





Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,  
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,  
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,  
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *without international search report and to be republished  
upon receipt of that report*

## Active matrix display

The invention relates to an active matrix display device, which display device includes display cells having opposite electrodes and driving means to address said display cells. The display device may belong to one of the groups of liquid crystal display devices, electrochromic display devices, electrophoretic display devices, reflective display devices including an interferometric modulator and luminescent display devices, foil displays or displays based on electrowetting. Examples of such active liquid crystal matrix display devices are TFT-LCDs or AM-LCDs, which are used in laptop computers and in organizers, but also find an increasingly wider application in GSM telephones.

The invention further relates to a sound and vision system based on such active matrix display devices.

Active matrix display devices are generally addressed by means of selection lines which periodically address (a group of) selection lines or rows, via switches such as MOS-transistors, while at the same time data (voltages) are provided via (a group of) data lines or columns. In some cases the display devices show frequency dependent behavior. Examples are the frequency dependent dielectric anisotropy of liquid crystal display devices and frequency dependent behavior of dielectrophoretic displays.

On the other hand it is possible to provide a sound and vision system with an acoustic transducer means by only or mainly making use of components already present in a known display device, without any significant loss of performance of the vision function itself.

In both cases it may be necessary to provide (a) picture element(s) with an oscillating voltage (or current). The present invention provides such a possibility. To this end in a display device according to the invention the driving means at the picture element comprise oscillating means.

In a first class of oscillating means (relaxation oscillators) the tuning of frequencies is based on the variation of a current supplied to a capacitor. To supply this current in a first embodiment the driving means of the display device at the picture element further comprise a current source. The current source may for example be part of a current mirror.

In a second embodiment the current source is voltage driven. By introducing a switch in the current path to the picture electrode, complementary to the selection switch, horizontal cross talk in the display device is reduced.

Since at the output of relaxation oscillators the amplitude of the output signal changes with frequency, preferably a buffer circuit is used to ensure frequency independent output voltages. The output of the buffer circuits may have either a fixed or a variable voltage, dependent on the application.

This also applies to a second class of oscillating means, so called ring oscillators.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Figure 1 schematically shows a (liquid crystal) display device according to the invention,

Figure 2 schematically shows a possible oscillator circuit for use in the (liquid crystal) display device according to Figure 1,

Figures 3 and 4 schematically show possible driving circuits for the oscillator of Figure 3 to be used in a picture element of the (liquid crystal) display device according to Figure 1,

Figures 5 and 6 schematically show further possible driving circuits for the oscillator of Figure 3 to be used in a picture element of the (liquid crystal) display device according to Figure 1, while

Figures 7 and 8 schematically show further possible oscillator circuits for use in the (liquid crystal) display device according to Figure 1 and

Figure 9 schematically shows a further possible oscillator circuit for use in the (liquid crystal) display device according to Figure 1.

The Figures are diagrammatic and not drawn to scale. Corresponding elements are generally denoted by the same reference numerals.

Figure 1 is an electric equivalent circuit diagram of a part of a display device to which the invention is applicable. It comprises a matrix of pixels at crossings of row or

selection electrodes 7 and column or data electrodes 6. The row electrodes are consecutively selected by means of a row driver 4, while the column electrodes are provided with data via a data register 5. To this end, incoming data 2 are first processed, if necessary, in a processor 3. Mutual synchronization between the row driver 4 and the data register 5 takes place via drive lines 9. Signals from the row driver 4 select the picture elements via driving circuits 10, which drive oscillator circuits 11. The signal which is present at the column electrode 6 is transferred via the driving circuits 10 and the oscillator circuits 11 to a picture electrode of a pixel 8. The other picture electrodes are connected to, for example, one (or more) common counter electrode(s) 12. The oscillator circuits 11 have (common) supply lines 13.

A typical oscillator circuit 11, a relaxation oscillator, is shown in Figure 2 and comprises cross-coupled transistors (in this case p-type field effect transistors) 14, 15 in series with resistors 16, 17 at their source connections, acting as a differential amplifier, whereas the drains are connected to current sources 18, 19, each supplying a current I.

