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Clausing

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[54] **CURRENT LIMITING CIRCUIT INTERRUPTER DEVICE**

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[52] **U.S. Cl.**..... **317/11 C,** 200/144 AP, 307/136

[51] **Int. Cl.** **H02h 7/22**

[58] **Field of Search** .. 200/144 AP; 317/11 C, 11 A; 323/43.5 R, 43.5 A; 307/136

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[57] **ABSTRACT**

A helically wound coil is connected in series with a circuit interrupter and electrical contacts on diametrically opposite sides of each turn of the coil form direct current paths in parallel for each coil so that substantially no inductance is in the power circuit when the contacts are closed. The contacts are opened sequentially in response to a fault current to gradually introduce one or more turns of the coil in the series circuit in order to limit the rise of fault current before the series interrupter device is operated.

17 Claims, 8 Drawing Figures

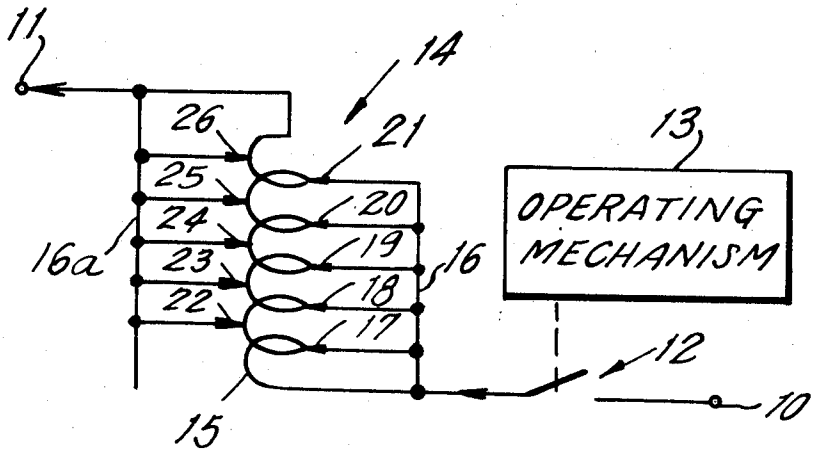


FIG. 1.

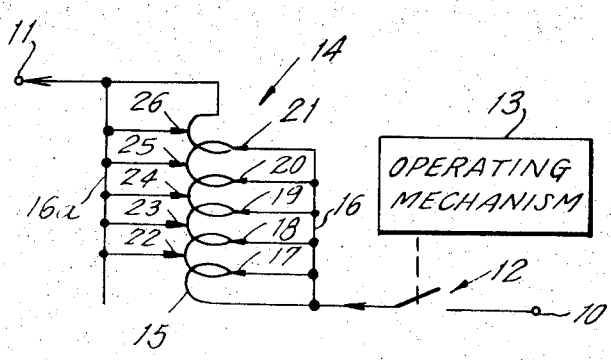

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OPERATING MECHANISM
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FIG. 3.

