - V_{n \max} < V_2 < V_1,$$

5 so that the display current is substantially independent of tolerance differences between the operating voltages associated with the normal display current of the display elements.

10 In the case shown in the drawing the column conductor  $6_{n-1}$  is selected during the period  $T_4$  and  $T_8$ . During the period  $T_4$  the row conductor  $5_{m-3}$  is energized so that the display element  $2_{m-3, n-1}$  lights up brightly during this period. Likewise,  $2_{m-1, n-1}$  lights up brightly during  $T_8$ . In the remaining periods  $T_1$  to  $T_3$  inclusive,  $T_5$  to  $T_7$  inclusive and  $T_9$  to  $T_{11}$  inclusive the transistor 36 conducts and the transistor 30 is cut-off so that only a quiescent current is supplied through the resistor 21 and the column conductor  $6_{n-1}$  to the respective one of the display elements  $2_{i, n-1}$ .

20 The remaining column conductors are energized in a corresponding manner through associated column selection circuits by means of selection pulses so that during each activation period all display elements of one row light up, weakly if the associated column conductor is not selected and brightly if it is selected, whilst the display elements of the remaining rows are all extinguished. In this manner a  $1/k^{\text{th}}$  portion of the desired display pattern is formed during an activation period.

35 When all row conductors have been scanned a full display pattern has been formed. Herewith it is desired to choose the scanning frequency so high that the picture repetition frequency exceeds the so-called flicked frequency of the human eye so that a visually steady picture is obtained.

40 After the completion of a full picture the row conductor  $5_1$  must be activated after the row conductor  $5_n$ . The display elements connected with this row conductor have not been pre-ionized by an adjacent row of ignited display elements. This can be accomplished by disposing, in known manner an additional row conductor  $5_0$  next to the row conductor  $5_1$  as a so-called reset cathode. With the column conductors this reset cathode constitutes a plurality of  $l$  gas discharge elements which are ignited prior to the beginning of a new picture cycle with a sufficiently high ignition-voltage. In general these gas discharge elements are shielded from visual observation as, owing to the higher ignition-voltage some elements achieve a current which exceeds the desired quiescent current through the display elements of the remaining row also when none of the column conductors is selected in the reset period.

65 If so desired the row conductors may, for example by means of resistors, be supplied

with a bias voltage so that the non-activated row conductors can lose any residual charges. This bias voltage should be so much more positive than  $V_4$  that parasitic ignitions cannot occur.

70 If so desired also the row scanning switch  $10_1$  can be connected to a more negative voltage than  $V_4$ . This is, on the one hand, cheaper than using a reset cathode, but on the other hand incidentally occurring higher quiescent currents in the first row of display elements may cause a reduction in contrast.

80 If the display of so-called "picture half tones" is required by, for example, television pictures of facsimile transmission, then this can be achieved by modulating the current through the display elements. Both amplitude modulation and pulse width modulation or a combination thereof is possible. Amplitude modulation is obtained by varying the supply voltage  $V_2$ , pulse width modulation is obtained by making the selection pulses shorter than the activation period  $T_i$ .

90 These modulation methods can also be used for changing the average picture brightness, for example to match the brightness of the display patterns to the ambient brightness.

95 It is easy to see that at the moment at which the row-scanning switch  $10_m$  is opened and the row scanning switch  $10_{m-1}$  is closed a plurality of other row scanning switches may be closed simultaneously with the row scanning switch  $10_{m-1}$ , for example the row scanning switches  $10_{m-4}$ ,  $10_{m-7}$  etc. The display elements associated with these rows have been pre-ionized to a much lower degree than the display elements associated with row  $m+1$  and consequently require a higher ignition-voltage. As a result the display elements of the row  $m+1$  can ignite easier than those of the remaining simultaneously scanned rows. As soon as this happens a voltage drop is produced across the resistors 21 or the series arrangement 30, 31 which causes the voltage between column conductors and energized row conductors to decrease to the operating voltage of the display elements, so that the ignitions cannot propagate any further along the column conductors.

