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W-8000 München 22(DE)(54) **CIRCUIT BREAKER.**

(57) A circuit breaker equipped with a mechanism for current limiting by the use of electromagnetic repulsion, aiming at solving a technical problem of improving current-limiting performance by increasing the contact-opening speed of a contact plate of a current-limiting type circuit breaker and realizing the device in a compact size. The current-limiting contact plate is rotatably supported at its central portion, with one end thereof facing a movable contact plate,

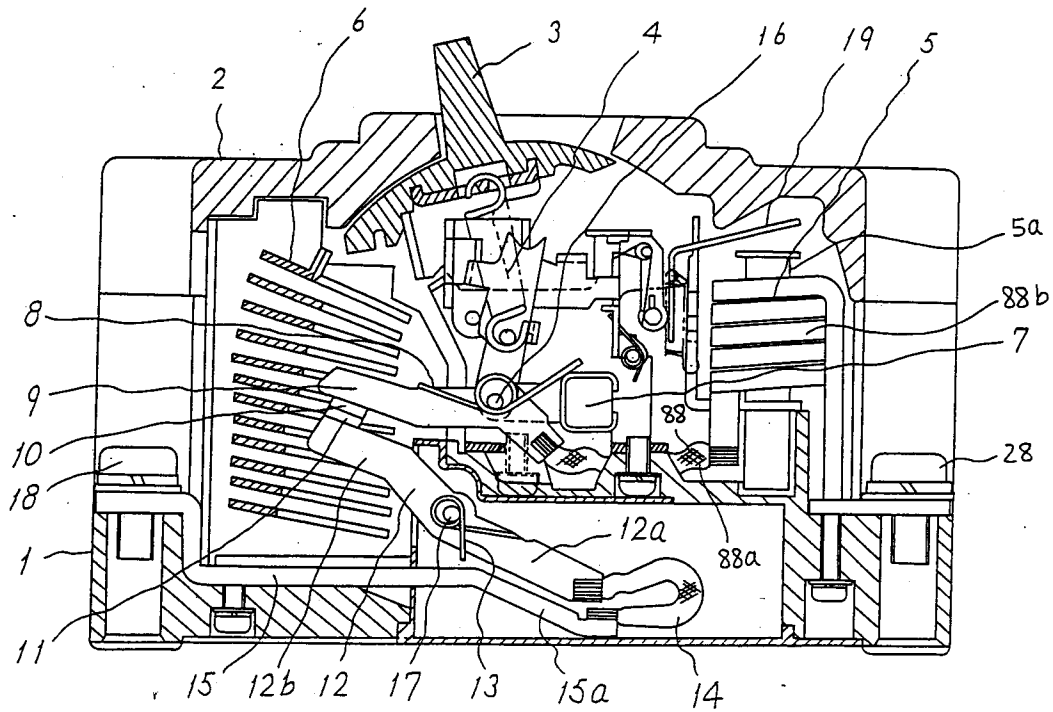
and with the other end facing a fixed conductor and electrically connected thereto. An electromagnetic repulsive force between the movable contact plate and the current-limiting contact plate and an electromagnetic repulsive force between the fixed conductor and the current-limiting contact plate are used as a couple of forces. It is therefore possible to increase the contact-opening speed and to decrease the distance between the current-limiting contact

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plate and the fixed conductor. The invention provides a circuit breaker which is small in size and is

excellent in breaking performance.

Fig. 1



TECHNICAL FIELD:

This invention relates to a circuit breaker, and more particularly, to one which is suitable for improving the current-limiting performance of a current-limiting breaker having an electromagnetic repulsion mechanism, and for reducing its size.

BACKGROUND ART:

A known device of the sort to which this invention pertains comprises a movable contactor on the load side which is connected to a switching mechanism (first movable contact support), a central movable contactor facing it, having contacts at both ends, and capable of rotating about its own middle portion (second movable contact support), and a movable contactor provided on the power source side and facing the central movable contactor, as disclosed in Japanese Utility Model Application laid open under No. 45164/1977. The movable contactor on the load side and the movable contactor on the power source side are also rotatably supported. An electric current flows in opposite directions through the movable contactor on the load side and the central movable contactor. The same is true with the directions in which an electric current flows through the central movable contactor and the movable contactor on the power source side. If a large amount of electric current is caused to flow through the device, a repulsive force is produced between the movable contactor on the load side and the central movable contactor by the flow of current in the opposite directions, and a repulsive force is likewise produced between the central movable contactor and the movable contactor on the power source side. As a result, a couple of forces act upon the central movable contactor about its middle portion defining the axis of its rotation and cause it to rotate in the direction in which the contacts are separated from each other.

The contacts are, however, provided between the central movable contactor and the movable contactor on the power source side. Therefore, it is necessary to maintain a sufficiently large distance therebetween to ensure electrical insulation when the contacts are separated from each other. This makes the device undesirably large. The device also has a high temperature due to the heat which is generated by an arc occurring across the contacts when the current is limited, the heat which is generated by an increased current density resulting from a reduction in the area of contact in which wiping is achieved between the contacts, and the heat which is generated by contact resistance at the contacts.

When the electromagnetic repulsive force causes the movable contactor on the power source side to move away from the central movable contactor to open or separate the contacts from each other to limit the flow of a large amount of current, the resulting increase in the distance therebetween and decrease in the amount of current flowing therethrough bring about a reduction in repulsive force and disable any satisfactorily high contact-opening speed to be attained.

DISCLOSURE OF THE INVENTION:

It is an object of this invention to provide a small circuit breaker having an improved contact-opening speed and an outstanding current-limiting capacity.

This object is attained by a circuit breaker which comprises a housing provided at one end with a power source terminal, and at another end with a load terminal, a stationary conductor having one end connected to the power source terminal and another end provided with conductive connecting means, a current-limiting contact support having one end connected to the conductive connecting means and facing the stationary conductor, another end provided with a current-limiting contact, and a middle portion at which it is rotatably supported, and a movable contact support facing the current-limiting contact support, supported rotatably, and carrying a movable contact facing the current-limiting contact. The movable contact support is connected to a switching mechanism for performing a switching and tripping operation. The tripping operation of the switching mechanism is carried out by a tripping device which detects an overcurrent in a line from the movable contact support to the load terminal and causes the switching mechanism to perform the tripping operation. The current-limiting contact support is provided at one end thereof with a repulsing portion, so that a repulsive force may be produced between the current-limiting contact support and the stationary conductor by the currents flowing in the opposite directions, and so that, if a large amount of current has flown as a result of e.g. shortcircuiting, the current-limiting contact support may be rotated by a couple of forces, i.e. the repulsive force produced between the movable contact support and the current-limiting contact support and the repulsive force produced between the stationary conductor and the current-limiting contact support, and thereby separate the current-limiting contact from the movable contact.