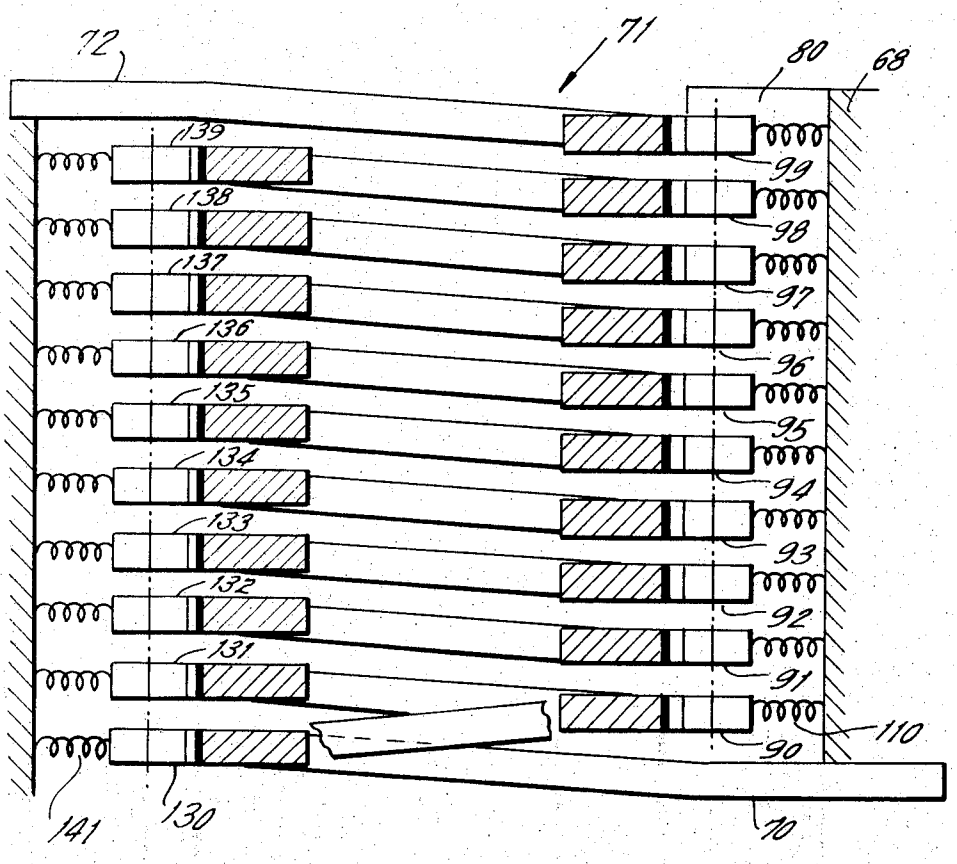
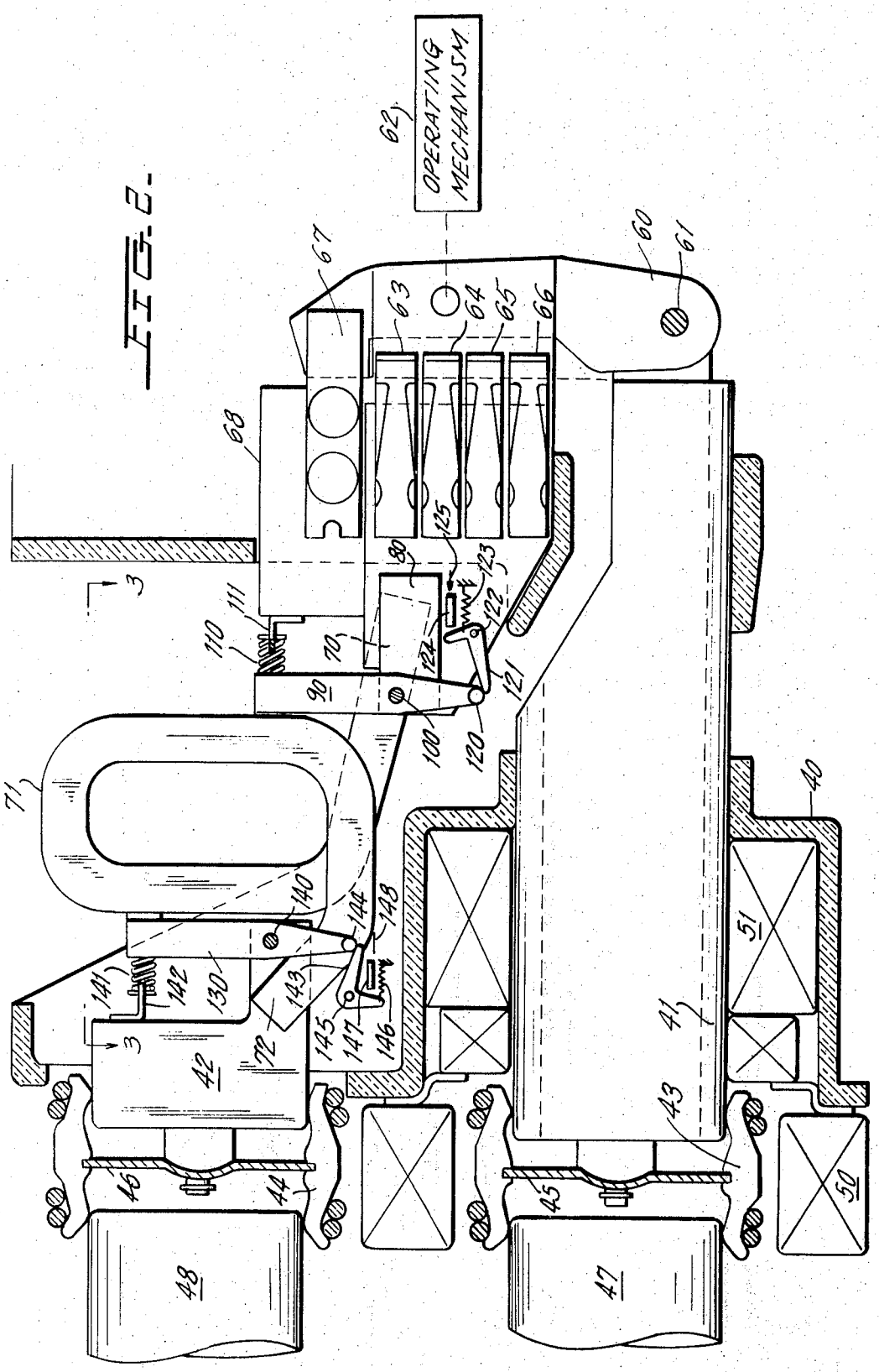

