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Mostosi

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[54] **CURRENT-LIMITING ELECTRIC SWITCH**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **335/195**

[51] **Int. Cl.** **H01h 77/10**

[58] **Field of Search** 335/16, 195

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Primary Examiner—Harold Broome
Attorney—Charles E. Brown et al.

[57] **ABSTRACT**

A current-limiting electric switch is disclosed, of the kind having at least one release per pole, each release comprising two contacts carried by respective supporting members, said contacts being electrically connected to a feed and a load terminal through a current path of which said supporting members form, when the contacts are closed, two parallel branches through which currents of opposite sign flow, so that a current increase beyond a preselected limit produces in said two branches electrodynamic repulsion forces to overcome the bias of resilient supporting members and to cause the supporting members to be set apart for separating the contacts, the improvement consisting in the fact that said parallel branches are a part of a closed loop which is made up by said current path in correspondence with each release. The switch according to this invention permits to construct apparatus having shorter working times than those of the prior art and a more reliable operability.

9 Claims, 17 Drawing Figures

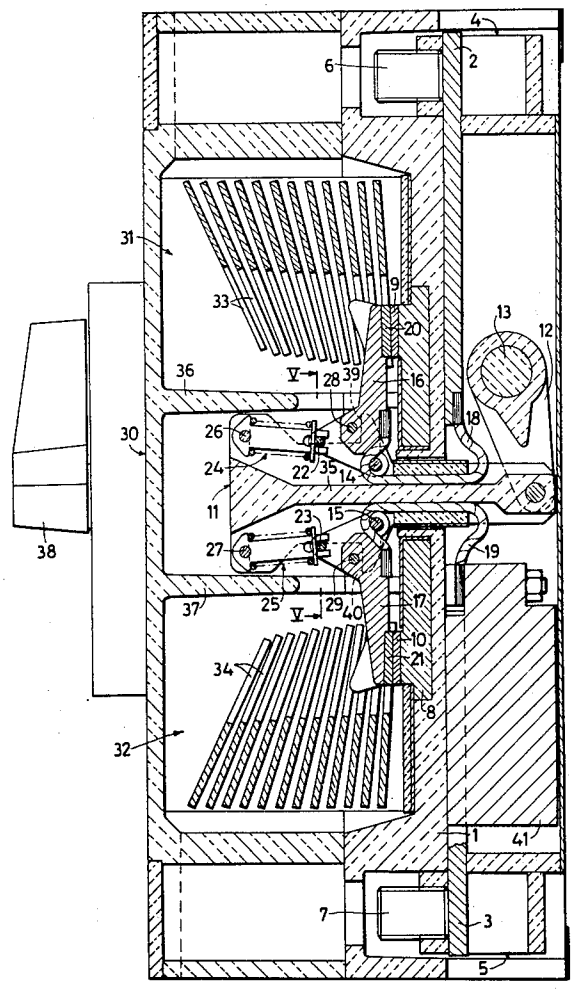

Fig.1

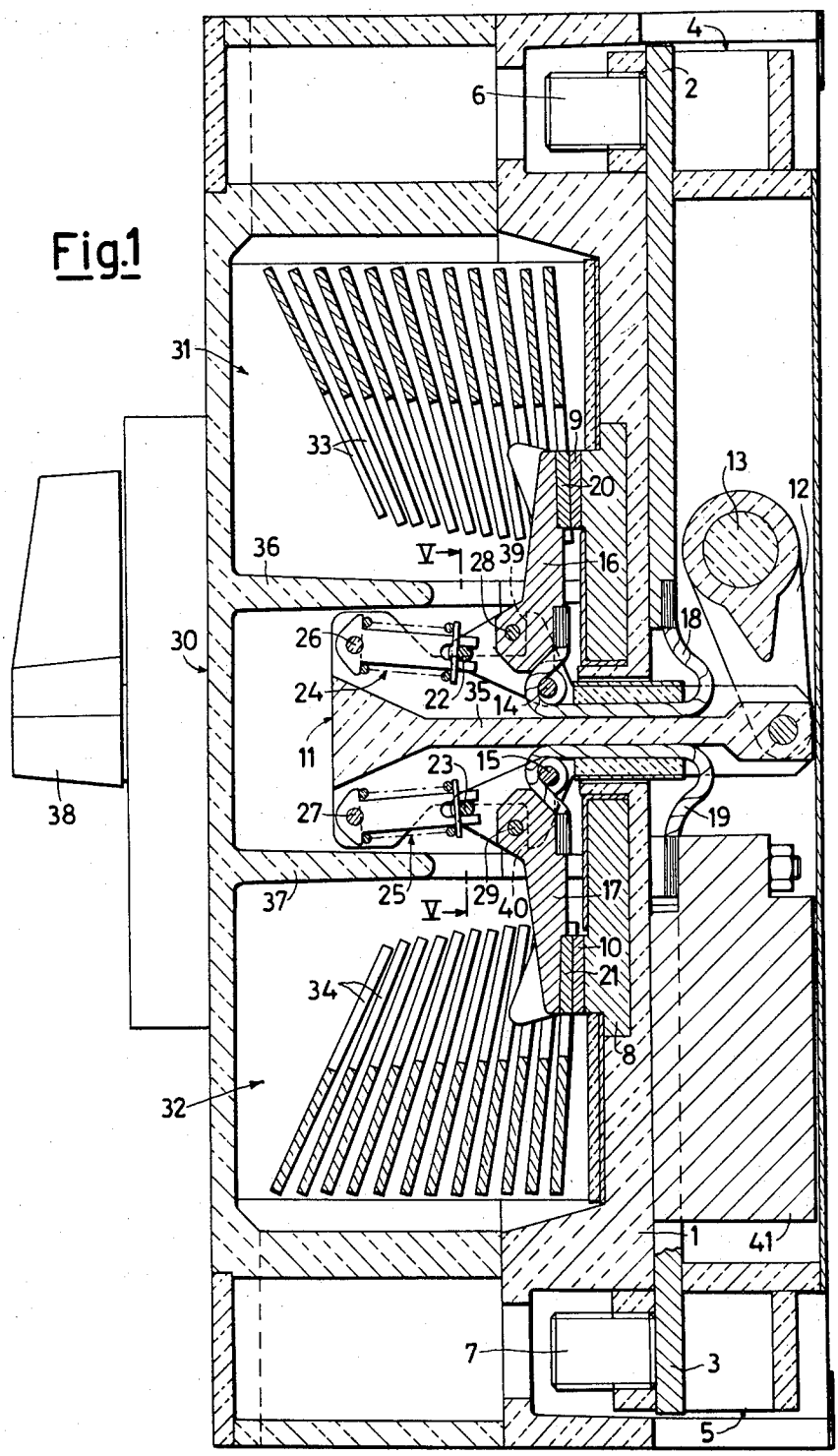
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Fig.3