The repulsive force produced between the repulsing portion and the stationary conductor can wholly be used as the force for rotating the current-limiting contact support, so that a high contact-

opening speed can be achieved. The current-limiting contact support and the stationary conductor have only a small distance therebetween, since no arc is likely to form therebetween, insofar as the former is conductively connected to the latter.

This invention provides a small circuit breaker having a high contact-opening speed and an outstanding current-limiting efficiency, as the current-limiting contact support is rotated by a couple of forces, i.e. not only the repulsive force produced between the movable and current-limiting contact supports, but also the repulsive force produced between the stationary conductor and the current-limiting contact support.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIGURE 1 is a side elevational view, partly in section, of a circuit breaker according to a first embodiment of this invention;

FIGURE 2 is a side elevational view showing the repulsive position of the main portion of the circuit breaker shown in FIGURE 1;

FIGURE 3 is a view similar to FIGURE 2, but showing its trip position;

FIGURE 4 is a side elevational view of the main portion of a circuit breaker according to a second embodiment of this invention;

FIGURE 5 is a side elevational view of the main portion of a circuit breaker according to a third embodiment of this invention;

FIGURE 6 is a side elevational view of the main portion of a circuit breaker according to a fourth embodiment of this invention;

FIGURE 7(a) is a side elevational view, partly in section, of the main portion of a circuit breaker according to a fifth embodiment of this invention;

FIGURE 7(b) is a perspective view of the current-limiting contact support in the circuit breaker shown in FIGURE 7(a);

FIGURE 7(c) is a cross sectional view of the current-limiting contact support shown in FIGURE 7(b);

FIGURE 8(a) is a side elevational view of the main portion of a modified form of the device shown in FIGURE 7(a);

FIGURE 8(b) is a cross sectional view of the current-limiting contact support in the device shown in FIGURE 8(a);

FIGURE 9(a) is a side elevational view, partly in section, of a circuit breaker according to a sixth embodiment of this invention;

FIGURE 9(b) is a cross sectional view of a sliding portion in the device shown in FIGURE 9(a);

FIGURE 10 is a side elevational view of the main portion of a circuit breaker according to a seventh embodiment of this invention;

FIGURE 11 is a perspective view of the device shown in FIGURE 10;

FIGURE 12(a) is a bottom plan view of the main portion of a circuit breaker according to an eighth embodiment of this invention;

FIGURE 12(b) is a bottom plan view showing the displacement of a part in the device shown in FIGURE 12(a);

FIGURE 12(c) is an enlarged view of the displacement shown in FIGURE 12(b);

FIGURE 13 is a bottom plan view of a modified form of the device shown in FIGURE 12(a);

FIGURE 14 is a side elevational view, partly in section, of a circuit breaker according to a ninth embodiment of this invention;

FIGURE 15 is a side elevational view showing in its repulsive position the main portion of the device shown in FIGURE 14;

FIGURE 16 is a side elevational view showing the trip position of the portion shown in FIGURE 15;

FIGURE 17(a) is a side elevational view, partly in section, of a circuit breaker according to a tenth embodiment of this invention;

FIGURE 17(b) is a cross sectional view of the magnetic drive shown at 80 in FIGURE 17(a);

FIGURE 17(c) is a cross sectional view of the magnetic drive shown at 80a in FIGURE 17(a);

FIGURE 17(d) is a cross sectional view of a modified form of the magnetic drive 80;

FIGURE 18 is a side elevational view, partly in section, of a circuit breaker according to an eleventh embodiment of this invention; and

FIGURE 19 is a side elevational view of the main portion of a circuit breaker according to a twelfth embodiment of this invention.

BEST MODE OF CARRYING OUT THE INVENTION:

The invention will now be described in detail with reference to the drawings showing a variety of preferred embodiments thereof.

Referring first to FIGURES 1 to 3, the circuit breaker according to a first embodiment of this invention includes a case 1 as a housing which is provided at one end with a power source terminal 18, and at another end with a load terminal 28. The case 1 contains at its bottom a stationary conductor 15 connected to the power source terminal 18. A current-limiting contact support 12 is rotatably supported by a pin 17 above the stationary conductor 15. The current-limiting contact support 12 has one end 12b carrying a current-limiting contact 11, and another end defining a repulsing portion

12a and carrying a flexible conductor 14 as means for conductive connection to the stationary conductor 15. A movable contact support 9 is provided above the current-limiting contact support 12 and is connected to a switching mechanism 4. The switching mechanism 4 performs the switching or tripping operation of the movable contact support 9 as a result of either manual operation by a handle 3, or the operation of an overcurrent detecting relay as a tripping device which comprises an oil dashpot relay 5 and a movable iron piece 19 which is thereby attracted.

The ON and OFF operation of the device as hereinabove described is performed by the handle 3 projecting from a molded cover 2. If the handle 3 is turned toward a power source, two links in the switching mechanism 4 including a toggle link mechanism function to rotate an interlocking shaft 7 provided at one end of the switching mechanism 4 for rotating the movable contact support 9. If the shaft 7 is rotated counterclockwise, the movable contact support 9 is rotated about a pin 16 and a movable contact 10 carried on one end of the movable contact support 9 and facing the current-limiting contact 11 is, therefore, moved until it abuts on the current-limiting contact 11. The current-limiting contact support 12 is located below the switching mechanism 4 and faces the movable contact support 9. The pin 17 about which the current-limiting contact support 12 is rotatable is provided with a return spring 13 urging the current-limiting contact support 12 clockwise. The spring 13 has one end engaging the molded case 1, and another end engaging the repulsing portion 12a of the current-limiting contact support 12. The flexible conductor 14 comprises a flexible twisted wire of copper and is connected to one end of the repulsing portion 12a for supplying an electric current from the stationary conductor 15 to the current-limiting contact support 12. The stationary conductor 15 has an extension 15a lying below the repulsing portion 12a of the current-limiting contact support 12 in parallel thereto. Thus, the electric current flows through the current-limiting contact support 12 in the direction opposite that in which it flows through the stationary conductor 15 and the movable contact support 9. A contact spring 8 is provided coaxially with the pin 16 about which the movable contact support 9 is rotatable, and supplies contact pressure between the movable contact 10 and the current-limiting contact 11. The movable contact support 9 is connected to the load terminal 28 by a line 88 which comprises a flexible conductor 88a connected to the movable contact support 9, and a coil 88b. The oil dashpot relay 5 comprises a cylinder 5a containing a plunger not shown, the coil 88b of the line 88, and the movable iron piece 19 which is attracted by the cylinder 5a.

