(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 102 295 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.05.2001 Bulletin 2001/21

(51) Int Cl.[7]: **H01H 33/59**

(21) Application number: **00123740.3**

(22) Date of filing: **31.10.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **17.11.1999 JP 32643999**

(71) Applicant: **Hitachi, Ltd.**
Chiyoda-ku, Tokyo 101-8010 (JP)

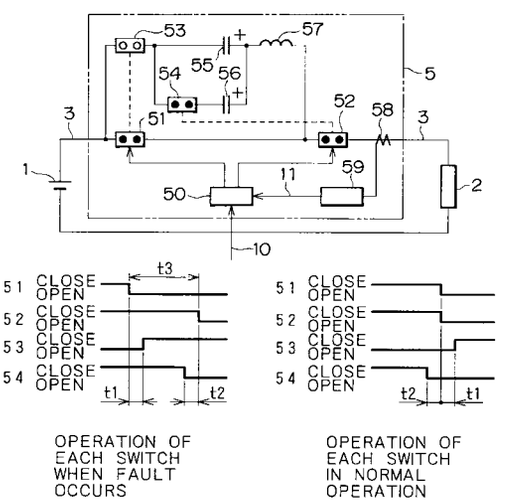
(72) Inventors:
- **Hosoda, Minoru**
  Hitachi-shi, Ibaraki 316-0001 (JP)
- **Oouchi, Shigetoshi**
  Hitachi-shi, Ibaraki 317-0076 (JP)
- **Yoshida, Tooru**
  Hitachi-shi, Ibaraki 316-0036 (JP)
- **Matsuda, Yoshihiko**
  Hitachi-shi, Ibaraki 316-0035 (JP)
- **Koga, Satoru**
  Hitachi-shi, Ibaraki 316-0033 (JP)

(74) Representative: **Strehl Schübel-Hopf & Partner**
Maximilianstrasse 54
80538 München (DE)

(54) Commutation type direct-current breaker

(57) A commutation type direct-current breaker (5) according to the present invention comprises a first main switch (51) and a second main switch (52) inserted in series into a direct-current circuit that connects a direct-current power supply (1) with a load (2); a commutating circuit connected in parallel with the first main switch (51) which includes a first auxiliary switch (53) operating in interlocked relation with the first main switch (51), a second auxiliary switch (54) operating in interlocked relation with the second main switch (52), a first capacitor (55), a second capacitor (56), and a reactor (57); a control unit (50) for controlling opening and closing operations of the two main switches (51,52); and an overcurrent tripping device (59). According to the above configuration, it is possible to prevent hazards caused by capacitor charging voltage by disconnecting the circuit on the load side from two capacitors having different capacitance values when the breaker is opened. Also, it is possible to reduce the number of systems to be supplied with an instruction for switch opening or closing to two.

FIG.1



EP 1 102 295 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a commutation type direct-current breaker, and particularly to a circuit configuration of a commutation type direct-current breaker that includes two pairs of main and auxiliary switches and two capacitors having different capacitance values, in which a commutating circuit corresponding to the kind of current to be interrupted can be chosen from two systems by selecting switch conditions for the two pairs of main and auxiliary switches.

[0002] Japanese Patent Laid-open No. Hei 8-148066 discloses a commutation type direct-current breaker having a commutating circuit configuration that includes two capacitors having different capacitance values connected in parallel with each other in a commutating circuit of the commutation type direct-current breaker so that the magnitude of commutating current can be selected.

[0003] However, the circuit configuration according to the prior art mentioned above allows a circuit on the load side and the two capacitors having different capacitance values to remain connected with each other. This may constitute a hazard because a capacitor charging voltage remains applied to the circuit on the load side even when the breaker is opened. In addition, a main contact, a first switch, and a second switch are each controlled independently, and therefore it is necessary to control three systems.

SUMMARY OF THE INVENTION

[0004] An object of the present invention is to provide a commutation type direct-current breaker having a circuit configuration that prevents a hazard when the breaker is opened and also reduces the number of systems to be supplied with an instruction for switch opening or closing to two.

[0005] In order to achieve the above object, according to the present invention, there are provided a first main switch and a second main switch inserted in series into a direct-current circuit that connects a direct-current power supply with a load; a series circuit having a first auxiliary switch, a first capacitor and a reactor which are connected in parallel with the first main switch; a series circuit having a second auxiliary switch and a second capacitor which are connected in parallel with the first capacitor; and a control unit for controlling opening and closing operations of the first main switch and the second main switch.