The frequency f of such an oscillation circuit at its output 21 is determined by the current I and by the value C of a capacitor 20 between both drain connections, in such a way that f is a function of I and C ( $f = I / C \cdot V(C)$ , V is the voltage over capacitor 20). So by varying the current I the frequency of oscillation of a pixel 8 is varied.

Figure 3 shows one of many possible circuits to impose a current I in the oscillator circuit 11 of Figure 2, in this case by means of a current mirror circuit. A data current  $I_1$  (data line 6) is sampled by closing switches 21 ( $S_1, S_2$ ) via a selection line 7. As a consequence a current  $I_1$  flows in transistor 22 ( $T_1$ ). By the current mirroring action a current  $I_2 = k \cdot I_1$  (k being the multiplication factor of the current mirror circuit) flows in transistor 23 ( $T_2$ ). In this example all switches 21, transistors 22, 23 can be realized in amorphous silicon technology, just like the transistors 14, 15 of the oscillator circuit 11 of Figure 2. On the other hand the functions can be realized in p-type or n-type polysilicon technology. Capacitance 24 ( $C_1$ ) is loaded by the current  $I_2$  to a certain value. After opening switches 21 ( $S_1, S_2$ ) via selection line 7 this current  $I_2$  continues to flow in transistor 23 ( $T_2$ ) and the oscillator circuit 11.

In the driving circuit of Figure 4 the same transistor 25 ( $T_4$ ), in this case an n-type field effect transistor is used for sampling the data current and for driving the oscillator circuit 11. This so-called "single TFT current mirror circuit" has the advantage that it is self-compensating and corrects for any variations in transistor characteristics (such as mobility and threshold voltage). A data current  $I_1$  (data line 6) is sampled by closing switches 21, 21' ( $S_1, S_1'$ , or making n-type field effect transistors  $T_1, T_1'$  conduct) via a selection line 7. As a

consequence a current  $I_1$  flows in transistor 21 ( $T_1$ ) and in transistor 21' ( $T_1'$ ) loading capacitance 24.

Capacitance 24 ( $C_1$ ) is loaded by the current  $I_2$  to a voltage  $V(I_1)$  at which the entire current  $I_1$  flows in transistor 25 ( $T_4$ ) and in transistor 22' ( $T_1'$ ) the current has stopped flowing. After opening switches 21 ( $S_1, S_2$ , transistors  $T_1, T_1'$  are no longer conducting) and closing p-type field effect transistor 26 ( $T_3$ ) via selection line 7 this current  $I_1$  continues to flow in transistor 25 ( $T_4$ ) and also flows in transistor 26 ( $T_3$ ) and the oscillator circuit 11 and consequently defines the oscillating frequency of pixel 8.

In the embodiments of Figures 5 and 6 the voltage at capacitance 24 ( $C_1$ ) is determined by a voltage on the data lines 6 during selection via selection lines 7. After selection the current source element, comprising capacitance 24 ( $C_1$ ) and transistor 25 ( $T_4$ ), determines the current in the oscillator circuit 11.

Figures 7 and 8 show variations of the oscillator circuit 11 of Figure 2 and comprise cross-coupled p-type field effect transistors 14, 15 in series with n-type field effect transistors 34, 35 acting as resistors, at their source connections. The current sources 18, 19 of Figure 2, each supplying a current  $I$ , have been realized in this embodiment by means of p-type field effect transistors 38, 39 and a capacitor 36.

The frequency  $f$  of such an oscillation circuit at its output 21 is determined by the current  $I$  in transistors 38, 39 and by the value  $C$  of a capacitor 20 again. The output voltage in this case however changes with frequency, whereas in many applications a substantially constant output voltage is needed. The latter is realized in the embodiment of Figure 7 by introducing an output buffer comprising transistors 33, 34. The frequency on its turn is, as mentioned above, dependent on the current  $I$ . To obtain a certain frequency this current  $I$  can be altered by varying the voltage on the gates of transistors 38, 39 via switch 31 which connects a variable voltage at point 30 to said gates. In a typical example a variation of the voltage at point 30 between 5.4 V and 6 V provides in this example an oscillation bandwidth varying from 330 Hz to 10 kHz for the oscillating circuit. The actual oscillation bandwidth is determined by transistor parameters of in this case the TFT transistors like gate width, gate length etc.

