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(54) SYSTEM AND METHOD FOR PROTECTING A COIL STRUCTURE IN A CONTROLLED SWITCH

SYSTEM UND VERFAHREN ZUM SCHUTZ EINER SPULENSTRUKTUR IN EINEM GESTEUERTEN SCHALTER

SYSTÈME ET PROCÉDÉ POUR PROTÉGER UNE STRUCTURE DE BOBINE DANS UN INTERRUPTEUR COMMANDÉ

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Description

BACKGROUND TO THE INVENTION

[0001] The present invention relates generally to a system and method for protecting a coil structure used in a controlled switch. More specifically, the present invention relates to a system for protecting a coil structure that provides a switching force used to actuate one or more load switches. The coil structure generates the switching force in response to a sizable current. However, continual application of the current at the same level to the coil structure can cause damage to the coil.

[0002] GB 272 012 A discloses a switch circuit according to the preamble of claim 1. This document further discloses a method of operating a switch circuit comprising a coil structure (1) configured to actuate at least one load switch (4) and at least one auxiliary switch (2, 3) in response to a control input, the coil structure comprising (1) a main coil (1) and a component coil (extending from b to a), the component coil being a portion of the main coil extending from a first end (b) of the main coil to a tap (a) of the main coil, the coil structure being switchable between an actuating configuration (see page 2, lines 100-107 and the figure) for actuating the at least one load switch and the at least one auxiliary switch from a default position, and a holding configuration (see from page 2, line 107 to page 3, line 6) for holding the at least one load switch (4) and the at least one auxiliary switch (2, 3) in a switched position, the method comprising:providing a switching current to the coil structure;generating, in response to the switching current, a force for switching the at least one load switch and the at least one auxiliary switch.

SUMMARY OF THE INVENTION

[0003] Systems and methods are described for protecting a coil structure in a controlled switch. In many embodiments, the coil structure includes a switching configuration and a hold configuration. A substantial current can be provided to the coil structure in the switching configuration while a smaller current can be provided in the hold configuration. To protect against damage to the coil structure in the switching configuration caused by the substantial current, a resettable current limiting device can used to substantially limit current when the current exceeds a threshold over a predetermined period of time.

[0004] The invention relates to a switch circuit according to claim 1.

[0005] A prefered embodiment of the invention relates to a switch circuit for actuating one or more load switches and at least an auxiliary switch, each of the one or more load switches and the auxiliary switches having a default position and a switched position, where the default position of the auxiliary switch is closed, the switch circuit including a main coil configured to receive a current from a control power source and to provide a force for holding the one or more load switches and the auxiliary switch in the switched position, where the main coil comprises a first end, a second end and a tap, a resettable current limiting device connected to the first end of the main coil and to the auxiliary switch, the resettable device configured to limit current flow when the current exceeds a threshold for a predetermined period of time, and a component coil comprising a portion of the main coil from the second end to the tap of the main coil, where the tap is connected to the auxiliary switch, and where the component coil is configured to provide a force for actuating the one or more load switches and the auxiliary switch from the default position.

[0006] A development of this switch circuit may further comprise a power source connected to the one or more load switches, which are connected to a load.

[0007] In another development of the switch circuit, the resettable device may be configured to substantially limit current flow when the current exceeds the threshold for a predetermined period of time, and/or may be configured to allow current to flow with minimal resistance when the current is below the threshold for a predetermined period of time.

[0008] In still another development of the switch circuit, a resistance of the resettable device may increase at least an order of magnitude when the current exceeds a threshold for a predetermined period of time.

[0009] Furthermore, the resettable device in the switch circuit may be a thermistor or a positive temperature coefficient device.

[0010] Furthermore, the invention relates to a method according to claim 11.

[0011] In a development of this method the switch circuit may further comprise a control power source configured to supply current to the coil structure, wherein the at least one load switch is connected between a power source and a load.

[0012] Moreover, the control power source and the power source may be aircraft electrical power sources, the load being an aircraft electrical load.

[0013] The limiting the switching current flowing through the coil structure using the resettable current limiting device when the switching current exceeds the current threshold for a predetermined period of time, in the above method, may comprise substantially limiting the switching current flowing through the coil structure in the actuating configuration using the resettable current limiting device when the switching current exceeds the threshold for a predetermined period of time.

[0014] Furthermore, the limiting the switching current flowing through the coil structure using the resettable current limiting device when the switching current exceeds the current threshold for a predetermined period of time, in the above method, may be performed by the resettable current limiting device, with the resistance of resettable device increasing at least an order of magnitude when the switching current exceeds the threshold for a predetermined period of time.

[0015] Also, a development of the above method may further comprise allowing the switching current to flow with minimal resistance when the switching current is below the current threshold.

[0016] In another development of said method, the switching current supplied by the control input may actuate the at least one load switch and the at least one auxiliary switch from the default position; in this development, a holding current supplied by the control input may hold the at least one load switch and the at least one auxiliary switch in the switched position, and the switching current may be greater than the holding current.

[0017] In the above method, furthermore, the default position of the at least one auxiliary switch may be closed, while the default position of the at least one load switch is, in one variant, open, or in another variant, closed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a schematic block diagram of a power control system in accordance with an embodiment of the present invention.

FIG. 2 is a schematic diagram of a power control system including a controlled switch with a current limiting device in accordance with an embodiment of the present invention.

FIG. 3 is a schematic diagram of a power control system including a controlled switch having normally closed load switches in accordance with an embodiment of the present invention.

FIG. 4 is a schematic diagram of a power control system including a controlled switch having three load switches in accordance with an embodiment of the present invention.

FIG. 5 is a schematic diagram of a power control system including a controlled switch having one load switch in accordance with an embodiment of the present invention.

FIG. 6 is a flowchart of a process for operating a controlled switch in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Turning now to the drawings, embodiments of systems and methods for protecting a coil in a controlled switch such as a contactor or a relay are illustrated. Controlled switches can be used to connect or disconnect loads of various sizes and phases from sources of power. Such controlled switches typically include a coil acting as an electromagnet to provide a force to switch the load when current is applied to the coil. This force can be used to switch one or more load switches together with an auxiliary switch. Substantial currents are provided to enable the coil to switch the load and the auxiliary switches. A hold or "economizer" coil is often used to decrease the amount of current needed to hold the armature(s) of the controlled switch in the switched position once the load and auxiliary switches have been actuated. In such case, a portion of the economizer coil can be used as an actuator or "pull-in" coil.

[0020] In operation, the control power source applies a voltage to generate a substantial current in the pull-in coil. The hold coil is placed in parallel with the normally closed auxiliary switch, causing it to short during the switching period. The pull-in coil can be placed in series with the auxiliary switch and can produce a switching force proportional to that substantial current supplied by the control power source. When the controlled switch is actuated by the switching force, the auxiliary contacts open and the economizer (hold) coil is placed in the current path. The economizer coil generally has a larger impedance than the pull-in coil, decreasing the current required from the control power source to keep the controlled switch in the switched position.

[0021] In the event that the auxiliary switch fails to operate, continuation of the substantial actuation current can cause permanent damage to, and the subsequent failure of, the coils. To avoid destruction of the coils and the controlled switch (e.g. relay) when the auxiliary switch fails to operate, a resettable current limiting device is placed in series with the pull-in coil and auxiliary switch. This resettable current limiting device substantially limits the current passing through the device when the current exceeds a threshold for a predetermined period of time. When the current drops below the threshold, the resettable device returns to its original state in which it conducts current with minimal limitation.

[0022] In one embodiment, the controlled switch can control the distribution of power in an aircraft electrical system. Power can be distributed using any of DC or AC (single, two or three phase) systems, or any combination thereof. In one embodiment, the controlled switch has two load switches that switch DC power sources. In several embodiments, the DC power sources operate at 28 volts, 26 volts or 270 volts. In one embodiment, DC power sources operate in the range of 11 to 28 volts. In other embodiments, the controlled switch has three load switches that switch AC power sources. In one embodiment, the AC power source operates at 115 volts and at a frequency of 400 hertz. In other embodiments, the controlled switch has a single load switch that can switch a DC power source or a single phase of an AC power source. In other embodiments, the power sources operate at other voltages and other frequencies. In one embodiment, the DC power sources can include batteries, auxiliary power units and/or external DC power sources. In one embodiment, the AC power sources can include generators, ram air turbines and/or external AC power sources.