[0006] In addition, according to the present invention, the first main switch and the first auxiliary switch are in switch states different from each other, the first auxiliary switch being closed after the first main switch opens. Also, the second main switch and the second auxiliary switch are in the same switch state, the second auxiliary switch being opened before the second main switch opens.

[0007] Furthermore, according to the present invention, the ratio between the capacitance of the first capacitor and that of the second capacitor is set to be in a range of 1:0.25 to 1:18. Moreover, according to the present invention, n capacitors (where n is an integer in a range of $1 \leqq n \leqq 18$) each having the same capacitance as the first capacitor and connected in parallel with one another are used as a second capacitor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a circuit diagram of a commutation type direct-current breaker according to a first embodiment of the present invention;

[0009] Fig. 2 is a circuit diagram of a commutation type direct-current breaker according to a second embodiment of the present invention;

[0010] Fig. 3 is a circuit diagram of a commutation type direct-current breaker according to a third embodiment of the present invention; and

[0011] Fig. 4 is a circuit diagram of a commutation type direct-current breaker according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A first embodiment of the present invention will be described with reference to Fig. 1.

[0013] Reference numeral 1 denotes a direct-current power supply which, in a typical direct-current feeder circuit, supplies a positive pole voltage of 1500 V. Reference numeral 2 denotes a load of a direct-current electric car or the like. Reference numeral 3 denotes a feeder line that supplies electricity to the load. Reference numeral 4 denotes a return wire that connects the load 2 to the direct-current power supply 1. Reference numeral 5 denotes a commutation type direct-current breaker inserted at an intermediate point of the feeder line 3 to perform switching of a current supplied from the direct-current power supply 1 to the load 2. The commutation type direct-current breaker 5 comprises a control unit 50, a first main switch 51, a second main switch 52, a first auxiliary switch 53, a second auxiliary switch 54, a first capacitor 55, a second capacitor 56, a reactor 57, a current transformer 58, and an overcurrent tripping device 59. The first main switch 51 and the second main switch 52 are inserted in the feeder line 3 in series, and the first main switch 51 is disposed on the side of the direct-current power supply 1 while the second main switch 52 is disposed on the load 2 side. A series circuit of the first auxiliary switch 53, the first capacitor 55, and the reactor 57 is connected in parallel with the first main switch 51, while a series circuit of the second auxiliary switch 54 and the second capacitor 56 is connected in parallel with the first capacitor 55. The current trans-

former 58 is placed on the feeder line 3 to detect a current flowing through the feeder line 3 and thereby input a current value to the overcurrent tripping device 59. The overcurrent tripping device 59 is provided with a value set for automatic breaking, and outputs an instruction 11 for switch opening when a value of the current flowing through the feeder line 3 exceeds the value set for automatic breaking. The control unit 50 receives an external instruction 10 or an instruction 11 for switch opening from the overcurrent tripping device 59, and thereby provides an instruction for switch opening only to the first main switch 51 and the second main switch 52.

[0014] The first auxiliary switch 53 operates in interlocked relation with the first main switch 51. Specifically, the first auxiliary switch 53 closes with a delay of a time t1 (for example 2 ms) after the first main switch 51 opens. The second auxiliary switch 54 operates in interlocked relation with the second main switch 52. Specifically, the second auxiliary switch 54 opens a time t2 (for example 2.5 ms) before the second main switch 52 opens. Thus, it suffices to provide an instruction to open or to close from the control unit 50 to only the first main switch 51 and the second main switch 52.

[0015] When the load 2 is operated, the first main switch 51 and the second main switch 52 are closed. Under this condition, a direct current with a voltage of 1500 V is applied to the load 2, and thereby the load 2 becomes operable. In this case, the first auxiliary switch 53, which is in an switch state opposite from that of the first main switch 51, is open, while the second auxiliary switch 54, which is in the same switch state as that of the second main switch 52, is closed. The first capacitor 55 and the second capacitor 56 are charged in advance at +2000 V with respect to the direct-current power supply 1 side.

