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(72) Inventors:

- **TOMIYASU, Kunihiko**
Chiyoda-ku, Tokyo 100-8280 (JP)
- **SATO, Takashi**
Chiyoda-ku, Tokyo 100-8280 (JP)
- **YABU, Masato**
Chiyoda-ku, Tokyo 101-0022 (JP)
- **TAMURA, Kozo**
Chiyoda-ku, Tokyo 101-0022 (JP)
- **TAI, Yuuki**
Chiyoda-ku, Tokyo 101-0022 (JP)

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

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to an electromagnetic operation device and an electromagnetic operation-type switching apparatus and, more particularly, to an electromagnetic operation device and an electromagnetic operation-type switching apparatus which are suitable for operating a switching device, such as a circuit breaker, by using electromagnetic force.

BACKGROUND ART

[0002] In general, when a switching device such as a circuit breaker is operated, an electromagnetic operation device that employs an electromagnet is used. This electromagnetic operation device is generally composed of an electromagnet coil for forming the electromagnet, a capacitor accumulating energy for exciting the electromagnet coil, and a control circuit for causing the electromagnet coil and the capacitor to be electrically conducted according to a turn-on command or turn-off command to the switching device.

[0003] Further, in an electromagnetic operation-type switching apparatus which is equipped with the above-mentioned electromagnetic operation device, a link mechanism which couples the electromagnetic operation device and the switching device is employed.

[0004] Further, in the switching device such as the circuit breaker, a contact pressure spring for applying contact force to a contact point in a turn-on state and a tripping spring for turning off the contact point are subjected to energy accumulation and the contact point is opened by using the accumulated energies of the both springs in a turn-off operation (for example, refer to Patent Document 1).

[0005] Further, the capacitor and the electromagnet coil which constitute the electromagnetic operation device are affected by ambient temperature to change their characteristics. For example, the electrostatic capacity of the capacitor is increased in response to a temperature increase. Since the energy that is accumulated in the capacitor is proportional to the electrostatic capacity of the capacitor, if the electrostatic capacity is increased, the excitation current of the electromagnet coil is increased.

[0006] Further, the resistance of a conducting wire constituting the electromagnet coil is increased in response to a temperature increase. If the resistance of the conducting wire is increased, the excitation current of the electromagnet coil is reduced.

[0007] Further, a permanent magnet that is used for retaining the turn-on state is reduced in residual magnetic flux in response to a temperature increase. In order to obtain a required turn-on speed even in a state where

the residual magnetic flux is reduced, the excitation current of the electromagnet coil is required to be increased. That is, a required electromagnetic force and a generated electromagnetic force are changed according to ambient temperature.

[0008] In order that turn-on operation is normally carried out even in any ambient temperature, the electromagnetic operation device is required to be designed on condition that the excitation current of the electromagnet coil is minimized. When the ambient temperature is changed and the excitation current of the electromagnet coil is increased, the electromagnetic operation device is operated at an excessive speed, and mechanical loads to components constituting equipment are increased. As a result, adverse effects of shortening the service life of the equipment and exceeding the design strength of the equipment occur.

[0009] Accordingly, a technology has been proposed in which resistors for limiting the excitation current of the electromagnet coil are switched according to ambient temperature and an electromagnetic force is controlled within a specified range (for example, Patent Document 2). This is to maintain the electromagnetic force, generated by limiting the excitation current of the electromagnet coil, within a certain range by selecting one resistor from a plurality of existing limiting-resistors according to the ambient temperature.

Citation List

Patent Document

[0010]

Patent Document 1: JP2005-44612A

Patent Document 2: JP2009-176527A

[0011] However, when one resistor is selected from the plurality of existing limiting-resistors and when a sensor reading the ambient temperature and a signal path from the sensor to a switching device fail, the switching device is in a state of connecting to any limiting resistors and does not operate. In this state, when the ambient temperature changes, the excitation current of the required electromagnet coil cannot be made to flow since the limiting resistors are large, and there is a probability that the turn-on operation will fail.

[0012] The present invention has been made in view of the foregoing, and its object is to provide an electromagnetic operation device and an electromagnetic operation-type switching apparatus which change an excitation current of an electromagnet coil in response to a change in ambient temperature and, even if a sensor that measures the ambient temperature fails, can normally realize (complete) a turn-on operation.