Figure 8 shows an oscillation circuit similar to the circuit of Figure 7 in which the variation of the pixel voltage can be regulated via a voltage on input 40 (e.g. 1.5 V- 2.9 V) if necessary by means of switch 41. If necessary the input voltage can be stored on an extra capacitor 50.

Another type of oscillation circuit, a ring oscillator, is shown in Figure 6. The ring oscillator comprises a series of identical elements 9 (each having complementary field effect transistors 42, 43 and capacitors 44) in a feedback loop 45, and the complete circuit has again an output buffer comprising transistors 33, 34. To obtain a certain frequency a voltage is provided, if necessary via the switch 31, on input 30 (e.g. 3.5 V- 6.5 V) the variation of the pixel voltage can be regulated via a voltage on input 46 via switch 47.

The protective scope of the invention is not limited to the embodiments described, while the invention is also applicable to other display devices, for example, (O) LED displays, electrophoretic displays, electrochromic displays, plasma displays, reflective display devices including an interferometric modulator and other display devices based on e.g. field emission electrowetting etc.

Alternatively, flexible substrates (synthetic material) may be used (wearable displays, wearable electronics).

The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Reference numerals in the claims do not limit their protective scope. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements other than those stated in the claims. Use of the article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

## CLAIMS:

1. An active matrix display device, which display device includes display cells having opposite electrodes and driving means to address said display cells, the driving means at the picture element further comprising oscillating means.
- 5 2. An active matrix display device as claimed in Claim 1 the driving means at the picture element further comprising a current source.
3. An active matrix display device as claimed in Claim 2 the current source being part of a current mirror.
- 10 4. An active matrix display device as claimed in Claim 3 the current paths of the current mirror having a common transistor.
5. An active matrix display device as claimed in Claim 2 the current source being  
15 voltage driven.
6. An active matrix display device as claimed in Claim 5 the current source being biased via a selection switch a switch, complementary to the selection switch, being provided in the current path between the current source and the picture electrode.
- 20 7. An active matrix display device as claimed in Claim 1 the oscillating means driving the picture elements via a buffer circuit.
8. An active matrix display device as claimed in Claim 1, the output of the buffer  
25 circuit having a variable voltage.
9. An active matrix display device as claimed in Claim 1 the oscillating means comprising a ring oscillator.



10. An active matrix display device as claimed in Claim 1, wherein the display device is one of the groups of liquid crystal display devices, electrochromic display devices, electrophoretic display devices, reflective display devices including an interferometric modulator and luminescent display devices.