If an overcurrent flows through the line 88, the plunger in the oil dashpot relay 5 rises to attract and thereby rotate the movable iron piece 19. This movement of the movable iron piece 19 is transmitted to the mechanism for performing a tripping operation.

If the formation of a short circuit results in the flow of a large amount of electric current through the circuit breaker, a shortcircuit current flows in opposite directions between the extension 15a of the stationary conductor 15 and the repulsing portion 12a of the current-limiting contact support 12, and between the end 12b of the current-limiting contact support 12 on which the current-limiting contact 11 is carried, and the movable contact support 9, whereby an electromagnetic repulsive force is produced. A couple of forces are, thus, produced to rotate the current-limiting contact support 12 counterclockwise about the pin 17 rapidly to thereby separate the contacts, as shown in FIGURE 2. If the circuit is broken, the current-limiting contact support 12 is returned by the return spring 13 to its original position, as shown in FIGURE 3.

As the extension 15a is stationary, the repulsive force which is produced between the repulsing portion 12a and the extension 15a is wholly used as a force for rotating the current-limiting contact support 12. As the current-limiting contact support 12 and the stationary conductor 15 are connected by the flexible conductor 14, no arc causing the loss of electric current occurs therebetween, but the repulsing portion 12a and the extension 15a produce a high repulsive force therebetween. Therefore, the current-limiting contact support 12 enables a contact-opening speed which is higher than has hitherto been possible. Moreover, the circuit breaker of this invention is smaller, as the current-limiting contact support 12 and the stationary conductor 15 can be positioned closer to each other.

Referring now to FIGURE 4, the circuit breaker according to a second embodiment of this invention is characterized by including an extension 12c connected to the repulsing portion 12a to prolong the distance along which the parallel conductors extend and an electric current flows in the opposite directions to produce an electromagnetic repulsive force, and thereby to increase to a further extent the speed at which the current-limiting contact 11 can be opened. The extension 12c is connected to the repulsing portion 12a by a hinge 22 and a flexible conductor 24 so as to form a joint which can be bent to permit the opening of the contact.

Referring to FIGURE 5, the circuit breaker according to a third embodiment of this invention is characterized by having an opening 20 formed in the extension 15a of the stationary conductor 15 to receive therein a part of the repulsing portion 12a

of the current-limiting contact support 12. The repulsive force which is produced between the opposite edges of the opening 20 and the opposite sides of the repulsing portion 12a makes it possible to maintain a low contact jump when a medium amount of electric current flows, while not allowing for any rise in contact pressure between the movable contact 10 and the current-limiting contact 11, and a couple of forces work to cause electromagnetic repulsion only when a large amount of current flows. As long as only a small amount of current flows through a short circuit, the repulsive force which is produced by the concentration of the current to the movable contact 10 and the current-limiting contact 11 is sufficient for breaking the circuit. Hardly any electromagnetic repulsion by a couple of forces is required. If a large amount of current flows, the current-limiting contact support 12 is somewhat rotated to have its repulsing-portion 12a rise to some extent from the opening 20 of the stationary conductor 15 and the repulsive force, therefore, changes its direction to cause repulsion by a couple of forces.

Attention is now drawn to FIGURE 6 showing the circuit breaker according to a fourth embodiment of this invention. The electric current flowing through that portion of the stationary conductor 15 which is close to the power source terminal 18 differs in direction from the current flowing through the end 12b of the current-limiting contact support 12. This difference produces a force acting against the electromagnetic repulsive forces produced in the form of a couple of forces. The device shown in FIGURE 6 is, therefore, characterized by including a magnetic force absorbing plate 25 provided on the stationary conductor 15 for absorbing the magnetic force producing any such contrary effect. That portion of the stationary conductor 15 which is closer to the power source terminal 18 has an opening 23 in which the end 12b of the current-limiting contact support 12 can be received, so that the magnetic force absorbing plate 25 may retain a magnetic force when the contact support 12 stays in its repulsive position. When the end 12b of the current-limiting contact support 12 stays below the opening 23 of the stationary conductor 15 and the corresponding hole 23 of the magnetic force absorbing plate 25, as shown in FIGURE 6, the short-circuit current which is already flowing produces a magnetic repulsive force between the side faces of the current-limiting contact support 12 and the stationary conductor 15. The repulsive force acting against the force urging the current-limiting contact support 12 to return works as an electromagnetic retaining force and thereby produces a magnetic locking effect.

Reference is now made to FIGURES 7(a) to 7(c) showing a circuit breaker according to a fifth embodiment of this invention. It is characterized by the current-limiting contact support 12 which is formed from a flat plate to acquire an increased repulsive force, and is reinforced so as not to be deformed by the repulsive force. The construction of the main part of the circuit breaker is shown in FIGURE 7(a), and the current-limiting contact support 12 in FIGURE 7(b), while FIGURE 7(c) is a sectional view taken along the line A-A of FIGURE 7(a). The current-limiting contact support 12 is formed from a flat plate, and is reinforced by a reinforcing member 30 secured to it at right angles thereto, as shown in FIGURE 7(b). The current-limiting contact support 12 has a width which is equal to that of the stationary conductor 15, as shown in FIGURE 7(c), so that the repulsing portion 12a may receive a greatly increased repulsive force from the extension 15a of the stationary conductor 15. All the other features of the device are identical to their counterparts in the device according to the first embodiment of this invention.

A modified form of the device shown in FIGURES 7(a) to 7(c) is shown in FIGURES 8(a) and 8(b). The modified device is characterized by a modified current-limiting contact support 12 which does not have any reinforcing member of the type shown at 30 in FIGURES 7(a) to 7(c), but has a pair of reinforcing portions 12d upstanding from its longitudinal edges, respectively, as shown in FIGURE 8(a). The current-limiting contact support 12 has a U-shaped cross section, as shown in FIGURE 8(b). This type of reinforcement can be made merely by bending and can, therefore, reduce the time and labor required for the preparation of the parts of the circuit breaker.

Referring to FIGURES 9(a) and 9(b), the circuit breaker according to a sixth embodiment of this invention is characterized by including a sliding member 36 connected as means for conductive connection to the stationary conductor 15, and a contact portion 12e extending from the repulsing portion 12a of the current-limiting contact support 12 and contacting the sliding member 36 to maintain electrical connection between the stationary conductor 15 and the current-limiting contact support 12. The ON position of the current-limiting contact support 12 and the repulsive position thereof are shown by solid and two-dot chain lines, respectively. When the current-limiting contact support 12 is rotated to its repulsive position, its contact portion 12e slides along the sliding member 36, while maintaining its electrical connection therewith. All the other features of the device are identical to their counterparts in the device according to the first embodiment of this invention. The device can be held at a satisfactorily low temperature,

since the heat which is generated in the current-limiting contact support 12 is transmitted to the stationary conductor 15 through the contact portion 12e and the sliding member 36.