[0016] If a failure in the load 2 or a ground fault in the feeder line 3 occurs, a very large, fast rising fault current, which is determined by a circuit constant, flows through the feeder line 3. When the circuit constant represents a circuit resistance of 15 mΩ and a circuit inductance of 150 μH, for example, the maximum value reached is 100 kA, and the maximum rush rate is 10 kA/ms. When such a fault current occurs, the fault current needs to be interrupted very rapidly in order to minimize adverse effects of the overcurrent on the apparatus. In the commutation type direct-current breaker 5, the current transformer 58 first detects a fault current value and then inputs the fault current value to the overcurrent tripping device 59. When an automatic breaking setting value of the overcurrent tripping device 59 is set at 12000 A, for example, the overcurrent tripping device 59 sends an instruction 11 for switch opening to the control unit 50 at the moment when the fault current value reaches 12000 A. The control unit 50 first opens the first main switch 51. The first auxiliary switch 53 closes with a delay of a time t1 (for example 2 ms) after the opening of the first main switch 51. This results in formation of an LC resonance circuit including the first capacitor 55, the second capacitor 56, the reactor 57, the first main switch 51, the first auxiliary switch 53, and the second auxiliary switch 54. Then the first capacitor 55 and the second capacitor 56, which have been charged in advance, discharge to feed a commutating current in an opposite direction from that of the fault current into the first main switch 51. When the capacitance of the first capacitor 55 is set at 600 μF and the capacitance of the second capacitor 56 is set at 1200 μF, the maximum commutating current value in the opposite direction is 40 kA. Thus, when tl is set in such a way that the first auxiliary switch 53 closes before the fault current value reaches 40 kA, the fault current and the commutating current cancel out each other. Then, circuit breaking by the first main switch 51 is ended when the current of the first main switch 51 becomes zero. Following the opening of the first main switch 51, the control unit 50 opens the second main switch 52 after a delay of a time t3 (for example 12 ms). The second auxiliary switch 54 opens a time t2 (for example 2.5 ms) before the opening of the second main switch 52. In this case, when t3 is set at a value that satisfies t3 > t1 + t2 (for example 12 ms (t3) > 2 ms (t1) + 2.5 ms (t2) = 4.5 ms), the second auxiliary switch 54 will not open before the closing of the first auxiliary switch 53. Therefore, it is possible for the second capacitor 56 to discharge together with the first capacitor 55, thereby allowing a large fault current as described above to be interrupted. The second main switch 52 completes circuit breaking when the first capacitor 55 and the second capacitor 56 have been charged by the direct-current power supply 1, and the circuit current becomes zero.

[0017] On the other hand, breaking operation of the commutation type direct-current breaker 5 in normal operating conditions is based on an external instruction 10. On receiving an external instruction 10 for switch opening, the control unit 50 simultaneously opens the first main switch 51 and the second main switch 52. In this case, the second auxiliary switch 54 has already been opened a time t2 (for example 2.5 ms) before the opening of the second main switch 52. Therefore, when the first auxiliary switch 53 closes, an LC resonance circuit including the first capacitor 55, the reactor 57, the first main switch 51, and the first auxiliary switch 53 is formed. Then, of the first capacitor 55 and the second capacitor 56, which have been charged, only the first capacitor 55 discharges to feed the first main switch 51 with a commutating current in a direction opposite to that of a load current flowing in normal operating conditions. The maximum value of the load current can reach 12000 A, which is a value set in the overcurrent tripping device 59. However, the maximum value of the commutating current obtained when only the first capacitor 55 discharges is 14 kA. Therefore, the maximum value 12000 A of the load current can be cancelled out by the commutating current. Then, circuit breaking by the first main switch 51 is ended when the current of the first main switch 51 becomes zero. Thus, it is possible to interrupt

the load current.

[0018] Thus, since the second main switch 52 is provided, the load 2, the first capacitor 55, and the second capacitor 56 are disconnected after the opening of the breaker. Therefore, it is possible to prevent hazards in the circuit on the load side that may be caused by capacitor charging voltage. Also, when the control unit 50 opens the first main switch 51 and the second main switch 52 by receiving an instruction 11 for switch opening from the overcurrent tripping device 59 in the case of a fault current and receiving an external instruction 10 in the case of load current, the control unit 50 can interrupt both the fault current and the load current by selecting a commutating circuit depending on which of the two currents is flowing.

[0019] In Fig. 1, the first auxiliary switch 53, the first capacitor 55, and the reactor 57, which form a series circuit, may be arranged in any given order. For example, Fig. 2 is a circuit diagram showing a case where the reactor 57 is disposed between the first auxiliary switch 53 and the first capacitor 55. In addition, Fig. 3 is a circuit diagram showing a case where the reactor 57 is disposed between the first main switch 51 and the second main switch 52. In this case, it is possible to obtain an effect of decreasing a rush rate when a fault current occurs, because a reactor component of the circuit constant is increased.