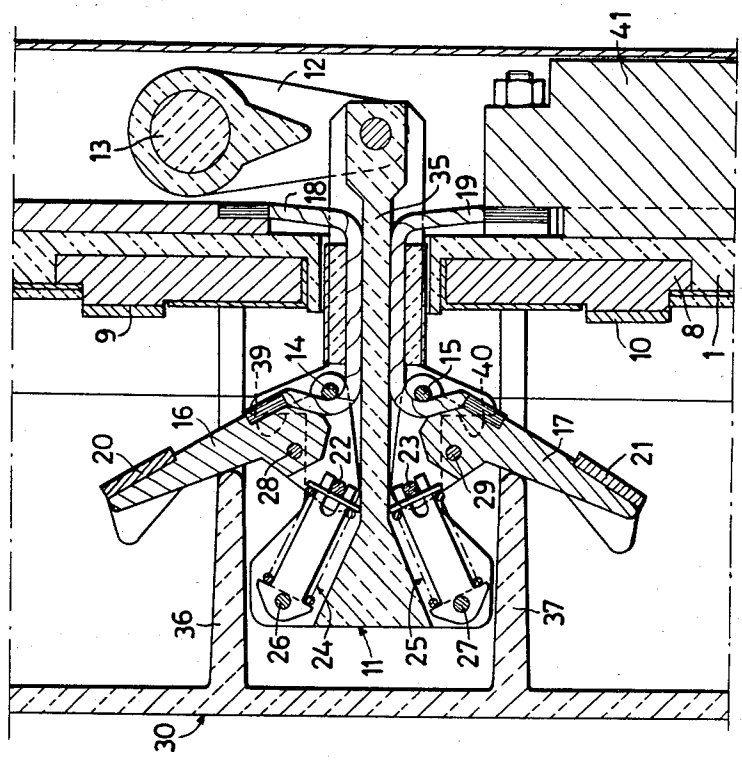
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Fig.2

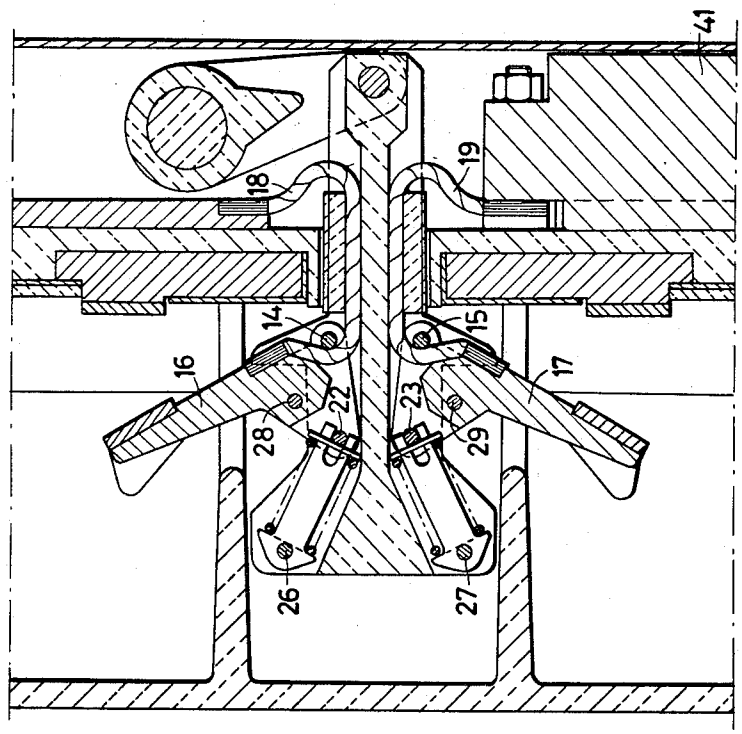
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Fig.4