5

11. A sound and vision system comprising an active matrix display device as claimed in Claim 1

1/6

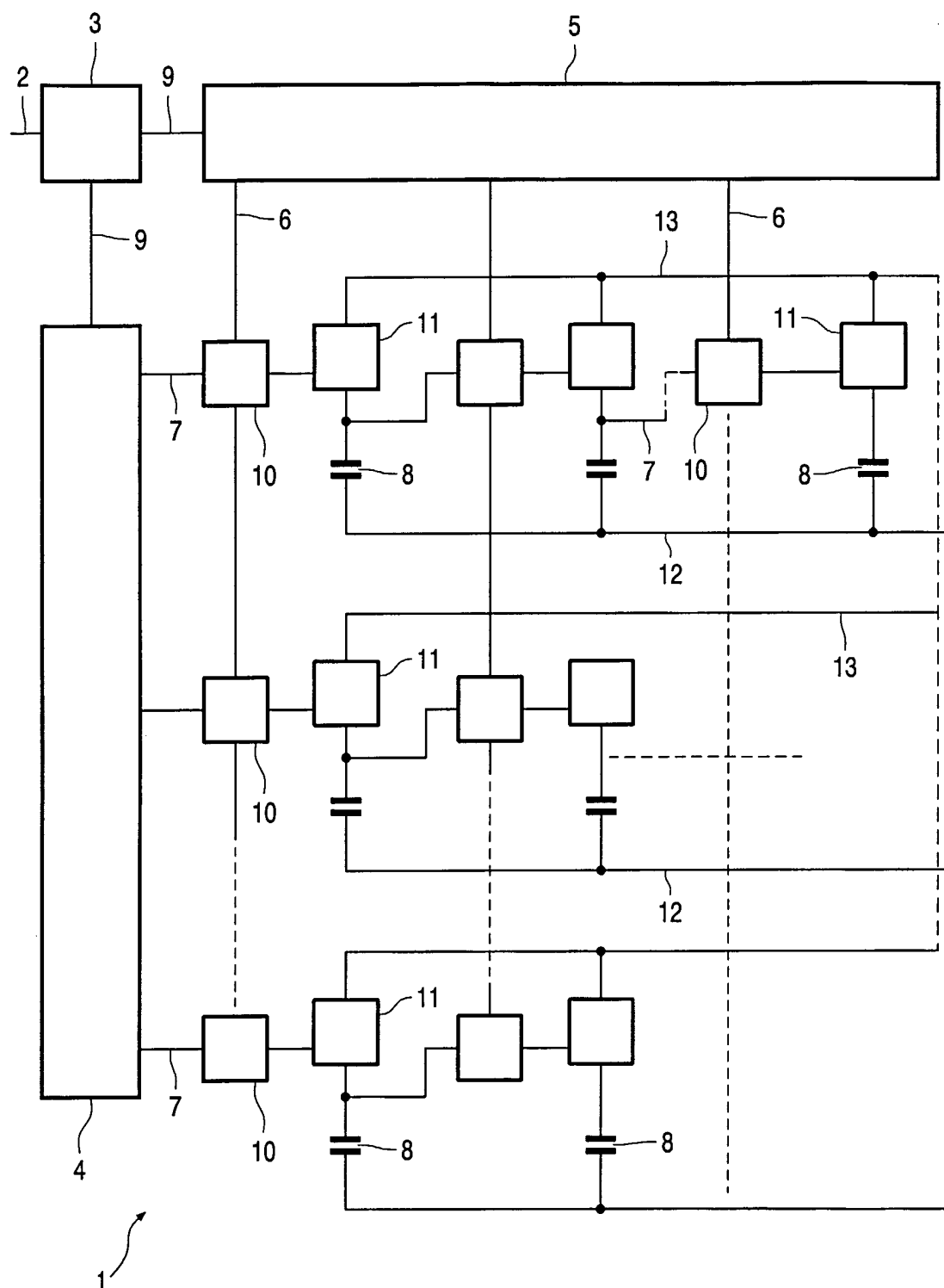


FIG. 1

2/6

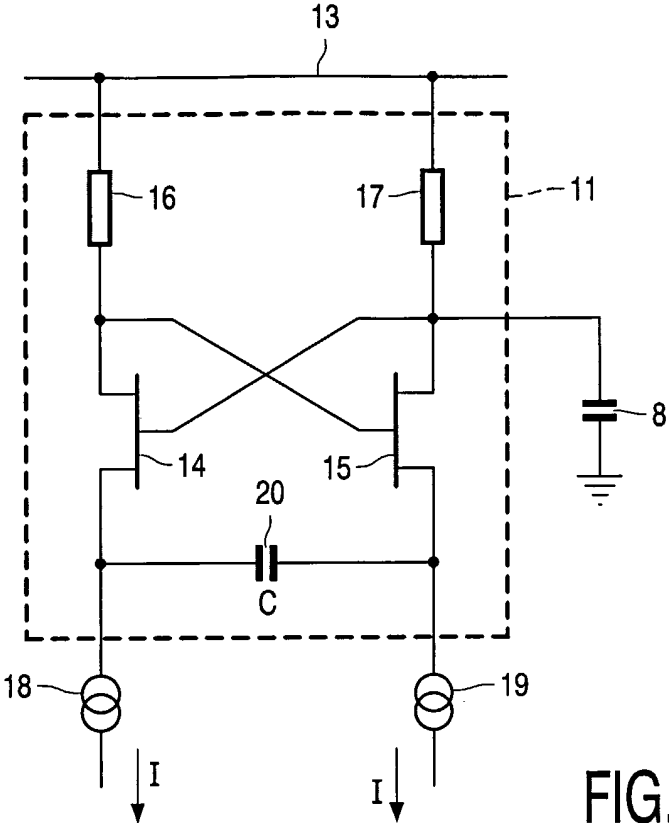


FIG. 2

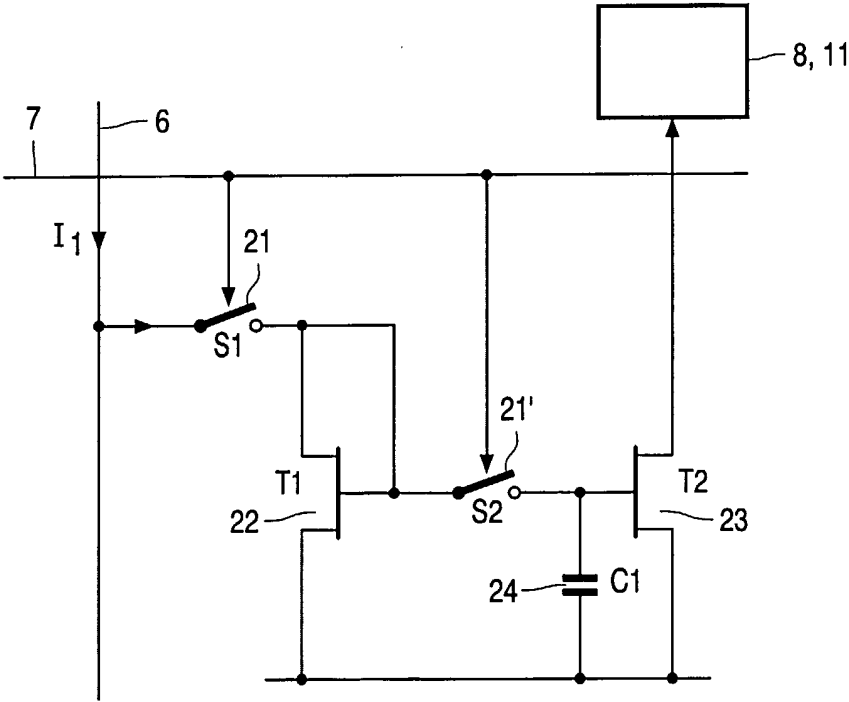