[0023] A schematic block diagram of a power control system in accordance with an embodiment of the present invention is shown in FIG. 1. The power control system 200 includes a controlled switch 202 connected to a power source 204, a load 206 and a control power source 208. In operation, if the controlled switch 202 receives a signal from the control power source 208, the switch 202 connects or disconnects the load 206 from the power source 204.

[0024] In one embodiment, the power control system 200 is a subsystem of an aircraft electrical system. The power source 204 can be a generator, a battery or other AC or DC power sources. The load 206 can include aircraft flight instruments, essential systems such as landing gear, exterior lights, aircraft motor controls and the like, and/or passenger services such as lights, air conditioning and entertainment systems. In one embodiment, the loads range from requiring 1 to 400 amps. In another embodiment, the loads typically require 50 to 60 amps. The control power source 208 can be a signal generated in response to either automated systems or manual systems. In many embodiments, the control power source is capable of supplying an amount of current adequate to operate the controlled switch 202. In one embodiment, 6 to 7 amps from the control power source is sufficient to cause the controlled switch to connect or disconnect the load. In one embodiment, the controlled switch is a contactor. In another embodiment, the controlled switch is a relay.

[0025] A schematic block diagram of a power control system including a controlled switch with a current limiting device in accordance with an embodiment of the present invention is shown in FIG. 2. The power control system 300 includes a controlled switch 302, a power source 304, a load 306 and a control power source 308. The controlled switch 302 includes a pull-in coil 310, an economizer coil 312, an auxiliary switch 320, a first load switch 322, a second load switch 324, and a current limiting device 330. The economizer coil 312 includes a first end 314, a tap 316, and a second end 318, where the pull-in coil consists of the portion of the economizer coil extending from the second end 318 to the tap 316.

[0026] The power source 304 is connected to the first load switch 322 and the second load switch 324. The first load switch 322 and the second load switch 324 are connected to the load 306. The control power source 308 is connected to both the first end 314 and the second end 318 of the economizer coil 312. The auxiliary switch and first and second load switches each include a switch arm (armature) and a switch contact. The tap 316 is connected to the auxiliary switch 320. In the illustrated embodiment, the auxiliary switch 320 is normally closed and operates complimentary to the load switches that are normally open. The three switches are arranged such that all three are switched together. The auxiliary switch 320 is connected to the current limiting device 330. The first end 314 of the economizer coil 312 is connected to the current limiting device 330.

[0027] In operation, the control power source 308 provides a voltage and switching current to the pull-in coil 310 at the second end 318. At this time, the current limiting device 330 has minimal resistance to current flowing through the device. Thus, nearly all of the switching current initially travels through the pull-in coil 310 and out of the tap 316, through the auxiliary switch 320 and current limiting device 330, and returns to the current power source 308 via the first end 314. In one embodiment, the switching current provided by the control power source 308 enters at the first end 314 of the economizer coil 312 and returns via the second end 318.

[0028] The initial switching current can be substantial in order to facilitate switching using the pull-in coil. In one embodiment, the initial switching current or inrush current is approximately 6 to 7 amps. The pull-in coil acts as an electromagnet to create a force that physically switches or actuates the auxiliary switch and both of the load switches. Upon successful switching of the auxiliary switch, the switching current supplied by the control power source can be reduced as the force required to hold the switch in the switched position is generally less than the force required to operate the switch. This is accomplished by opening the auxiliary contact in parallel to the hold coil and therefore placing the hold coil, with greater impedance, in the path of the current.

[0029] The auxiliary switch can fail to open because of failed switch contacts, low voltage from the control power source or another reason. In any such case, the current limiting device senses the continuing switching current and acts to limit the current flowing through the device. In one embodiment, the current limiting device is a resettable fuse such as a thermistor or a polymer positive temperature coefficient (PPTC) fuse. In such case, the resettable fuse has a threshold or trip current such that when the threshold is exceeded for a predetermined period of time, the resettable fuse begins to heat up quickly. The heat changes the resistive properties of the resettable fuse such that the resistance of the device increases dramatically when the threshold is exceeded. In one embodiment, the resistance increases by at least an order of magnitude. In another embodiment, the resistance increases exponentially. However, when the current through the resettable fuse returns to a level below the threshold, the resistance of the fuse becomes minimal again as though it had been reset. In this way, the resettable fuse can be used any number of times to prevent switch failures from destroying the switching coil.

[0030] In one embodiment, the current limiting device can be a combination of components capable of comparing an input current level and a threshold over some period of time, and changing the overall impedance seen by the input current based on the comparison. The combination can include any number of devices including integrated circuits, processors and/or discrete devices coupled to one another.

[0031] In one embodiment, the threshold current must be exceeded for a period of time greater than 20 to 30 milliseconds before the resettable fuse heats up quickly to limit current flow. In one embodiment, the resettable fuse can be a POLYFUSE® resettable positive temperature coefficient fuse such as any of the 60R250, 60R300, and 60R375 fuses made by Littlefuse, Inc. of Des Plaines, Illinois. In such case, the threshold current can be 5, 6, and 7.5 amps, respectively. In one embodiment, the inrush current is greater than 6 to 7 amps. In another embodiment, the threshold current must be exceeded for a period of time much greater than 20 to 30 milliseconds. In one embodiment, two or more resettable fuses can be used together in parallel to increase the current capability and to extend the time for the combination of favor to substantially change their impedance. In another embodiment, two or more resettable fuses can be used together in series.

[0032] Returning briefly to FIG. 1, the controlled switch 202 functions in the same manner described above for the controlled switch 302 of FIG. 2, in one embodiment of the invention.

[0033] A schematic block diagram of a power control system including a controlled switch having normally closed load switches in accordance with an embodiment of the present invention is shown in FIG. 3. The power control system 400 includes a controlled switch 402, a power source 404, a load 406 and a control power source 408. The controlled switch 402 includes a pull-in coil 410, an economizer coil 412, an auxiliary switch 420, a first load switch 422, a second load switch 424, and a current limiting device 430. The economizer coil 412 includes a first end 414, a tap 416, and a second end 418, where the pull-in coil consists of the portion of the economizer coil extending from the second end 418 to the tap 416.

[0034] The power source 404 is connected to the first load switch 422 and the second load switch 424. The first load switch 422 and the second load switch 424 are connected to the load 406. The control power source 408 is connected to both the first end 414 and the second end 418 of the economizer coil 412. The auxiliary switch and first and second load switches each include a switch arm and a switch contact. The tap 416 is connected to the auxiliary switch 420. In the illustrated embodiment, the auxiliary switch 420 and the load switches are normally closed. The three switches are arranged such that all three are switched together. The auxiliary switch is connected to the current limiting device 430. The first end 414 of the economizer coil 412 is connected to the current limiting device 430.

[0035] The power control system 400 of FIG. 4 is identical to the embodiment shown in FIG. 3, except that load switch 422 and load switch 424 are normally closed switches. The power control system 400 can operate as described previously for the embodiment shown in FIG. 3.

[0036] A schematic block diagram of a power control system including a controlled switch having three load switches in accordance with an embodiment of the present invention is shown in FIG. 4. The power control system 500 includes a controlled switch 502, a power source 504, a load 506 and a control power source 508. The controlled switch 502 includes a pull-in coil 510, an economizer coil 512, an auxiliary switch 520, a first load switch 522, a second load switch 524, a third load switch 526, and a current limiting device 530. The economizer coil 512 includes a first end 514, a tap 516, and a second end 518, where the pull-in coil consists of the portion of the economizer coil extending from the second end 518 to the tap 516.