SUMMARY OF THE INVENTION

[0013] To address the above-mentioned object, an electromagnetic operation device of the present invention includes an electromagnet coil for forming an electromagnet, a capacitor accumulating energy for exciting the electromagnet coil, and a control circuit for causing the electromagnet coil and the capacitor electrically conducted according to a turn-on command or a turn-off command to a switching device, wherein the control circuit includes a limiting resistor at the time of turn-on operation of the switching device, and a short-circuiting mechanism that is provided in parallel with the limiting resistor at the time of turn-on operation and short-circuits the limiting resistor at the time of turn-on operation by using a normally-closed contact point that is normally "closed" and is "opened" when a signal is inputted.

[0014] Also, an electromagnetic operation-type switching apparatus of the present invention includes a switching device, an electromagnetic operation device operating the switching device, and a lever connecting the electromagnetic operation device and the switching device via link mechanisms, wherein the electromagnetic operation device is an electromagnetic operation device that includes an electromagnet coil for forming an electromagnet, a capacitor accumulating energy for exciting the electromagnet coil, and a control circuit for causing the electromagnet coil and the capacitor to be electrically conducted according to a turn-on command or a turn-off command to the switching device, and wherein the control circuit includes a limiting resistor at the time of turn-on operation of the switching device, and a short-circuiting mechanism that is provided in parallel with the limiting resistor at the time of turn-on operation and short-circuits the limiting resistor at the time of turn-on operation by using a normally-closed contact point that is normally "closed" and is "opened" when a signal is inputted.

[0015] In accordance with the present invention, the excitation current of the electromagnet coil is changed in response to a change in ambient temperature and, even if a sensor that measures the ambient temperature fails, the turn-on operation can be normally realized (completed).

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIG. 1 is a side view showing an electromagnetic operation-type switching apparatus which is equipped with an electromagnetic operation device of a first embodiment according to one embodiment of the present invention.

FIG. 2 is a circuit diagram of a control circuit for driving the electromagnetic operation device shown in Fig. 1.

FIG. 3 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a second

embodiment according to another embodiment of the present invention.

FIG. 4 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a third embodiment according to still another embodiment of the present invention.

FIG. 5 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a fourth embodiment according to yet still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] An electromagnetic operation device and electromagnetic operation-type switching apparatus of the present invention will be explained hereinafter based on illustrated embodiments. Incidentally, in each embodiment, like components are labelled by like reference signs.

FIRST EMBODIMENT

[0018] FIG. 1 is a side view showing an electromagnetic operation-type switching apparatus which is equipped with an electromagnetic operation device of a first embodiment according to one embodiment of the present invention.

[0019] As shown in Fig. 1, the electromagnetic operation-type switching apparatus 100 is generally composed of a switching device (a switching portion 15) such as a vacuum circuit breaker, an electromagnetic operation device 1 operating the switching portion 15, and a lever 10 connecting the electromagnetic operation device 1 and the switching portion 15 via a first link mechanism 7, a second link mechanism 9, and a third link mechanism 12.

[0020] The electromagnetic operation device 1 is generally composed of a rod 3 and a movable flat plate 4, which are connected to a movable iron core 2 vertically moving up and down, an electromagnet coil 5, and a permanent magnet 6, and is connected to the lever 10 via the first link mechanism 7, a connection component 8, and the second link mechanism 9.

[0021] Further, though unshown, a control circuit is fixed to a right side surface of a case 32, when viewed from a direction of an arrow P in Fig. 1, by using a bolt and a nut through a spacer. Excitation current is supplied to the electromagnet coil 5 from this control circuit and the movable iron coil 2 then moves up and down. When the rod 3 coupled to the movable iron coil 2 moves up and down, the lever 10 rotates about a shaft 11, whereby a connection component 13 and a rod 14 that are coupled to the lever 10 through the third link mechanism 12 move up and down and a contact point provided in the switching portion 15 separates (breaks down).

[0022] In turn-on operation, a contact pressure spring 16 and a tripping spring 17 are compressed, and elastic energy is accumulated in the contact pressure spring 16

and the tripping spring 17. By this elastic energy that is accumulated in the contact pressure spring 16 and the tripping spring 17, break-down operation is performed. When the switching portion 15 is in a turn-on state, the movable iron coil 2 and the movable flat plate 4 are retained by the magnetic attraction force of the permanent magnet 6. By passing electric current through the electromagnet coil 5 in an opposite direction from the turn-on operation, magnetic flux is generated in a direction of canceling the magnetic attraction force of the permanent magnet 6 and, by releasing the energy accumulated in the contact pressure spring 16 and the tripping spring 17, the rod 3 moves upward and the break-down operation of the switching portion 15 is performed.

[0023] FIG. 2 is a circuit diagram of a control circuit for driving the electromagnetic operation device 1 shown in FIG. 1.