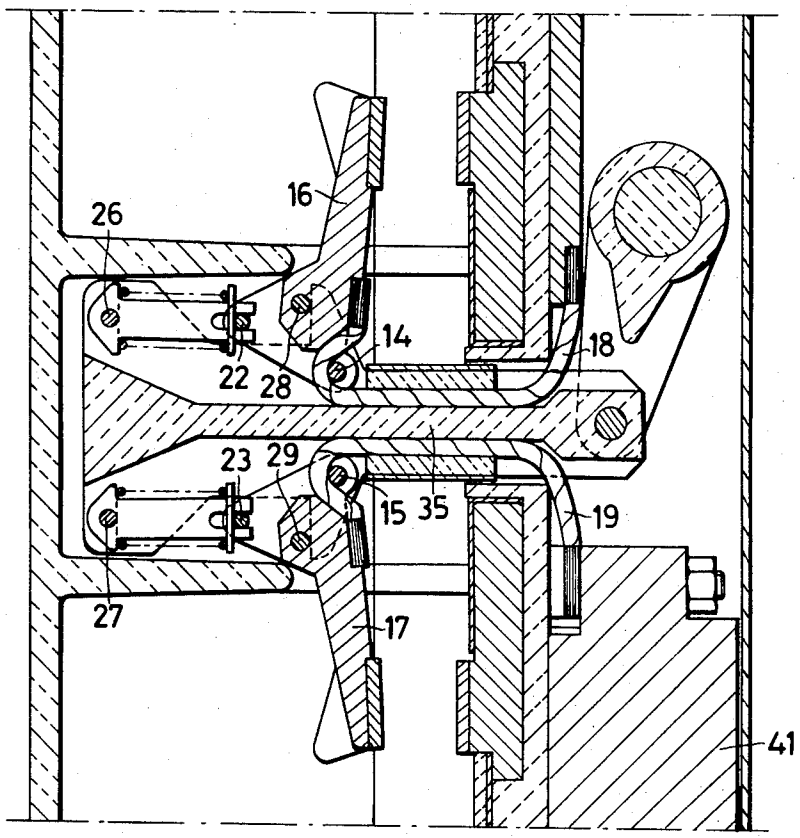


Fig.5

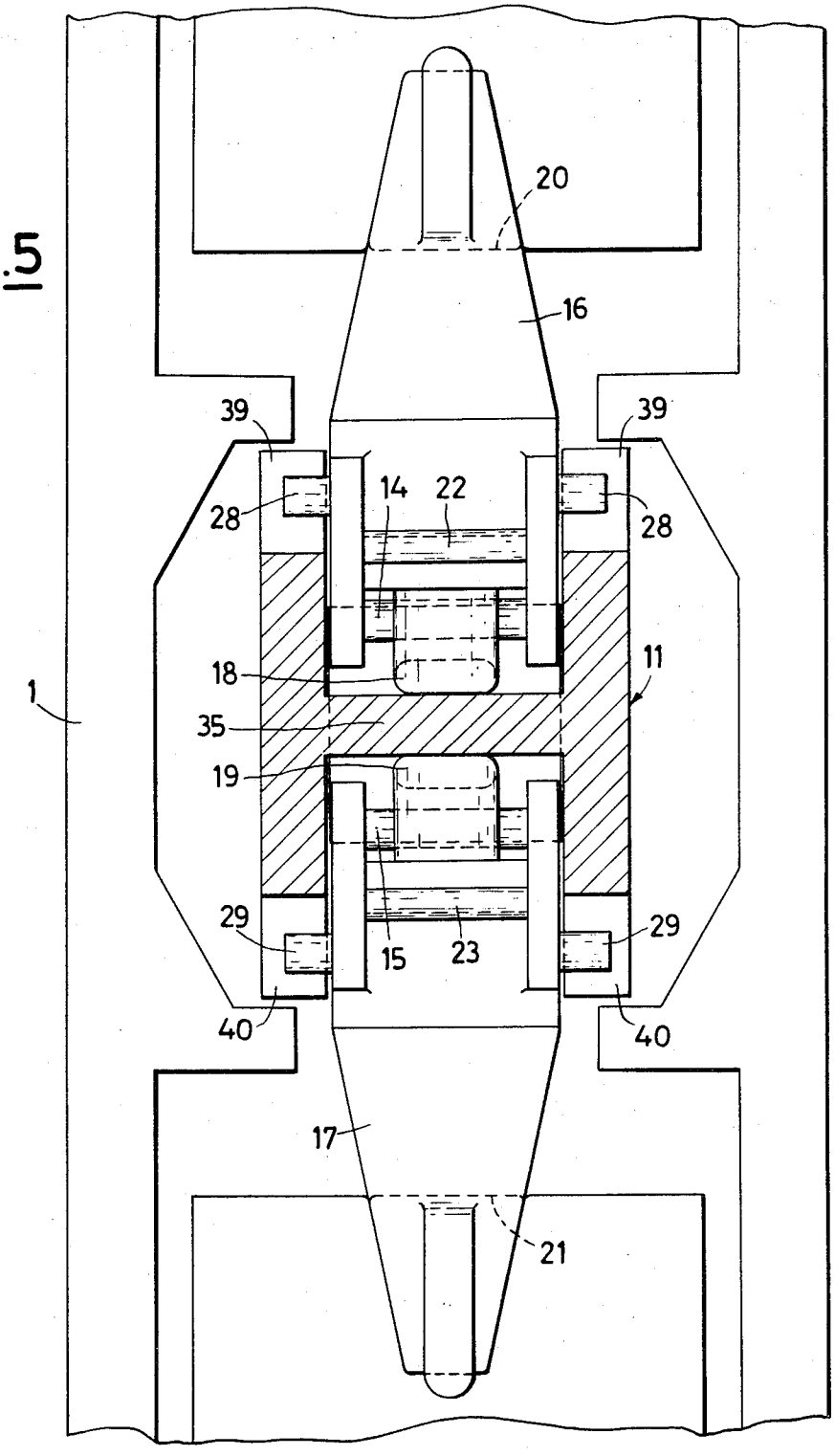


Fig.8

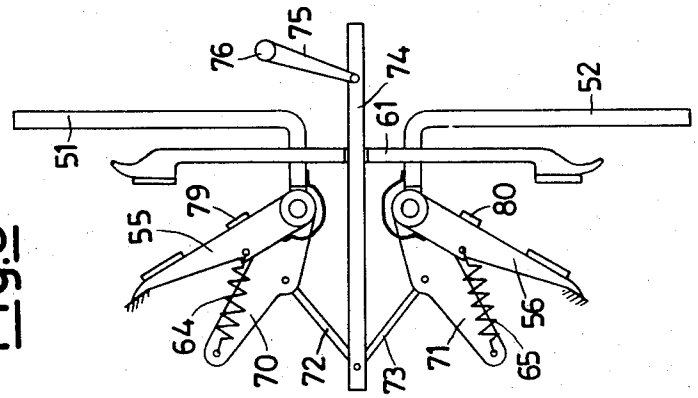


Fig.7

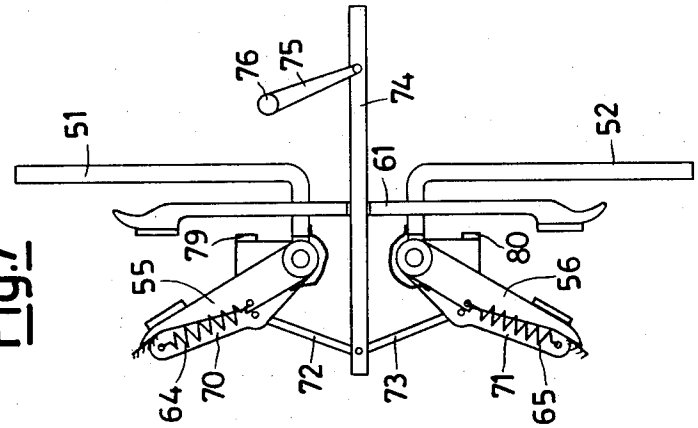


Fig.6

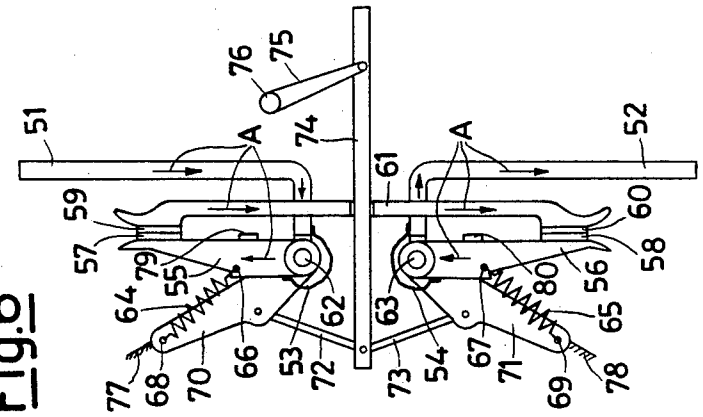


Fig.11

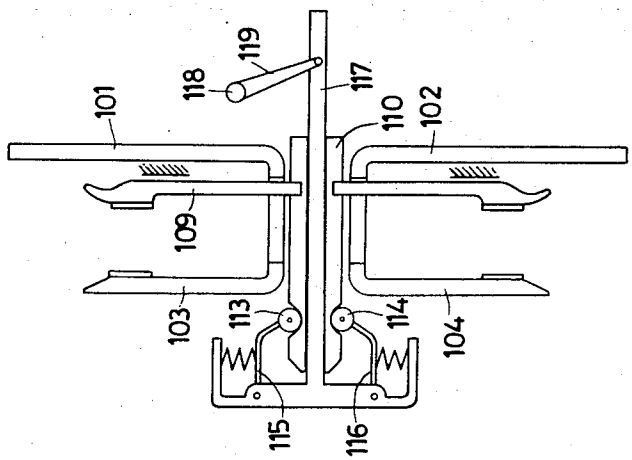


Fig.10

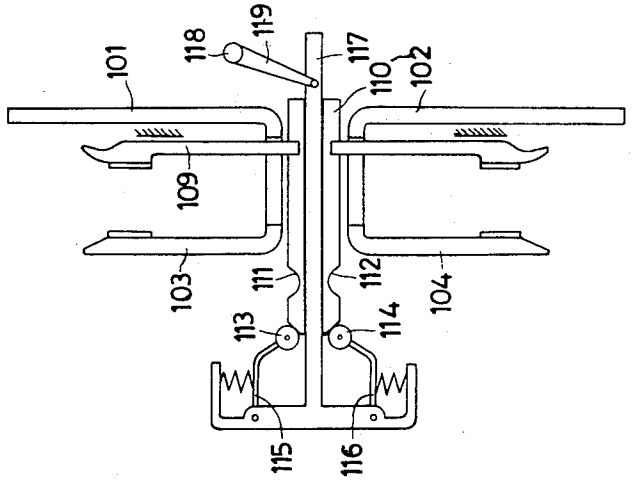


Fig.9

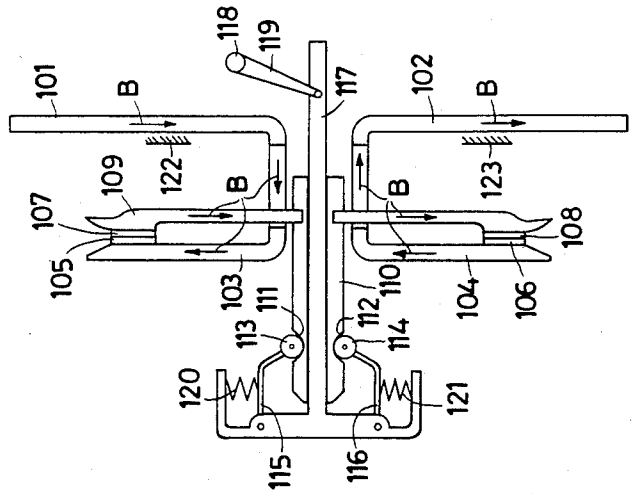


Fig.14

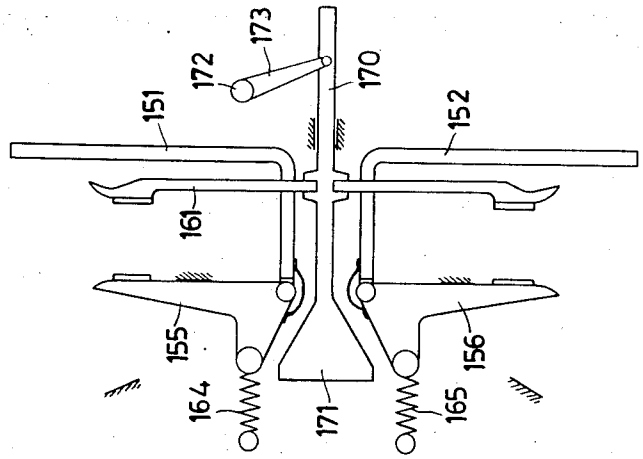


Fig.13

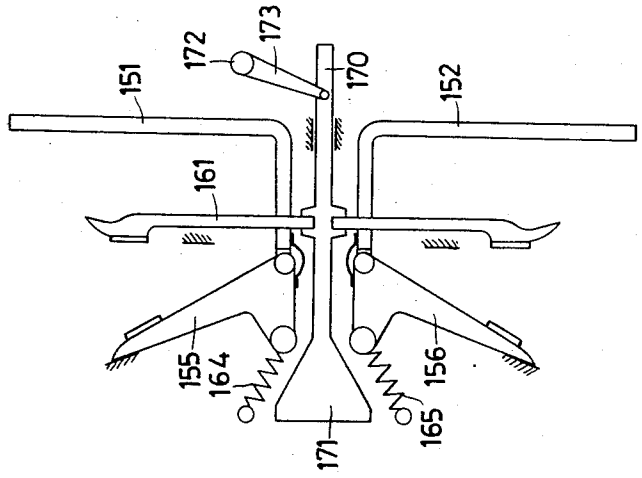