[0037] The power source 504 is connected to the first load switch 522, the second load switch 524, and the third load switch 526. The first load switch 522, the second load switch 524 and the third load switch 526 are connected to the load 506. The control power source 508 is connected to both the first end 514 and the second end 518 of the economizer coil 512. The auxiliary switch and first and second load switches each include a switch arm and a switch contact. The tap 516 is connected to the auxiliary switch 520. In the illustrated embodiment, the auxiliary switch 520 is normally closed and the load switches are normally open. The four switches are arranged such that all three are switched together. The auxiliary switch is connected to the current limiting device 530. The first end 514 of the economizer coil 512 is connected to the current limiting device 530.

[0038] The power control system 500 of FIG. 5 is nearly identical to the embodiment shown in FIG. 3, except that it includes an additional load switch. The power control system 500 can operate as described previously for the embodiment shown in FIG. 3.

[0039] A schematic block diagram of a power control system including a controlled switch having one load switch in accordance with an embodiment of the present invention is shown in FIG. 5. The power control system 600 includes a controlled switch 602, a power source 604, a load 606 and a control power source 608. The controlled switch 602 includes a pull-in coil 610, an economizer coil 612, an auxiliary switch 620, a load switch 622, and a current limiting device 630. The economizer coil 612 includes a first end 614, a tap 616, and a second end 618, where the pull-in coil consists of the portion of the economizer coil extending from the second end 618 to the tap 616.

[0040] The power source 604 is connected to the load switch 622. The load switch 622 is connected to the load 606. The control power source 608 is connected to both the first end 614 and the second end 618 of the economizer coil 612. The auxiliary switch and the load switch each include a switch arm and a switch contact. The tap 616 is connected to the auxiliary switch 620. In the illustrated embodiment, the auxiliary switch 620 is normally closed and the load switch is normally open. The two switches are arranged such that they are both switched together. The auxiliary switch is connected to the current limiting device 630. The first end 614 of the economizer coil 612 is connected to the current limiting device 630.

[0041] The power control system 600 of FIG. 5 is nearly identical to the embodiment shown in FIG. 2, except that it includes only one load switch. The power control system 600 can operate as described previously for the embodiment shown in FIG. 2.

[0042] In one embodiment, any number of load switches can be used in conjunction with at least one auxiliary switch in any number of arrangements of normally open or normally closed default switch settings.

[0043] A flowchart of a process for operating a controlled switch in accordance with an embodiment of the present invention is shown in FIG. 6. The process 750 begins when it provides (752) switching current to a coil (e.g. a pull-in coil). The process then generates (754) a force for switching one or more load switches and an auxiliary switch. In one embodiment, the force is proportional to, or a function of, the switching current. The process then determines (756) whether the auxiliary switch failed to operate. In one embodiment, the determination is made based on the amount of current flowing through the current limiting device and the coil. If the auxiliary switch fails to operate, then the process limits (758) the current flowing through the coil and returns to determining (756) whether the auxiliary switch failed to open. In one embodiment, the current flowing through the coil is limited using a resettable fuse. If the auxiliary switch does not fail to operate, then the process allows (760) the full amount of current to flow through the coil.

[0044] While the above description contains many specific embodiments of the invention, these should not be construed as limitations on the scope of the invention, but rather as an example of one embodiment thereof. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims.

Claims

1. A switch circuit comprising:

    at least one load switch (322, 324, 422, 424, 522, 524, 526, 622) connectable between a power source (304, 404, 504, 604) and a load (306, 406, 506, 606) and at least one auxiliary switch (320, 420, 520, 620), each switch actuable between a default position and a switched position;
    a coil structure comprising a main coil (312, 412, 512, 612) and a component coil (310, 410, 510, 610), the component coil being a portion of the main coil extending from a first end (318, 418, 518, 618) of the main coil to a tap (316, 416, 516, 616) of the main coil, the coil structure being configured to actuate the at least one load switch and at least one auxiliary switch in response to a control input, the coil structure being switchable between:

        an actuating configuration for actuating the at least one load switch and the at least one auxiliary switch from the default position, and
        a holding configuration for holding the at least one load switch and the at least one auxiliary switch in the switched position;

    wherein the at least one auxiliary switch is configured to switch the coil structure from the actuating configuration to the holding configuration, **characterized in that** the switch circuit comprises a resettable current limiting device (330, 430, 530, 630) configured to limit the current flow in the actuating configuration of the coil structure if the current flow exceeds a threshold for a predetermined period of time,
    wherein the resettable current limiting device is coupled to a second end (314, 414, 514, 614) of the main coil and the tap through the auxiliary switch.

2. The switch circuit of claim 1:

    wherein the control input and the power source are aircraft electrical power sources; and
    wherein the load is an aircraft electrical load.

3. The switch circuit of claim 1, wherein an impedance of the resettable current limiting device increases at least an order of magnitude when the current exceeds the threshold for the predetermined period of time.

4. The switch circuit of claim 1, wherein the resettable current limiting device is configured to allow current to flow with minimal impedance when the current is below the threshold for another predetermined period of time.

5. The switch circuit of claim 1:

    wherein a first current supplied by the control input actuates the at least one load switch and the at least one auxiliary switch from the default position;
    wherein a second current supplied by the control input holds the at least one load switch and the at least one auxiliary switch in the switched position; and
    wherein the first current is greater than the second current.

6. The switch circuit of claim 1, wherein the resettable current limiting device is one of a thermistor and a positive temperature coefficient device.

7. The switch circuit of claim 1:

    wherein the default position of the at least one auxiliary switch is closed; and
    wherein the default position of the at least one load switch is open.

8. The switch circuit of claim 1:

wherein the default position of the at least one auxiliary switch is closed; and
wherein the default position of the at least one load switch is closed.

9. The switch circuit of claim 1, wherein the component coil is used in the actuating configuration for actuating the at least one load switch and the at least one auxiliary switch from the default position; and wherein the main coil is used in the holding configuration for holding the at least one load switch and the at least one auxiliary switch in the switched position.

10. The switch circuit of claim 9, wherein the default position of the at least one auxiliary switch is closed.

11. A method of operating a switch circuit comprising a coil structure configured to actuate at least one load switch (322, 324, 422, 424, 522, 524, 526, 622) and at least one auxiliary switch (320, 420, 520, 620) in response to a control input, the coil structure comprising a main coil (312, 412, 512, 612) and a component coil (310, 410, 510, 610), the component coil being a portion of the main coil extending from a first end (318, 418, 518, 618) of the main coil to a tap (316, 416, 516, 616) of the main coil, the coil structure being switchable between an actuating configuration for actuating the at least one load switch and the at least one auxiliary switch from a default position, and a holding configuration for holding the at least one load switch and the at least one auxiliary switch in a switched position, and a resettable current limiting device (330, 430, 530, 630) having a current threshold, the resettable current limiting device being coupled to a second end (314, 414, 514, 614) of the main coil and the tap through the auxiliary switch outside of a flow of a holding current provided when the coil structure is in the holding configuration, the method comprising:

providing a switching current to the coil structure;
generating, in response to the switching current, a force for switching the at least one load switch and the at least one auxiliary switch; and
limiting the switching current flowing through the coil structure using the resettable current limiting device when the switching current exceeds the current threshold for a predetermined period of time.

12. The method of claim 11:

wherein the switch circuit further comprises a control power source configured to supply current to the coil structure; and
wherein the at least one load switch is connected between a power source and a load.

13. The method of claim 12:

wherein the control power source and the power source are aircraft electrical power sources; and
wherein the load is an aircraft electrical load.

14. The method of claim 11, wherein the limiting the switching current flowing through the coil structure using the resettable current limiting device when the switching current exceeds the current threshold for the predetermined period of time comprises substantially limiting the switching current flowing through the coil structure in the actuating configuration using the resettable current limiting device when the switching current exceeds the threshold for the predetermined period of time.

15. The method of claim 11, wherein the limiting the switching current flowing through the coil structure using the resettable current limiting device when the switching current exceeds the current threshold for the predetermined period of time is performed by the resettable current limiting device, where a resistance of the resettable current limiting device increases at least an order of magnitude when the switching current exceeds the threshold for the predetermined period of time.

