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Katayama et al.

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(54) **DRIVER CIRCUIT FOR CAPACITIVE DISPLAY ELEMENTS**

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(73) Assignee: **Denso Corporation**, Kariya (JP)

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Feb. 17, 2000 (JP) 2000-039642

(51) **Int. Cl.**[7] **G09G 3/30**
(52) **U.S. Cl.** **345/76**; 345/212; 315/169.3
(58) **Field of Search** 345/45, 76, 80, 345/52, 98, 211, 212

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(57) **ABSTRACT**

A display panel having plural capacitive elements such as electroluminescent elements is driven by an integrated circuit connected between the display panel and a power source. A pair of power transistors such as MOSFETs is connected between the power source and the integrated circuit. The capacitive elements are selectively charged and discharged by operating switching elements in the integrated circuit. The pair of transistors disposed separately from the integrated circuit is turned on or off after the switching elements in the integrated circuit are closed, so that the switching loss only occurs in the transistors outside the integrated circuit, thereby suppressing temperature rise in the integrated circuit. A pair of resistors may be used in place of the transistors to divide a voltage supplied to the capacitive elements between the resistors and the integrated driver circuit. A step-recycle circuit including a condenser for recycling a part of energy stored in the capacitive elements may be further connected between the power source and the pair of transistors, to further reduce power consumption in the integrated circuit.