120 Fig. 2 shows a circuit in accordance with the invention wherein all switches which may be operated in parallel in each case are combined to one switch. Herewith the row conductors 1, 4, 7, . . .  $m$ ,  $m+3$ , . . . etc. are mutually interconnected and 125 coupled together through a scanning switch 50 to the supply input 11 of the display device. Likewise the row conductors 2, 5, 8, . . .  $m+1$ ,  $m+4$  . . . etc. are coupled through a scanning switch 51 to the supply 130

input 11 and the remaining row conductors 3, 6, 9, . . .  $m + 2$ ,  $m + 5$ , . . . etc. through a scanning switch 52.

In the example shown in Figure 2 the scanning switch 50 is closed during the activation periods  $T_1$ ,  $T_4$ ,  $T_7$  and  $T_{10}$ , the scanning switch 51 during  $T_2$ ,  $T_5$ ,  $T_8$  and  $T_{11}$  and the scanning switch 52 during  $T_3$ ,  $T_6$  and  $T_9$ .

If these scanning switches are closed in cyclic sequence the operation of the circuit according to Fig. 2 is in all other respects fully identical to that of Fig. 1.

If during the period  $T_1$  the row  $m$  is energized and all display elements  $2_{m,j}$  are ignited, then the display elements of the rows  $m - 1$  and  $m + 1$  have a reduced ignition-voltage owing to the pre-ionisation present. At the end of  $T_1$  the scanning switch 50 opens and the scanning switch 51 closes whilst the scanning switch 52 remains open. As the row  $m - 1$  is not energized only the display elements of the row  $m + 1$  will take over the ignition from the display elements of the row  $m$ . Opening the scanning switch 50 causes the display elements of row  $m$  to extinguish. Depending on the associated selection signals a plurality of the display elements of the row  $m + 1$  may carry only the quiescent current and light up weakly and a plurality of other display elements of this row may light up brightly during the entire period  $T_2$  or will light up more or less brightly during a portion of the period  $T_2$  if pulse width modulation or amplitude modulation is applied.

In the period  $T_3$  the display elements of the row  $m + 2$  ignite in the same manner, etc.

The pre-ionisation of the first row is also here obtained in known manner by means of a reset cathode, not shown.

Fig. 3 shows an embodiment of a display device in accordance with the invention wherein the temporary increase in the voltage which is required for igniting the display element is supplied through the row conductors instead of through the column conductors. Herewith the common connections of the switches 50, 51 and 52 are coupled through a conductor 57 and a switch 61 to the supply input 11 to which a supply voltage  $V_4$  can be supplied and through a switch 60 to a supply input 55 of the display device to which a supply voltage  $V_5$  can be supplied. This voltage  $V_5$  has been chosen such that  $V_4 - V_5$  is equal to, or approximately equal to, the voltage difference  $V_4 - V_1$  in the display devices of Fig. 1 and Fig. 2. The switch 60 is closed during each period portion  $T_{i,1}$  and the switch 61 is closed during each period portion  $T_{i,2}$ . The resistors 21 which serve as quiescent current supply cir-

cuits are now connected between an associated column conductor on the one hand and the supply input 29 on the other hand.

For igniting display elements a voltage  $V_1 - V_5$  is available during the period portions  $T_{i,1}$ . As the voltages have been chosen such that  $V_4 - V_5 = V_3 - V_1$  and thus  $V_1 - V_5 = V_3 - V_4$ , that is the available ignition-voltage is equally as great as in the embodiment of Fig. 1 and Fig. 2. During the period portions  $T_{i,2}$  a supply voltage  $V_1 - V_4$  is available for maintaining the ignition as in the other embodiments. In other respects the operation of the display device according to Fig. 3 is fully identical to the operation of the embodiment of Fig. 2.