Attention is now directed to FIGURES 10 and 11 showing the circuit breaker according to a seventh embodiment of this invention. The device is particularly intended for making and breaking a DC circuit and maintaining the necessary breaking distance. It is small and yet maintains the necessary breaking distance between the contacts having the current-limiting and repulsing construction. It also provides a switching mechanism which is effective for an AC circuit, too. Moreover, it has an improved current-limiting and breaking capacity. The electromagnetically repulsed contact supports are held in their repulsed positions until the circuit is completely broken.

The current-limiting switching mechanism is enclosed in a molded insulating case 58 and is of the doubly insulated construction. The mechanism is not damaged by any arc occurring when the circuit is broken, nor does any molten matter adhere to it. Therefore, it is a highly reliable mechanism.

When the handle is turned for a switching operation, the current-limiting contact supports which are moved by electromagnetic repulsion are moved to maintain the breaking distance. In other words, they are moved by repulsion not only when a large amount of electric current, such as a short-circuit current, has flowed, but also when the switching operation is made.

One electromagnetically repulsive contact support is provided for each phase. The contact supports are all moved together to maintain the breaking distance for a DC power source and provide a simultaneous three-phase repulsion mechanism for an AC power source to thereby achieve an improved current-limiting performance. The three movable contact supports 12 are connected together by two insulating shafts 17 and 54 and are rotatable together about the pin 17.

A movable frame 57 secured to the interlocking shaft 7 in the switching mechanism 4 is provided for each movable contact support and a metal fixture 56 is connected to the frame 57 by the pin 16 about which the movable contact support is rotatable. The metal fixture 56 as a connecting member has another end engaging the insulating shaft 54 connecting the three contact supports 12 which are movable together by repulsion. If the movable frames 57 are rotated clockwise, the insulating shaft 54 is raised to rotate the three current-limiting contact supports 12 counterclockwise about the shaft 17, so that they may maintain the breaking distance by moving to nearly the same position as when they are moved by repul-

sion. The contact supports 12 are returned together to their original positions by the return spring 13 fastened to the middle support 12 and supported on a shaft 55. The ON operation of the current-limiting contact supports 12 is performed by the counterclockwise rotation of the movable frames 57, as opposed to the OFF (opening) operation thereof, whereupon the supports 12 are moved up to have the contacts 11 abut on the movable contacts 9.

The three movable contact supports are connected by the shafts 17 and 54 to form an integral structure and when they are moved by electromagnetic repulsion, they are moved by the total amount of the electromagnetic force produced by the electric current flowing therethrough. The movable frames 57 are engaged with the shaft 54 to allow for a large breaking distance between the movable contacts and the current-limiting contacts to break a DC circuit and the breaking operation of the mechanism 4 causes the three current-limiting contact supports 12 to rotate counterclockwise about the pin 17. Therefore, it is possible to maintain the same breaking distance when they are in the OFF position, as when they are moved by electromagnetic repulsion.

Referring to FIGURES 12(a) to 12(c), the circuit breaker according to an eighth embodiment of this invention is characterized by including means for preventing the lateral displacement of the current-limiting contact support which might otherwise be caused by the gap, if any, between it and the pin, and result in the failure of the contacts to make proper contact. The pin 17 is held by a frame 62 having projections 62a and 62b between which the pin 17 is located, and which are provided for restraining the movement of the current-limiting contact support 12 in the direction perpendicular to the plane in which it is rotatable, as shown in FIGURE 12(a).

The current-limiting contact support 12 which has been laterally displaced, or rotated about the pin 17 in the plane thereof, is shown by one-dot chain lines in FIGURE 12(b). No further displacement of the support 12, however, occurs, as it abuts on the projections 62a and 62b of the frame 62. FIGURE 12(c) is an enlarged view of a portion of the support 12 close to the pin 17. When the current-limiting contact support 12 is in its normal position, it and the pin 17 have a gap A therebetween, but if it is displaced as shown by one-dot chain lines, they have a smaller gap B. The projections on both sides of the pin 17 prevent any further displacement of the support 12, irrespective of the gap B. Although the gap A is shown as being larger than the gap B, they are of the same width if the distance between the opposite projections 62a and the distance between the opposite

projections 62b are both equal to the thickness of the current-limiting contact support 12. The projections 62a and 62b can be provided at any desired distances from the pin 17 to prevent the displacement of the support 12 and thereby any insulation failure by the formation of an arc, even if the projections 62b may not be located near the contact.

The frame 62 can be made of an insulating material to ensure to a further extent that no insulation failure occur. The projections 62a are sufficient to prevent any insulation failure. Although the eighth embodiment of the invention has been shown as applied to the current-limiting contact support 12, it is equally applicable to the movable contact support 9. It is also applicable to a stationary current-limiting contact support, or a movable contact support in a non-current-limiting circuit breaker.

A modified form of the device shown in FIGURE 12(a) is shown in FIGURE 13. The modified device has, instead of the projections 62a, a guide pin 64 secured to the current-limiting contact support 12 for restraining its lateral displacement. Each end of the guide pin 64 that is engageable with the frame 62 is spherically shaped so as to have a low coefficient of friction.

Referring to FIGURES 14 to 16, the circuit breaker according to a ninth embodiment of this invention is characterized by including at least two electromagnetic repulsion mechanisms each for rotating a current-limiting contact support by a couple of electromagnetic repulsive forces produced on both sides of the axis of its rotation.

The device includes a first current-limiting contact support 12 and a second current-limiting contact support 72 located below it and rotatably supported on a pin 71. A flexible twisted wire 14 has one end connected to one end of the current-limiting contact support 12, and another end connected to one end of a stationary contact support 73.

The stationary contact support 73 has another end carrying a stationary contact 74 and the second current-limiting contact support 72 carries a movable contact 75 facing the stationary contact 74. The pin 71 is provided with a spring 76 urging the second current-limiting contact support 72 counterclockwise. A flexible twisted wire 14 is connected between the end of the second current-limiting contact support 72 remote from the contact 75 and one end of a stationary conductor 15. The current-limiting contact support 12 is rotatable about a pin 17 by a couple of electromagnetic repulsive forces which are produced between the movable contact support 9 and the current-limiting

contact support 12, and between the current-limiting contact support 12 and the stationary conductor 15, respectively.

The second current-limiting contact support 72 is rotatable about the pin 71 by a couple of electromagnetic repulsive forces which are produced between the stationary conductor 15 and the second current-limiting contact support 72, and between the second current-limiting contact support 72 and the stationary contact support 73, respectively.