Patentansprüche

1. Schaltstromkreis, umfassend:

mindestens einen Lastschalter (322, 324, 422, 424, 522, 524, 526, 622), der zwischen eine Leistungsquelle (304, 404, 504, 604) und einen Verbraucher (306, 406, 506, 606) schaltbar ist, und mindestens einen Hilfsschalter (320, 420, 520, 620), wobei jeder Schalter zwischen einer Normalstellung und einer Umschaltstellung verstellt werden kann;
eine Spulenstruktur, die eine Hauptspule (312, 412, 512, 612) und eine Nebenspule (310, 410, 510, 610) umfasst, wobei die Nebenspule ein Abschnitt der Hauptspule ist, der sich von einem ersten Ende (318, 418, 518, 618) der Hauptspule zu einem Abgriff (316, 416, 516, 616) der Hauptspule erstreckt, wobei die Spulenstruktur so gestaltet ist, dass sie den mindestens einen Lastschalter und den mindestens einen Hilfsschalter als Reaktion auf einen Steuerungseingang verstellt, wobei die Spulenstruktur umschaltbar ist zwischen:

einer Betätigungskonfiguration zum Verstellen des mindestens einen Lastschalters und des mindestens einen Hilfsschalters aus der Normalstellung, und
einer Haltekonfiguration zum Halten des mindestens einen Lastschalters und des mindestens einen Hilfsschalters in der Umschaltstellung, und

wobei der mindestens eine Hilfsschalter so gestaltet ist, dass er die Spulenstruktur aus der Betätigungskonfiguration in die Haltekonfiguration umschaltet,
dadurch gekennzeichnet, dass der Schaltstromkreis eine zurücksetzbare Strombegrenzungsvorrichtung (330, 430, 530, 630) umfasst, die so gestaltet ist, dass sie den Stromfluss in der Betätigungskonfiguration der Spulenstruktur begrenzt, wenn der Stromfluss für eine vorgegebene Zeitspanne einen Schwellenwert überschreitet,
wobei die zurücksetzbare Strombegrenzungsvorrichtung durch den Hilfsschalter mit einem zweiten Ende (314, 414, 514, 614) der Hauptspule und dem Abgriff verbunden ist.

2. Schaltstromkreis nach Anspruch 1:

wobei der Steuerungseingang und die Leistungsquelle Stromquellen für ein Flugzeug sind; und wobei der Verbraucher ein elektrischer Verbraucher an einem Flugzeug ist.

3. Schaltstromkreis nach Anspruch 1, wobei eine Impedanz der zurücksetzbaren Strombegrenzungsvorrichtung um mindestens eine Größenordnung zunimmt, wenn der Strom den Schwellenwert für die vorgegebene Zeitspanne überschreitet.

4. Schaltstromkreis nach Anspruch 1, wobei die zurücksetzbare Strombegrenzungsvorrichtung so gestaltet ist, dass sie einen Strom mit minimaler Impedanz fließen lässt, wenn der Strom für eine andere vorgegebene Zeitspanne unter dem Schwellenwert bleibt.

5. Schaltstromkreis nach Anspruch 1:

wobei ein erster Strom, der vom Steuerungseingang geliefert wird, den mindestens einen Lastschalter und den mindestens einen Hilfsschalters aus der Normalstellung verstellt, und
wobei ein zweiter Strom, der vom Steuerungseingang geliefert wird, den mindestens einen Lastschalter und den mindestens einen Hilfsschalters in der Umschaltstellung hält, und
wobei der erste Strom stärker ist als der zweite Strom.

6. Schaltstromkreis nach Anspruch 1, wobei die zurücksetzbare Strombegrenzungsvorrichtung eine Thermistor und/oder eine Vorrichtung auf Basis eines positiven Temperaturkoeffizienten ist.

7. Schaltstromkreis nach Anspruch 1:

wobei die Normalstellung des mindestens einen Hilfsschalters Geschlossen ist; und
wobei die Normalstellung des mindestens einen Lastschalters Offen ist.

8. Schaltstromkreis nach Anspruch 1:

wobei die Normalstellung des mindestens einen Hilfsschalters Geschlossen ist; und
wobei die Normalstellung des mindestens eien Lastschalters Geschlossen ist.

9. Schaltstromkreis nach Anspruch 1, wobei die Nebenspule in der Betätigungskonfiguration verwendet wird, um den mindestens einen Lastschalter und den mindestens einen Hilfsschalter aus der Normalstellung umzuschalten; und
wobei die Hauptspule in der Haltekonfiguration verwendet wird, um den mindestens einen Lastschalter und den mindestens einen Hilfsschalter in der Umschaltstellung zu halten.

10. Schaltstromkreis nach Anspruch 9, wobei die Normalstellung des mindestens einen Hilfsschalters geschlossen ist.

11. Verfahren zum Betreiben eines Schaltstromkreises, der aufweist: eine Spulenstruktur, die so gestaltet ist, dass sie als Reaktion auf einen Steuerungseingang mindestens einen Lastschalter (322, 324, 422, 424, 522, 524, 526, 622) und mindestens einen Hilfsschalter (320,420,520, 620) betätigt, wobei die Spulenstruktur eine Hauptspule (312,412, 512, 612) und eine Nebenspule (310,410, 510, 610) umfasst, wobei die Nebenspule ein Abschnitt der Hauptspule ist, der sich von einem ersten Ende (318,418,518,618) der Hauptspule zu einem Abgriff (316,416,516,616) der Hauptspule erstreckt, wobei die Spulenstruktur umschaltbar ist zwischen einer Betätigungskonfiguration zum Verstellen des mindestens einen Lastschalters und des mindestens einen Hilfsschalters aus eine Normalstellung und einer Haltekonfiguration zum Halten des mindestens einen Lastschalters und des mindestens einen Hilfsschalters in einer Umschaltstellung, und eine zurücksetzbare Strombegrenzungsvorrichtung (330,430, 530, 630) mit einem Stromschwellenwert, wobei die zurücksetzbare Strombegrenzungsvorrichtung durch den Hilfsschalter außerhalb eines Stroms eines Haltestroms, der bereitgestellt wird, wenn die Spulenstruktur in der Haltekonfiguration ist, mit einem zweiten Ende

(314,414,514,614) der Hauptspule und dem Abgriff verbunden ist, wobei das Verfahren umfasst:

Liefern eines Umschaltstroms zur Spulenstruktur;
Erzeugen einer Kraft zum Umschalten des mindestens einen Lastschalters und des mindestens einen Hilfsschalters als Reaktion auf den Umschaltstrom; und
Begrenzen des Umschaltstroms, der durch die Spulenstruktur fließt, unter Verwendung der zurücksetzbaren Strombegrenzungsvorrichtung, wenn der Umschaltstrom den Stromschwellenwert für eine vorgegebene Zeitspanne überschreitet.

12. Verfahren nach Anspruch 11:

wobei der Schaltstromkreis ferner eine Steuerungsleistungsquelle umfasst, die so gestaltet ist, dass sie Strom zur Spulenstruktur liefert; und wobei der mindestens eine Lastschalter zwischen eine Leistungsquelle und einen Verbraucher geschaltet ist.

13. Verfahren nach Anspruch 12:

wobei die Steuerungsleistungsquelle und die Leistungsquelle Stromquellen für ein Flugzeug sind; und
wobei der Verbraucher ein elektrischer Verbraucher an einem Flugzeug ist.

14. Verfahren nach Anspruch 11, wobei das Begrenzen des Umschaltstroms, der durch die Spulenstruktur fließt, unter Verwendung der zurücksetzbaren Strombegrenzungsvorrichtung, wenn der Umschaltstrom für die vorgegebene Zeitspanne den Stromschwellenwert überschreitet, das wesentliche Begrenzen des Umschaltstroms, der durch die Spulenstruktur fließt, in der Betätigungskonfiguration unter Verwendung der zurücksetzbaren Strombegrenzungsvorrichtung, wenn der Umschaltstrom den Schwellenwert für die vorgegebene Zeitspanne überschreitet, umfasst.