[0020] In general, a value set for automatic breaking in the overcurrent tripping device 59 is 3000 A to 12000 A, and the maximum value of commutating current needs to be 15000 A to 55000 A. Therefore, the ratio between the capacitance of the first capacitor 55 and that of the second capacitor 56 can assume any value within a range having a minimum of 12000 A:(15000 A - 12000 A) = 1:0.25 and a maximum of 3000 A: (55000 A - 3000 A) = 1:17.3.. ≒1:18. Fig. 4 is a circuit diagram showing a case where n capacitors (n is a positive integer) each having the same capacitance as the first capacitor 55 and connected in parallel with one another are used as a second capacitor 56, which connection is utilized especially when the ratio between the capacitance of the first capacitor 55 and that of the second capacitor 56 is 1:n.

[0021] According to the present invention, it is possible to prevent hazards caused by capacitor charging voltage by disconnecting the circuit on the load side from two capacitors having different capacitance values when the breaker is opened. Also, it is possible to reduce the number of systems to be supplied with an instruction for switch opening or closing to two.

Claims

1. A commutation type direct-current breaker comprising:

   a first main switch and a second main switch inserted in series into a direct-current circuit that connects a direct-current power supply with a load;
   a series circuit having a first auxiliary switch, a first capacitor, and a reactor which are connected in parallel with the first main switch;
   a series circuit having a second auxiliary switch and a second capacitor which are connected in parallel with the first capacitor; and
   a control unit for controlling opening and closing operations of said first main switch and said second main switch.

2. A commutation type direct-current breaker comprising:

   a first main switch and a second main switch inserted in series into a direct-current circuit that connects a direct-current power supply with a load;
   a series circuit having a first auxiliary switch, a first capacitor, and a reactor which are connected in parallel with the first main switch;
   a series circuit having a second auxiliary switch and a second capacitor which are connected in parallel with the first capacitor;
   a control unit for controlling opening and closing operations of said first main switch and said second main switch; and
   an overcurrent tripping device for outputting an instruction for switch opening to the control unit when a value of a current flowing through the circuit reaches a specified value.

3. A commutation type direct-current breaker as claimed in claim 1, wherein said first main switch and said first auxiliary switch are in switch states different from each other, the first auxiliary switch being closed after the first main switch opens.

4. A commutation type direct-current breaker as claimed in claim 1, wherein said second main switch and said second auxiliary switch are in the same switch state, the second auxiliary switch being opened before the second main switch opens.

5. A method for controlling a commutation type direct-current breaker including a first main switch and a second main switch inserted in series into a direct-current circuit that connects a direct-current power supply with a load; a first auxiliary switch operating in interlocked relation with the first main switch; a second auxiliary switch operating in interlocked relation with the second main switch; a first capacitor; a second capacitor; and a reactor; wherein opening and closing operations of said first main switch and said second main switch are controlled, said method comprising:

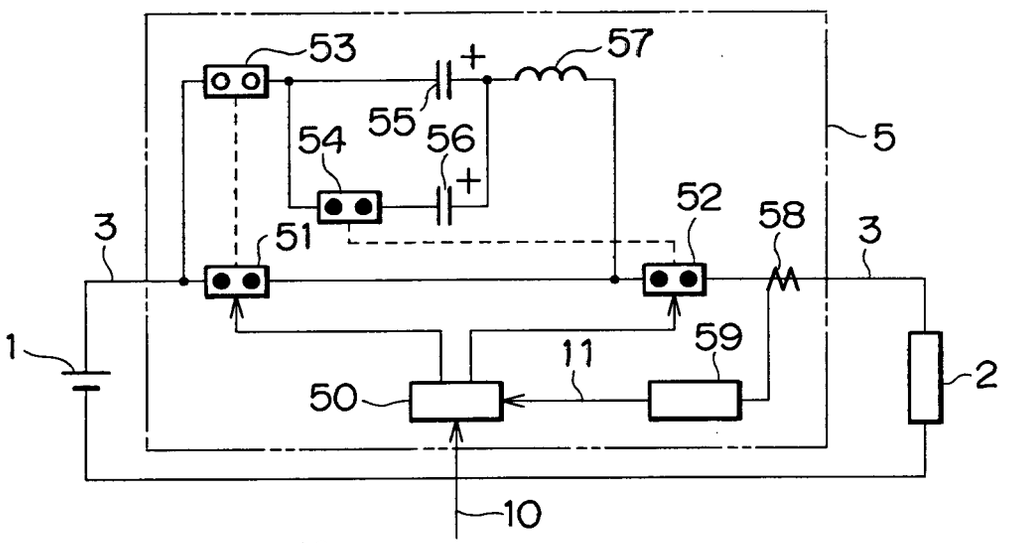
using properly a control method of opening the second main switch after the opening of the first main switch or a control method of opening the first main switch and the second main switch simultaneously depending on operating conditions.