If a shortcircuit has caused a large amount of electric current to flow into the breaker through the stationary conductor 15, the current-limiting contact support 12 is rotated counterclockwise about the pin 17 to break the circuit rapidly, as is the case with any other device embodying this invention. A couple of electromagnetic repulsive forces are produced between the stationary conductor 15 and the repulsing portion 72b of the second current-limiting contact support 72, and between the end portion 72a of the support 72 on the opposite side of the pin 71 from the repulsing portion 72b and that portion of the second stationary conductor 73 which is close to the stationary contact, respectively, and cause the second current-limiting contact support 72 to rotate clockwise about the pin 71 rapidly. If the circuit is completely broken, the first and second current-limiting contact supports 12 and 72 are returned by the springs 13 and 76, respectively, to their respective original positions, as shown in FIGURE 16.

The circuit breaker shown in FIGURES 14 to 16 has not only a greatly improved breaking speed, but also a greatly improved current-limiting efficiency, since the presence of two current-limiting contact supports makes twice as high an arc voltage.

The provision of the two electromagnetic repulsion mechanisms which produce a couple of forces to cause the circuit breaker to function enables an increase breaking speed, a prolonged breaking distance, and a greatly improved current-limiting efficiency due to an increased arc voltage.

Attention is now drawn to FIGURES 17(a) to 17(d) showing the circuit breaker according to a tenth embodiment of this invention. It includes magnetic flux holding means provided for the extension 15a of a stationary conductor 15 facing the end portion 12a of a current-limiting contact support 12 remote from a current-limiting contact 11, as shown in FIGURE 17(a). It is provided for ensuring that the necessary magnetic repulsive force and breaking speed be maintained. Another magnetic flux holding means may be provided in a region remote from an arc-suppressing chamber for improving the reliability in performance of the

circuit breaker by protecting it from any influence by molten matter which may be produced when the breaker works.

A magnetic drive 80 as magnetic flux holding means is formed from a magnetic material and has a U-shaped cross section, as shown in FIGURE 17-(b), which is a sectional view taken along the line A-A of FIGURE 17(a). The extension 15a and the repulsing portion 12a facing it extend through the magnetic drive 80 adjacent to its inner bottom surface. The flow of a large amount of current through the repulsing portion 12a produces a magnetic flux flowing clockwise about it as shown by thin arrow lines in FIGURE 17(b). The repulsion which occurs between the repulsing portion 12a and the extension 15a causes the repulsing portion 12a to move in the direction of a thick arrow line to the position shown by two-dot chain lines. As the magnetic flux moves within the magnetic drive 80, it does not undergo any reduction, but retains a high driving force in the direction of the thick arrow line to thereby maintain a high speed for the movement of the repulsing portion 12a. This enables the current-limiting contact support 12 to maintain a high breaking speed and thereby achieve a high current-limiting efficiency.

If the magnetic drive 80 is situated within the space defined by molded walls 40a to 40c immediately below the mechanism, it can protect the circuit breaker from any influence of molten matter on its performance and thereby improve its reliability.

Another magnetic drive 80a may be provided between a movable contact support 9 and the current-limiting contact support 12 to achieve a still improved current-limiting efficiency. It is also formed from a magnetic material and has a U-shaped cross section, as shown in FIGURE 17(c), which is a sectional view taken along the line B-B of FIGURE 17(a). The magnetic fluxes which are formed by the electric current flowing through the movable contact support 9 and the current-limiting contact support 12, respectively, pass through the magnetic material. Therefore, no reduction in magnetic flux occurs during the movement of the movable contact support 9 and the current-limiting contact support 12, but a satisfactorily high breaking speed can be maintained.

A U-shaped magnetic plate 82 may be provided about the repulsing portion 12a in the magnetic drive 80, so that the core and the magnetic plate 82 may have a small gap therebetween, as shown in FIGURE 17(d). It contributes to improving the performance of the magnetic drive 80.

Referring to FIGURE 18, the circuit breaker according to an eleventh embodiment of this invention is a modified form of the circuit breaker according to the ninth embodiment thereof and in-

cludes magnetic drives 80b and 80c provided as magnetic flux holding means for the stationary conductor 15 and the stationary contact support 73, respectively. An improved breaking speed is achieved between the contacts 74 and 75 by the magnetic drive 80c, as well as the electromagnetic repulsive force which is produced between the extension 15a of the stationary conductor 15 and the portion 72a of the second current-limiting contact support 72.

Referring to FIGURE 19, the circuit breaker according to a twelfth embodiment of this invention is a modified form of the device shown in FIGURE 18. It includes a stationary contact support 78 secured by a screw 97 to one end of the stationary conductor 15, and the magnetic drive 80b for the stationary conductor 15 is secured to the stationary contact support 78.

In the device shown in FIGURE 19, the repulsion of the first current-limiting contact support 12 occurs before the repulsion of the second current-limiting contact support 72, as the breaking speed of the former is increased by the magnetic drive. The current-limiting contact support 12 is still connected electrically to the first stationary conductor 15 through the flexible conductor 14 and the second current-limiting contact support 72. The magnetic drive 80b is secured to the stationary contact support 78 by a screw 99. The stationary conductor 15, the stationary contact support 78 and the magnetic drive 80b can be prepared as a unitary assembly to improve the efficiency with which the circuit breaker is assembled. The magnetic drive 80b can be secured to the stationary conductor 15 directly in a circuit breaker of the type according to the tenth embodiment of this invention which has no stationary contact support as shown at 78 in FIGURE 19. The unitary assembly as hereinabove described contributes to realizing the automatic fabrication of the circuit breaker. All the other features of the device are identical to their counterparts in the device shown in FIGURE 18.

Although the circuit breakers embodying this invention have been described as having an electromagnetic tripping device including an oil dashpot relay, it is also possible to employ another type of tripping device, such as an electronic device having an electronic circuit for urging a magnetic tripping device in response to the current flowing in a line as detected by a current transformer, etc., or a thermal device employing a bimetal, etc., or a combination thereof. If an electronic device is employed, the line 88 is formed by a flexible conductor 88a connected to the movable contact support, and a conductor not shown, but connected to the flexible conductor 88a and leading through a current transformer to the load terminal. If a thermal device is employed, the line 88 is formed by a

flexible conductor 88a connected to the movable contact support, and a heater not shown, but connected to the flexible conductor 88a, provided for heating a bimetal, and leading to the load terminal.