12 Claims, 11 Drawing Sheets

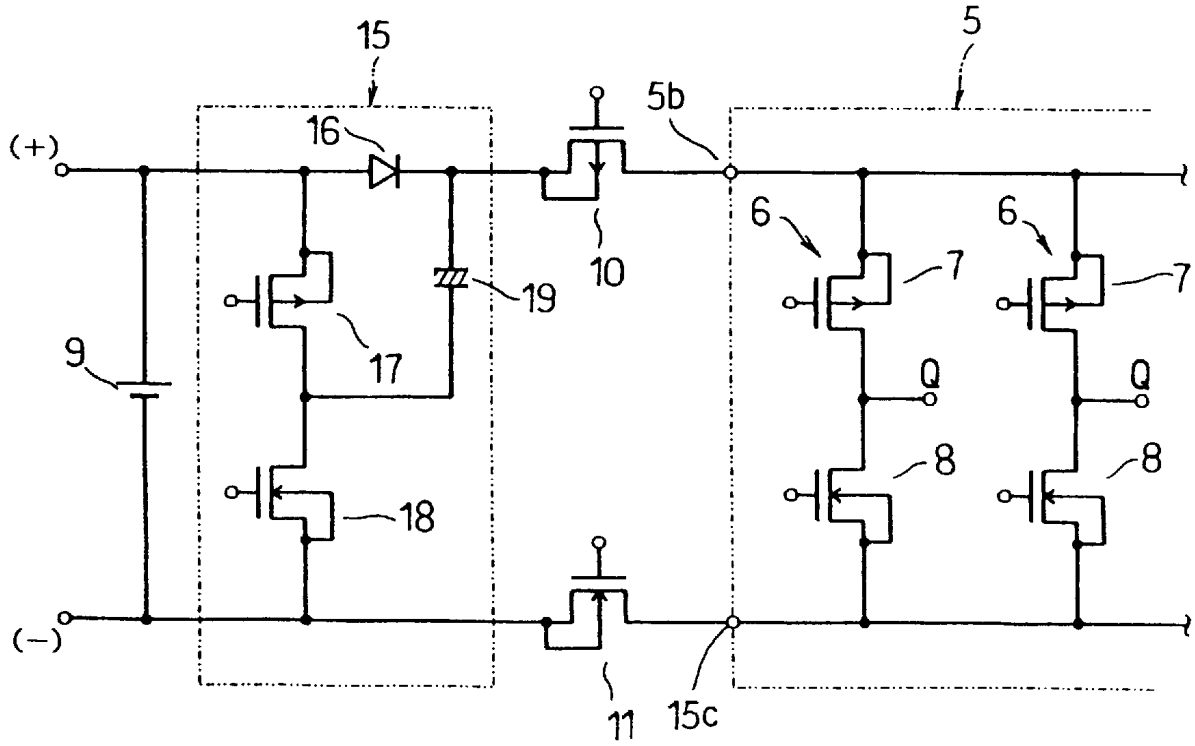


FIG. 1

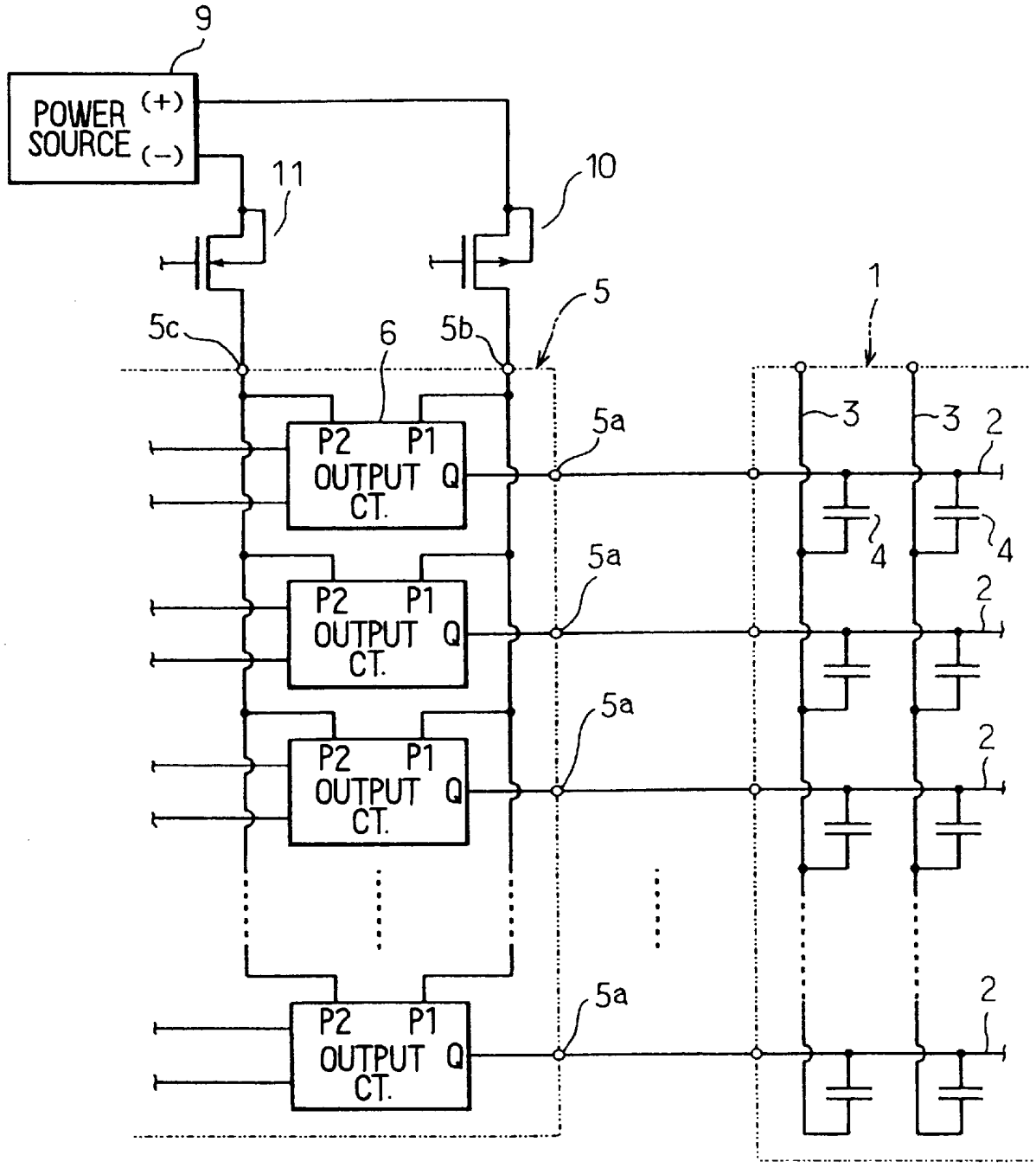


FIG. 2

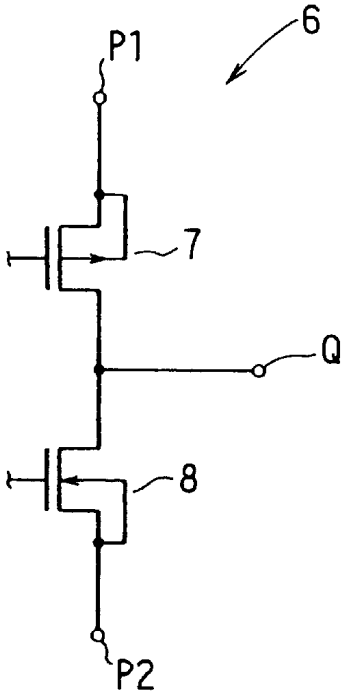


FIG. 4

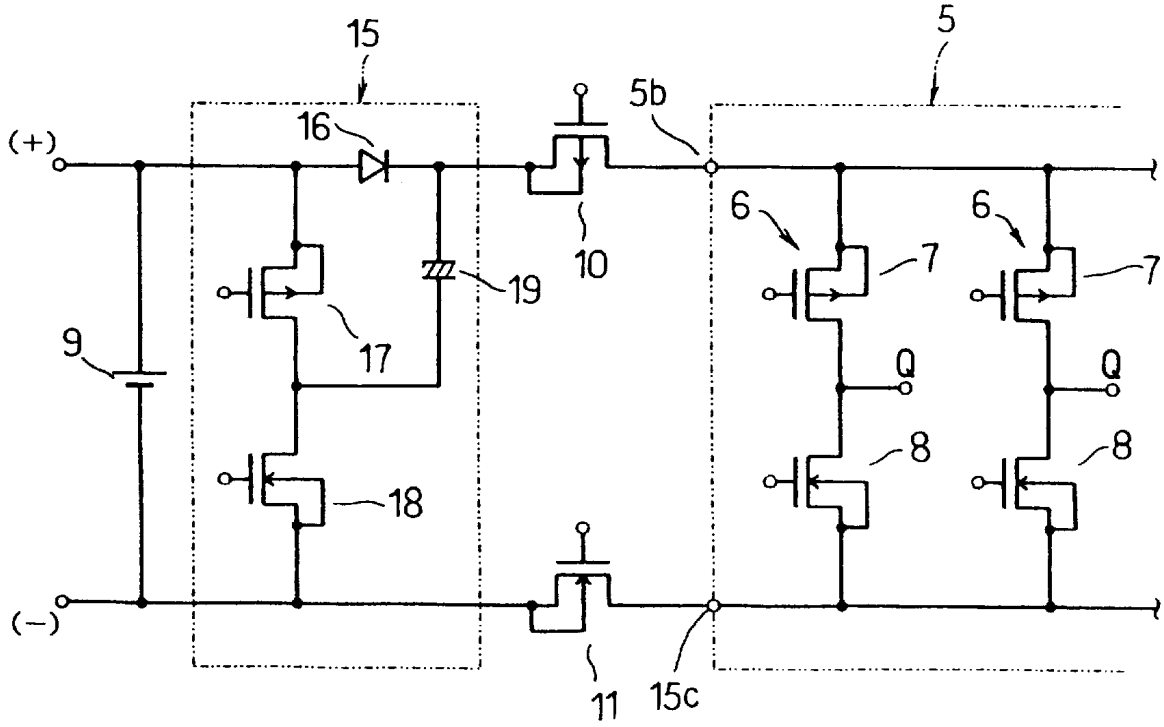


FIG. 3

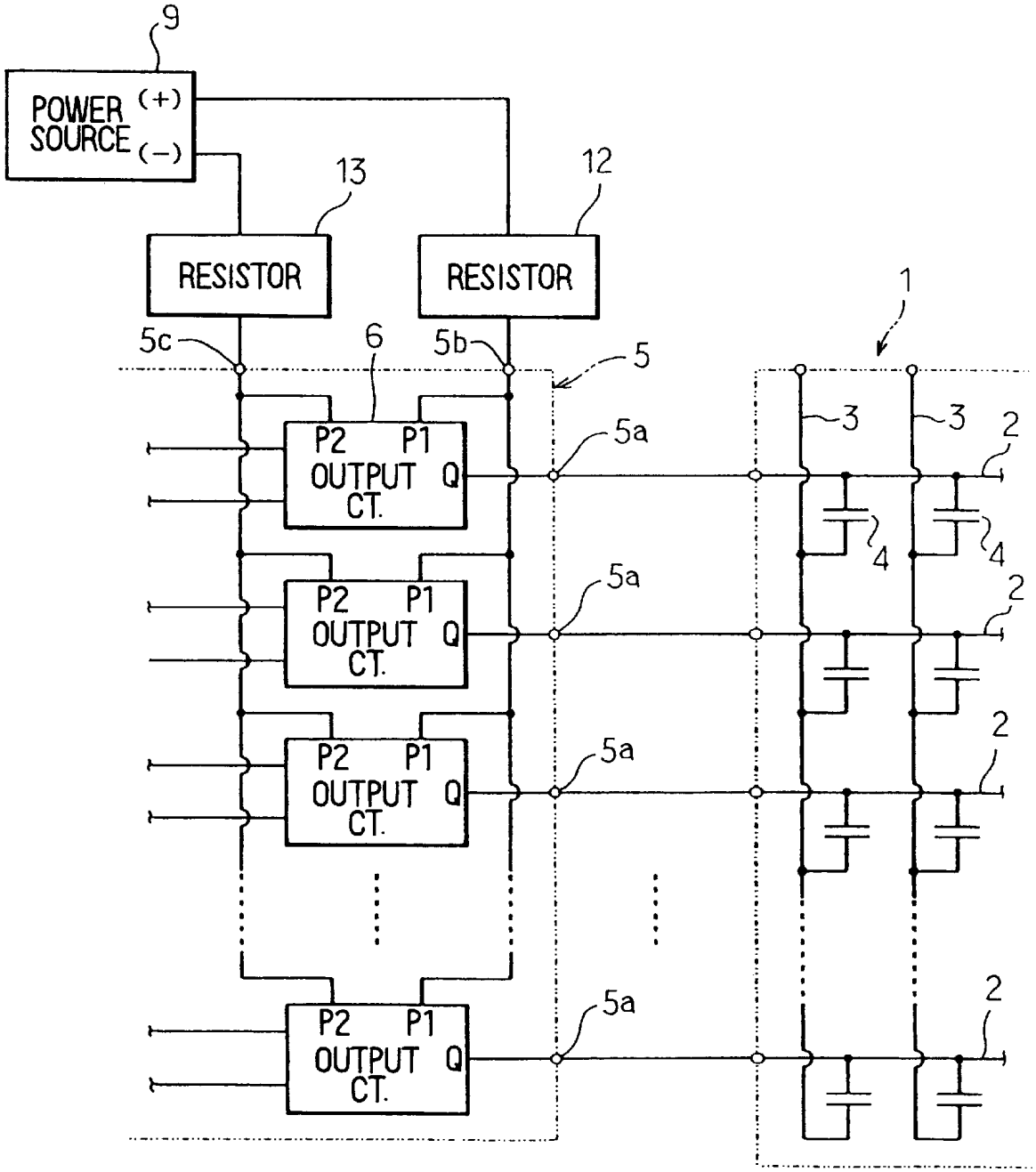

9
POWER SOURCE
(+)
(−)
13
12
RESISTOR
RESISTOR
1
5c
6
5b
5
P2 P1
OUTPUT Q
CT.
5a
3
2
4

FIG. 5A