FIG. 3

3/6

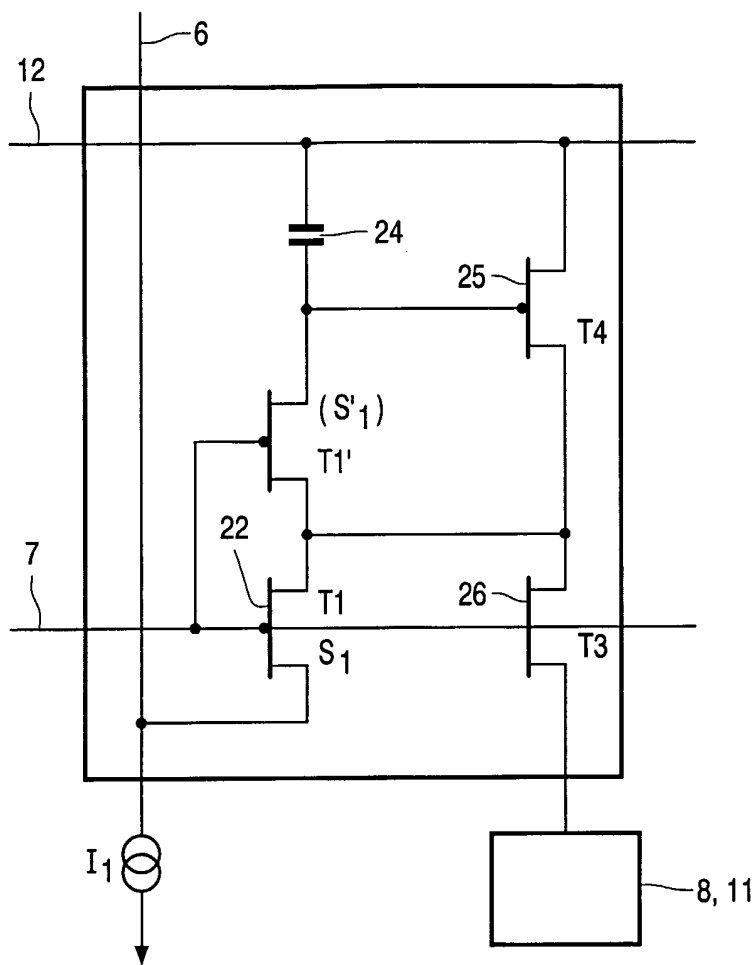


FIG. 4

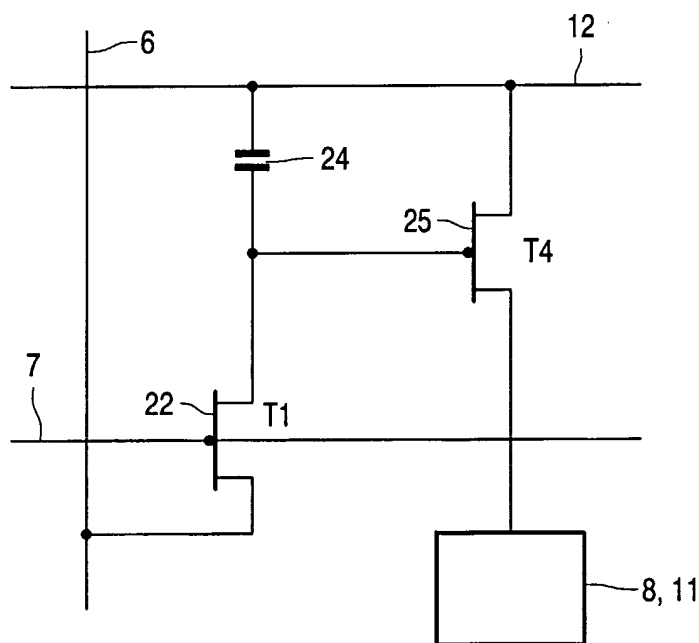