If so desired, in a column selection circuit 20 the resistor 21 may be connected to the emitter 32 of the transistor 30 instead of to the supply terminal 29. This results in a negligible reduction in the quiescent current as the resistors 21 are chosen to be much greater than the resistors 31, for example with a resistance value fifty times as great. Depending on the available standard resistance values and their required tolerances a somewhat lower resistance value may possibly be chosen for the resistance value of the resistors 21 than in the preceding embodiments but in general a difference of approximately 2% in the quiescent currents will fall within the measuring tolerance. A likewise small reduction occurs in the display current which might be compensated by adapting the choice of the resistance value of the resistor 31. The attainable contrast remains the same.

Fig. 4 shows a fourth embodiment of a display device in accordance with the invention. Herein the quiescent current supply circuit of the column selection circuits comprises a series arrangement of two resistors 70 and 71 and the selection circuit comprises a transistor 72 which shunts the resistor 70. The emitter of the transistor 72 and one side of the resistor 70 are connected to the supply input 29 of the display device, the collector of the transistor 72 and the other side of the resistor 70 are connected to one side of the transistor 71 whose other side is connected to the corresponding column conductor and the base of transistor 72 is connected to the output 39 of the gate circuit 35. If the corresponding column conductor is selected the transistor 72 conducts, the resistor 70 is short-circuited and the display current through the display element which couples the corresponding column conductor to the row conductor scanned at that moment is determined substantially exclusively by the resistor 71. In the non-selected case the quiescent current is determined by the sum of the resistance value of the resistor 71

and the much higher resistance value of the resistor 70. In this circuit the series arrangement of resistor 71 and transistor 72 does not act as current source circuit, the transistor 72 serves as switch only. Consequently the control of the display elements becomes somewhat more dependent on the spread in the operating voltages. This is offset by the advantage that the gate circuits 35 may be dispensed with if the selection signal is also available in inverse logic polarity in the logic control circuit. Especially with large display devices having many column conductors this may furnish a considerable saving.

At the same time Fig. 4 shows how in the row selection circuit the switch 61 (Fig. 3) can be replaced by a diode 81 whose cathode is connected to the supply input 11 of the display device and the anode to the conductor 57. If during  $T_{i, 1}$  the switch 60 is closed the conductor 57 gets a voltage  $V_5 < V_4$  so that the diode 81 is non-conducting. As soon as the switch opens during  $T_{i, 2}$  the diode conducts so that the conductor 57 is brought to a voltage approximately equal to  $V_4$  as the reset cathode of one of the row conductors carries at least 1 quiescent currents and not more than 1 display currents.

It is easy to see that also other combinations of the various types of column selection circuits and row scanning circuits than those shown are possible. An expert skilled in the art will be able to replace switches by semi-conductors or to replace the shown pnp-and-npn transistors respectively by, for example, MOS transistors. Likewise the selected semiconductors can be combined together with other components to an integrated circuit, for example with the logic control circuit. In the chosen embodiments it invariably applied that  $V_3 > V_1 > V_4 > V_5$ . If so desired it is possible to drive the display device with inverse polarities wherein  $V_3 < V_1 < V_4 < V_5$ , while adapting the type-selection for the semiconductor switches. In general, in view of the coupling to the logic control circuits it will be desirable to select the supply voltage  $V_1$  at chassis potential.

#### WHAT WE CLAIM IS:—

1. A display device comprising a matrix of gas discharge display elements disposed together in a gas filled space, which display elements have a bistable current-voltage characteristic and have a first and a second electrode, a control circuit having a plurality of row conductors and a plurality of column conductors, the first electrode of each display element being connected to one of the row conductors and the second electrode to one of the column conductors in such a way that each dis-

play element couples a different combination of a row conductor and a column conductor, a row scanning circuit for successively periodically activating each of the row conductors and a plurality of column selection circuits for selecting those display elements which must be energized with a display current in a period in which a row conductor is activated, which column selection circuits effect at the beginning of the activation of a row conductor the excitation of all display elements connected to the activated row conductor, wherein each column selection circuit also comprises a quiescent current supply circuit which couples a column conductor to a d.c. voltage source for supplying a quiescent current so that a quiescent current is supplied during the period wherein the row conductor is activated to those non-selected display elements which are connected to the activated row conductor which quiescent current has such a low value that the display level of the non-selected display elements has a negligible influence on the observation of a formed display pattern.