Fig.12

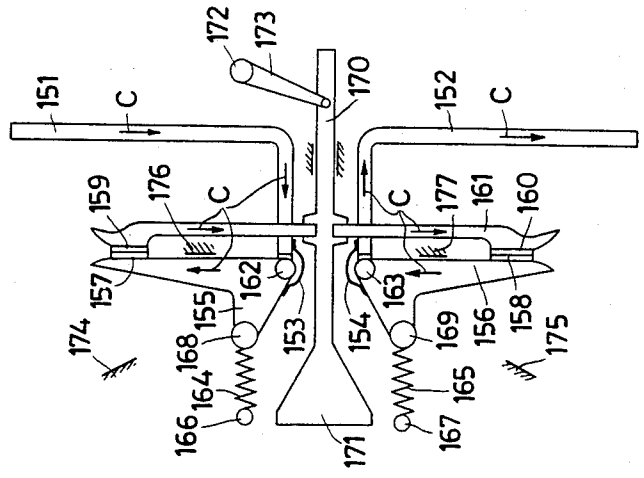


Fig.17

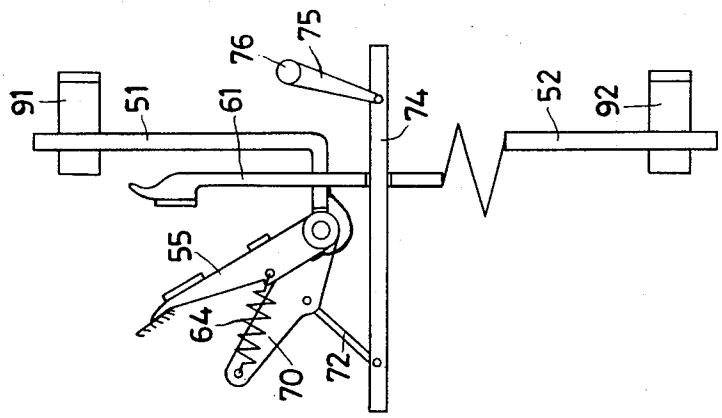


Fig.16

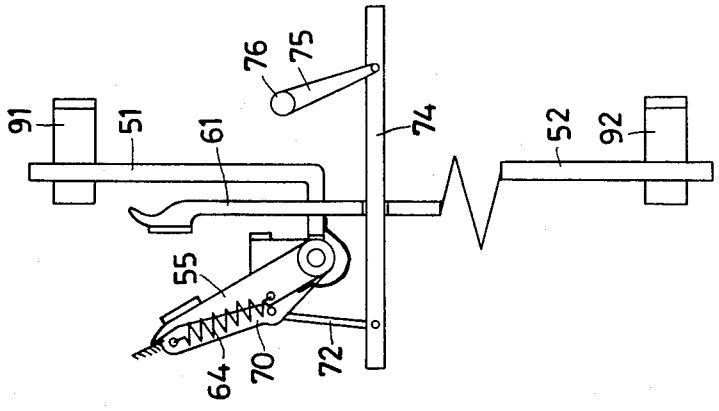
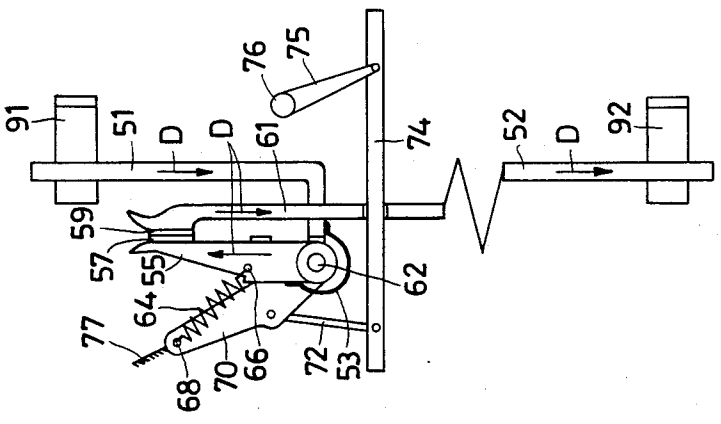


Fig.15



CURRENT-LIMITING ELECTRIC SWITCH

This invention relates to a current-limiting electric switch, which is particularly adapted to apparatus intended to operate in the field of low voltages (up to 1,000 volts) and with currents in the order of magnitude of a few hundreds of amperes on continuous duty, wherein the switch release under overcurrent conditions due to short circuiting is automatically brought about by the electrodynamic repulsion forces as produced by the flow of strong currents of opposite signs through two parallel and properly approached branches of the current path which connects the movable and the fixed contacts of the switch to the feeding and loading terminals, said parallel branches being usually the supporting members themselves for the movable and the fixed contacts.