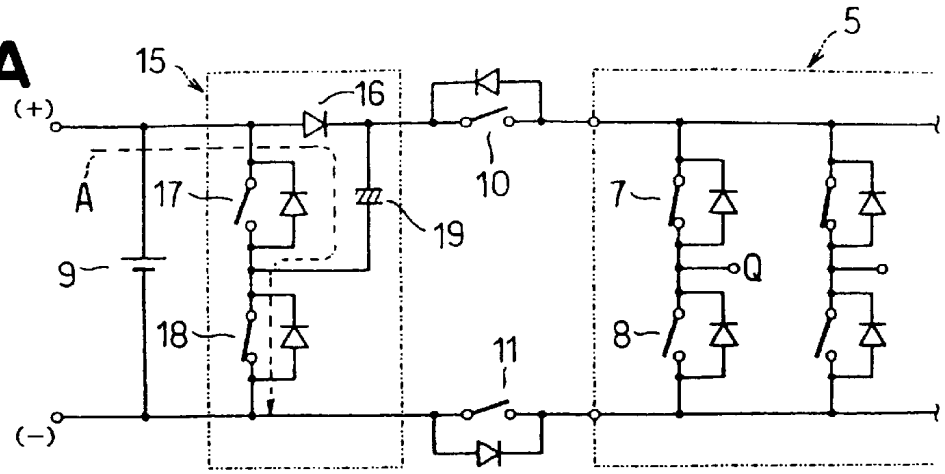


FIG. 5B

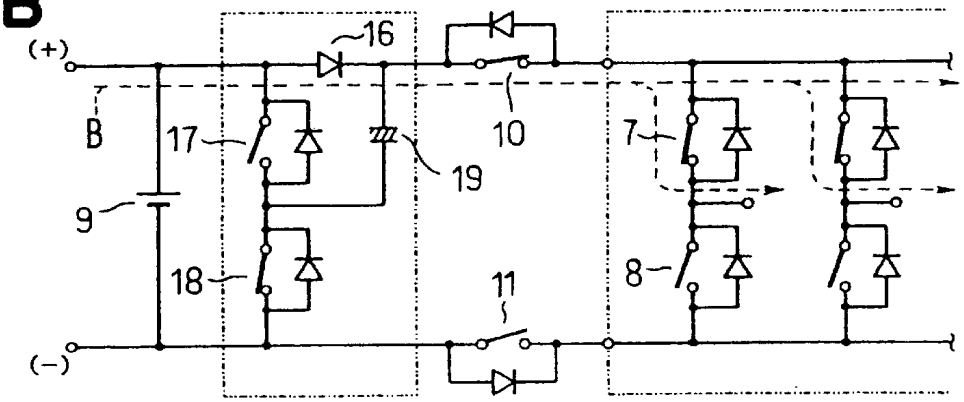


FIG. 5C

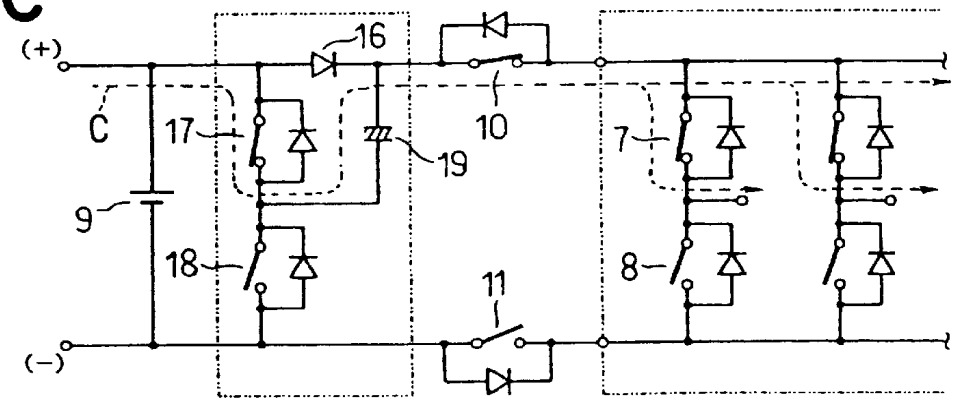


FIG. 5D

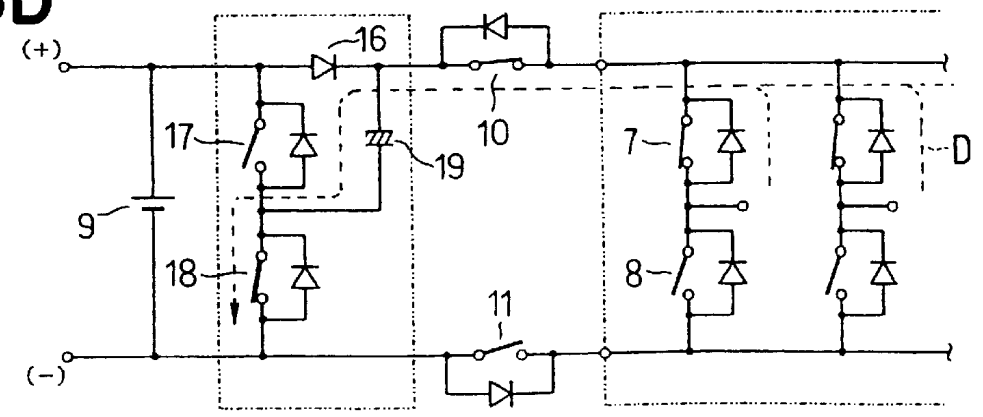


FIG. 6

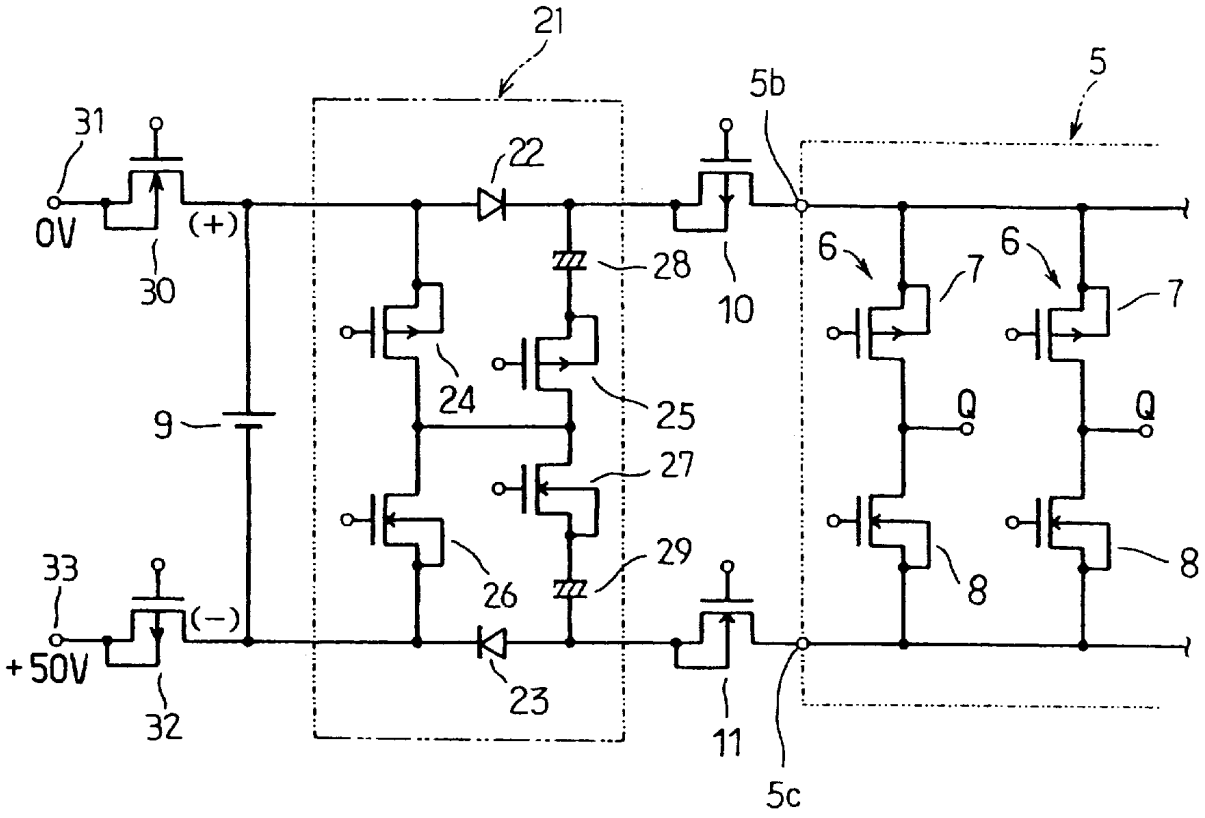
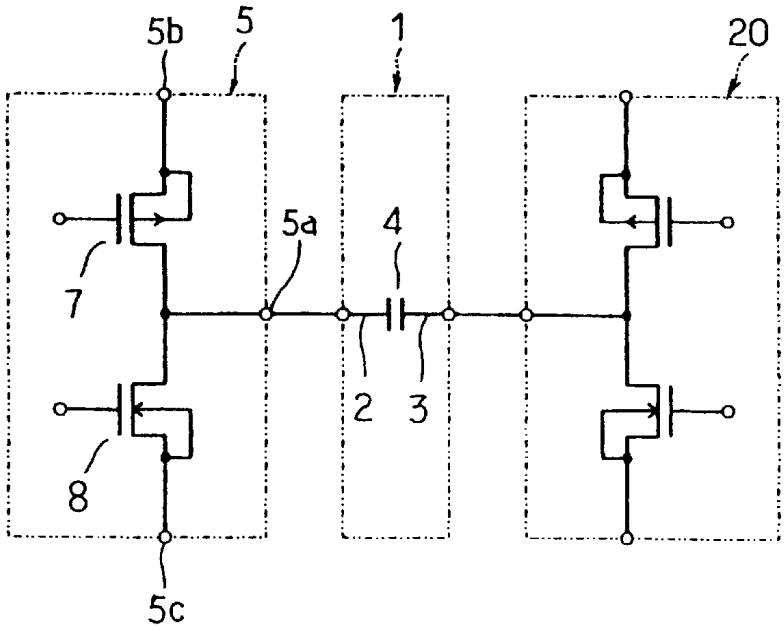

21
5
5b
31
22
0V
(+)
30
28
10
6
7
6
7
24
25
9
Q
Q
27
29
33
26
8
8
(−)
+50V
32
23
11
5c