[0024] As shown in FIG. 2, the control circuit of this embodiment is composed of a capacitor 21, an on-off switch 22, a limiting resistor 23 for limiting electric current at the time of turn-on operation, a limiting resistor 24 for limiting electric current at the time of turn-off operation, a first switching relay 25 that is switched in conjunction with the turn-on operation and the turn-off operation, a second switching relay 26, a third switching relay 27, a fourth switching relay 28, a state sensor 29 monitoring an ambient temperature state, and a relay 30 that is a short-circuiting mechanism connected in parallel with the limiting resistor 23 at the time of turn-on operation and interlocking the state sensor 29 to short-circuit the limiting resistor 23 at the time of turn-on operation.

[0025] In the turn-on operation, as shown by solid lines in Fig. 2, contact points c of the first switching relay 25, second switching relay 26, third switching relay 27, and fourth switching relay 28 connect to contact points a and, in the turn-off operation, as shown by broken lines in Fig. 2, the contact points c of the first switching relay 25, second switching relay 26, third switching relay 27, and fourth switching relay 28 connect to contact points b. Thereby, when the on-off switch 22 turns on electricity, excitation current flowing through the electromagnet coil 5 with the turn-off operation and the turn-on operation is reversed.

[0026] Further, the relay 30 is a normally-closed contact point (normally "closed" and, when a signal (power) is inputted, "opened") and inserted in such a manner to short-circuit the limiting resistor 23 at the time of turn-on operation. That is, when the relay 30 is electrically conducted by a command from the state sensor 29 (when the signal (power) is inputted), the relay 30 becomes an off-state.

[0027] Further, the state sensor 29 includes, for example, a temperature measuring means (a thermocouple, a thermometer, etc.) measuring ambient temperature, and directs opening of the relay 30 according to the resistance of the electromagnet coil 5 that corresponds to ambient temperature, the residual magnetic flux of the permanent magnet 6, and a temperature characteristic such as the electrostatic capacity of the capacitor 21.

[0028] In this embodiment configured in this way, when the ambient temperature becomes a state in which it increases electromagnetic force at the time of turn-on operation, the relay 30 is opened. By the opening of the relay 30, the excitation current of the electromagnet coil 5 is restricted, and a mechanical load at the time of turn-on operation by excessive electromagnetic force can be reduced.

[0029] If by any chance the state sensor 29 that monitors the ambient temperature fails, a signal (power) is not inputted to the relay 30, so that the relay 30 is "closed" since it is the normally-closed contact point, and the limiting resistor 23 at the time of turn-on operation is brought into a short-circuited state. In the state in which the limiting resistor 23 is short-circuited, the excitation current of the electromagnet coil 5 becomes the largest, so that the turn-on operation can be completed even in any state within a design range.

[0030] Further, when a signal path fails, for example, when a cable that connects the relay 30 and the state sensor 29 is broken, the signal (power) is not inputted to the relay 30 as well, so that the same state as described above occurs, so that the excitation current of the electromagnet coil 5 becomes the largest and the turn-on operation can be completed even in any state within the design range.

[0031] According to such embodiment, the excitation current of the electromagnet coil 5 is restricted, the mechanical load at the time of turn-on operation by the excessive electromagnetic force can be reduced and, even if by any chance the state sensor 29 that obtains information of the ambient temperature, or the signal path fails, the turn-on operation can be normally completed.

SECOND EMBODIMENT

[0032] FIG. 3 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a second embodiment according to another embodiment of the present invention.

[0033] The control circuit shown in Fig. 3 is configured to have a structure in which n pairs (a plurality) of combinations of the limiting resistor 23 at the time of turn-on operation and the relay 30 in the control circuit shown in the first embodiment of Fig. 2, that is, plural pairs of limiting resistors 231 at the time of turn-on operation and relays 301, and plural pairs of limiting resistors 232 at the time of turn-on operation and relays 302-plural pairs of limiting resistors 23n and relays 30n are connected in series. The other configurations are the same as described in the first embodiment. Incidentally, resistance values of the limiting resistors 231 to 23n are arbitrary.

[0034] In such configuration of this embodiment, the relays 301 to 30n that are the n short-circuiting mechanisms are independently controlled by the state sensor 29. Thereby, a total limiting resistance value can be selected as a sum of resistances selected with a combination of arbitrary k resistors equal to or less than n among

the n limiting resistors 231 to 23 n at the time of turn-on operation, so that a combination according to $((2^{n+1})-(2^n)-1)$ can be realized.