There are known at present two kinds of current-limiting switches whose release is caused by the electrodynamic forces as produced by the current flowing through said switches, that is, switches having one or more releases per each pole and in which the fixed and the movable contacts are connected to the feeding and loading terminals through a current path forming an open loop, of which the supporting members of the contacts form two parallel branches through which currents of opposite signs flow, and switches having two releases per pole in which the fixed and the movable contacts are connected to the feeding and loading terminals through a current path forming a single closed loop, of which the supporting members for the contacts form two parallel branches through which currents of opposite sign flow.

An object of the present invention is to provide a current-limiting electric switch having a higher interrupting capacity. that is, a current-limiting electric switch wherein the electric connection between the fixed and movable contacts and the feed and load terminals is obtained in such a way as to produce higher repulsion forces and thus a higher contact-separation speed, the impressed currents being equal, or equal repulsion forces when the impressed current is lower.

The object of the invention is achieved by means of a current-limiting electric switch equipped with at least a release per pole, each release comprising two contacts carried by the respective supporting members, said contacts being electrically connected to a feed and a load terminal through a current path of which, when the contacts are closed, said surpports form two parallel branches through which currents of opposite signs flow, so that a current increase above a predetermined limit produces in said branches electrodynamic repulsion forces capable of overcoming the bias of resilient retaining members and of causing the supporting members to be driven apart from one another for the separation of the contacts, characterized in that said parallel branches are a part of a closed loop as formed by said current path in correspondence with each interruption.

It is apparent that this arrangement introduces a substantial improvements over the conventional art both in the case of a switch having a single interruption per hole (current path with a single closed loop) and in the case of a switch having two interruptions per pole (current path with two closed loops), inasmuch that every couple of contacts, that is, each release, is associated with a respective closed loop of current, that which permits to obtain higher repulsion forces and thus high

contact-separation speeds when the impressed currents are equal, or equal repulsion forces with lower currents, that is, with smaller current values which originate the contact separation.

Summing up, the switch according to the present invention permits to construct apparatus which are characterized, as compared with the conventional constructions, by shorter operation times and thus, the arc-extin-guishing means being the same, by a higher ability to limit the maximum value of the current and energy that the switch allows to be established under short-circuit conditions.

The features of the present invention, along with the advantages deriving therefrom, will be better understood upon a scrutiny of the ensuing detailed description of a few possible embodiments thereof. In such detailed description, which is given by way of a non-limiting example only, reference will be had to the accompanying drawings, wherein :

FIGS. **1, 2, 3** and **4** are vertical cross-sectional views showing, in four different working conditions, a pole of a two-release switch according to a preferred embodiment of the invention.

FIG. **5** is a partial cross-sectional view taken along the line V—V of FIG. **1.**

FIGS. **6, 7** and **8** are diagrammatical elevational views showing three different operative conditions of a pole of a switch having two releases per pole according to another possible embodiments of the invention.

FIGS. **9, 10** and **11** are diagrammatical elevational views showing three different working conditions of a pole of a switch having two releases per pole according to still another embodiment of the invention.

FIGS. **12, 13** and **14** are diagrammatical elevational views showing three different working conditions of a pole of a switch having two releases per pole according to a further possible embodiment of the invention.

FIGS. **15, 16** and **17** are diagrammatical elevational views showing three different working conditions of a pole of a switch having a single release per pole according to still another embodiment of the invention.

The switch shown in FIGS. **1–5,** comprises, above all, a fixed frame **1,** of an electrically insulating material, which supports two stiff conductors **2–3** which can be connected to electric feed and load cables (not shown) by means of terminal clamps **4-5** equipped with set screws **6–7** and an annular conducting plate **8** which is the supporting member for two fixed contacts **9–10.** In the interior of the hole of the conducting plate **8** there is, slidably housed, a shaped rod **11,** of an electrically insulating material, which is driven so as to be shifted between the position of FIG. **1** and the position of FIG. **4,** by the agency of a lever **12** keyed to an actuating shaft **13.** To the rod **11** are pivoted at **14–15** two movable arms **16–17** of an electrically conducting material, which are electrically connected to the rigid conductors **2–3** by means of flexible cables **18–19** and carry the respective movable contacts **20–21** cooperating with the fixed contacts **9–10.** The two movable arms **16–17,** furthermore, carry the respective pins **22–23** which engage the corresponding ends of two compression springs **24–25,** whose other ends engage, at **26–27,** the slidable rod **11.** Lastly, the two movable arms **16–17** carry the respective couples of trunnions **28–29** (FIG. **5**) whose function will become clearer hereinafter. To the fixed frame **1** is then coupled a lid **30,** also of an electrically insulating material, which, along with

the framing aforementioned, defines two arc-extinguishing chambers **31–32**, within which respective arc-splitting sets of ferromagnetic plates **33–34**, are housed.

Assuming that the terminal **4** is connected to a feeding source and the terminal **5** is connected to a load, the result is that, until such time as the movable contacts **20–21** are in their closed position where they contact the fixed contacts **9–10** (FIG. 1), an electric circuit, having a double closed loop going from the terminal **4** to the terminal **5** through the rigid conductor **2**, the flexible cable **18**, the movable arm **16**, the movable contact **20**, the fixed contact **9**, the conducting plate **8**, the fixed contact **10**, the movable contact **21**, the movable arm **17**, the flexible cable **19** and the rigid conductor **3**, is made. Under these conditions, the springs **24–25** act on the movable arms **16–17** so as to cause them to rotate in the clockwise and anticlockwise direction, respectively, thus maintaining a close contact between the movable contacts **20–21** and the fixed contacts **9–10**.