FIG. 7


5b
5
1
20
5a
4
7
2
3
8
5c

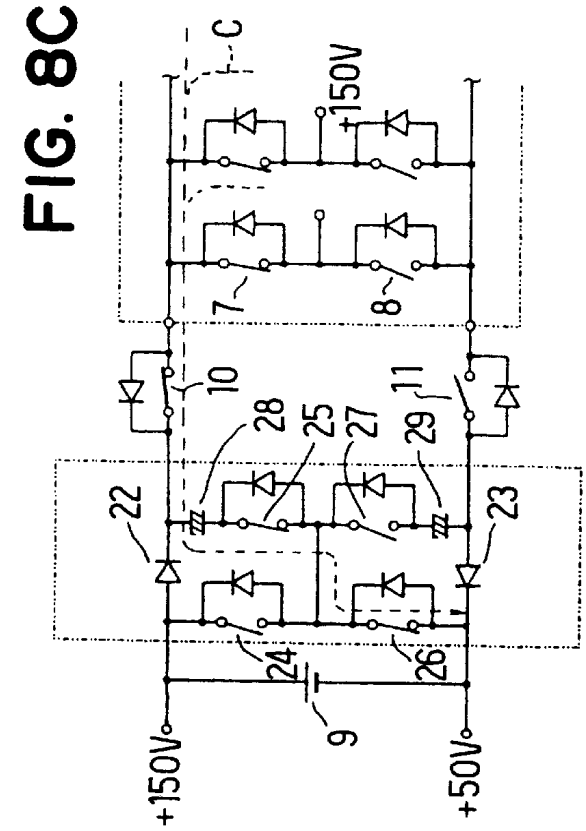


FIG. 8C

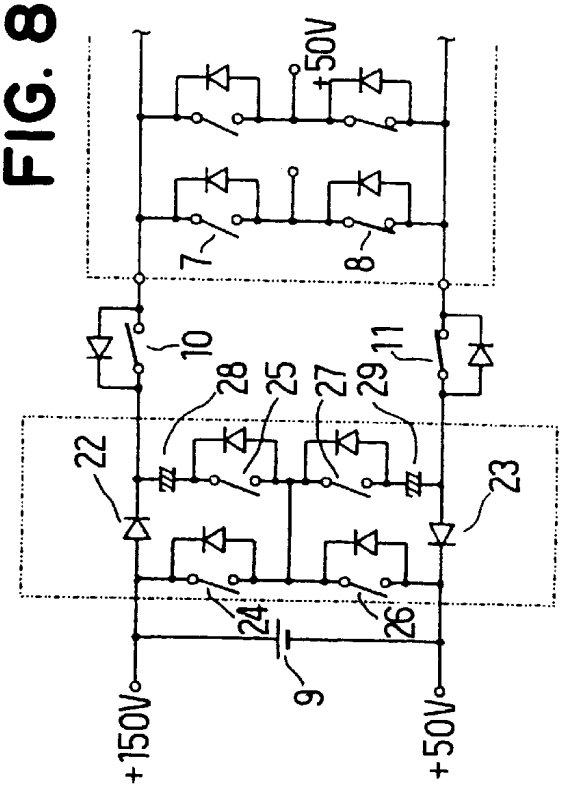


FIG. 8D

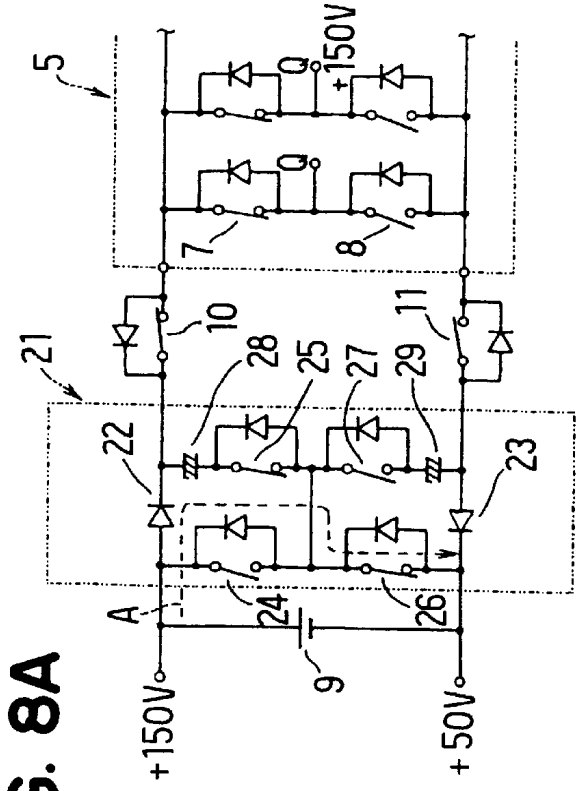


FIG. 8A

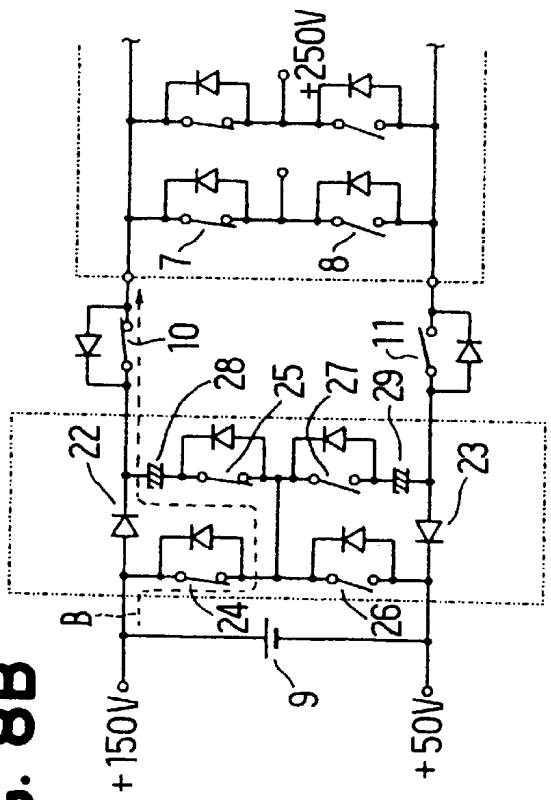


FIG. 8B

FIG. 9C

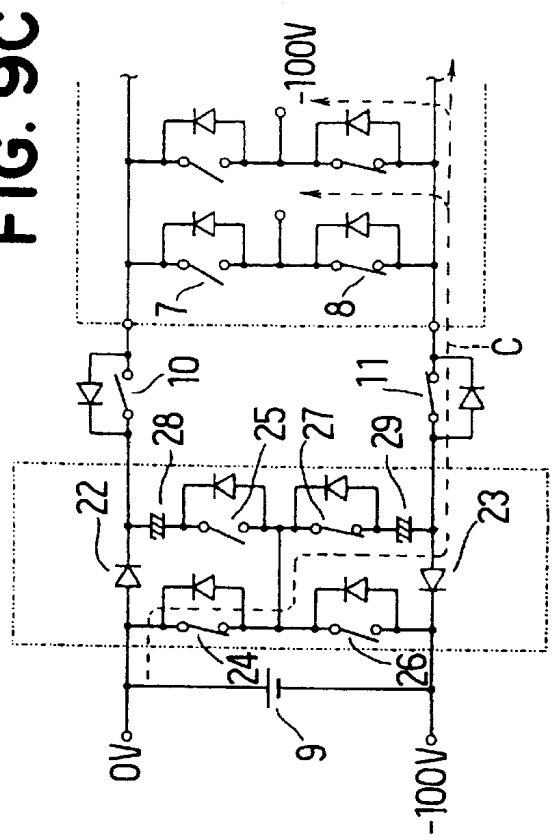


FIG. 9D

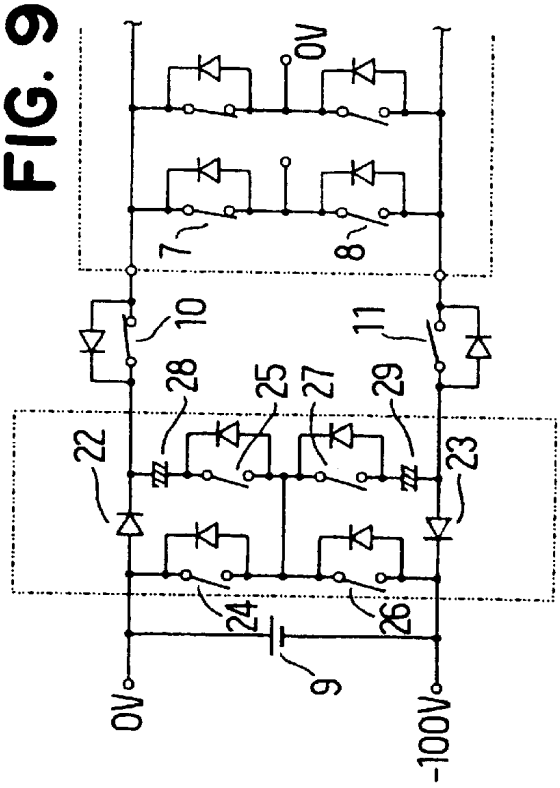


FIG. 9A

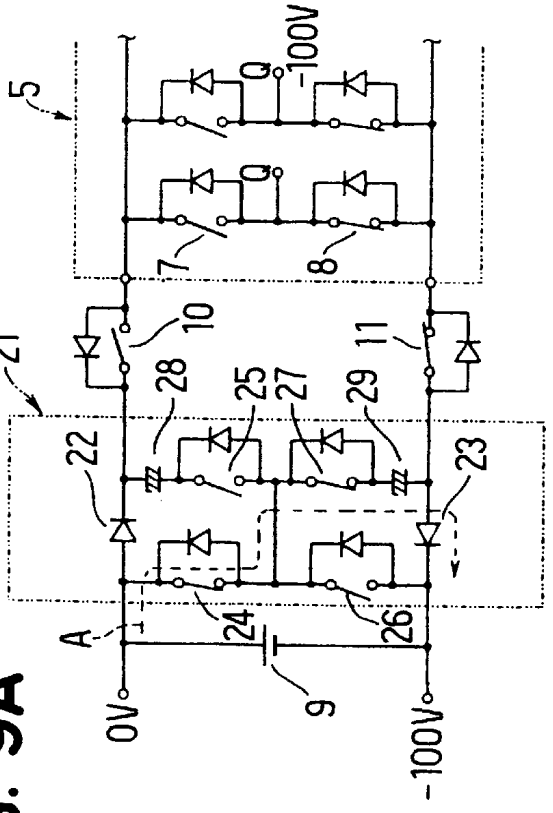


FIG. 9B

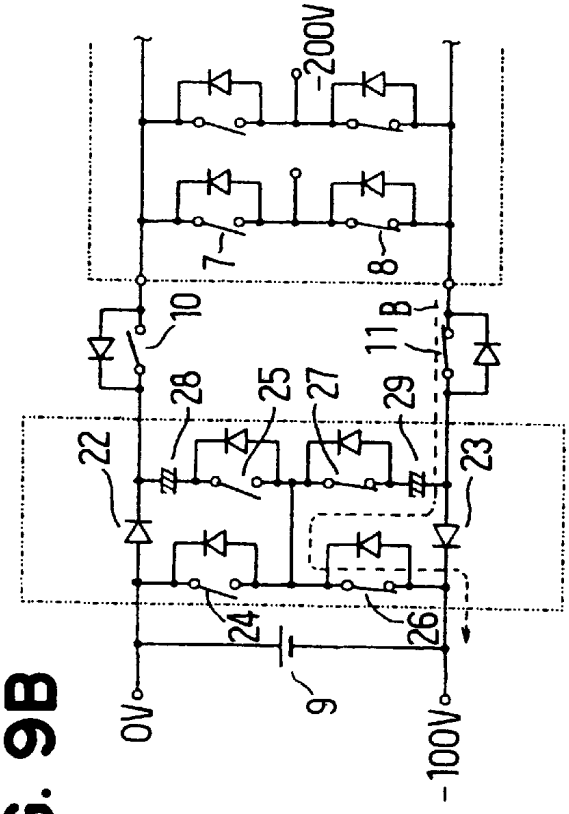
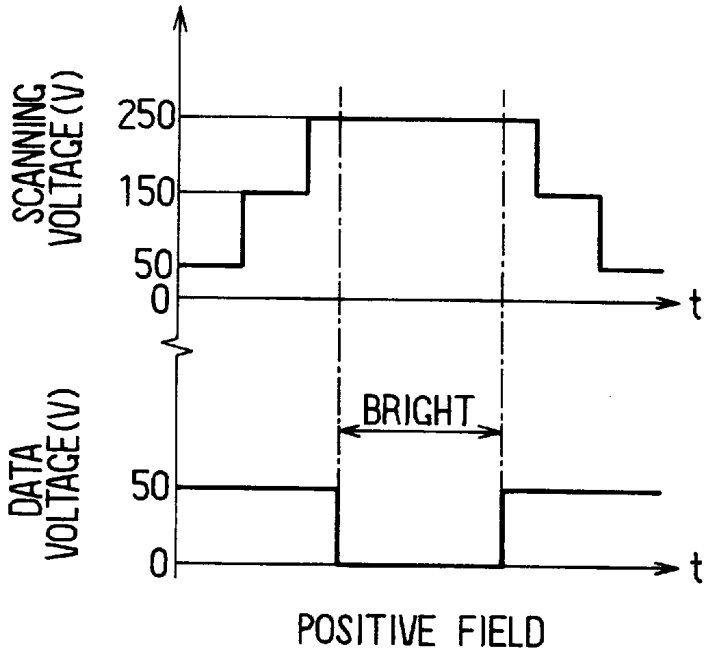
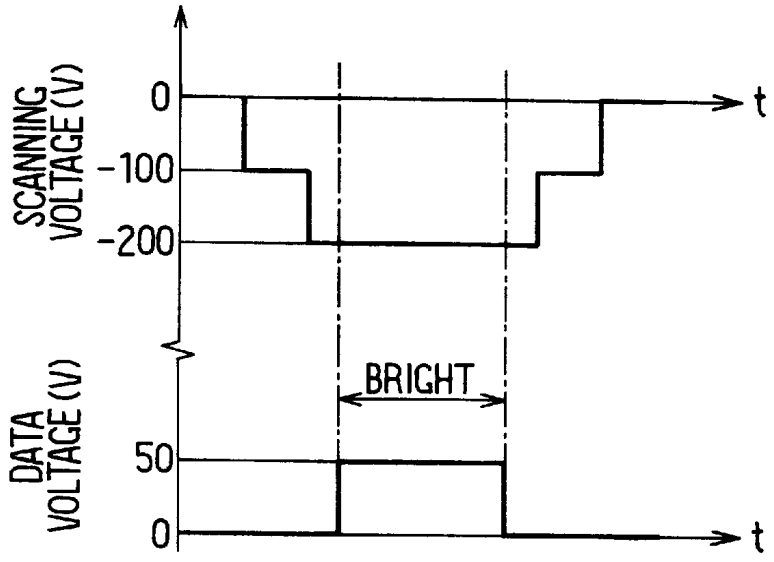


FIG. 10A



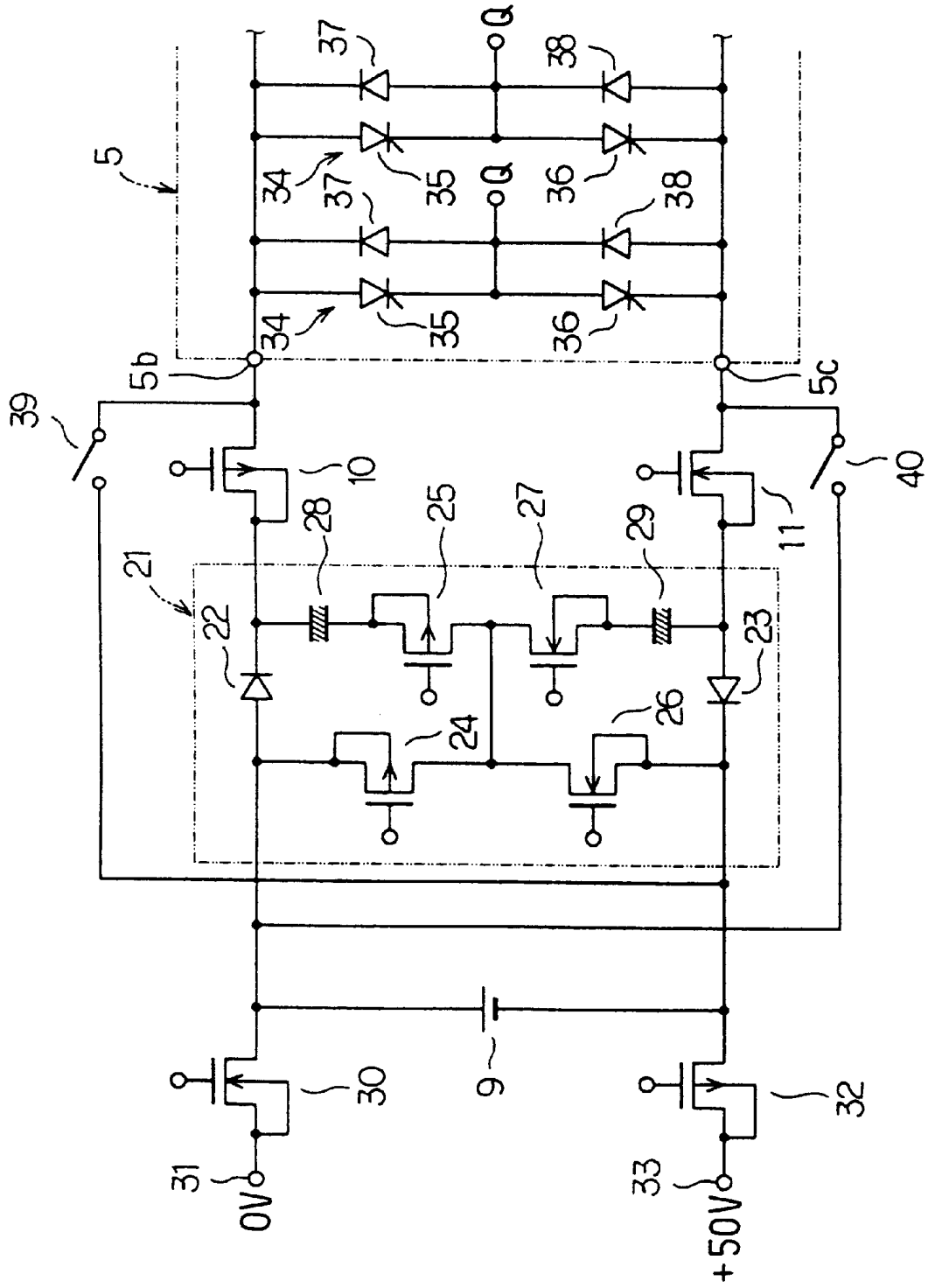
POSITIVE FIELD

FIG. 10B



NEGATIVE FIELD

FIG. 11


5
5b
5c
Q
Q
34
35
36
37
38
39
40
10
11
21
22
23
24
25
26
27
28
29
9
30
31
0V
32
33
+50V