15. Verfahren nach Anspruch 11, wobei das Begrenzen des Umschaltstroms, der durch die Spulenstruktur fließt, unter Verwendung der zurücksetzbaren Strombegrenzungsvorrichtung, wenn der Umschaltstrom für die vorgegebene Zeitspanne den Stromschwellenwert überschreitet, von der zurücksetzbaren Strombegrenzungsvorrichtung durchgeführt wird, wobei ein Widerstand der zurücksetzbaren Strombegrenzungsvorrichtung um mindestens eine Größenordnung steigt, wenn der Umschaltstrom den Schwellenwert für die vorgegebene Zeitspanne überschreitet.

Revendications

1. Circuit de commutation comprenant :

au moins un commutateur de charge (322, 324, 422, 424, 522, 524, 526, 622) pouvant être connecté entre une source de puissance (304, 404, 504, 604) et une charge (306, 406, 506, 606) et au moins un commutateur auxiliaire (320, 420, 520, 620),
chaque commutateur pouvant être actionné entre une position par défaut et une position commutée ;
une structure de bobines comprenant une bobine principale (312, 412, 512, 612) et une bobine de composant (310, 410, 510, 610), la bobine de composant étant une partie de la bobine principale s'étendant d'une première extrémité (318, 418, 518, 618) de la bobine principale vers une prise (316, 416, 516, 616) de la bobine principale, la structure de bobines étant configurée pour actionner ledit au moins un commutateur de charge et au moins un commutateur auxiliaire en réponse à une entrée de commande, la structure de bobines pouvant être commutée entre :

une configuration d'actionnement pour actionner ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire à partir de la position par défaut, et une configuration de maintien pour maintenir ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire dans la position commutée ;
dans lequel ledit au moins un commutateur auxiliaire est configuré pour commuter la structure de bobines de la configuration d'actionnement vers la configuration de maintien, **caractérisé en ce que** le circuit de commutation comprend un dispositif de limitation de courant réarmable (330, 430, 530, 630) configuré pour limiter la circulation de courant dans la configuration d'actionnement de la structure de bobines si la circulation de courant dépasse un seuil pendant une période de temps prédéterminée, dans lequel le dispositif de limitation de courant réarmable est couplé à une deuxième extrémité (314, 414, 514, 614) de la bobine principale et à la prise par l'intermédiaire du commutateur auxiliaire.

2. Circuit de commutation selon la revendication 1, dans lequel l'entrée de commande et la source de puissance sont des sources de puissance électrique d'avion ; et
dans lequel la charge est une charge électrique d'avion.

3. Circuit de commutation selon la revendication 1, dans lequel une impédance du dispositif de limitation de courant réarmable augmente d'au moins un ordre de grandeur lorsque le courant dépasse le seuil pendant la période de temps prédéterminée.

4. Circuit de commutation selon la revendication 1, dans lequel le dispositif de limitation de courant réarmable est configuré pour permettre la circulation du courant avec une impédance minimale lorsque le courant est au-dessous du seuil pendant une autre période de temps prédéterminée.

5. Circuit de commutation selon la revendication 1,
dans lequel un premier courant délivré par l'entrée de commande actionne ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire à partir de la position par défaut ;
dans lequel un deuxième courant délivré par l'entrée de commande maintient ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire dans la position commutée ; et
dans lequel le premier courant est plus grand que le deuxième courant.

6. Circuit de commutation selon la revendication 1, dans lequel le dispositif de limitation de courant réarmable est l'un d'une thermistance et d'un dispositif à coefficient de température positif.

7. Circuit de commutation selon la revendication 1,
dans lequel la position par défaut dudit au moins un commutateur auxiliaire est la position fermée ; et
dans lequel la position par défaut dudit au moins un commutateur de charge est la position ouverte.

8. Circuit de commutation selon la revendication 1,
dans lequel la position par défaut dudit au moins un commutateur auxiliaire est la position fermée ; et
dans lequel la position par défaut dudit au moins un commutateur de charge est la position fermée.

9. Circuit de commutation selon la revendication 1,
dans lequel la bobine de composant est utilisée dans la configuration d'actionnement pour actionner ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire à partir de la position par défaut ; et
dans lequel la bobine principale est utilisée dans la configuration de maintien pour maintenir ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire dans la position commutée.

10. Circuit de commutation selon la revendication 9, dans lequel la position par défaut dudit au moins un commutateur auxiliaire est la position fermée.

11. Procédé de mise en oeuvre d'un circuit de commutation comprenant une structure de bobines configurée pour actionner au moins un commutateur de charge (322, 324, 422, 424, 522, 524, 526, 622) et au moins un commutateur auxiliaire (320, 420, 520, 620) en réponse à une entrée de commande, la structure de bobines comprenant une bobine principale (312, 412, 512, 612) et une bobine de composant (310, 410, 510, 610), la bobine de composant étant une partie de la bobine principale s'étendant d'une première extrémité (318, 418, 518, 618) de la bobine principale jusqu'à une prise (316, 416, 516, 616) de la bobine principale, la structure de bobines pouvant être commutée entre une configuration d'actionnement pour actionner ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire à partir d'une position par défaut et une configuration de maintien pour maintenir ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire dans une position commutée, et un dispositif de limitation de courant réarmable (330, 430, 530, 630) ayant un seuil de courant, le dispositif de limitation de courant réarmable étant couplé à une deuxième extrémité (314, 414, 514, 614) de la bobine principale et à la prise par l'intermédiaire du commutateur auxiliaire à l'extérieur d'une circulation d'un courant de maintien fourni lorsque la structure de bobines est dans la configuration de maintien, le procédé comprenant :

la fourniture d'un courant de commutation à la structure de bobines ;
la génération, en réponse au courant de commutation, d'une force pour commuter ledit au moins un commutateur de charge et ledit au moins un commutateur auxiliaire ; et
la limitation du courant de commutation circulant à travers la structure de bobines en utilisant le dispositif de limitation de courant réarmable lorsque le courant de commutation dépasse le seuil de courant pendant une période de temps prédéterminée.

12. Procédé selon la revendication 11,
dans lequel le circuit de commutation comprend en outre une source de puissance de commande configurée pour fournir du courant à la structure de bobines ; et
dans lequel ledit au moins un commutateur de charge est connecté entre une source de puissance et une charge.

13. Procédé selon la revendication 12,
dans lequel la source de puissance de commande et la source de puissance sont des sources de puissance électrique d'avion ; et
dans lequel la charge est une charge électrique d'avion.

14. Procédé selon la revendication 11, dans lequel la limitation du courant de commutation circulant à travers la structure de bobines en utilisant le dispositif de limitation de courant réarmable lorsque le courant de commutation dépasse le seuil de courant pendant la période de temps prédéterminée comprend la limitation sensiblement du courant de commutation circulant à travers la structure de bobines dans la configuration d'actionnement en utilisant le dispositif de limitation de courant réarmable lorsque le courant de commutation dépasse le seuil pendant la période de temps prédéterminée.

15. Procédé selon la revendication 11, dans lequel la limitation du courant de commutation circulant à travers la structure de bobines en utilisant le dispositif de limitation de courant réarmable lorsque le courant de commutation dépasse le seuil de courant pendant la période de temps prédéterminée est effectuée par le dispositif de limitation de courant réarmable, dans lequel une résistance du dispositif de limitation de courant réarmable augmente d'au moins un ordre de grandeur lorsque le courant de commutation dépasse le seuil pendant la période de temps prédéterminée.