2. A display device as claimed in Claim 1, wherein the d.c. voltage source for supplying a quiescent current supplies a pulsating d.c. voltage, such that at the beginning of each period wherein a row conductor is activated a voltage is supplied to the column conductors for igniting the display elements connected to the activated row conductors and during the remaining part of the period a voltage is supplied to the column conductors for maintaining a current through these display elements.

3. A display device as claimed in Claim 1, further comprising means for supplying scanning pulses to the row conductors which scanning pulses have such a form that at the beginning of a period in which any row conductor is activated a voltage is supplied to the activated row conductor for igniting the display elements connected to that row conductor and during the remaining part of that period a voltage is connected to this row conductor for maintaining a current through the display elements connected to this row conductor.

4. A display device as claimed in any one of Claims 1 to 3, wherein a quiescent current supply circuit comprises a resistor which couples the associated column conductor to the d.c. voltage source for supplying a quiescent current and a column selection circuit comprises in addition a series arrangement of a resistor and selection switch which series arrangement can couple the associated column conductor to a d.c. voltage source for supplying a display current.

5. A display device as claimed in any one of Claims 1 to 3, wherein a column

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- selection circuit comprises a series arrangement of a resistor and a selection switch which series arrangement can couple the associated column conductor to a d.c. voltage source and furthermore comprises a quiescent current supply circuit which shunts the selection switch. 5
6. A display device as claimed in any one of Claims 1 to 5, wherein the row conductors are mutually interconnected in at least three groups in such a way that there are at all times between two row conductors of the same group at least two row conductors of other groups, the row scanning circuit supplying periodically and in cyclic sequence scanning pulses to the groups of row conductors. 10 15
7. A display device as claimed in any one of Claims 1 to 6, further comprising a setting circuit for setting a desired display level and a selection-pulse circuit for controlling the column selection circuits, which selection-pulse circuit supplies selection pulses to the column selection circuits, the form of these pulses being determined by the setting circuit in such a way that the current through a selected display element furnishes the desired display level. 20 25
8. A display device substantially as hereinbefore described with reference to and as shown in Figure 1, 2, 3 or 4 of the accompanying drawings. 30

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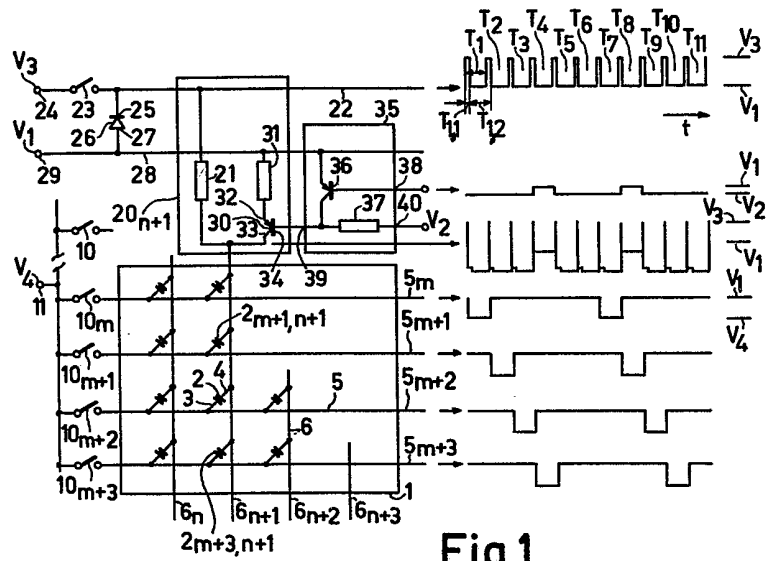