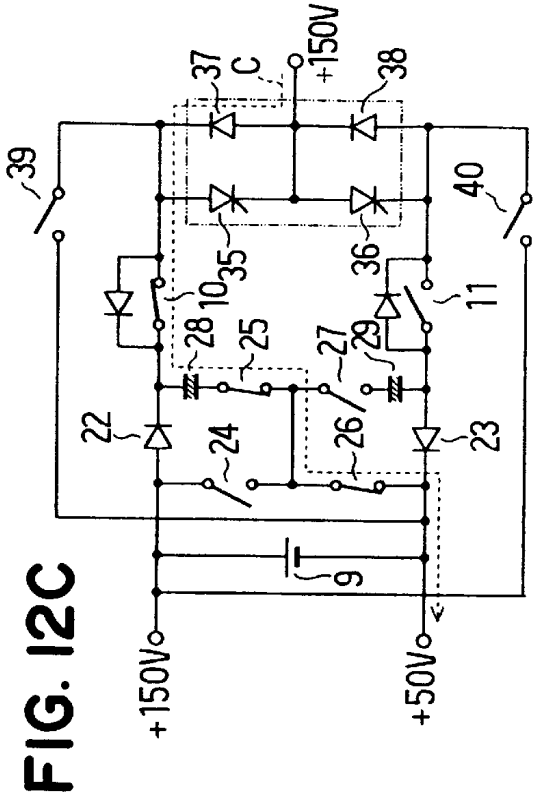


FIG. 12C

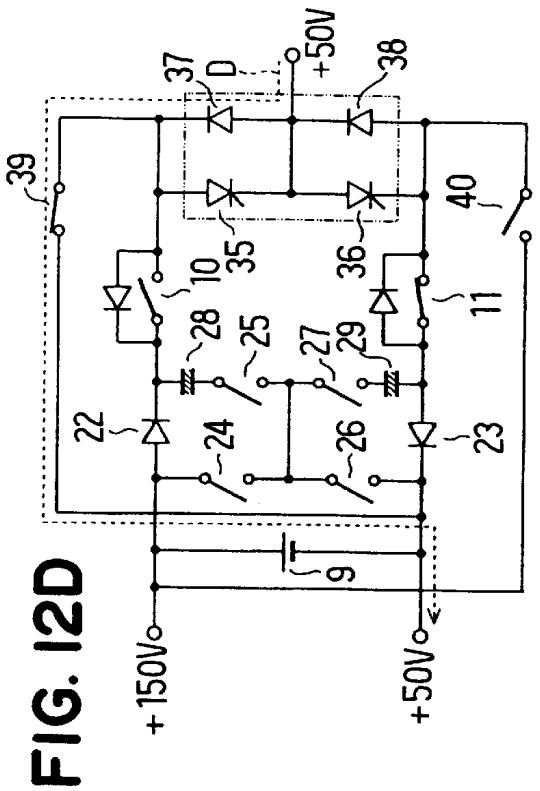


FIG. 12D

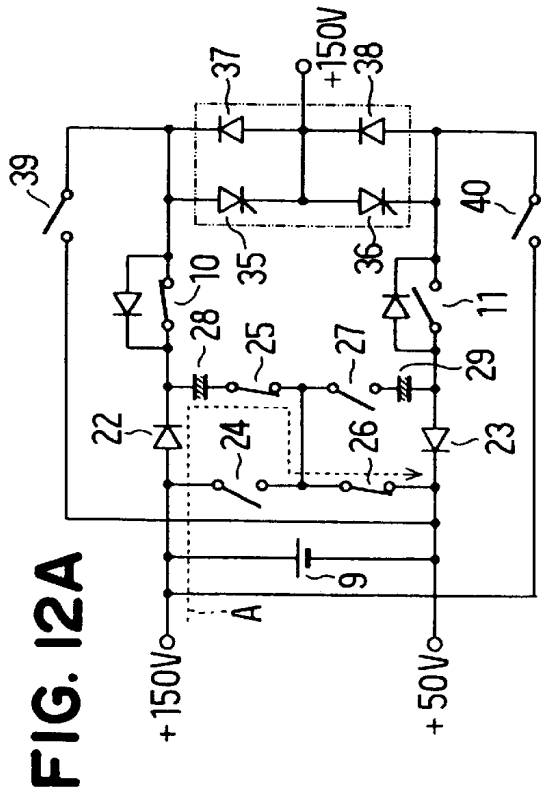


FIG. 12A

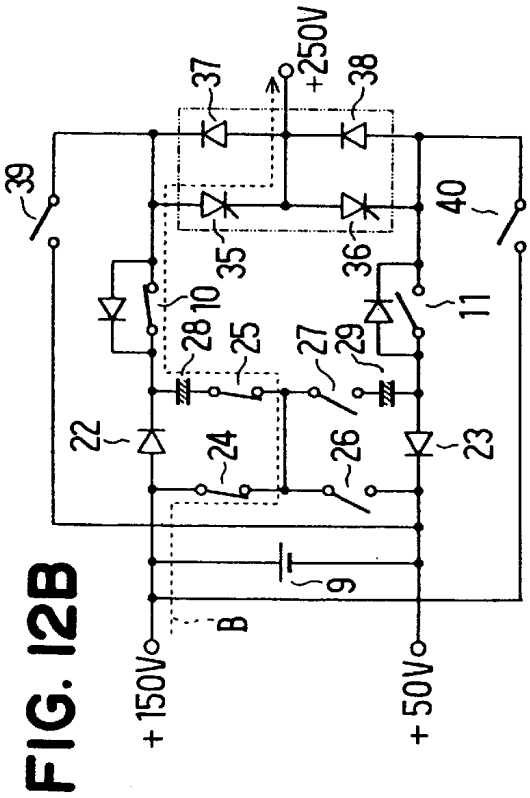


FIG. 12B

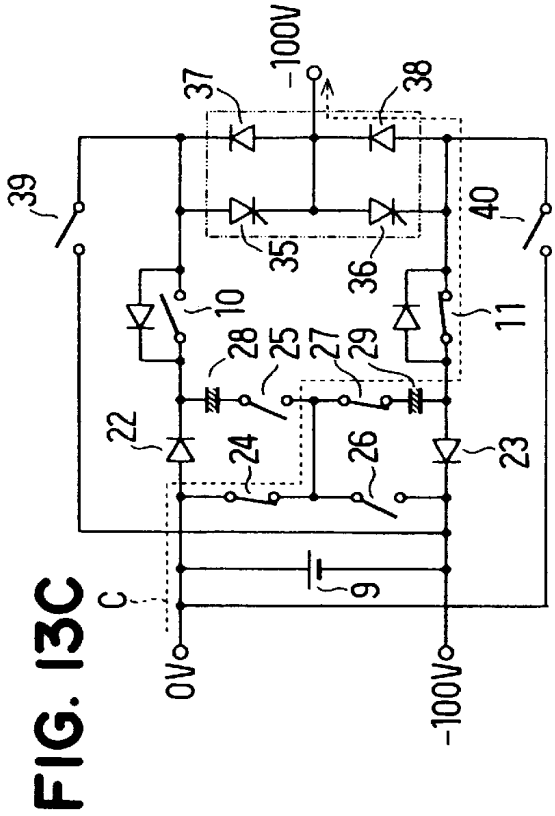


FIG. 13C

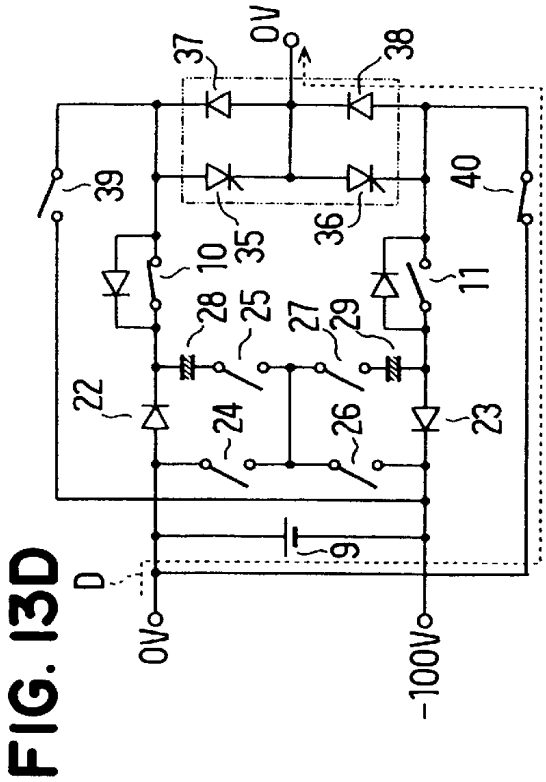


FIG. 13D

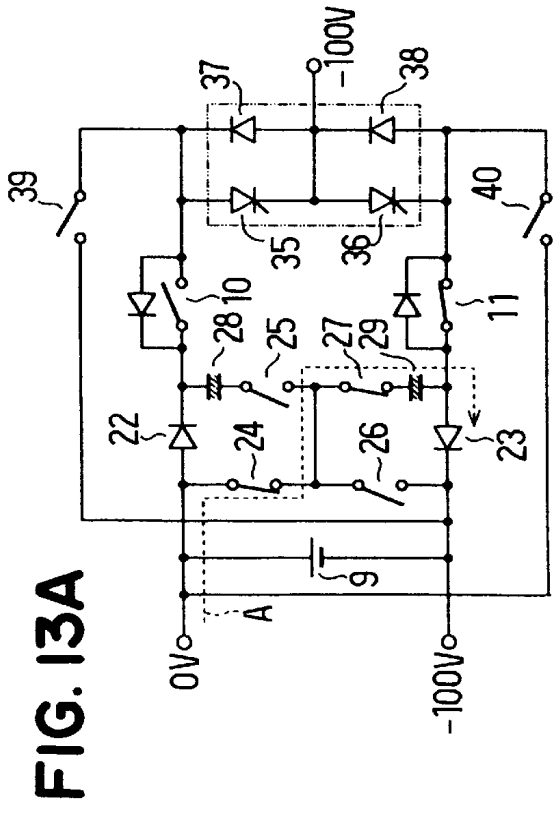


FIG. 13A

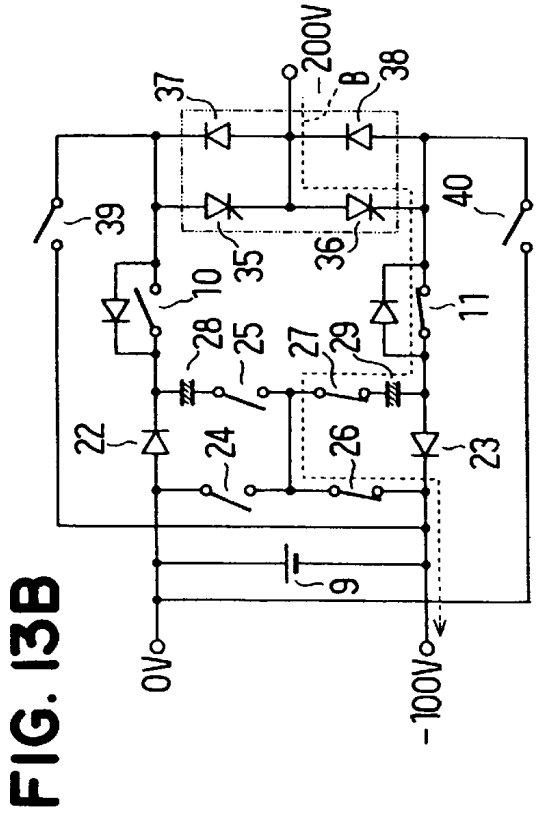


FIG. 13B

DRIVER CIRCUIT FOR CAPACITIVE DISPLAY ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims benefit of priority of Japanese Patent Applications No. Hei-11-106500 filed on Apr. 14, 1999 and No. Hei-2000-39642 filed on Feb. 17, 2000, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a driver circuit for driving a display panel that includes plural capacitive elements such as electroluminescent elements, optical characteristics of which change according to voltages imposed thereon.

2. Description of Related Art

An electroluminescent display panel (referred to as an EL display panel) that includes a number of capacitive electroluminescent elements (referred to as EL elements) is driven by selectively charging and discharging the EL elements. A relatively large current flows in a scanning electrode driving circuit that supplies scanning voltages to scanning electrodes in such an EL panel, and a relatively large amount of power is consumed mainly as a switching loss in the scanning electrode driving circuit. Therefore, there has been a possibility that the scanning electrode driving circuit malfunctions due to heat generated by power loss.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above-mentioned problem, and an object of the present invention is to provide an improved driver circuit which consumes less power and operates always stably.

A display panel having plural capacitive display elements is driven by supplying a driving voltage through a driver circuit. The driving circuit includes an integrated circuit having plural output circuits, each connected to each scanning electrode corresponding to the capacitive display elements aligned along the scanning electrode, and voltage dividing loads. The voltage dividing loads such as power transistors or resistors are connected between the power source and the integrated circuit. Each output circuit in the integrated circuit is composed of a first switching element for charging the capacitive display element and a second switching element for discharging the same, both constituting a push-pull circuit. LDMOS transistors or SCRs are used as the switching elements.