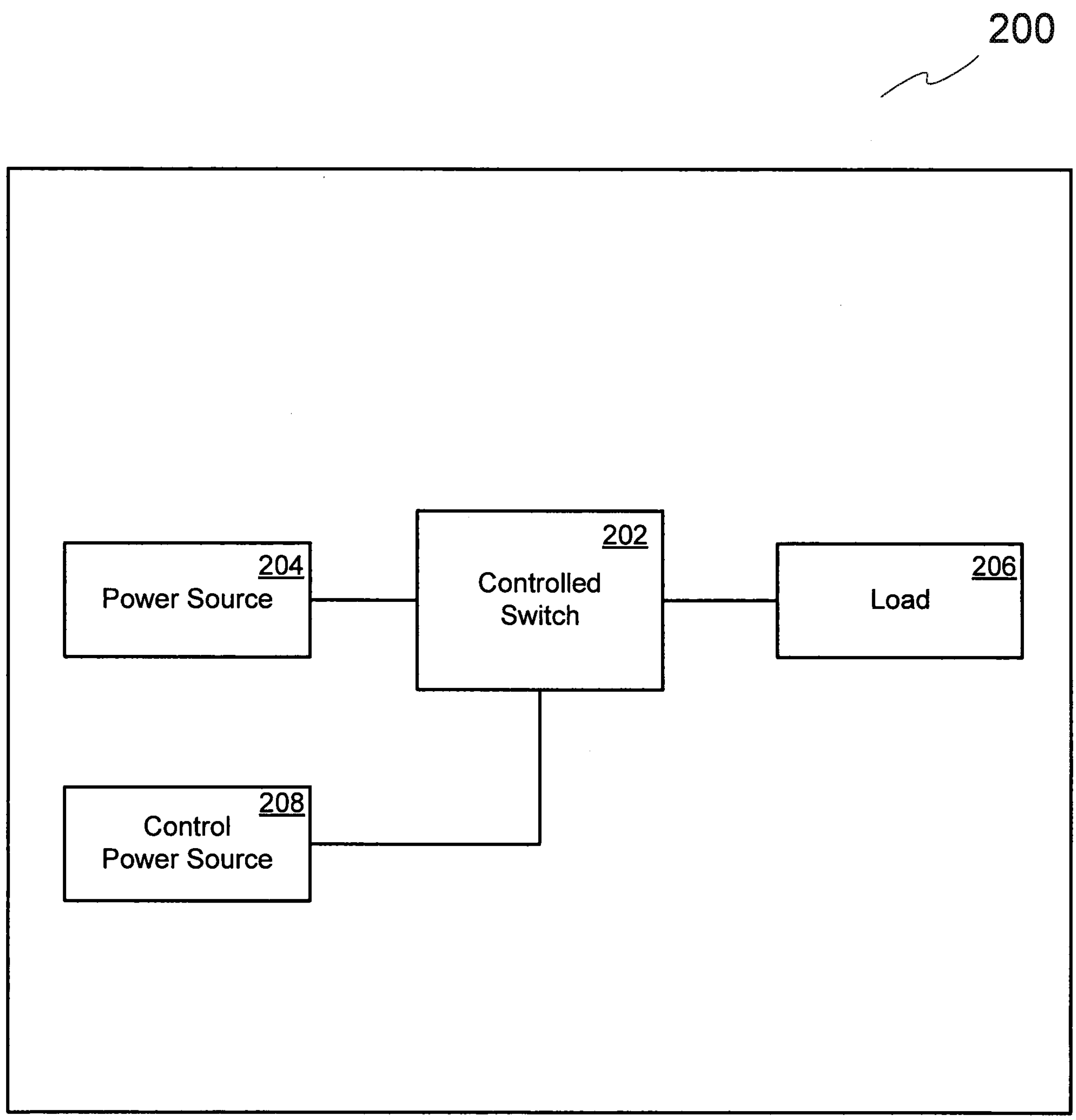
200
204
Power Source
202
Controlled
Switch
206
Load
208
Control
Power Source

FIG. 1

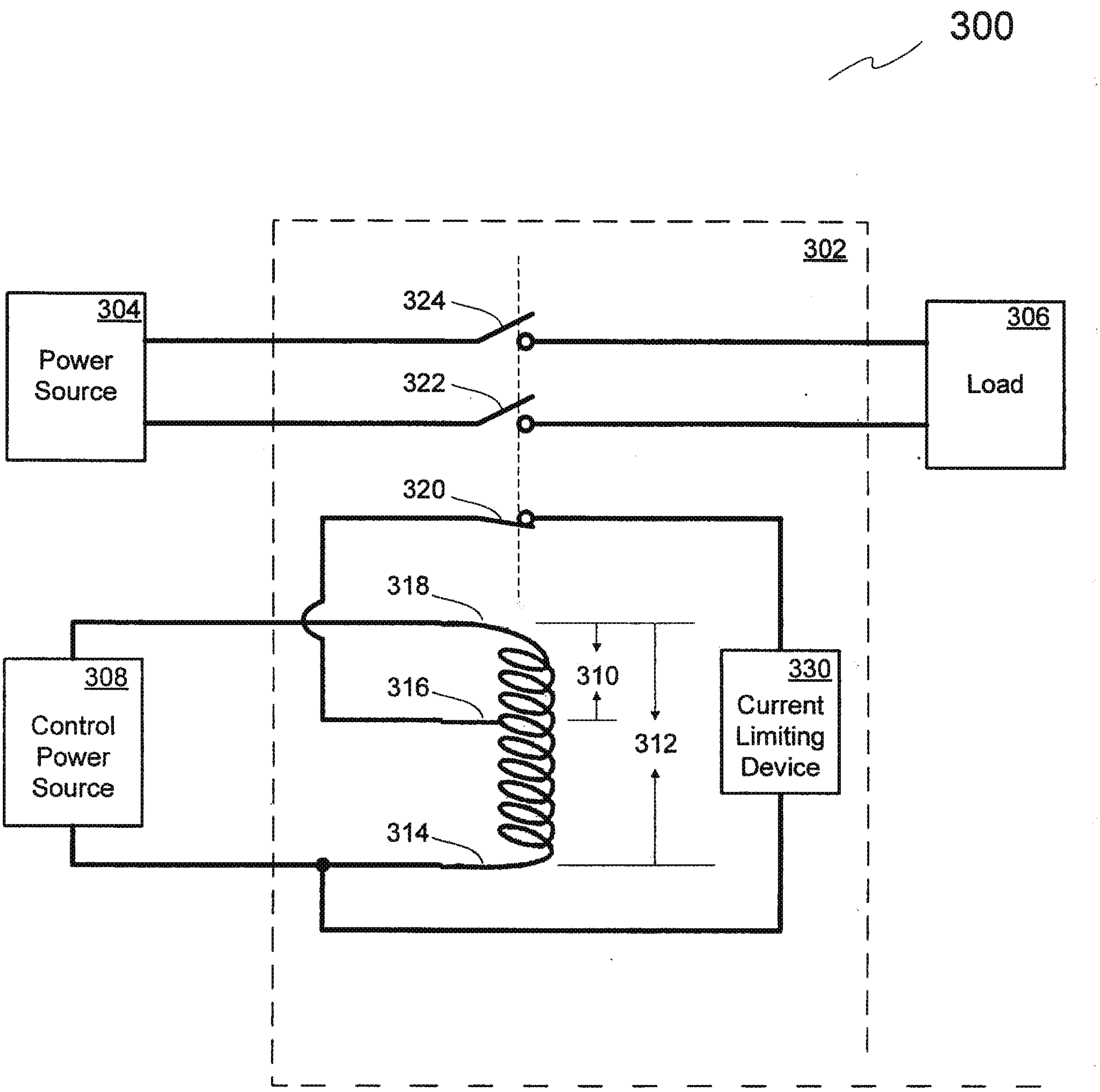
300
302
304
Power Source
324
322
320
306
Load
318
316
314
310
312
308
Control Power Source
330
Current Limiting Device