FIG. 5

4/6

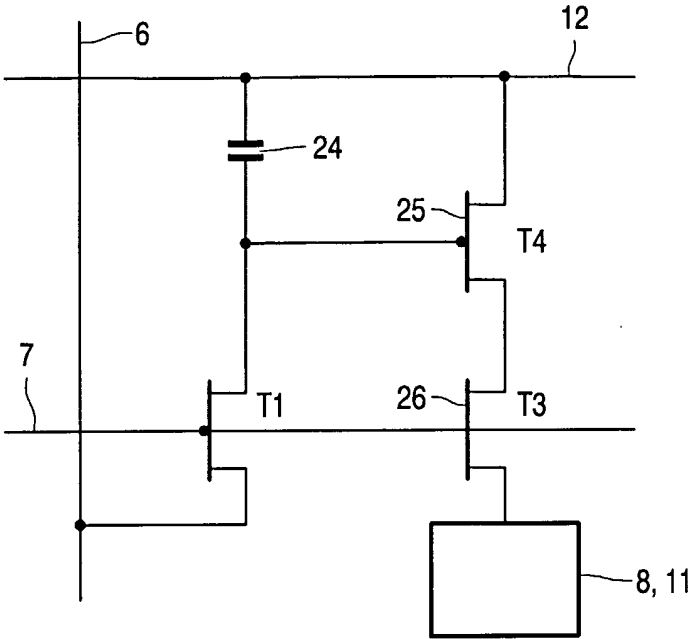


FIG. 6

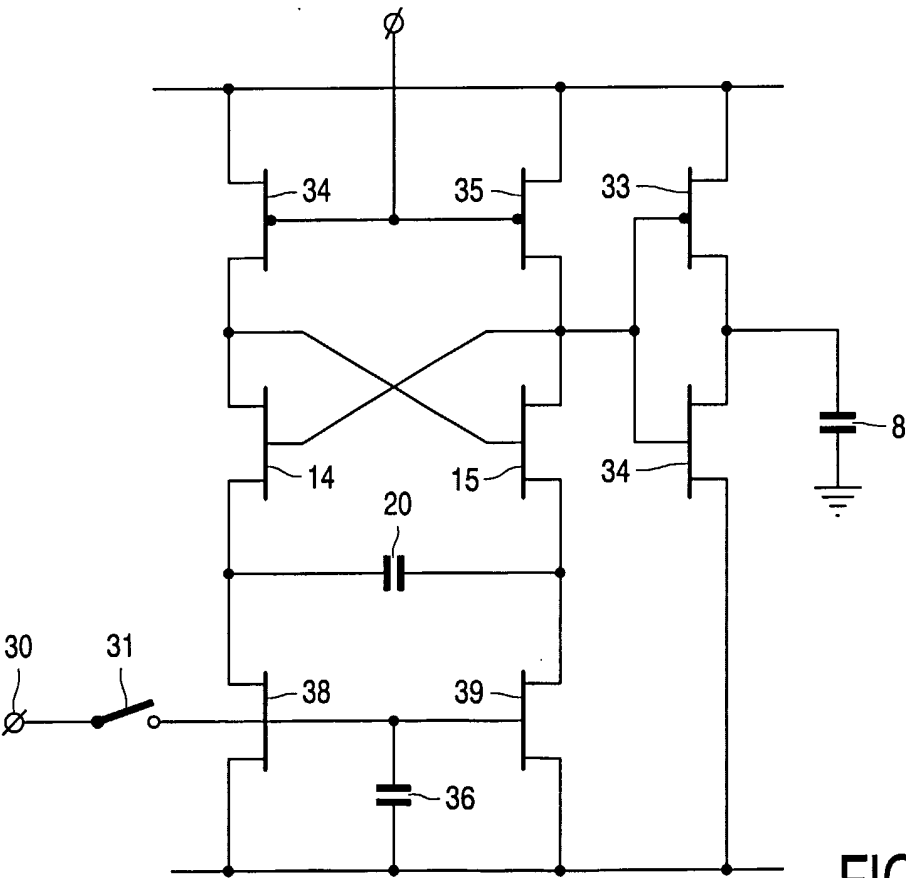