[0035] Therefore, according to this embodiment, it is possible not only to obtain the same effects as those in the first embodiment but also to realize resistance values more than the case where one resistor is selected from the n resistors in the case where n is equal to or more than 2, and it is possible to change the resistance values more continuously.

THIRD EMBODIMENT

[0036] FIG. 4 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a third embodiment according to still another embodiment of the present invention.

[0037] The control circuit shown in FIG. 4 is configured to have a structure in which the first switching relay 25, the second switching relay 26, the third switching relay 27, and the fourth switching relay 28 in the control circuit shown in the first embodiment of Fig. 2 are excluded, or the on-off switch 22 is replaced with a turn-on switch 31, and is a circuit exclusive for turn-on operation.

[0038] By employing such configuration of this embodiment, not only the same effects as those in the first embodiment are obtained but also the relay 30 becomes the off-state according to the command from the state sensor, and the excitation current flowing through the electromagnet coil 5 is restricted by the limiting resistor 23, and the mechanical load at the time of the turn-on operation by the excessive electromagnetic force can be reduced.

FOURTH EMBODIMENT

[0039] FIG. 5 is a circuit diagram of a control circuit for driving an electromagnetic operation device of a fourth embodiment according to still yet another embodiment of the present invention.

[0040] The control circuit shown in Fig. 5 is configured to have a structure in which n pairs (plurality) of combinations of the limiting resistors 23 at the time of turn-on operation and the relays 30 in the control circuit shown in the third embodiment of Fig. 4 are connected in series.

[0041] By employing such configuration of this embodiment, it is possible not only to obtain the same effects as those in the first embodiment but also to realize resistance values more than the case where one resistor is selected from the n resistors in the case where n is equal to or more than 2, as with the second embodiment shown in FIG. 3, and it is possible to change the resistance values more continuously.

[0042] Incidentally, the embodiments mentioned above have been explained in details for the purpose of explaining the present invention easily, but they are not necessarily limited to those having all the structures. Also, a portion of a structure of a certain embodiment can

be replaced by a structure of another embodiment, and a structure of a certain embodiment can be also added to a structure of another embodiment. Further, addition, deletion, or replacement of other structures can be carried out for portions of structures of the respective embodiments.

REFERENCE SIGNS LIST

10 [0043]

- 1...Electromagnetic operation device
- 2...Movable iron core
- 3, 14...Rod
- 4...Movable flat plate
- 5...Electromagnet coil
- 6...Permanent magnet
- 7...First link mechanism
- 8, 13...Connection component
- 9...Second link mechanism
- 10...Lever
- 11...Shaft
- 12...Third link mechanism
- 15...Switching portion
- 16...Contact pressure spring
- 17...Tripping spring
- 21...Capacitor
- 22...On-off switch
- 23, 231 to 23 n ...Limiting resistor at the time of turn-on operation
- 24...Limiting resistor at the time of turn-off operation
- 25...First switching relay
- 26...Second switching relay
- 27...Third switching relay
- 28...Fourth switching relay
- 29...State sensor
- 30, 301 to 30 n ...Relay
- 31...Turn-on switch
- 32...Case
- 100...Electromagnetic operation-type switching apparatus

Claims

1. An electromagnetic operation device comprising:

an electromagnet coil (5) for forming an electromagnet; a capacitor (21) accumulating energy for exciting the electromagnet coil (5); and a control circuit for causing the electromagnet coil (5) and the capacitor (21) to be electrically connected according to a turn-on command or a turn-off command to a switching device (15); **characterized in that** the control circuit comprises a limiting resistor (23) at the time of turn-on operation of the switching device (15), and a short-circuiting mechanism that is provided in parallel

with the limiting resistor (23) at the time of turn-on operation and short-circuits the limiting resistor (23) at the time of turn-on operation by using a normally-closed contact point that is normally "closed" and is "opened" when a signal is input-

2. The electromagnetic operation device according to claim 1,

characterized in that the control circuit comprises a capacitor, turn-on switches (22, 31) of the switching device (15), a limiting resistor (23) at the time of turn-on operation of the switching device (15), a state sensor (29) monitoring an ambient temperature state, and a relay (30) that is provided in parallel with the limiting resistor (23) at the time of turn-on operation and short-circuits the limiting resistor (23) at the time of turn-on operation by using a normally-closed contact point that interlocks the state sensor (29) to be normally "closed" and is "opened when a signal is inputted.

3. The electromagnetic operation device according to claim 2,

characterized in that a plurality of combinations of limiting resistors (231 to 232n) at the time of turn-on operation and relays (301 to 30n) are connected in series, each of the combinations of limiting resistors at the time of turn-on operation and relays (301 to 30n) being connected to the state sensor (29).