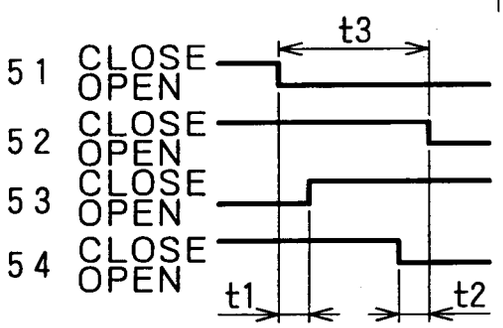
6. A commutation type direct-current breaker as claimed in claim 1, wherein a vacuum interrupter is used for each of said first main switch, said second main switch, said first auxiliary switch, and said second auxiliary switch.

7. A commutation type direct-current breaker as claimed in claim 1, wherein a ratio between the capacitance of said first capacitor and that of said second capacitor is in a range of 1:0.25 to 1:18.

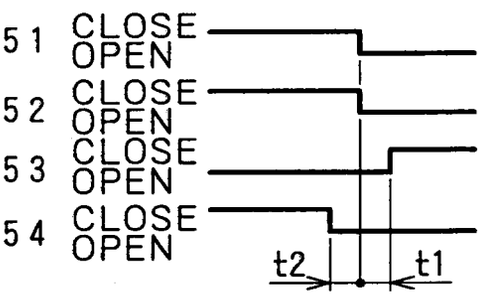
8. A commutation type direct-current breaker as claimed in claim 1, wherein n capacitors (where n is an integer in a range of $1 \leqq n \leqq 18$) each having the same capacitance as the first capacitor and connected in parallel with one another are used as said second capacitor.