FIG. 2

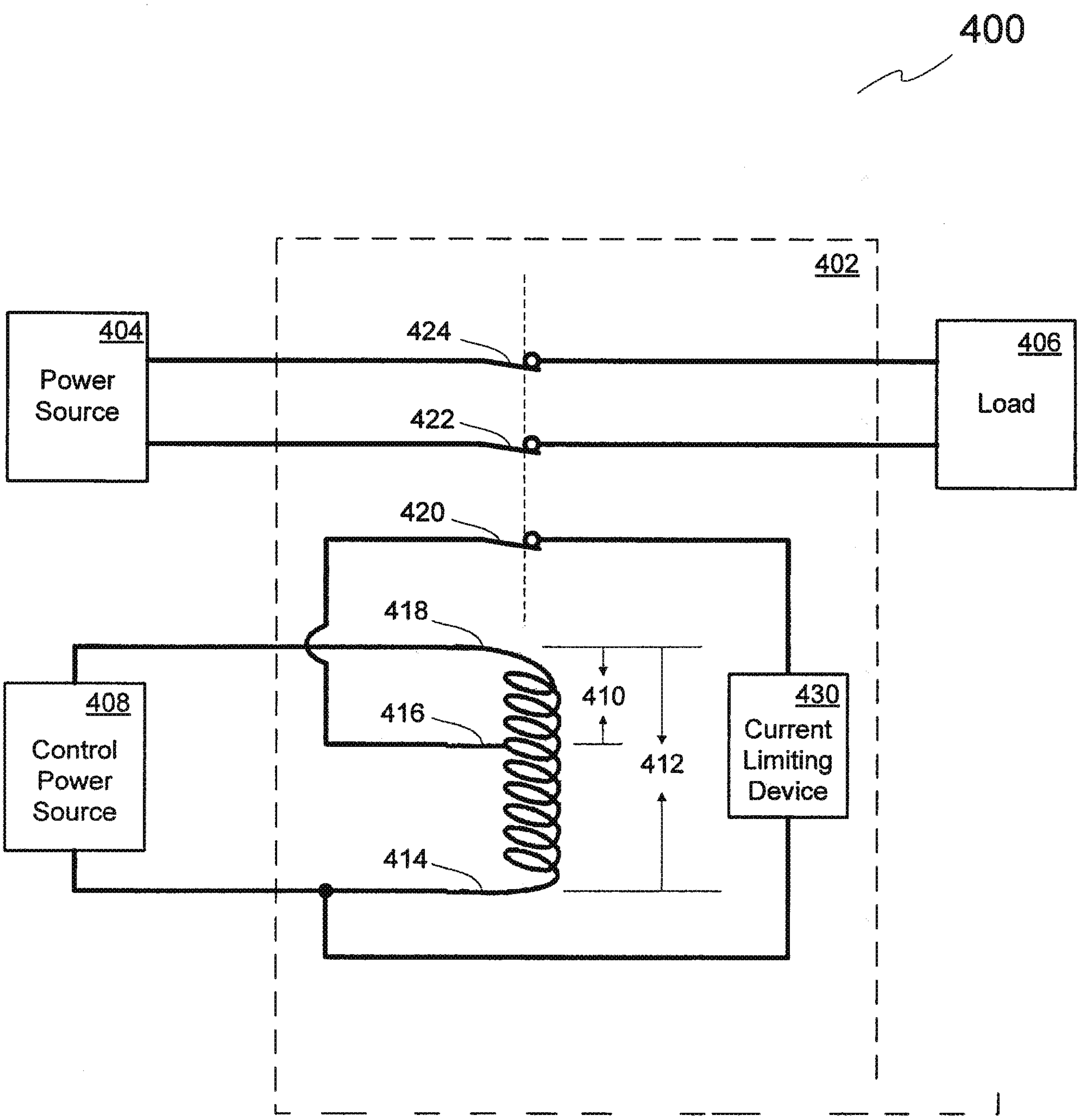
400
402
404
Power Source
406
Load
424
422
420
418
416
414
410
412
408
Control Power Source
430
Current Limiting Device

FIG. 3

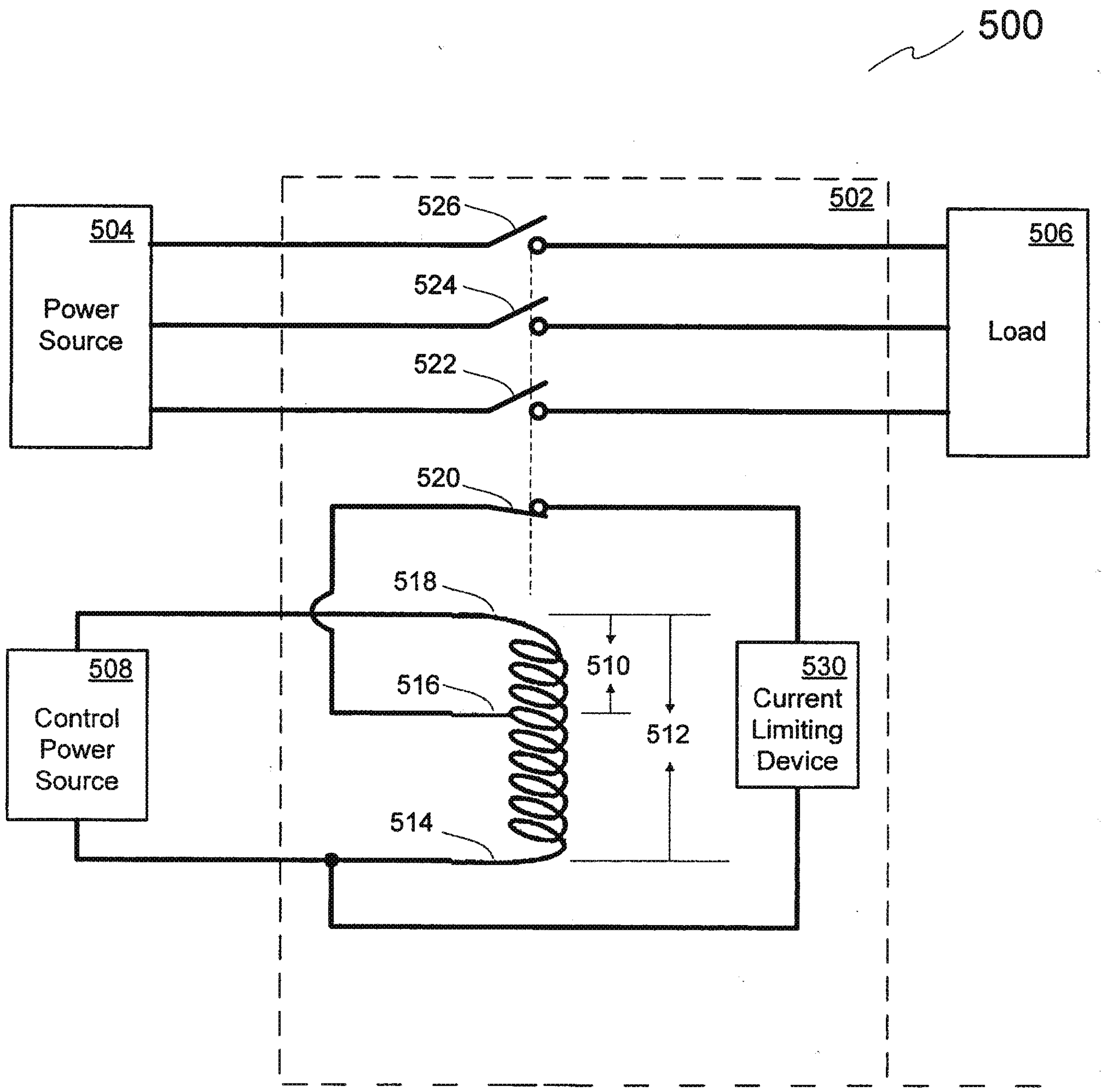
500
502
504
Power Source
506
Load
526
524
522
520
518
516
514
510
512
508
Control Power Source
530
Current Limiting Device