Fig. 1

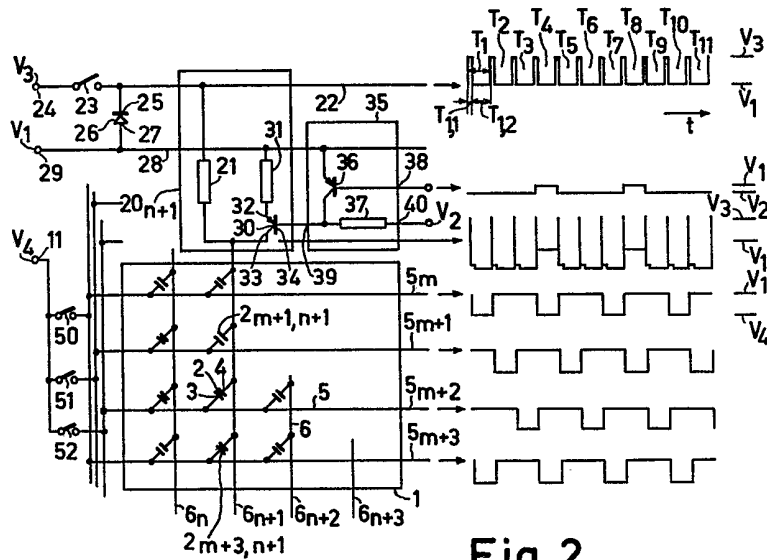


Fig. 2

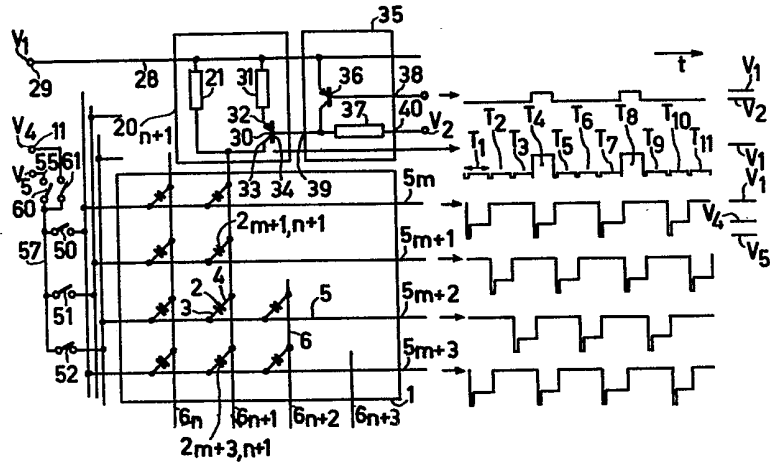


Fig. 3

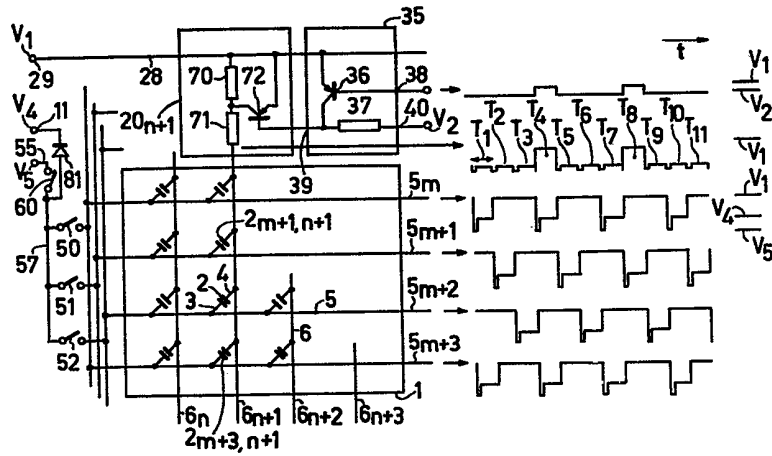


Fig. 4