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FIG. 2.


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OPERATING MECHANISM
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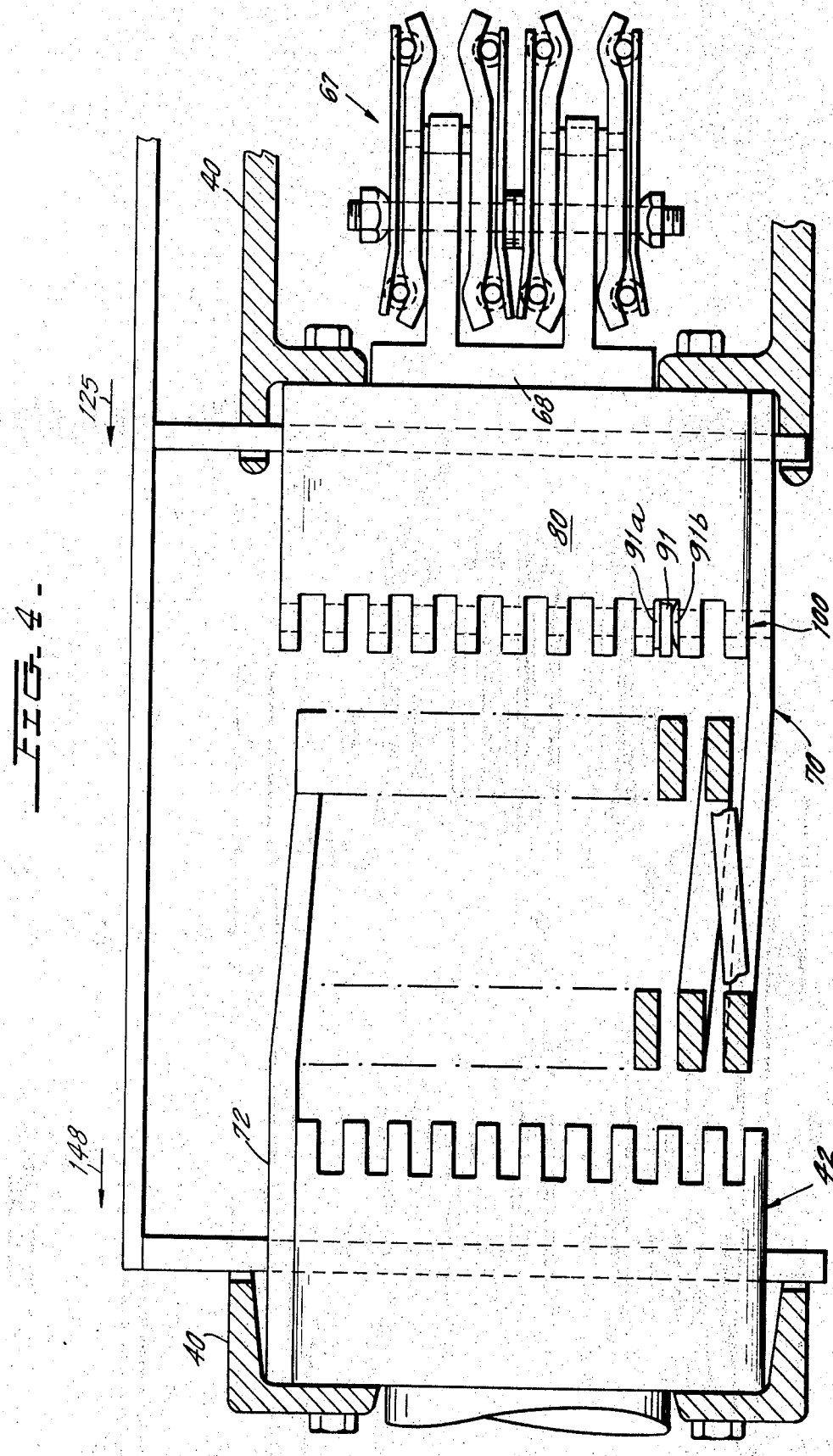


FIG. 4.