The voltage between the power source and the display panel is divided between the voltage dividing loads and the integrated circuit, and accordingly power consumption is also allocated to the voltage dividing load and the integrated circuit. Therefore, temperature rise in the integrated circuit is suppressed, and malfunction of the integrated circuit due to the temperature rise therein is avoided. When resistors are used as the voltage dividing loads, the power consumption in the circuit is allocated to the resistors and the integrated circuit according to respective impedance thereof.

When the power transistors such as MOSFETs are used as the voltage dividing loads, they are closed or opened after the switching elements in the integrated circuit are closed. Therefore, switching loss occurs only in the power transistors, avoiding switching loss in the integrated circuit. In this manner, the temperature rise in the integrated circuit is further suppressed, and the integrated circuit stably operates without being affected by the temperature rise.

Preferably, a step-recycle circuit including a condenser is connected between the power source and the power transistors. The level of the driving voltage supplied to the capacitive display elements is changed stepwise by charging and discharging the condenser. The power for driving the capacitive display elements are saved in this manner. At the same time, the condenser is used as a power recycling element. A portion of the energy charged in the capacitive display element is returned to the condenser in the step-recycle circuit and is used again to charge the element in the next cycle. The driving energy is further saved by recycling the energy in the capacitive display element.

Preferably, the display panel is driven with positive and negative voltages alternatively supplied thereto. In this case, a first and a second condenser are disposed in the step-recycle circuit. The first condenser functions to generate the stepwise changing driving voltage and to recycle the energy in the capacitive display element when the panel is driven with the positive voltage. The second condenser performs the same functions when the panel is driven with the negative voltage.

According to the present invention, the amount of power consumed in the integrated circuit is reduced, and thereby malfunctions of the integrated circuit due to temperature rise are avoided.

Other objects and features of the present invention will become more readily apparent from a better understanding of the preferred embodiments described below with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing an electroluminescent display panel and a driver circuit thereof as a first embodiment of the present invention;

FIG. **2** is a circuit diagram showing switching elements in an output circuit of the driver circuit shown in FIG. **1**;

FIG. **3** is a block diagram showing an electroluminescent display panel and a driver circuit thereof as a second embodiment of the present invention;

FIG. **4** is a circuit diagram showing a main portion of a driver circuit as a third embodiment of the present invention;

FIGS. **5**A–**5**D are circuit diagrams showing operation of the driver circuit shown in FIG. **4**;

FIG. **6** is a circuit diagram showing a main portion of a driver circuit as a fourth embodiment of the present invention;

FIG. **7** is a conceptual circuit diagram showing a whole structure of an electroluminescent panel and drivers thereof;

FIGS. **8**A–**8**D are circuit diagrams showing operation of the fourth embodiment in a positive field;

FIGS. **9**A–**9**D are circuit diagrams showing operation of the fourth embodiment in a negative field;

FIG. **10**A is a graph showing scanning voltages and data voltages in a positive field of the fourth embodiment;

FIG. **10**B is a graph showing scanning voltages and data voltages in a negative field of the fourth embodiment;

FIG. **11** is a circuit diagram showing a main portion of a driver circuit as a fifth embodiment of the present invention;

FIGS. **12**A–**12**D are circuit diagrams showing operation of the fifth embodiment in a positive field; and

FIGS. **13A–13D** are circuit diagrams showing operation of the fifth embodiment in a negative field.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will be described with reference to FIGS. **1** and **2**. First, referring to FIG. **1**, a whole structure of an EL display device will be described. The EL display panel **1** includes plural scanning electrodes **2** running in the row direction, plural data electrodes running in the column direction and an electroluminescent layer interposed between both the scanning and data electrodes. Capacitive EL elements (pixels) **4** are formed at each intersection of the both scanning and data electrodes together with the EL layer. The EL elements are driven by supplying scanning voltages to the scanning electrodes **2** and data voltages to the data electrodes **3**. The scanning voltages are supplied from a scanning electrode driving circuit **5** that is an integrated circuit and referred to as a driver IC **5**, and the data voltages are supplied from a data electrode driving circuit (not shown).

The driver IC **5** includes plural output circuits **6**, each corresponding to each scanning electrode **2**. As shown in FIG. **2**, each output circuit **6** includes a P-channel LDMOS **7** (a first switching element) and an N-channel LDMOS **8** (a second switching element), both connected in series. A junction of the LDMOS **7** and the LDMOS **8** is connected to an output terminal Q, a first terminal P1 of the series circuit is connected to a first power supply terminal **5***b* of the driver IC **5**, and a second terminal P2 is connected to a second power supply terminal **5***c*. The output terminal Q is connected to an output terminal **5***a* of the driver IC **5**. The output terminal **5***a* is further connected to the scanning electrode **2**.

A power source **9** having a relatively high voltage, e.g., 250 V, is connected to the driver IC **5** through a pair of power MOSFETs **10** and **11**. Namely, a plus terminal of the power source **9** is connected to the first power supply terminal **5***b* through a P-channel MOSFET **10**, and a minus terminal of the power source **9** is connected to the second power supply terminal **5***c* through an N-channel MOSFET **11**. The power MOSFET **10** is controlled so that it turns on after the LDMOS **7** in the output circuit **6** is turned on, while the power MOSFET **8** is controlled so that it turns on after the LDMOS **8** in the output circuit **6** is turned on.

The driver IC **5** also includes a control circuit that selectively turns on or off either one of the LDMOSs **7**, **8** according to signals fed from an outside circuit. Both power MOSFETS **10**, **11** are controlled by the same controller, or may be controlled by a separate controller.

To charge the EL element **4**, the LDMOS **7** is first turned on and then the power MOSFET **10** is turned on. The charging current flows from the plus terminal of the power source **9** to EL element **4** through the power MOSFET **10** and the LDMOS **7** and the scanning electrode **2**. On the other hand, to discharge the EL element **4**, the LDMOS **8** is first turned on and then the power MOSFET **11** is turned on. The discharging current flows from the EL element **4** to the minus terminal of the power source **9** through the scanning electrode **2**, the LDMOS **8** and the power MOSFET **11**.

The energy for charging and discharging the EL elements is proportional to CV^2, irrespective of resistance in the charging and discharging circuit, where C is a total capacitance of all the EL elements and V is an imposed voltage. On the other hand, switching and conduction losses occur in the charging and discharging circuit. Since the power MOSFETs **10** and **11** are turned on or off after the LDMOSs **7** and **8** in the driver IC **5** are closed, the switching loss only occurs in the power MOSFETs **10** and **11** located outside the driver IC **5**. Only a small amount of conduction loss occurs in the LDMOSs **7** and **8** due to on-resistances thereof. Therefore, a temperature rise in the driver IC **5** is suppressed at a low level, and malfunctions of the driver IC **5** due to the temperature rise are avoided. Accordingly, the driver IC **5** can be stably operated. Since the output circuit **6** in the driver IC **5** is a push-pull circuit composed of the LDMOSs **7** and **8**, its voltage endurance is high. Moreover, power consumption in the output circuit **6** is suppressed at a low level, because LDMOSs are driven with a small gate current. Further, since the power MOSFETs **10** and **11** are discrete elements disposed separately from the driver IC **5**, the heat generated by the switching loss is easily dissipated.

A second embodiment of the present invention is shown in FIG. **3**. In this embodiment, the power MOSFETs **10** and **11** used in the first embodiment are replaced with resistors **12** and **13**. More particularly, the resistor **12** is connected between the plus terminal of the power source **9** and the first power supply terminal **5***b* of the driver IC **5**, thereby forming a series charging circuit including the resistor **12** and the LDMOS **7**. The resistor **13** is connected between the minus terminal of the power source **9** and the second power supply terminal **5***c* of the driver IC **5**, thereby forming a series discharging circuit including the resistor **13** and the LDMOS **8**.

In charging operation, the voltage between the EL element and the plus terminal of the power source **9** is divided by the resistor **12** and the LDMOS **7**. Accordingly, power consumption in the charging circuit is proportionally distributed to the resistor **12** and the LDMOS **7** according to respective impedances thereof. Similarly, in discharging operation, the power consumption in the discharging circuit is proportionally distributed to the resistor **13** and the LDMOS **8** according to respective impedances thereof. In other words, both in the charging and discharging operations, power consumption in the driver IC **5** can be made small relative to total power consumption in the charging and discharging circuits. Therefore, the temperature rise in the driver IC **5** is suppressed, and the operation of the driver IC **5** is stabilized, only by using two outside resistors **12** and **13**.

Referring to FIGS. **4–5D**, a third embodiment of the present invention will be described. In this embodiment, the level of voltage imposed on the EL element **4** is changed stepwise, and the charging energy is recycled. For this purpose, a step-recycle circuit **15** is added between the power source **9** and the power MOSFETs **10**, **11**, compared with the first embodiment shown in FIG. **1**.

As shown in FIG. **4**, the step-recycle circuit **15** is composed of a diode **16**, a P-channel MOSFET **17** (a second auxiliary switching element), an N-channel MOSFET **18** (a first auxiliary switching element) and a condenser **19**. More particularly, the diode **16** is connected between the plus terminal of the power source **9** and the power MOSFET **10** in the forward direction. A series circuit consisting of the P-channel MOSFET **17** and the N-channel MOSFET **18** is connected between the anode of the diode **16** and the minus terminal of the power source **9**. The condenser **19** is connected between the cathode of the diode **16** and a junction of both MOSFETs **17**, **18**. The MOSFET **18** is controlled so that it turns on during a predetermined period including a starting period of the charging operation of the EL element **4**. During the predetermined period in which the MOSFET **18** is turned on, two circuits for charging the condenser **19**

are formed. One is a circuit including the plus terminal of the power source **9**, the diode **16**, the condenser **19** and the MOSFET **18**. The other is a circuit including the EL element **4**, a parasitic diode (not shown in FIG. **4**, connected in parallel to the LDMOS **7** in the reverse direction), the power MOSFET **10**, the condenser **19** and the MOSFET **18**. On the other hand, the MOSFET **17** is controlled so that it turns on for a predetermined period after the MOSFET **18** is turned off. During the period in which the MOSFET **17** is turned on, to charges on the condenser **19** is superimposed on the voltage of the power source **9**.

Referring to FIGS. **5**A–**5**D, operation of the third embodiment will be described. In FIGS. **5**A–**5**D, the LDMOSs **7**, **8**, the power MOSFETs **10**, **11**, and the MOSFETs **17**, **18** are all shown as switches, and parasitic diodes associated with those transistors are all shown. FIG. **5**A shows a stage where the LDMOS **7** in the driver IC **5** and the MOSFET **18** are turned on while other switches are turned off. At this stage, a circuit charging the condenser **19** is formed through a dotted line "A" that includes the diode **16**, the condenser **19** and MOSFET **18**, and thereby the condenser **19** is charged. Then, the power MOSFET **10** is turned on, as shown in FIG. **5**B, the EL element **4** is charged with the power source voltage through a charging circuit shown with a dotted line "B" that includes the plus terminal of the power source **9**, the diode **16**, the power MOSFET **10** and LDMOS **7**.

Then, the MOSFET **17** is turned on, and the MOSFET **18** is turned off at the same time, thereby forming a circuit shown with a dotted line "C" that includes the plus terminal of the power source **9**, the MOSFET **17**, the condenser **19**, the power MOSFET **10**, the LDMOS **7** and the EL element **4**. At this stage, the EL element **4** is charged with a composite voltage composed of the power source voltage and the voltage of condenser **19** which is superimposed on the power source voltage. The level of the composite voltage is about two times the power source voltage. This means that the EL element **4** is stepwise charged, i.e., first with the power source voltage and then with the composite voltage.