Whenever a short-circuit or anyhow a strong overcurrent condition is experienced, the strong currents of opposite signs which flow through the movable arm **16** and the fixed plate **8** (parallel branches of the first closed loop) and those, also of opposite signs which flow through the fixed plate **8** and the movable arm **17** (parallel branches of the second closed loop), produce intense electrodynamic repulsive forces, which urge the movable arms **16–17** to be rotated in the anticlockwise direction and the clockwise direction, respectively, so as to give rise to the separation of the movable contacts **20–21** from the fixed contacts **9–10** (the arcs which are thus formed are simultaneously urged by the electrodynamic forces which always try to widen a current loop and are drawn into the interior of the arc chamber by the ferromagnetic material plates **33–34**)? During the first portion of their contact-separation movement, the movable arms **16–17** are biassed by the bias of the springs **24-25**; then, as the axes of the spring have attained and overtaken the line jointing the pins **26–14** and **27–15**, the couple of springs is inverted and the movable arms **16–17** are quickly driven towards the position of maximum rotation which is defined by the abutment between the back of the arms and a central core **35** of the shaped rod **11** (FIG. 2). Subsequently, the action of an appropriate element which is sensitive to strong current intensities (not shown in the drawings) as housed in the container **41**, causes a clockwise rotation of the driving shaft **13** (as an alternative, if the sensitive member aforesaid is not mounted in the switch, said clockwise rotation of the shaft **13** can be manually obtained by the agency of the lever **38**). This fact causes the shift (towards the left with respect to FIG. 2) of the shaped rod **11** and the resultant similar displacement of the movable arms **16–17**, which meet, at a certain spot, specially provided ribs **36–37** of the lid **30** (FIG. 3), which cause the rotation thereof (clockwise and anticlockwise, respectively) until the jointing lines of the pins **26–14** and **27–15** are overcome in the reverse direction by the axes of the springs **24–25** and the trunnions **28–29** of the movable arms **16–17** go to rest against specially provided bracket-like projections **39–40** of the shaped rod **11**. As the switch reaches the end position of FIG. 4, as defined by appropriate end-of-stroke abutments coupled to the shaft **13** (and not shown in the drawings), the switch is in readiness for a new circuit-closing operation, which can be easily performed by acting upon the driving member **38** so as to rotate the shaft **13** in the reverse direction.

Of course, in the practical embodiment of the switch according to FIGS. **1–5**, means should also be provided which are capable of allowing the manual release by an operator, as well as the release in the case of overcurrents which are not strong enough to originate such electrodynamic forces as to overcome the bias of the springs **24–25**. These means, at any rate, are not a part of the claimed invention and are thus not described herein in detail, or shown in the drawings, either. They are intended, in any case, to act upon the driving shaft **13** so as to cause the rotation from the position of FIG. 1 to the position of FIG. 4, so as to cause the shift of the rod **11** and of the arms **16–17** from the closed position of FIG. 1 to the opened position of FIG. 4, said shift being an integral movement on account of the abutment between the trunnions **28–29** of the arms **16–17** and the bracket-like projections **39–40** of the rod **11**.

The basic features of the present invention are maintained unaltered also in the embodiment shown in FIGS. **6** to **8**, which diagrammatically show a pole of a switch having two releases per pole, in which the two couples of fixed and movable contacts of the two releases are connected to the feeding and loading terminals (not shown) by a current path having two closed loops (as indicated by the arrows A) which comprises a first rigid conductor **51**, a first flexible cable **53**, a first movable arm **55**, a first movable contact **57**, a first fixed contact **59**, a conducting plate **61**, a second fixed contact **60**, a second movable contact **58**, a second movable arm **56**, a second flexible cable **54** and a second rigid conductor **52**. The two movable arms **55–56** are pivoted to respective fixed pivot pins **62–63** and are driven towards the closed position of FIG. **6** by springs **64–65** arranged between pins **66–67** as carried by the movable arms **55–56** and pins **68–69** as carried by movable supporting members **70–71** also pivoted to the fixed pins **62–63** and linkably connected by tie rods **72–73** to a slidable rod **74** driven by a lever **75** keyed to a driving shaft **76**, which is controlled in the same way as the shaft **13** of the embodiment of the FIGS. **1** to **5**.

In operation, whenever a short-circuit or anyhow a strong overcurrent is experienced, the high electrodynamic forces as produced by the currents of opposite signs which flow through the movable arm **55** and the plate **61** (first closed loop) and the plate **61** and the movable arm **56** (second closed loop) urge the movable arms **55–56** to overcome the bias of the springs **64–65** (which act contrariwise to one another at the outset and then assist each other) to rotate in the anticlockwise and clockwise direction, respectively, until reaching the end position as defined by fixed abutments **77–78** (FIG. 7). Subsequently, the driving shaft **76** is rotated so as to cause the displacement of the rod **74** towards the position of FIG. **8**, so that, due to the effect of the rotation of the supporting members **70–71**, the springs **64–65** urge the movable arms **55–56** again towards a clockwise and an anticlockwise rotation, respectively, said rotation being prevented by two abutments **79–80** as carried by the supports **70–71**. Under the conditions of FIG. **8**, the switch is preset for a new closure operation (which can be effected by the reverse displacement of the rod **74**).

Still conformant with the features of this invention, there is the embodiment of FIGS. **9–11**, in which the two couples of fixed and movable contacts of the two releases of each pole of the switch are connected to the two feeding and load terminals (not shown) by means of a current path formed by two closed loops (arrows B) which comprises a first rigid conductor **101**, a first fixed arm **103**, a first fixed contact **105**, a first movable contact **107**, a movable plate **109**, a second movable contact **108**, a second fixed contact **106**, a second fixed arm **104** and a second rigid conductor **102**. The movable plate **109**, which is a supporting member for the movable contacts **107–108**, is held by a fixed sleeve **110** equipped with two peripheral notches **111–112**, in whose interior two rollers **113–114** can be engaged, which are carried by arms **115–116**, the latter being rotatably carried by a T-shaped rod **117** which is slidably housed within the sleeve **110** and is driven by a driving shaft **118** through a lever **119**. Two springs **120–121** are active upon the arms **115–116** so as to urge them against one another.