INDUSTRIAL UTILITY:

According to this invention, the current-limiting contact support is rotatably supported in its middle portion, and has one end facing the movable contact support, while the other end thereof faces the stationary conductor and is connected to it by conductive connecting means, so that a couple of electromagnetic repulsive forces are produced between the movable and current-limiting contact supports, and between the stationary conductor and the current-limiting contact support. This invention, therefore, provides a small circuit breaker having a small distance between the current-limiting contact support and the stationary conductor, a high breaking speed, and an outstanding breaking efficiency.

Claims

1. A circuit breaker comprising a housing provided at one end with a power source terminal, and at another end with a load terminal; a stationary conductor having one end connected to said power source terminal and another end provided with conductive connecting means; a current-limiting contact support having one end connected to said conductive connecting means and facing said stationary conductor, and another end carrying a current-limiting contact, said support being rotatably supported in its middle portion, said one end of said support defining a repulsing portion, so that the flow of an electric current in opposite directions through said stationary conductor and said repulsing portion may produce an electromagnetic repulsive force therebetween; a movable contact support facing said current-limiting contact support, supported rotatably, and carrying a movable contact facing said current-limiting contact; a switching mechanism connected to said movable contact support for performing a switching and tripping operation; and a tripping device for detecting an overcurrent in a line extending from said movable contact support to said load terminal and causing said switching mechanism to perform a tripping operation, said conductor, supports, mechanism, and device being all enclosed in said housing.
2. A circuit breaker as set forth in claim 1, wherein said repulsing portion includes a hinged extension.
3. A circuit breaker as set forth in claim 1, wherein said stationary conductor includes an extension lying along said repulsing portion and having an opening for receiving a part of said repulsing portion therein.
4. A circuit breaker as set forth in claim 1, wherein said stationary conductor has an opening located below said current-limiting contact, so that said other end of said current-limiting contact support may be received in said opening when electromagnetic repulsion has resulted from the flow of a large amount of electric current.
5. A circuit breaker as set forth in claim 1, wherein said current-limiting contact support is formed from an elongated plate having a width which is substantially equal to that of said stationary conductor, and is provided with a reinforcing member.
6. A circuit breaker as set forth in claim 1, wherein said conductive connecting means comprises a sliding member connected to said other end of said stationary conductor, and said one end of said current-limiting contact support is slidable along said sliding member, while maintaining electrical connection between said stationary conductor and said current-limiting contact support.
7. A circuit breaker as set forth in claim 1, wherein said current-limiting contact support is rotatably supported on a first shaft, said breaker further including a second shaft lying in parallel to said first shaft and extending through said current-limiting contact support at right angles thereto on the opposite side of said first shaft from said current-limiting contact, and a member connecting said second shaft to the junction between said movable contact support and said switching mechanism to move said second shaft to rotate said current-limiting contact support in the direction of its rotation by electromagnetic repulsion when said switching mechanism is actuated for a circuit-breaking operation.
8. A circuit breaker as set forth in claim 7, wherein a plurality of current-limiting contact supports, including said current-limiting contact support, are provided in a spaced apart and parallel relation to one another, and are joined

to one another by said first and second shafts so as to be rotatable together in said direction upon actuation of said switching mechanism for said circuit-breaking operation.

9. A circuit breaker as set forth in claim 1, further including means for restraining the movement of said current-limiting contact support in the direction which is perpendicular to the plane of its rotation.
10. A circuit breaker comprising, in a housing provided at one end with a power source terminal, and at another end with a load terminal, a stationary conductor having one end connected to said power source terminal and another end provided with conductive connecting means; a second current-limiting contact support having one end connected to said conductive connecting means and facing one side of said stationary conductor, and another end carrying a second current-limiting contact, said support being rotatably supported in its middle portion; a stationary contact support facing said second current-limiting contact support, and having one end carrying a stationary contact facing said second current-limiting contact, and another end provided with a second conductive connecting means; a first current-limiting contact support having one end connected to said second conductive connecting means and facing another side of said stationary conductor, and another end carrying a first current-limiting contact, said first current-limiting contact support being rotatably supported in its middle portion; a movable contact support facing said first current-limiting contact support, supported rotatably, and carrying a movable contact facing said first current-limiting contact; a switching mechanism connected to said movable contact support for performing a switching and tripping operation; and a tripping device for detecting an overcurrent in a line extending from said movable contact support to said load terminal and causing said switching mechanism to perform a tripping operation, said one end of each of said first and second current-limiting contact supports defining a repulsing portion, so that the flow of an electric current in opposite directions through said stationary conductor and said repulsing portion may produce an electromagnetic repulsive force therebetween.
11. A circuit breaker comprising, in a housing provided at one end with a power source terminal, and at another end with a load terminal, a stationary conductor having one end connect-

ed to said power source terminal and another end provided with conductive connecting means; a current-limiting contact support having one end connected to said conductive connecting means and facing said stationary conductor, and another end carrying a current-limiting contact, said support being rotatably supported in its middle portion, said one end of said support defining a repulsing portion, so that the flow of an electric current in opposite directions through said stationary conductor and said repulsing portion may produce an electromagnetic repulsive force therebetween; a movable contact support facing said current-limiting contact support, supported rotatably, and carrying a movable contact facing said current-limiting contact; a switching mechanism connected to said movable contact support for performing a switching and tripping operation; a tripping device for detecting an overcurrent in a line extending from said movable contact support to said load terminal and causing said switching mechanism to perform a tripping operation; and magnetic flux holding means provided close to said repulsing portion and extending in the direction in which said repulsing portion is movable.

12. A circuit breaker as set forth in claim 11, wherein said stationary conductor includes an extension lying along said repulsing portion, and said magnetic flux holding means comprises a member having a substantially U-shaped cross section through which said repulsing portion and said extension extend.
13. A circuit breaker comprising, in a housing provided at one end with a power source terminal, and at another end with a load terminal, a stationary conductor having one end connected to said power source terminal; a stationary contact support having one end connected to said stationary conductor on one side of said stationary conductor, and another end carrying a stationary contact; a second current-limiting contact support having one end carrying a second current-limiting contact facing said stationary contact, and another end provided with conductive connecting means, said current-limiting contact support being rotatably supported in its middle portion, said one end of said current-limiting contact support defining a repulsing portion, so that the flow of an electric current in opposite directions through said stationary conductor and said repulsing portion may produce an electromagnetic repulsive force therebetween; a first current-limiting contact support having one end connected to said

conductive connecting means, facing another side of said stationary conductor, and carrying a first current-limiting contact at another end, said first current-limiting contact support being rotatably supported in its middle portion; a 5
movable contact support facing said first current-limiting contact support, supported rotatably, and carrying a movable contact facing said first current-limiting contact; a switching mechanism connected to said movable 10
contact support for performing a switching and tripping operation; a tripping device for detecting an overcurrent in a line extending from said movable contact support to said load terminal and causing said switching mechanism to per- 15
form a tripping operation; and magnetic flux holding means attached integrally to said stationary contact support in the vicinity of said repulsing portion and extending in the direction in which said repulsing portion is movable. 20