Then, as shown in FIG. **5**D, the MOSFET **17** is turned off and the MOSFET **18** is turned on at the same time, thereby forming a circuit charging the condenser **19** with energy stored in the EL element **4** through a dotted line "D" that includes the EL element **4**, the parasitic diode of the LDMOS **7**, the power MOSFET **10**, the condenser **19** and the MOSFET **18**. Thus, a portion of energy supplied to the EL element **4** is recycled again to the condenser **19**.

As described above, the voltage for charging the EL element **4** is stepwise increased, and thereby less power is consumed in the driver IC **5** and the temperature rise in the driver IC is suppressed. Since the switching loss occurs only in the power MOSFETs **10** and **11**, the temperature rise is suppressed in the same manner as in the first embodiment. Moreover, since a portion of the energy supplied to the EL element is recycled to the condenser **19** and is used again for charging the EL element, the power consumption is further saved. Though the voltage for charging the EL element is increased with two steps in the third embodiment described above, it may be increased with more than two steps.

In reference to FIGS. **6**–**10**B, a fourth embodiment of the present invention will be described. In this to embodiment, positive scanning voltages are supplied to the scanning electrodes **2** in a positive field, and negative scanning voltages in a negative field. Both fields are alternated every time the EL display panel is scanned from its top to the bottom. The voltage levels for charging the EL element **4** are stepwise changed, and a portion of the energy supplied to the EL element **4** is recycled and reused in a similar manner as in the third embodiment.

A conceptual structure of the display device according to this embodiment is shown in FIG. **7**. The scanning voltages are supplied to the scanning electrodes **2** from the driver IC **5** (a scanning electrode driving circuit), and the data voltages are supplied to the data electrodes **3** from a data electrode driving circuit **20** having a structure similar to that of the driver IC **5**. A positive scanning voltage of, e.g., +250 V is supplied to the scanning electrodes **2** in the positive field, and a negative scanning voltage of, e.g., −200 V in the negative field. In synchronism with the scanning voltages, data voltages of, e.g., 0 V and +50 V are selectively supplied to the data electrodes **3**. As a result, the EL elements **4** on which +250 V is imposed are activated to emit light in the positive field, while the EL elements **4** on which −250 V is imposed are activated to emit light in the negative field.

Now, referring to FIG. **6**, the driver circuit of the fourth embodiment which includes a step-recycle circuit **21** will be described. The step-recycle circuit **21** is composed of: a first diode **22**; a second diode **23**; a P-channel MOSFET **24** (a first auxiliary switching element); a P-channel MOSFET **25** (a third auxiliary switching element); an N-channel MOSFET **26** (a second auxiliary switching element); an N-channel MOSFET **27** (a fourth auxiliary switching element); a first condenser **28**; and a second condenser **29**. More particularly, the first diode **22** is connected between the plus terminal of the power source **9** and the power MOSFET **10** in the forward direction. The second diode **23** is connected between the minus terminal of the power source **9** and the power MOSFET **11** in the forward direction. A series circuit consisting of the MOSFETs **24** and **26** is connected between the anode of the first diode **22** and the cathode of the second diode **23**. A series circuit consisting of the first condenser **28**, the MOSFETs **25**, **27** and the second condenser **29** is connected between the cathode of the first diode **22** and the anode of the second diode **23**. A junction of the MOSFETS **24** and **26** is connected to a junction of the MOSFETs **25** and **27**.

The plus terminal of the power source **9** is connected to a base voltage terminal **31** having a voltage level of, e.g., 0 V through an N-channel MOSFET **30**. The minus terminal of the power source **9** is connected to another base voltage terminal **33** having a voltage level of, e.g., 50 V through a P-channel MOSFET **32**. The MOSFET **32** is turned on in the positive field, while the MOSFET **30** is to turned on in the negative field. The voltage of the power source **9** is set to 100 V in this particular embodiment. Accordingly, in the positive field, the voltage level of the minus terminal of the power source **9** is fixed to 50 V which is the base voltage, while the voltage level of the plus terminal of the power source **9** is shifted to 150 V. In the negative field, the plus terminal of the power source **9** is fixed to 0 V which is the base voltage, while the voltage level of the minus terminal of the power source **9** is shifted to −100 V.

Operation of the fourth embodiment will be described in reference to FIGS. **8**A–**10**B. FIGS. **8**A–**8**D and FIG. **10**A show the operation in the positive field, while FIGS. **9**A–**9**D and FIG. **10**B show the operation in the negative field. All the transistors used in the circuit are shown as switches, and parasitic diodes associated with those transistors are also shown in the drawings.

Referring to FIGS. **8**A–**8**D, the operation of the driver circuit in the positive field will be described. The plus terminal of the power source **9** is set at +150 V and the minus terminal is set at +50 V in the positive field, as described

above. To supply charging voltage to the EL element **4**, the power MOSFET **10** is turned on after the MOSFETs **25**, **26** and the LDMOS **7** are turned on, as shown in FIG. **8**A. At this stage, the first condenser **28** is charged through a circuit "A" (shown with a dotted line) that includes the plus terminal of the power source **9**, the first diode **22**, the first condenser **28** and the MOSFETs **25**, **26**. At the same time, the scanning voltage is supplied to the EL element **4** through a circuit composed of the plus terminal of the power source **9**, the first diode **22**, the power MOSFET **10**, the LDMOS **7** and the scanning electrode **2**. The level of the scanning voltage at this time is 150 V.

Then, the MOSFET **26** is turned off and the MOSFET **24** is turned on at the same time, thereby forming a circuit "B" shown with a dotted line in FIG. **8**B. At this stage, the charges stored in the first condenser **28** are superimposed on the power source voltage (150 V), thereby raising the scanning voltage level to about 250 V. Accordingly, the EL element **4** is charged with this composite voltage of 250 V.

Then, the MOSFET **24** is turned off and the MOSFET **26** is turned on again at the same time, as shown in FIG. **8**C, forming a circuit "C" shown with a dotted line. At this stage, the energy supplied to the EL element **4** is supplied to the first condenser **28** through the circuit "C" composed of a parasitic diode connected in parallel to the LDMOS **7** in the reverse direction, the power MOSFET **10**, the first condenser **28** and MOSFETs **25**, **26**. Thus, a portion of the energy supplied to the EL element **4** is returned to the first condenser **28** to recycle that energy. At the same time, the scanning voltage becomes 150 V.

Then, the power MOSFET **10** is turned off and the power MOSFET **11** is turned on after the LDMOS **8** is turned on in place of the LDMOS **7** and the MOSFETs **25**, **26** are turned off, as shown in FIG. **8**D. At this stage, the charges stored in the first condenser **28** are maintained, and the scanning voltage becomes to an initial level of 50 V, because the scanning electrode **2** is connected to the minus terminal of the power source **9** through the LDMOS **8**, the power MOSFET **11**, the second diode **23**.

The operation in the positive field is summarized as shown in FIG. **10**A. The scanning voltages supplied to the scanning electrode **2** change stepwise, i.e., 50 V→150 V→250 V→150 V→50 V. On the other hand, the data voltage having a 50 V level is supplied to the data electrode **3** during a non-luminance (dark) period, and the data voltage having a 0 V level is supplied during a luminance (bright) period. The EL element **4** emits light when 250 V (a difference between the scanning voltage and the data voltage) is imposed thereon.

Referring to FIGS. **9**A–**9**D, the operation of the driver circuit in the negative field will be described. The plus terminal of the power source **9** is set at 0 V and the minus terminal is set at −150 V in the negative field, as described above. To supply charging voltage to the EL element **4**, the power MOSFET **11** is turned on after the MOSFETs **24**, **27** and the LDMOS **8** are turned on, as shown in FIG. **9**A. At this stage, the second condenser **29** is charged through a circuit "A" (shown with a dotted line) that includes the plus terminal of the power source **9**, the MOSFETs **24**, **27**, the second condenser **29** and the second diode **23**. At the same time, the scanning voltage is supplied to the EL element **4** through a circuit composed of the minus terminal of the power source **9**, the second diode **23**, the power MOSFET **11**, the LDMOS **8** and the scanning electrode **2**. The level of the scanning voltage at this time is −100 V.

Then, the MOSFET **24** is turned off and the MOSFET **26** is turned on at the same time, thereby forming a circuit "B" shown with a dotted line in FIG. **9**B. At this stage, the charges stored in the second condenser **29** are superimposed on the power source voltage (−100 V), thereby supplying the scanning voltage of about −200 V to the scanning electrode **2**. Accordingly, the EL element **4** is charged with this composite voltage of −200 V.

Then, the MOSFET **26** is turned off and the MOSFET **24** is turned on again at the same time, as shown in FIG. **9**C, forming a circuit "C" shown with a dotted line. At this stage, the energy supplied to the EL element **4** is supplied to the second condenser **29** through the circuit "C" composed of a parasitic diode connected in parallel to the LDMOS **8** in the reverse direction, the power MOSFET **11**, the second condenser **29** and MOSFETs **24**, **27**. Thus, a portion of the energy supplied to the EL element **4** is returned to the second condenser **29** to recycle that energy. At the same time, the scanning voltage becomes −100 V.

Then, the power MOSFET **11** is turned off and the power MOSFET **10** is turned on after the LDMOS **7** is turned on in place of the LDMOS **8** and the MOSFETs **24**, **27** are turned off, as shown in FIG. **9**D. At this stage, the charges stored in the second condenser **29** are maintained, and the scanning voltage becomes to an initial level of 0 V, because the scanning electrode **2** is connected to the plus terminal of the power source **9** through the LDMOS **7**, the power MOSFET **10**, the first diode **22**.

The operation in the negative field is summarized as shown in FIG. **10**B. The scanning voltages supplied to the scanning electrode **2** change stepwise, i.e., 0 V→−100 V→−200 V→−100 V→0 V. On the other hand, the data voltage having a 0 V level is supplied to the data electrode **3** during a non-luminance (dark) period, and the data voltage having a 50 V level is supplied during a luminance (bright) period. The EL element **4** emits light when −250 V (a difference between the scanning voltage and the data voltage) is imposed thereon.

As described above, the voltage for charging the EL element **4** is stepwise changed, and thereby less power is consumed in the driver IC **5** and the temperature rise therein is suppressed. Since the switching loss occurs only in the power MOSFETs **10** and **11**, the temperature rise is suppressed in the same manner as in the first embodiment. Moreover, since a portion of the energy supplied to the EL element is recycled to the condensers **28**, **29** and is used again for charging the EL element, the power consumption is further reduced. Especially, when the display panel is driven alternately with positive and negative voltages as in the fourth embodiment, the first and the second condensers **28**, **29** in the step-recycle circuit **21** are not unnecessarily discharged, and accordingly the charging energy is surely recycled. Moreover, since the output circuit **6** is composed of the push-pull circuit, it is suitable for driving the panel in alternating fields.

Referring to FIGS. **11**–**13**D, a fifth embodiment of the present invention will be described. This embodiment is similar to the fourth embodiment. The output circuit **6** of the fourth embodiment is replaced with an output circuit **34** in which SCRs **35**, **36** are used in place of the LDMOSs **7**, **8**. A first discharging diode **37** is connected in parallel to and in the reverse direction to the SCR **35**, and a second discharging diode **38** is connected in parallel to and in the reverse direction to the SCR **36**. An output terminal Q of the output circuit **34** is connected to a junction of both SCRs **35** and **36**, and the output circuit **34** constitutes a push-pull circuit. A switching element **39** such as a MOSFET is connected between the minus terminal of the power source

9 and the first power supply terminal **5***b* of the driver IC **5**. Similarly, a switching element **40** such as a MOSFET is connected between the plus terminal of the power source **9** and the second power supply terminal **5***c* of the driver IC **5**. Other structures are the same as those of the fourth embodiment. FIGS. **12**A–**12**D and **13**A–**13**D are schematic circuit diagrams for explaining the operation of the fourth embodiment. In those circuit diagrams, all the transistors are shown as switches, parasitic diodes associated with the power MOSFETs **10**, **11** are shown together with those MOSFETs, and the MOSFETs **30**, **32** are not shown.