4. The electromagnetic operation device according to claim 1,

characterized in that the control circuit comprises a capacitor (21), an on-off switch (22) of the switching device, a resistor (23) at the time of turn-on operation of the switching device (15), a resistor (24) at the time of turn-off operation of the switching device (15), a plurality of switching relays (25, 26, 27, 28) that are switched in conjunction with the turn-on operation and turn-off operation of the switching device (15), a state sensor (29) monitoring an ambient temperature state, and a relay (30) that is provided in parallel with the limiting resistor (23) at the time of turn-on operation and short-circuits the resistor (23) at the time of turn-on operation by using a normally-closed contact point that is normally "closed" in conjunction with the state sensor (29) and is "opened" when a signal is inputted.

5. The electromagnetic operation device according to claim 4,

characterized in that a plurality of combinations of limiting resistors (231 to 23n) at the time of turn-on operation and relays (301 to 30n) are connected in series, each of the combinations of limiting resistors (231 to 23n) at the time of turn-on operation and relays (301 to 30n) being connected to the state sensor (29).

6. The electromagnetic operation device according to claim 4 or 5,

characterized in that the state sensor (29) comprises a temperature measuring means that measures ambient temperature, and opening of the relays (30, 301-30n) is directed according to the ambient temperature that is detected by the temperature measuring means.

7. The electromagnetic operation device according to claim 6,

characterized in that the relays (30, 301 to 30n) are directed to be opened according to resistance of the electromagnet coil (5), that corresponds to the ambient temperature, or temperature characteristic of electrostatic capacity of the capacitor (21).

8. An electromagnetic operation-type switching Apparatus (100) comprising: a switching device (15); an electromagnetic operation device (1) operating the switching device (15); and a lever (10) connecting the electromagnetic operation device (1) and the switching device (15) via link mechanisms (7, 9, 12), the electromagnetic operation device (1) being the electromagnetic operation device (1) according to any one of claims 1 to 7.