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Fig. 1

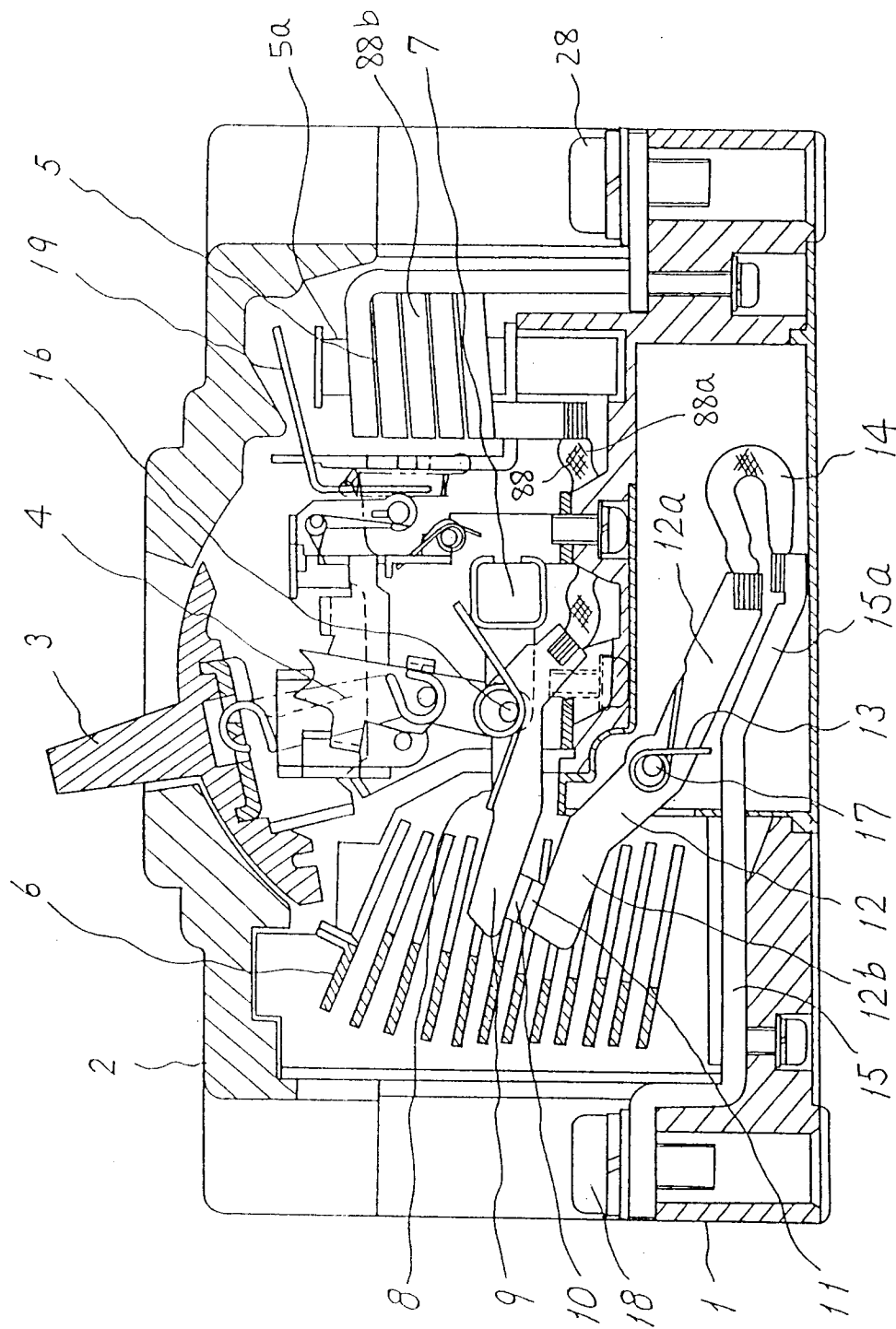


Fig. 2

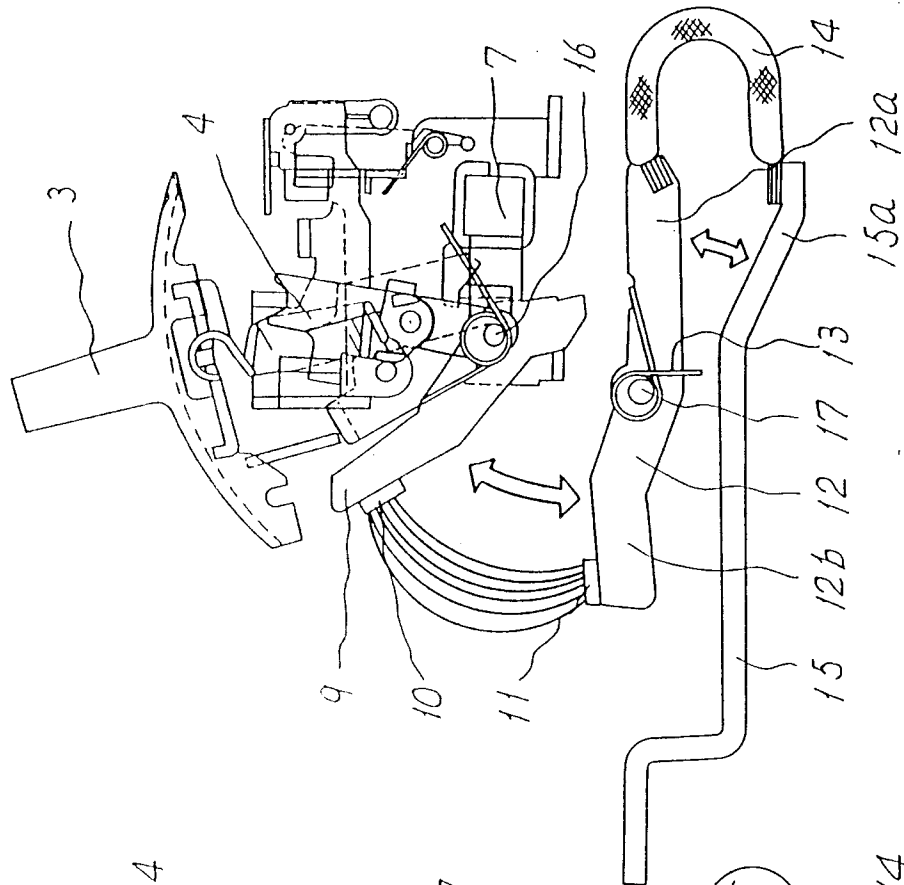