FIG.1





OPERATION OF EACH SWITCH WHEN FAULT OCCURS



OPERATION OF EACH SWITCH IN NORMAL OPERATION

FIG. 2

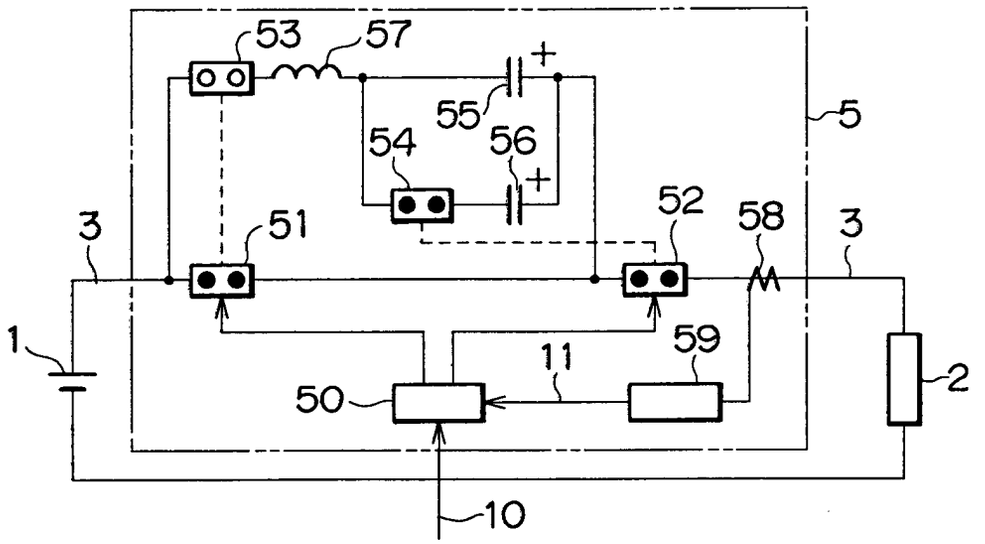

53
57
55
+
5
54
56
+
3
51
52
58
3
1
59
11
2
50
10

FIG. 3

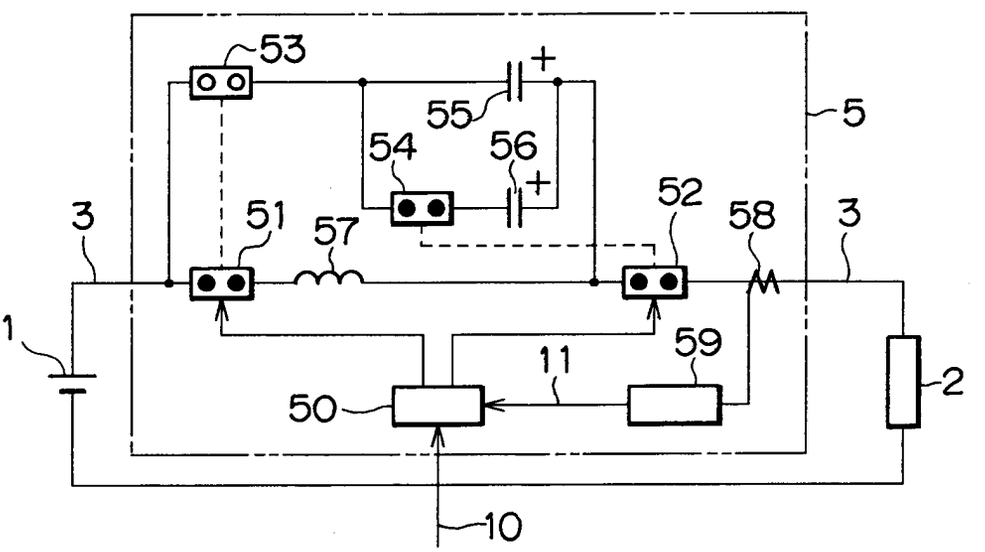
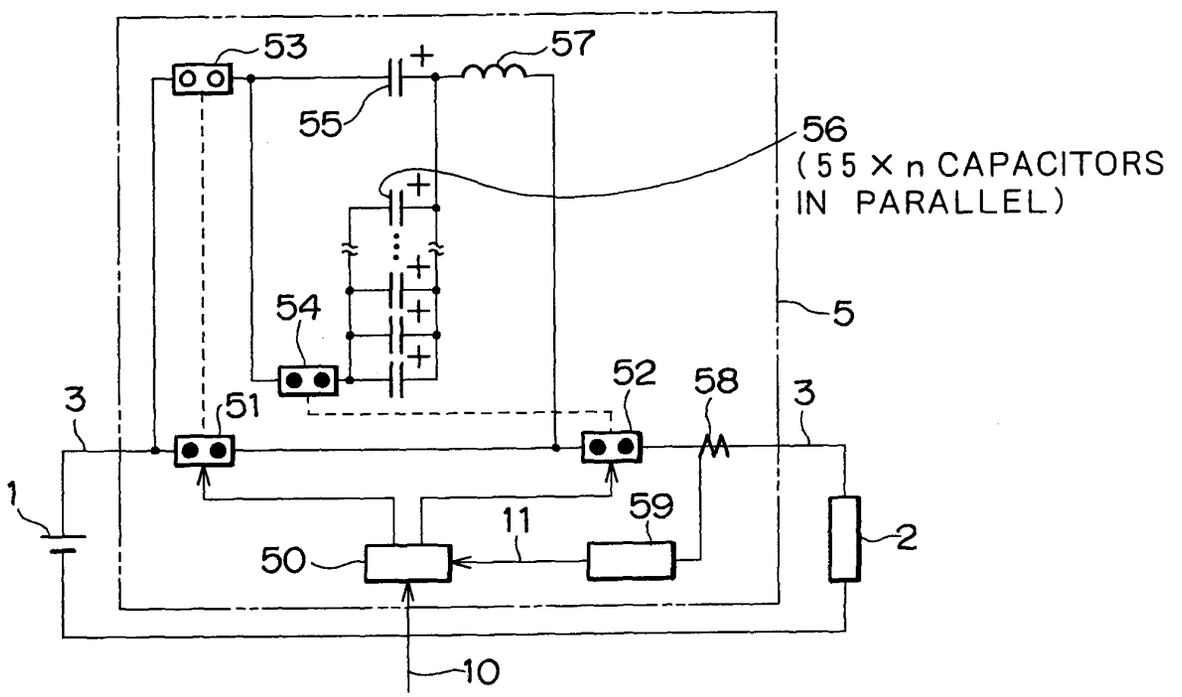

53
55
+
5
54
56
+
3
51
57
52
58
3
1
59
11
2
50
10

FIG. 4


53
57
55
56
(55 X n CAPACITORS
IN PARALLEL)
54
5
52
58
3
51
3
1
59
11
2
50
10