FIG. 5.

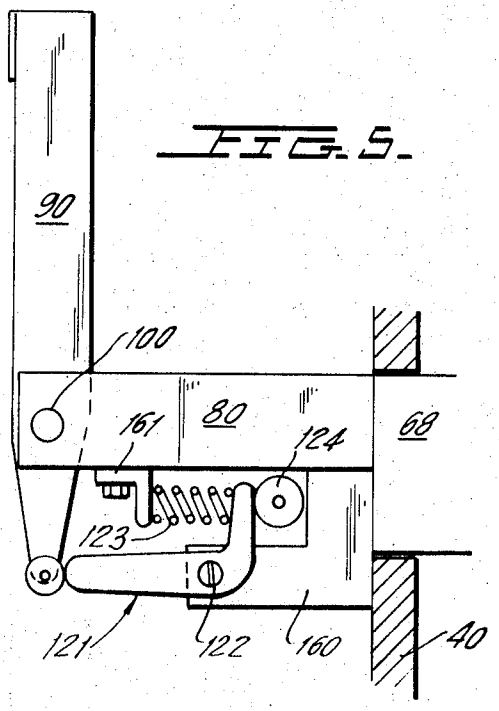


FIG. 7.

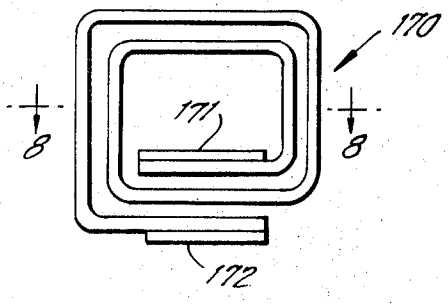
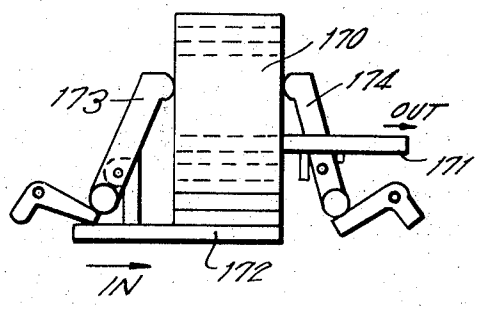


FIG. 6.



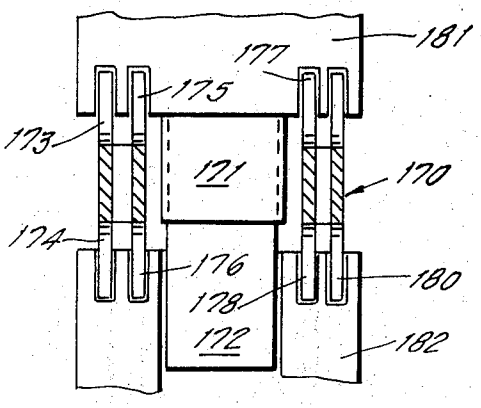


FIG. 8.

CURRENT LIMITING CIRCUIT INTERRUPTER DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a current limiting device, and more specifically relates to a novel device for introducing impedence into a circuit in response to some predetermined condition, such as a fault or overload condition, in order to limit the magnitude of the fault current.

Current limiting devices are well known to those skilled in the art and frequently take the form of current limiting fuses or the like which tend to substantially increase circuit impedance over the range of their operation. Such current limiting fuses are frequently used in combination with circuit breakers so that the fuse will tend to substantially limit the magnitude of fault current if the short circuit would exceed breaker rating. The circuit breaker interrupts relatively low currents up to its rating and the fuse clears fault currents which could have been supplied from the circuit being protected above the breaker rating. Other arrangements are well known for limiting the fault current in a circuit in which impedance, and particularly resistance, is sequentially introduced into the circuit as a circuit interrupter is operated.

BRIEF DESCRIPTION OF THE PRESENT INVENTION

The present invention provides a novel current limiting device which can be formed as a subassembly, and used by itself or in combination with series connected power fuses or circuit breakers, or the like. The novel device can then be sized to limit current to a value within the rating of the main interrupter device and is resettable and reusable.