In operation, whenever a short circuit or anyhow a strong overcurrent is experienced, the strong electrodynamic forces as produced by the currents of opposite signs which flow through the fixed arm **103** and the movable plate **109** (first closed loop) and the movable plate **109** and the fixed arm **104** (second closed loop) urge the plate **109** to overcome the holding bias imparted by the springs **120–121** (on account of the engagement between the rollers **113–114** and the notches **111–112**) and to be withdrawn from the fixed arms **103–104** until reaching the end position as defined by an abutting relationship with fixed abutments **122–123**. The subsequent displacement of the rod **117**, which does not affect the plate **109** and the sleeve **110**, restores the engagement between the rollers **113–114** and the notches **111–112** (FIG. **11**) and thus presets the switch for a new closure operation (which can be carried out by a reverse displacement of the rod **117**).

In another embodiment of the invention, as shown in FIGS. **12–14**, the two couples of fixed and movable contacts of the two releases of each pole of the switch, are connected, in turn, to the feeding and loading terminals (not shown) by a current path having two closed loops (arrows C) which comprises a first rigid conductor **151**, a first flexible cable **153**, a first movable arm **155**, a first movable contact **159**, a movable conducting plate **161**, a third movable contact **160**, a fourth movable contact **158**, a second movable arm **156**, a second flexible cable **154** and a second rigid conductor **152**. The two movable arms **155–156** are pivoted on fixed pivots **162–163** and, when in the closure position of FIG. **12**, they are maintained in such position by springs **164–165** inserted between fixed pivots **166–167** and pins **168–169** carried by the arms **155–156**. The movable plate **161**, in turn, is rigidly connected to a slidable rod **170** which is terminated by a wedge head **171** and is driven by a driving shaft **172** through a lever **173**.

In operation, whenever a short circuit or, anyhow, a strong overcurrent is experienced, the strong electrodynamic forces as produced by the current of opposite signs which flow through the two closed loops formed by the movable arm **155** and the plate **161** (first loop) and the movable arm **156** (second loop) urge the movable arms to overcome the initial contrary bias of the springs **164–165** and to reach the end position as defined by the abutting relationship with fixed abutments **174–175** (FIG. **13**). The presetting of the switch for the subsequent closing operation can then be obtained by displacing the rod **170** so as to allow the wedge head **171** of the latter to penetrate between the two confronting backs of the arms **155–156**, so as to overcome the initially counteracting bias of the springs **164–165** and to restore the arms **155–156** to the other end position as defined by the abutting relationship with fixed abutments **176–177** (FIG. **14**). The closure of the switch can then obviously be carried out by displacing the rod **170** in the opposite direction.

Lastly, FIGS. **15** to **17** show the case of a switch having a single release per pole, constructed in accordance with the principles of the invention. The structure of this switch is practically equal to one half of the structure of the switch as shown in FIG. **6** to **8**. Thus, it will not be described in detail herein and, to the ends of its understanding, reference will be had to the above mentioned FIGS. **6** to **8**, of which the same reference numerals have been used herein also. The only fact which deserves emphasis herein is that, in the present case, the two contacts **57** and **59** are connected to the feed and load terminals **91–92** by a current path (arrows D) formed by a single closed loop, of which the supporting members **55** and **61** are two parallel branches through which currents with opposite signs flow.

It will obviously be understood that, just as it is possible to construct a switch having a single release per pole, which substantially corresponds to one half of the switch of FIG. **6** to **8**, it will be likewise possible to construct switches having a single release per pole which substantially correspond to one half of the switches shown in FIG. **1** to **5**, **9** to **11** and **12** to **14**. These switches will be obviously characterized by a current path forming a single closed loop, in which the supporting members are two parallel branches through which currents of opposite signs flow.

What is claimed is:

1. A current-limiting electric switch having at least one release per pole, each release comprising two contacts carried by the respective supporting members, said contacts being electrically connected to a feeding terminal and to a loading terminal through a current path of which, when the contacts are closed, said supporting members form two parallel branches through which currents of opposite signs flow, so that a current increase beyond a predetermined limit produces in said branches electrodynamic repulsion forces such as to overcome the contrary bias of resilient holding means and to cause the supporting members to be set apart for separating the contacts, characterized in that said parallel branches form a portion of a closed loop formed by said current path in correspondance with each release.

2. A switch according to claim **1**, equipped with two releases per pole, characterized in that said current path makes up two closed loops.

3. A switch according to claim **2**, characterized in that the two releases comprise first contacts placed at the ends of a common conducting supporting member and respective second contacts placed at the ends of respective movable arms the latter being located and electrically connected to the feed and load terminals so that the two current paths which electrically connect said terminals to said second contacts may form respective open loops which, as the contacts are closed, are

closed and connected to one another by said common conducting supporting menber.

4. A switch according to claim **3**, characterized in that said second contacts are carried by rotatable arms and are maintained in the closed position by resilient means which are urged, by the rotation of the arms for effecting the rotation of the arms under the control of the electrodynamic repulsion forces; to switch from a biassing condition to a condition of aid to said rotation.

5. A switch according to claim **2**, characterized in that the two releases comprise respective fixed contacts placed at one end of respective fixed arms arranged and electrically connected to the feed and load terminals so that the two current paths which electrically connect said terminals with said fixed contacts from respective open loops, the two releases further comprising respective movable contacts arranged at the ends of a movable common conducting supporting member for closing said loops.

6. A switch according to claim **5**, characterized in that said common movable conducting supporting member is fastened to a translatable supporting member which is held in the contact-closing position by resilient means of the groove and tongue type.

7. A switch according to claim **1**, equipped with a single release per pole, characterized in that said current path is a single closed loop.

8. A switch according to claim **7**, characterized in that the release comprises a movable contact carried by a rotatable arm which is maintained in the closed position by resilient means which are urged, by the rotation of the arm for the separation of the contacts under the control of the electrodynamic repulsion forces, to switch from a biassing condition to a condition of aid to said rotation.

9. A switch according to claim **7**, characterized in that the release comprises a movable contact carried by a translatable arm which is maintained in the closed position of the contacts by resilient means of the groove and tongue type.

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