Referring to FIGS. **12**A–**12**D, the operation in the positive field where the minus terminal of the power source **9** is fixed to 50 V will be described. To charge the EL element **4**, the power MOSFET **10** is turned on after the MOSFETs **25**, **26** and the SCR **35** are turned on, as shown in FIG. **12**A. At this stage, the first condenser **28** is charged through a circuit "A" shown with a dotted line composed of the plus terminal of the power source **9**, the first diode **22**, the first condenser **28**, and the MOSFETs **25**, **26**. The El element **4** is charged through a circuit composed of the plus terminal of the power source **9**, the first diode **22**, the power MOSFET **10**, the SCR **35** and the scanning electrode **2**. The scanning voltage at this stage is 150 V.

Then, the MOSFET **26** is turned off and the MOSFET **24** is turned on at the same time, as shown in FIG. **12**B. At this stage, charges stored in the first condenser **28** are superimposed on the voltage (150 V) of the power source **9** through a circuit "B." The scanning voltage supplied to the EL element becomes to a level of 250 V. This means that the scanning voltage increases stepwise from 150 V to 250 V.

Then, the MOSFET **24** is turned off and the MOSFET **26** is turned on again, as shown in FIG. **12**C. At this stage, energy of the EL element **4** is supplied to the first condenser **28** though a circuit "c" composed of the first discharging diode **37**, the power MOSFET **10**, the first condenser **28**, and the MOSFETs **25**, **26**. A portion of the energy supplied to the EL element **4** is returned to the first condenser **28** to use it again. The scanning voltage becomes 150 V at this stage.

Then, the MOSFETs **25**, **26** and the power MOSFET **10** are turned off and the switching element **39** is turned on at the same time, as shown in FIG. **12**D. At this stage, the charges stored in the first condenser **28** are maintained, and the scanning voltage supplied to the EL element **4** is changed to an initial level. of 50 V through a circuit "ID" composed of the first discharging diode **37** and the switching element **39**.

Referring to FIGS. **13**A–**13**D, the operation in the negative field where the plus terminal of the power source **9** is fixed to 0 V will be described. To charge the EL element **4**, the power MOSFET **11** is turned on after the MOSFETs **24**, **27** and the SCR **36** are turned on, as shown in FIG. **13**A. At this stage, the second condenser **29** is charged through a circuit "A" shown with a dotted line composed of the plus terminal of the power source **9**, the MOSFETs **24**, **27**, the second condenser **29** and the second diode **23**. The EL element **4** is charged through a circuit composed of the minus terminal of the power source **9**, the second diode **23**, the power MOSFET **11**, the SCR **36** and the scanning electrode **2**. The scanning voltage at this stage is −100 V.

Then, the MOSFET **24** is turned off and the MOSFET **26** is turned on at the same time, as shown in FIG. **13**B. At this stage, charges stored in the second condenser **29** are superimposed on the voltage (−100 V) of the power source **9** through a circuit "B." The scanning voltage supplied to the EL element becomes to a level of −200 V. This means that the scanning voltage changes stepwise from −100 V to −200 V.

Then, the MOSFET **26** is turned off and the MOSFET **24** is turned on again, as shown in FIG. **13**C. At this stage, energy of the EL element **4** is supplied to the second condenser **29** though a circuit "C" composed of the second discharging diode **38**, the power. MOSFET **11**, the second condenser **29**, and the MOSFETs **24**, **27**. A portion of the energy supplied to the EL element **4** is returned to the second condenser **29** to use it again. The scanning voltage becomes −100 V at this stage.

Then, the MOSFETs **24**, **27** and the power MOSFET **11** are turned off and the switching element **40** is turned on at the same time, as shown in FIG. **13**D. At this stage, the charges stored in the second condenser **29** are maintained, and the scanning voltage supplied to the EL element **4** is changed to an initial level of 0 V through a circuit "D" composed of the second discharging diode **38** and the switching element **40**.

The same advantages as those of the fourth embodiment are obtained in the fifth embodiment, too. In addition, a large amount of current can be flown in the output circuit **34** of the fifth embodiment because the SCRs **35**, **36** are elements which are latched-up to an on-condition. Therefore, in distributing power consumption to the driver IC **5** and the power MOSFETs **10**, **11**, a smaller portion of the power is allocated to the driver IC **5**, and thereby the temperature rise in the driver IC **5** is further reduced. Further, the luminance of the EL elements can be increased because they are charged at a higher speed with a large amount of current. Moreover, since the first and second discharging diodes **37**, **38** are connected in parallel to and in the reverse direction to the respective SCRs **35**, **36**, the disadvantage that the operation speed of the SCRs is slow is compensated by those discharging diodes **37**, **38**.

Though the power MOSFETs **10**, **11** are used as the voltage dividing loads in the first, third, fourth and fifth embodiments, they may be replaced with other elements such as bipolar transistors or IGBTs. Though the EL display panel is driven by the driver circuit described above, other display panels having capacitive elements such as plasma display panels may be similarly driven by the driver circuit according to the present invention.

While the present invention has been shown and described with reference to the foregoing preferred embodiments, it will be apparent to those skilled in the art that changes in form and detail may be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A driver circuit for driving capacitive display elements by charging and discharging the capacitive display elements with a voltage of a power source, the driver circuit comprising:

an integrated circuit connected to the capacitive display elements, the integrated circuit including a plurality of switching elements for charging and discharging the capacitive display elements; and

voltage dividing loads constituted by transistors connected between the power source and the integrated circuit, so that a voltage supplied to the capacitive display elements is divided between the transistors and the integrated circuit, wherein:

the voltage supplied to the capacitive display elements is increased in a stepwise manner; and

the transistors are turned off before the switching elements are turned on, and the transistors are turned on after the switching elements are turned on.

2. The driver circuit as in claim 1, wherein:

the switching elements in the integrated circuit are composed of plural pairs of switching elements; and

each pair of the switching elements constitutes a push-pull circuit and is composed of a first switching element for charging the capacitive display element and a second switching element for discharging the same element.

3. The driver circuit as in claim 2, wherein:

the first switching element is a P-channel LDMOS, and the second switching element is an N-channel LDMOS.

4. The driver circuit as in claim 2, wherein:

the first and the second switching elements are SCRs.

5. The driver circuit as in claim 4, wherein:

a discharging diode is connected in parallel to and in a reverse direction to each SCR.

6. The driver circuit as in claim 2, the driver circuit further including:

a diode connected between the power source and the first switching element in a forward direction of the first switching element;

a condenser one terminal of which is connected to a cathode of the diode;

a first auxiliary switching element connected to the other terminal of the condenser, the first auxiliary switching element being turned on for a predetermined period including an initial period for charging the capacitive display element, thereby forming a circuit for charging the condenser from the power source through the diode, and the first auxiliary switching element forming another circuit for supplying energy charged in the capacitive display element to the condenser; and

a second auxiliary switching element connected between the other terminal of the condenser and an anode of the diode, the second auxiliary switching element being turned on for a predetermined period after the first auxiliary switching element is turned off, thereby forming a circuit for superimposing charges stored in the condenser on voltage of the power source.

7. The driver circuit as in claim 2, the driver circuit further including:

a first diode connected between a plus terminal of the power source and the first switching element, so that an anode of the first diode is connected to the plus terminal of the power source;

a second diode connected between a minus terminal of the power source and the second switching element, so that a cathode of the second diode is connected to the minus terminal of the power source;

a first and a second auxiliary switching element connected in series between the anode of the first diode and the cathode of the second diode;

a first condenser and a third auxiliary switching element connected in series between the cathode of the first condenser and a junction of the first and second auxiliary switching elements; and

a second condenser and a fourth auxiliary switching element connected in series between the anode of the second diode and a junction of the first and second auxiliary switching elements, wherein:

the capacitive display element is driven alternatively with a positive voltage and a negative voltage;

when the capacitive display element is driven with the positive voltage, a potential of the minus terminal of the power source is fixed to a first base voltage so that a potential of the plus terminal of the power source becomes a plus potential, the second and third auxiliary switching elements are turned on during a predetermined period including a period for supplying the positive voltage to the capacitive display element, thereby forming a circuit including the first diode through which the first condenser is charged with the power source voltage and another circuit through which the first condenser is charged with an charging energy of the capacitive display element, and then the second auxiliary switching element is turned off and the first auxiliary switching element is turned on at the same time, thereby superimposing charges stored in the first condenser on the power source voltage; and

when the capacitive display element is driven with the negative voltage, a potential of the plus terminal of the power source is fixed to a second base voltage so that a potential of the minus terminal of the power source becomes a minus potential, the first and fourth auxiliary switching elements are turned on during a predetermined period including a period for supplying the negative voltage to the capacitive display element, thereby forming a circuit including the first and fourth auxiliary switching elements through which the second condenser is charged with the power source voltage, and then the first auxiliary switching element is turned off and the second auxiliary switching element is turned on at the same time, thereby superimposing charges stored in the second condenser on the power source voltage.

8. The driver circuit as in claim 7, wherein:

when the display element is driven with the positive voltage, the first auxiliary switching element is turned off and the second auxiliary switching element is turned on at the same time after the charges stored in the first condenser is superimposed on the power source voltage, thereby forming a circuit for supplying energy charged in the capacitive display element to the first condenser as a charging current.

9. The driver circuit as in claim 7, wherein:

when the display element is driven with the negative voltage, the second auxiliary switching element is turned off and the first auxiliary switching element is turned on at the same time after the charges stored in the second condenser is superimposed on the power source voltage, thereby forming a circuit for supplying energy charged in the capacitive display element to the second condenser as a charging current.

10. The driver circuit of claim 1, wherein the transistors are turned on after the switching elements are turned on so that switching losses occur at the transistors.

11. The driver circuit of claim 1, wherein the transistors are turned on after the switching elements are turned on to suppress an increase in temperature in the integrated circuit.

12. The driver circuit of claim 1, wherein the transistors are turned on after the switching elements are turned on so that switching losses occur at the transistors to thereby suppress an increase in temperature in the integrated circuit.

* * * * *

专利名称(译)	用于电容显示元件的驱动电路		
公开(公告)号	US6556177	公开(公告)日	2003-04-29
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[标]申请(专利权)人(译)	日本电装株式会社		
申请(专利权)人(译)	DENSO CORPORATION		
当前申请(专利权)人(译)	DENSO CORPORATION		
[标]发明人	KATAYAMA OSAMU IWAMURA TAKAHIRO		
发明人	KATAYAMA, OSAMU IWAMURA, TAKAHIRO		
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摘要(译)

具有多个电容元件（例如电致发光元件）的显示面板由连接在显示面板和电源之间的集成电路驱动。诸如MOSFET的一对功率晶体管连接在电源和集成电路之间。通过操作集成电路中的开关元件来选择性地对电容元件充电和放电。在集成电路中的开关元件闭合之后，与集成电路分开设置的一对晶体管导通或截止，使得开关损耗仅发生在集成电路外部的晶体管中，从而抑制集成电路中的温度升高。可以使用一对电阻器代替晶体管，以在电阻器和集成驱动器电路之间划分提供给电容元件的电压。包括用于再循环存储在电容元件中的一部分能量的电容器的步进再循环电路可以进一步连接在电源和一对晶体管之间，以进一步降低集成电路中的功耗。