The current limiting device of the invention consists of an electrical winding having a plurality of turns. The winding is connected in series with a circuit to be protected. The individual turns of the winding are normally short-circuited by individual contact element bearing on opposite sides of the individual turns or groups of turns of the winding. These individual contacts are then spring-biased into engagement with their respective turn, and are arranged to "blow off" due to the magnetic field of a fault current which may be produced in this circuit. When these contacts blow off, the individual turn which they cooperate with is inserted into the power circuit, thereby to insert an inductive impedance in the circuit.

The various contacts may be further arranged so that they are sequentially forced out of engagement with their respective coils, so that the full impedance of the entire winding is relatively gradually inserted into the circuit.

The current through the circuit may then be limited either until it returns to some normal value, or the limited current can be interrupted by a conventional interrupter in series with the circuit. As pointed out previously, the current will be limited to a value within the rating of this main interrupter device. Once the current has returned to its normal value or has been interrupted by the main interrupter device, the individual contacts bearing on the turns of the helical coil can be reclosed by releasing latches which latch the contacts open when they reach an opened position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates the present invention where the current limiting impedance is a helical winding.

FIG. **2** is a side view, partially in cross-section, of a circuit breaker equipped with the novel current limiting device of the invention, wherein the impedance takes the form of a helical winding.

FIG. **3** is a cross-sectional view of FIG. **2** taken across the section line **3—3** in FIG. **2.**

FIG. **4** is a plan view of the top of the circuit breaker of FIG. **2.**

FIG. **5** shows a modified arrangement for the mounting of a contact finger.

FIG. **6** is a side view of a further embodiment of the invention wherein the coil is spirally wound as contrasted to the helically wound coil of FIGS. **2, 3** and **4.**

FIG. **7** is an end view of the coil of FIG. **6.**

FIG. **8** is a cross-sectional view through section line **8—8** of FIG. **7** which illustrates the inter-connection between the contact elements of the spiral coil.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates the circuit of the present invention, and shows one phase of a power circuit having input and output terminals **10** and **11,** respectively, wherein a circuit breaker **12,** which may be of any conventional type, is connected in series with terminals **10** and **11** and is provided with a conventional operating mechanism.

The current limiting device of the invention is shown as device **14** and consists of a multi-turn winding **15** connected in series with the main power circuit. The input side of the circuit has a conductive support **16** which supports a plurality of moving contacts **17** to **21** which, as will be later seen, are spring-loaded into engagement with individual turns at locations which are physically on the same side of the coil **15.** The output of the device **14** contains similar contact fingers **22** to **26,** supported from conductive support **16***a*, which are in engagement with individual coil turns on the opposite side of coil **15** from the side which receives contacts **17** to **21.**

The normal current flow in the circuit of FIG. **1** will then be from terminal **10** through interrupter **12,** through all of input fingers **17** to **21** and then through all of the output fingers **22** to **26** of the terminal **11.** The current flow from contacts **17** to **21** to contacts **22** to **26** for a given coil turn will be in one direction over the top of the turn and the opposite direction through the bottom of the turn. Thus, the entire winding **15** is, in effect, split up into parallel conductors with no current flowing around the coil as in an inductive device. Thus, the coil **15** has no intentional impedance. The various contact fingers **17** to **26** are then arranged, as will be later seen, to be blown off by the current flow through the sections of the coil. Note, however, that any other desired operating mechanism can be provided to operate the individual contact fingers **17** to **26.** If the blow-off mode is used when a short-circuit occurs, the contact fingers **17** to **26** will blow off at some level determined by respective contact pressure springs. Once open, each finger may be held open by an individual latch. Note that the blow open action will be cumulative in that, as soon as one finger blows off, more cur-

rent must flow in the remaining parallel paths to force the sequential operation of each of the contact fingers **17** to **26.** The springs may further be adjusted to ensure a particular sequence of operation such that contacts **17** through **21** blow off in sequence, contacts **22** through **26** blow off next in sequence. By properly controlling the number of turns and the geometry of coil **15,** arcing at the individual contact fingers can be eliminated, or minimized to a point where the arc can be easily extinguished.

After the circuit has been operated and the circuit breaker **12** is opened, the contact fingers can be reset by spring pressure of their biasing springs when the individual latches of contacts **17** to **26** are removed.