FIG. 1

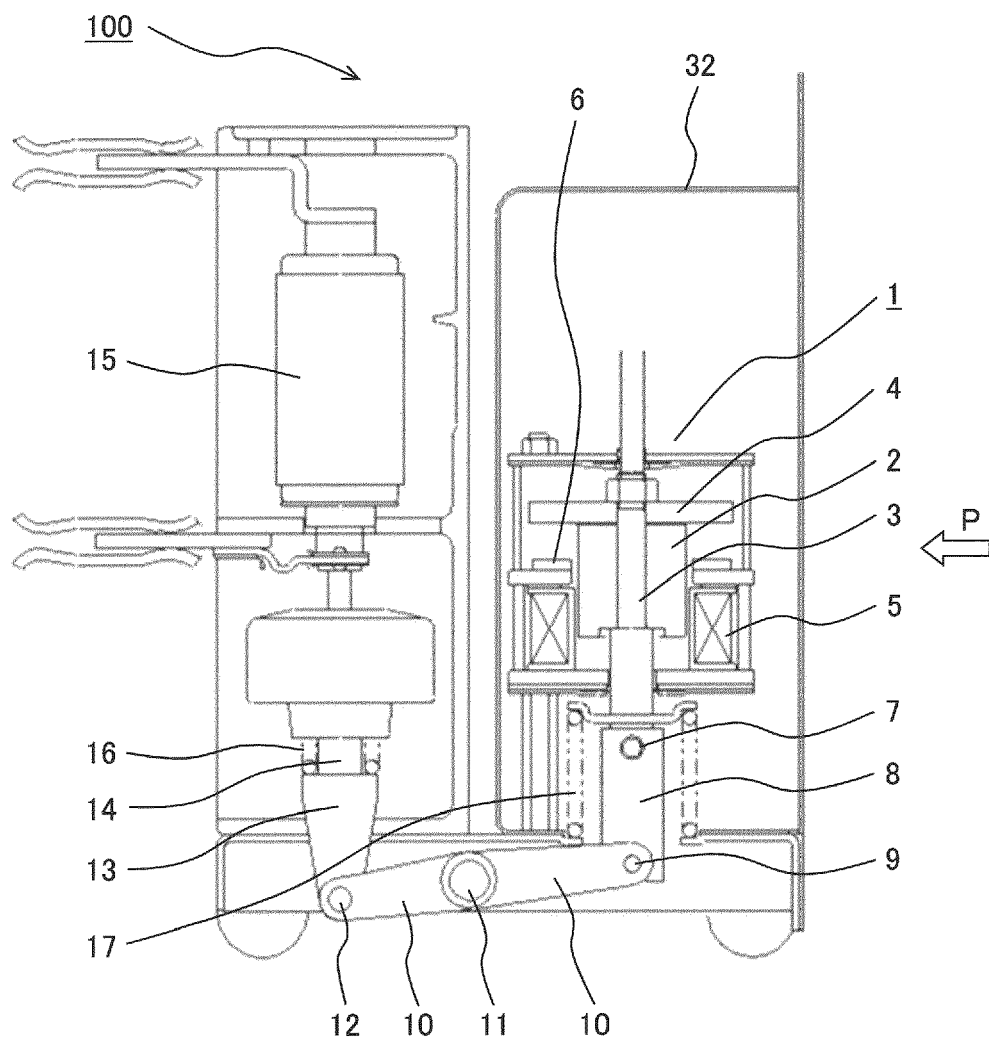


FIG. 2

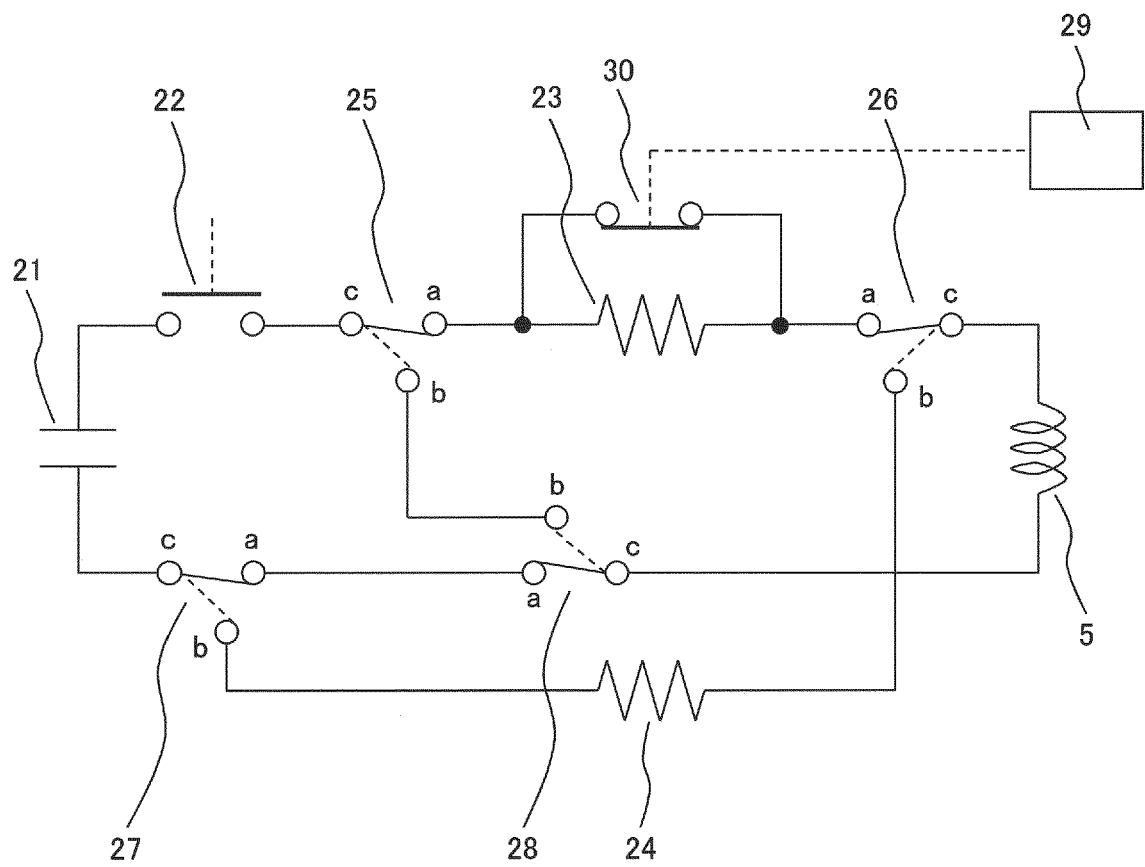


FIG. 3

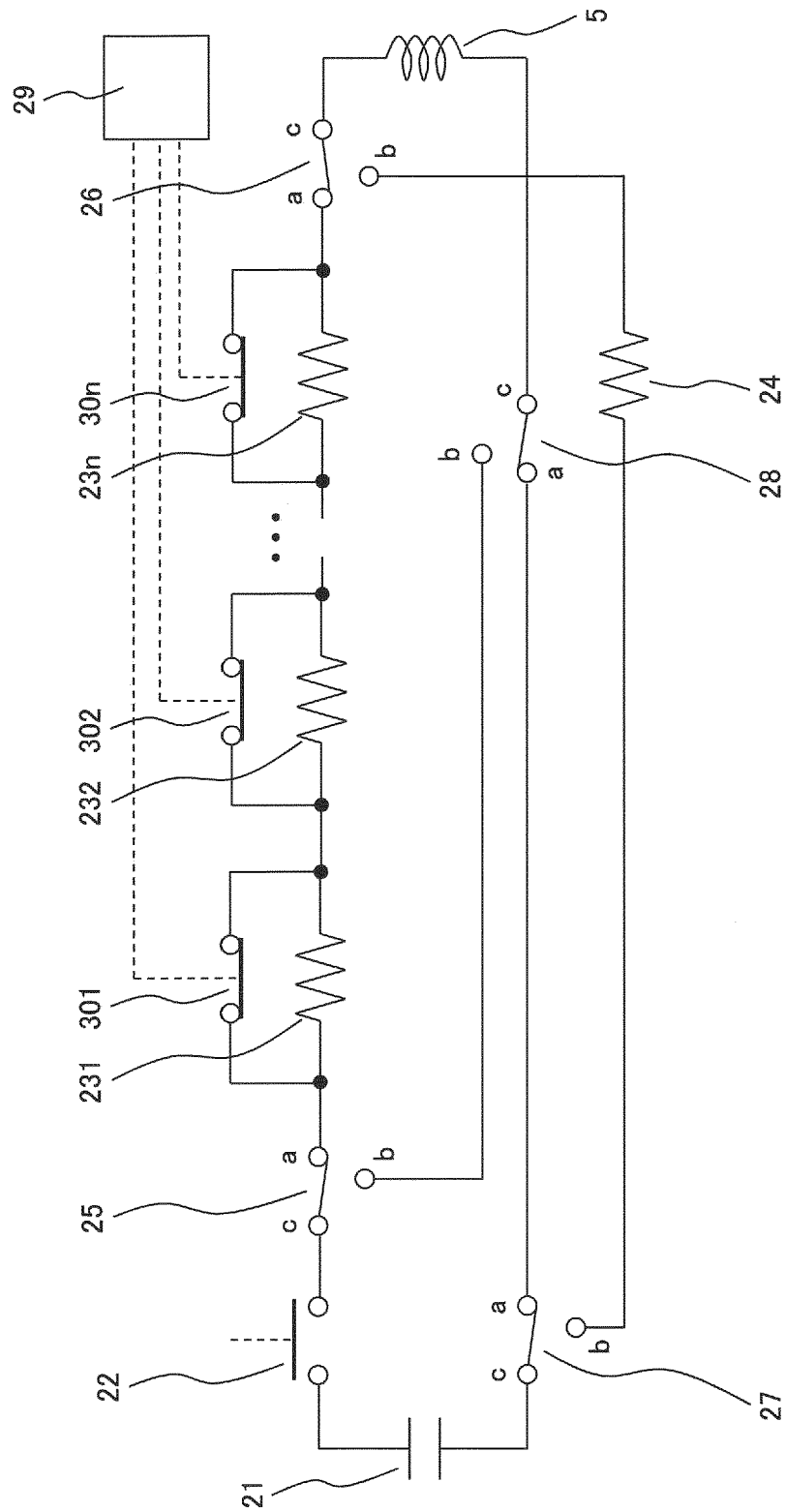