FIG. 4

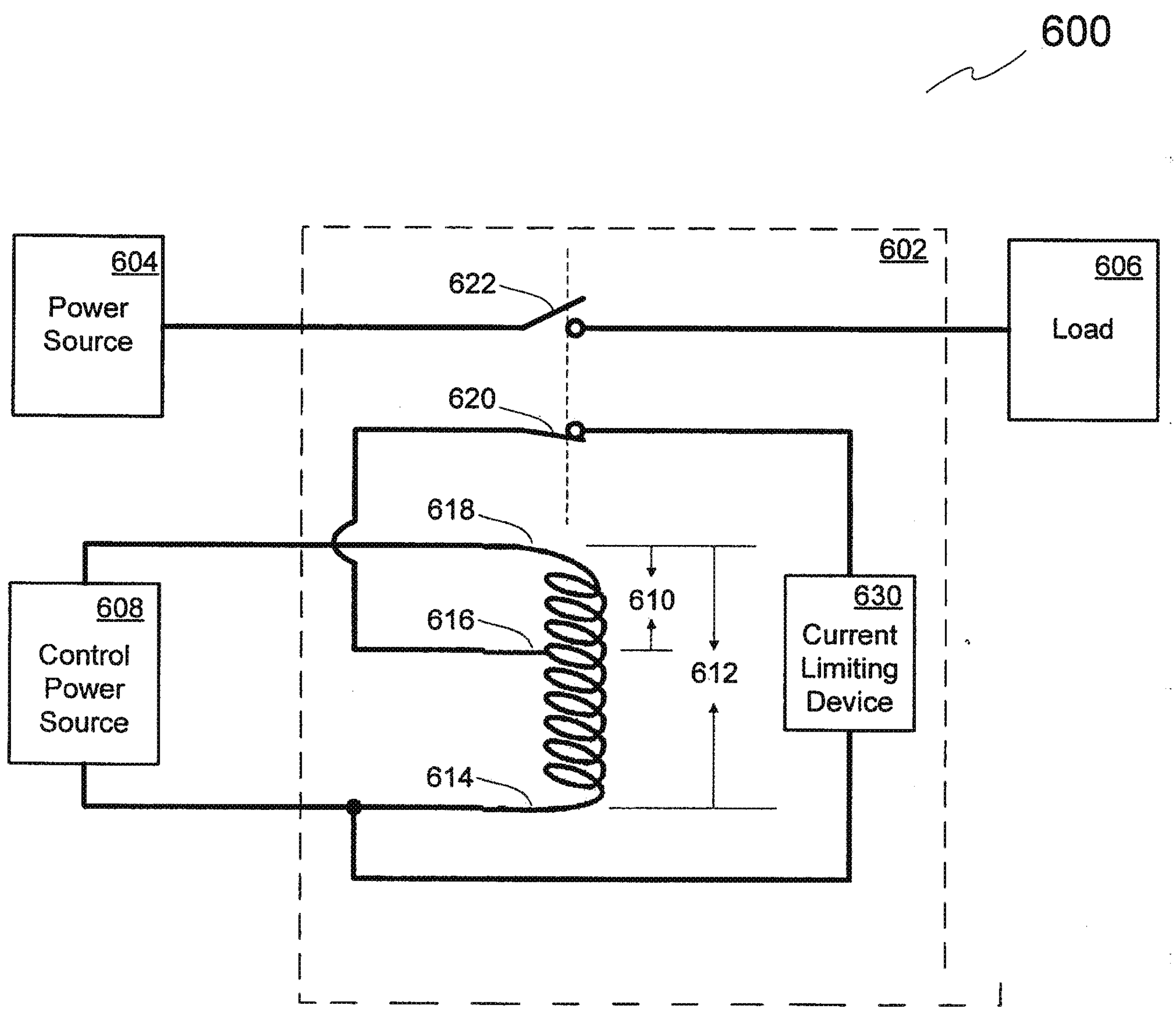
600
604
Power Source
602
622
620
606
Load
618
616
614
610
612
608
Control Power Source
630
Current Limiting Device

FIG. 5

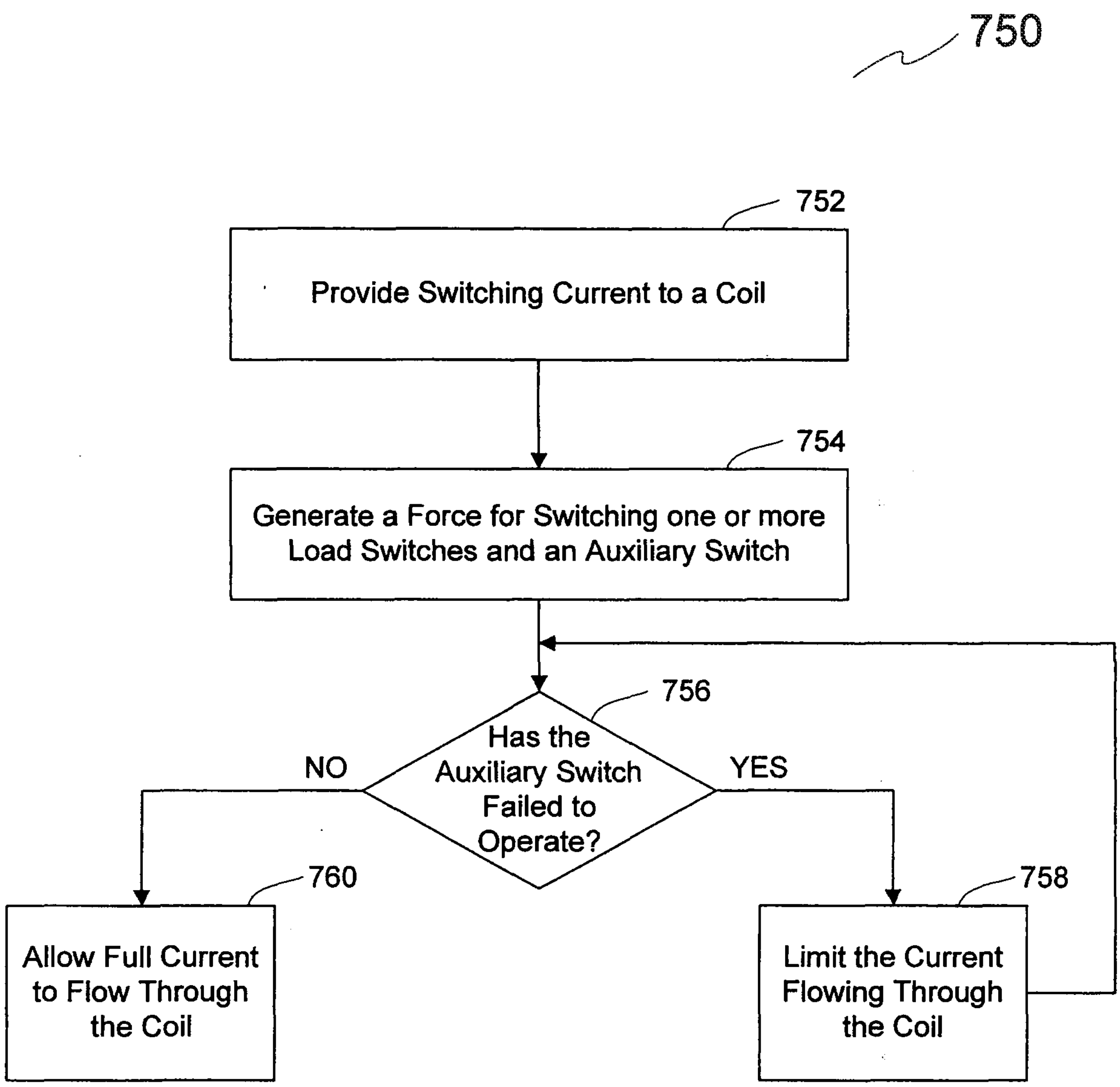
750
752
Provide Switching Current to a Coil
754
Generate a Force for Switching one or more Load Switches and an Auxiliary Switch
756
Has the Auxiliary Switch Failed to Operate?
NO
YES
760
Allow Full Current to Flow Through the Coil
758
Limit the Current Flowing Through the Coil

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- GB 272012 A **[0002]**