FIGS. **2, 3** and **4** schematically illustrate a conventional type of circuit interrupter which has been modified to receive a current limiting device of the general type shown in FIG. **1.** Referring first to FIG. **2,** there is schematically illustrated a circuit breaker of a generally conventional type and which has a molded support housing **40** which carries tubular conductive terminals **41** and **42** which have tulip type disconnect contact assemblies **43** and **44** connected thereto by webs **45** and **46,** respectively. The tulip type disconnect contacts **43** and **44** are then engageable with appropriate stationary conductors such as the stationary conductors **47** and **48,** respectively, which may be the stationary disconnect contacts contained in the interior of a conventional switchgear housing. Note that the breaker shown in FIG. **2** is of the type that is conventionally racked in and out of its switchgear cubicle. Conventional auxiliary equipment is provided for the circuit breaker such as the current transformers **50** and **51** which encircle the lower terminal of the device.

The lower elongated terminal **41** is then connected to a movable contact arm **60** which is pivotally mounted on stationary pivot **61** and which is operated by rotation about pivot **61** by a conventional operating mechanism **62.** Operating mechanism **62** is equivalent to mechanism **13** in FIG. **1.** The movable contact **60** then cooperates with stationary contact elements, such as contact fingers disposed beneath contact springs **63** to **66** and by an arcing contact **67.** These various contact elements make sliding contact with contact arm **60** to complete a current path to the stationary conductive member **68.**

All of the foregoing structure described in connection with FIGS. **2** and **4** is of any desired conventional type and is simply intended to show a circuit breaker which can be of the type schematically show for the circuit interrupter **12** of FIG. **1.**

In accordance with the invention, the current conducting member **68** of FIG. **2** is connected as by brazing or bolting, or the like, to the terminal **70** of the multi-helical winding **71.**

The helical winding **71** of FIG. **2** is also shown in FIGS. **3** and **4** along with its input conductor **70.** It will be seen from FIGS. **3** and **4** that the winding **71** is a ten-turn winding and has an output conductor **72** which is appropriately connected as by bolting or brazing, or the like, to the conductive support **42** of the circuit breaker.

The conductive member **68** of the circuit breaker of FIG. **2** has an elongated conductive plate member **80,** shown in FIGS. **2, 3** and **4,** which serves as a support for a plurality of contact fingers **90** to **99** which, as can be best seen from FIG. **2,** are pivotally mounted on a pivotal shaft **100** connected with contact finger **90.**

Note that the pivot **100** can be a common pivot for each of contact fingers **90** to **99** or, alternatively, each contact finger can have its own pivotal support cooperating with an extending support finger of conductive body **80.** Note further that the pivotal connection between the member **80** and the fingers **90** to **99** is a current carrying connection which can be conventionally achieved in any desired manner as by conductive washers and the like. Thus, in FIG. **4** and for the case of contact finger **91** there is shown a silver washer **91a** which makes good electrical connection between the finger **91** and the extending comb-like recess of elongated conductive plate **80.** A belleville type washer **91b** presses finger **91** against the washer **91a.**

It will be noted that each of the fingers **90** through **99** is arranged to engage the lateral side of each respective turn of the coil **71.** Moreover, each of the contact fingers is provided with a biasing spring, such as the biasing spring **110,** shown for finger **90,** where the spring **110** is carried on bracket **111.** A similar compression spring is provided for each of the contact fingers **91** through **99** as schematically illustrated in FIG. **3,** where these springs are supported from the block **68.**

The bottom of contact fingers **90** through **99** are then provided with latch rollers, such as the latch roller **120,** shown in FIG. **2** for finger **90,** where the latch roller **120** cooperates with pivotally mounted latch **121** which is pivoted on a fixed support shaft **122.** Latch **121** is further provided with a tension spring **123** which tends to normally rotate the latch clockwise and into engagement with a reset bar and stop member **124.** Thus, the bar **124,** which is movable from the position shown and to the left and in the direction of arrow **125** of FIG. **2,** may be a single bar which operates all of the latches similar to latch **121,** which cooperate with the fingers **91** to **99.**

It can now be understood that when the latch **121** and the other similar latches are in the position shown, that the spring **110** and finger **90** along with the other contact fingers will be pressed into engagement with the respective turns of windings **71.** Note, however, that if the contact fingers **90** to **99** are operated to an open position by rotation in a clockwise direction about pivot **100,** that the latches such as latch **121** will rotate clockwise to the stop position defined by bar **124** in order to latch the individual latch rollers, such as roller **120** of FIG. **2.**