FIG. 7

5/6

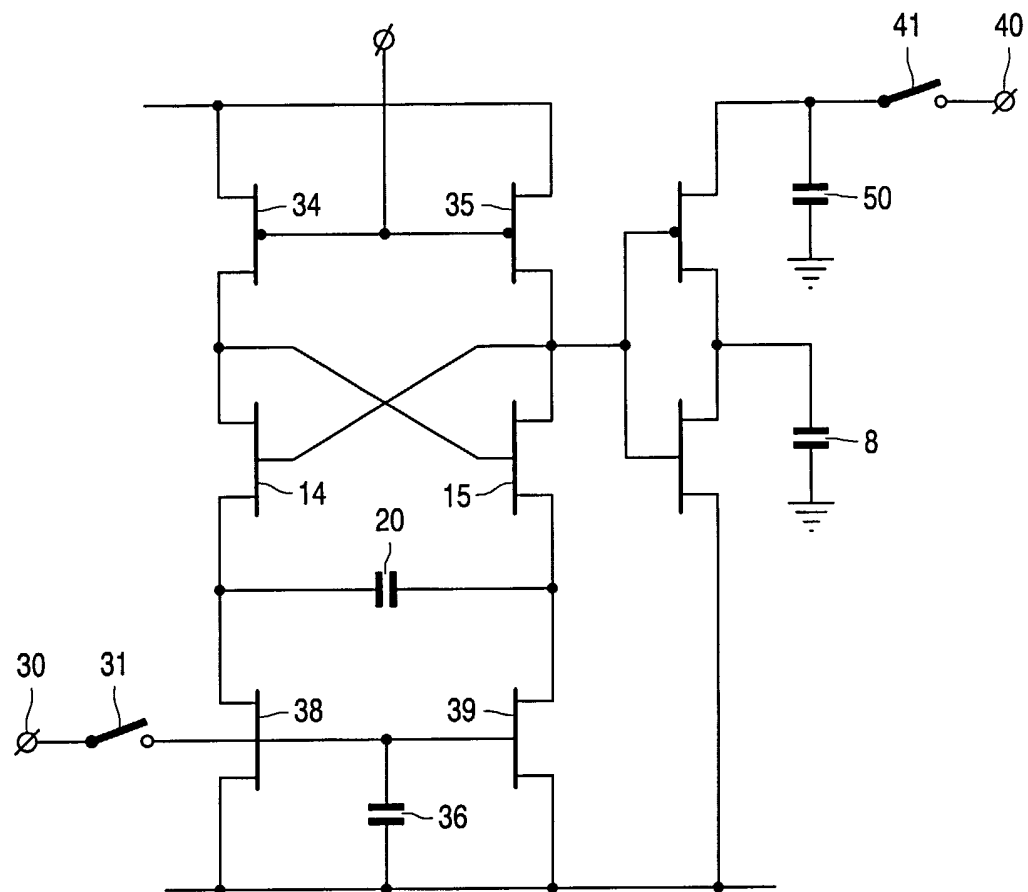


FIG. 8

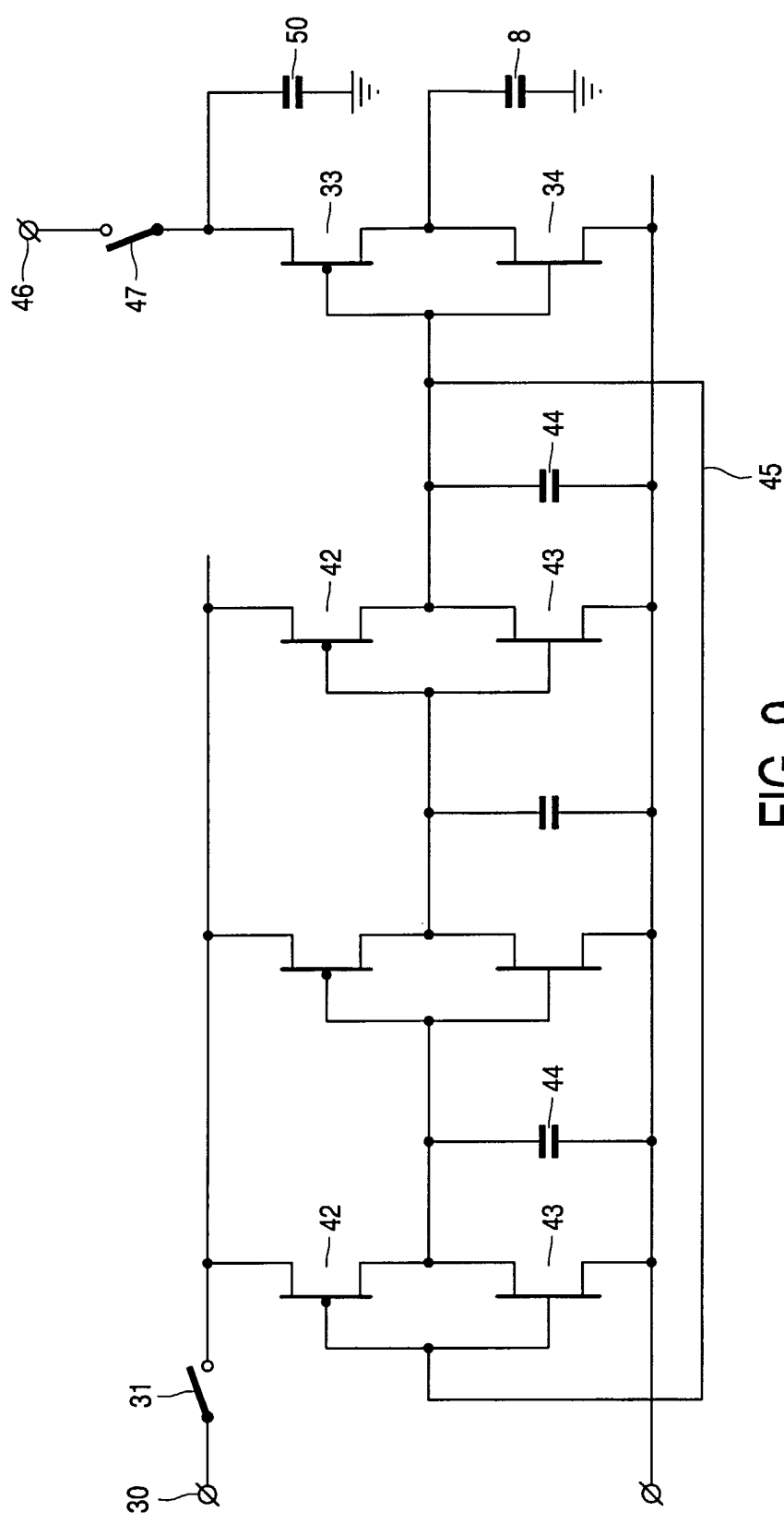


FIG. 9