FIG. 4

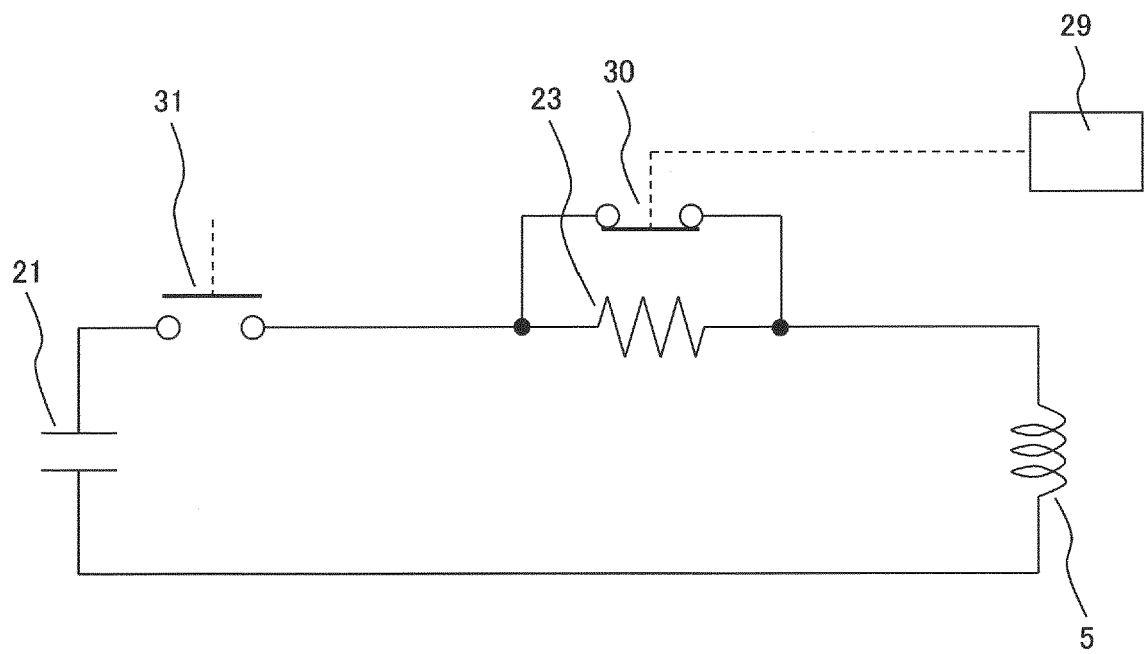
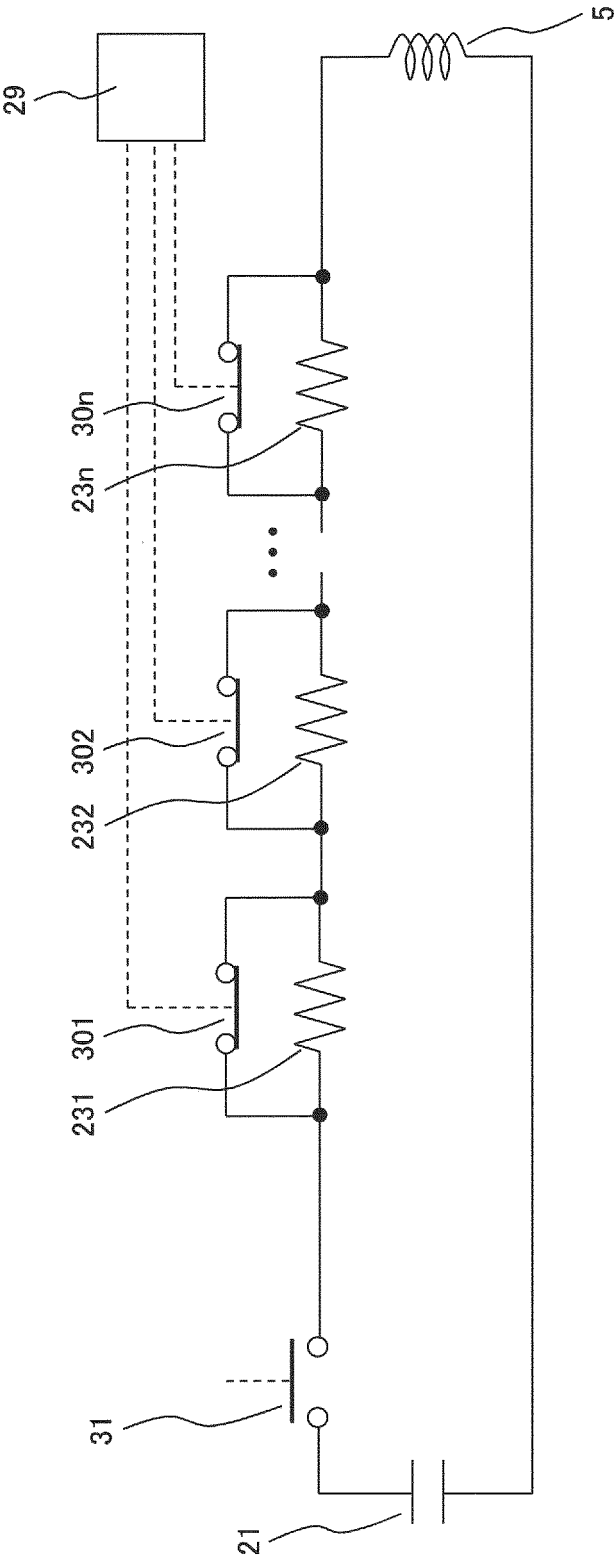


FIG. 5





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**ANNEX TO THE EUROPEAN SEARCH REPORT
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