A substantially identical contact finger configuration is provided on the opposite side of winding **71** and is shown in FIG. **3** by the contact fingers **130** to **139.** These contact fingers are mounted and biased and latched in a manner substantially identical to that described above in connection with fingers **90** to **99.** Thus, the fingers are pivotally mounted on pivots such as pivot **140** which are current carrying pivots, and are spring biased into engagement with each of the turns of the coil by biasing springs, such as the biasing spring **141** carried from bracket **142** carried on member **42.**

Latches such as latch **143** are similarly provided to latch the latch rollers, such as latch roller **144** of the contact fingers **130** to **139,** where the latch **143** and similar latches are biased counterclockwise about their support pivots, such as pivot **145** by tension springs **146.** A reset stop bar **147** is also provided which is mov-

able in the direction of arrow **148** in order to allow reset of the individual contact fingers **130** to **139** under the influence of their biasing springs, such as spring **141.**

The current limiting device shown in FIGS. **2** and **3** is operated in response to the current flow through the individual contact fingers **90** through **99** and **130** through **139,** where these fingers are opened due to the magnetic blow-off effect of the current. Thus, the normal current path through the entire assemblage of FIGS. **2** and **3** will be from terminal **47** through conductor **41,** movable contact **60,** stationary contact elements **63, 64, 65, 66** and **67,** into the conductive members **68** and **80** and then into the parallel conductive fingers **90** through **99** and then in parallel through the individual turns of coil **71.** The parallel flowing currents exit through the parallel fingers **130** and **139** and into terminal **42** and then terminal **48.** The current path across the coil **71** is such that the current divides above and below the coil to flow in parallel around the upper and lower half loops formed by the turns of the coil.

The current flow, for example, through finger **90** will then be upwardly and then changing to the left to enter the right-hand side of the turn of coil **71** which is engaged by contact **90.** This change in current direction then forms a blow off path which creates a force which would tend to rotate the contact finger **90** (as well as fingers **91** to **99**) in a clockwise direction and in opposition to the biasing force spring **110.** Under normal current conditions, the biasing force of spring **110** is sufficiently high to maintain good pressure contact but, when the current increases, as due to a short circuit in the circuit being protected by the device, the magnetic forces created are sufficiently strong to rotate fingers **90** to **99** to an open position, where they are latched by their respective latches, such as latch **121.** A similar blow-off path is formed for each of contacts **130** to **139,** so that they too will be blown off when the current carried through these contact fingers becomes sufficiently high.

Preferably, the biasing springs, such as biasing springs **110** and **141,** are so arranged that the fingers blow off in a sequential manner. Thus, the biasing forces can be so arranged that contact finger **90** will be the first to open when a predetermined current magnitude appears. Then fingers **91** through **99** will blow off in sequence. This will then insert the first turn of the inductive winding **71** into the circuit to cause a relatively small inductive impedance to appear in the circuit which will tend to limit current. At the same time, an increased current will flow into the remaining closed fingers so that the next fingers will open, such as contact fingers **130** through **139** in sequence, thereby to insert successive turns into the circuit which is being protected. Ultimately, each of the contact fingers will be opened so that the full coil **71** is inserted in series with the circuit being protected in order to limit the current flow in the circuit.

FIG. **5** shows an alternate arrangement for mounting and latching the contact fingers and is shown in connection with contact finger **90.** Thus, in FIG. **5** an angle member **160** is secured to plate **80** or may be otherwise secured, for example, to the support molding **40** and carries the shaft **122** which pivotally mounts the various latches, such as latch **121.**

The biasing spring **123** for latch **121** is shown in FIG. **5** as a compression spring which is seated at one end on the bracket **161** and at its other end on the interior surface of latch **121,** thereby to bias latch **121** in a clockwise direction and against stop bar **124.** Clearly, other support arrangements could be provided for supporting and biasing the latches such as latch **121.**

The novel invention has been described above in connection with a helically wound inductance coil where current flow through the coil from the contact fingers is along the winding length. FIGS. **6** to **8** schematically illustrate a further embodiment of the invention in connection with a spirally wound coil where current flow between the contact elements is perpendicular to the length of the winding, with the contacts engaging the winding at its end surfaces rather than its lateral surfaces as in FIGS. **2, 3** and **4.**

Thus, in FIGS. **6, 7** and **8** there is shown a two-turn spiral winding **170** which has terminal ends **171** and **172** (FIG. **7**).

As best shown in FIGS. **6** and **8,** contact means including contact pairs **173–174, 175–176, 177–178** and **179–180** are electrically connected to and supported by conductive members **181** and **182.** Terminal **172** is electrically and mechanically connected to conductive member **182** while terminal **171** is electrically and mechanically connected to conductive member **181.** Thus, the terminals of coil **170** are connected so that the coil is in series between conductive members **181** and **182** which are, in turn, appropriately connected to a circuit interrupting device as in the case of FIGS. **2, 3** and **4.** The individual contact members **173** to **180** are then arranged in a manner similar to that described, for example, in connection with FIGS. **3, 4** and **5** where, for example, the contacts are associated with appropriate biasing springs and latches, and the like.

During operation, the individual contact slements engage the ends of respective coil portions so that the electrical winding is simply a conductive shunt between the conductive members **181** and **182.** However, when the electrical contacts **173** to **180** open, the inductance of the coil **170** is inserted in series with conductive members **181** and **182** to introduce impedance into a circuit which could, in turn, limit current rise in the circuit.

Although this invention has been described with respect to preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of this invention be limited, not by the specific disclosure herein, but only the the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. A current limiting device comprising a helically wound winding having first and second terminals at its opposite ends for connecting said winding in series with a circuit to be protected, first and second contact means disposed on opposite sides of said winding and movable into and out of engagement with respective opposite surfaces of at least one turn of said winding, means connecting said first and second contact means to said first and second terminals respectively, and operating means disposed relative to each of said first and second contact means to move said contact means to their said out of engagement positions in response to a given electrical condition, thereby to introduce the in-

ductance of at least said one turn into a circuit connected to said first and second terminals.

2. The device of claim 1 wherein said operating means includes circuit connection means defining a blow-off path for magnetically moving each of said first and second contact means to their said out of engagement positions with said lateral surfaces of said at least one turn.

3. The device of claim 1 which further includes biasing means for normally biasing said first and second contact means to their said engagement positions with said lateral surfaces of said at least one turn.

4. The device of claim 1 which further includes circuit interrupter means connected in series with said first and second terminals.

5. The device of claim 1 which further includes latch means for latching each of said first and second contact means in their said out of engagement positions after they are moved to said out of engagement positions by said operating means.

6. The device of claim 3 which further includes latch means for latching each of said first and second contact means in their said out of engagement positions after they are moved to said out of engagement positions by said operating means.

7. The device of claim 3 wherein said operating means includes circuit connection means defining a blow-off path for magnetically moving each of said first and second contact means to their said out of engagement positions with said lateral surfaces of said at least one turn.

8. The device of claim 6 wherein said operating means includes circuit connection means defining a blow-off path for magnetically moving each of said first and second contact means to their said out of engagement positions with said lateral surfaces of said at least one turn.

9. The device of claim 8 which further includes circuit interrupter means connected in series with said first and second terminals.

10. A current limiting device comprising a helically wound winding having first and second terminals at its opposite ends for connecting said winding in series with a circuit to be protected, first and second pluralities of contact means disposed on laterally opposite sides of said winding and movable into and out of engagement with respective lateral surfaces of respective turns of said winding, means connecting said first and second pluralities of contact means to said first and second terminals respectively, and operating means disposed relative to each of said first and second pluralities of contact means to move said contact means to their said out of engagement positions in response to a given electrical condition, thereby to introduce the inductance of said respective turns into a circuit connected to said first and second terminals.

11. The device of claim 10 which further includes biasing means for normally biasing each of said first and second pluralities of contact means to their said engagement positions.

12. The device of claim 11 which further includes circuit interrupter means connected in series with said first and second terminals.

13. The device of claim 12 which further includes latch means for latching each of said first and second contact means in their said out of engagement positions after they are moved to said out of engagement positions by said operating means.

14. The device of claim 13 wherein said operating means includes circuit connection means defining a blow-off path for magnetically moving each of said first and second contact means to their said out of engagement positions with said lateral surfaces of said at least one turn.

15. The device of claim 10 wherein said first and second pluralities of contact means are sequentially operated by said operating means.

16. The device of claim 1 wherein said winding is helically wound and wherein said contact means are disposed adjacent lateral surfaces of said winding and move in a direction perpendicular to the axis of said winding.

17. The device of claim 1 wherein said winding is spirally wound and wherein said contact means are disposed adjacent end surfaces of said winding and move in a direction parallel to the axis of said winding.

* * * * *