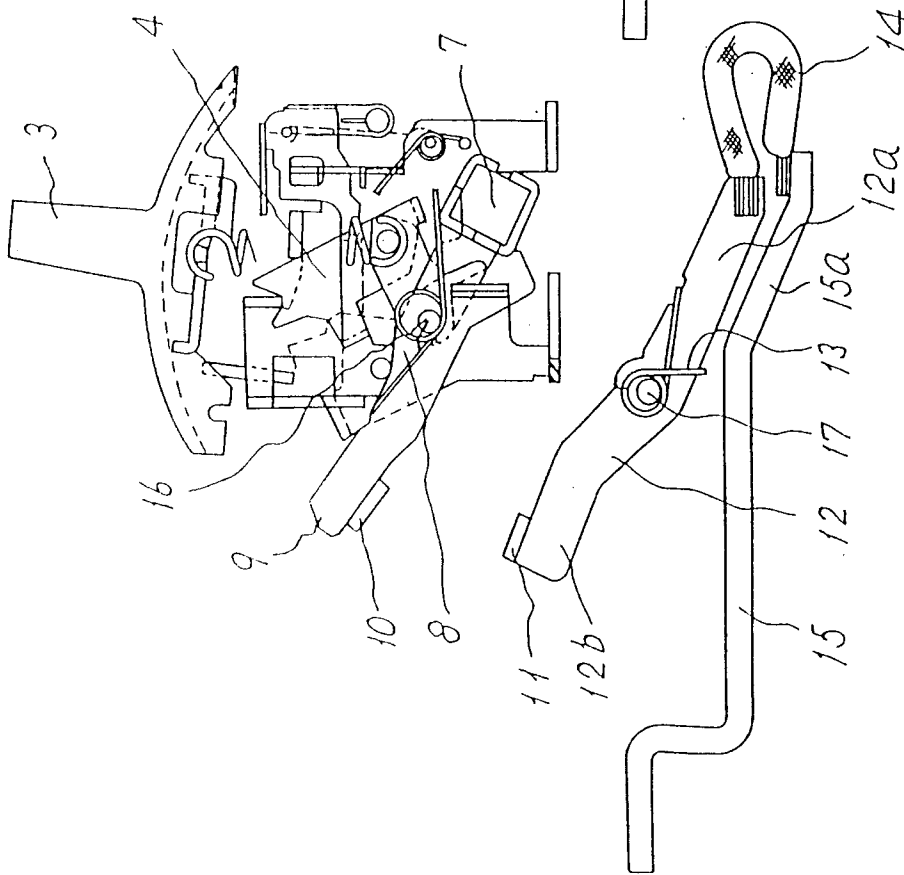


Fig. 3



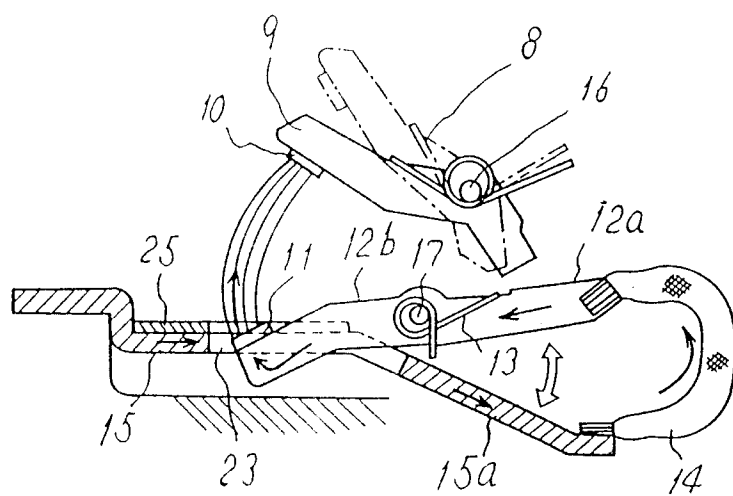
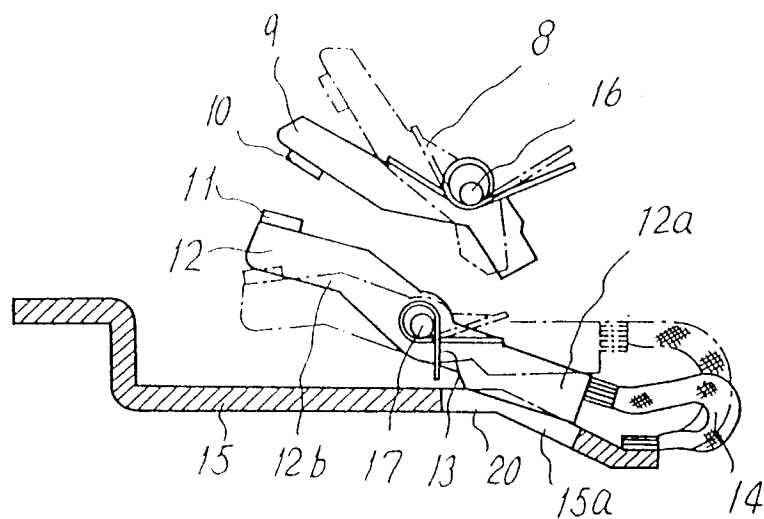
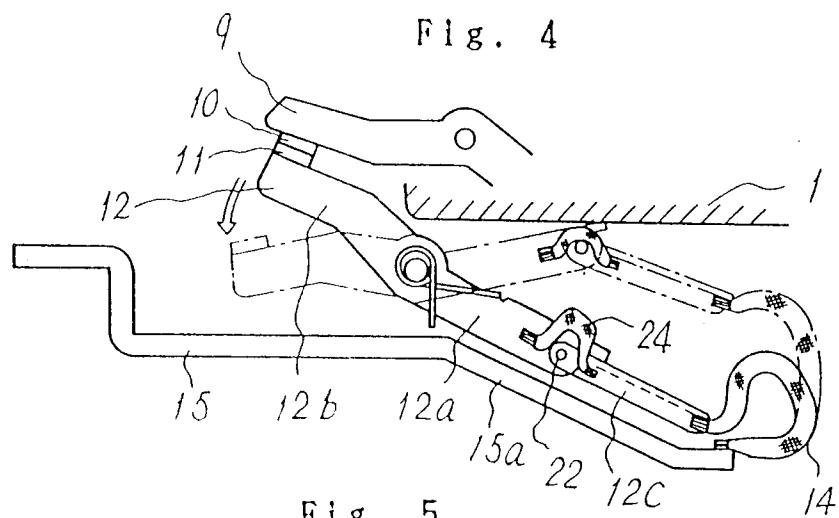


Fig. 7

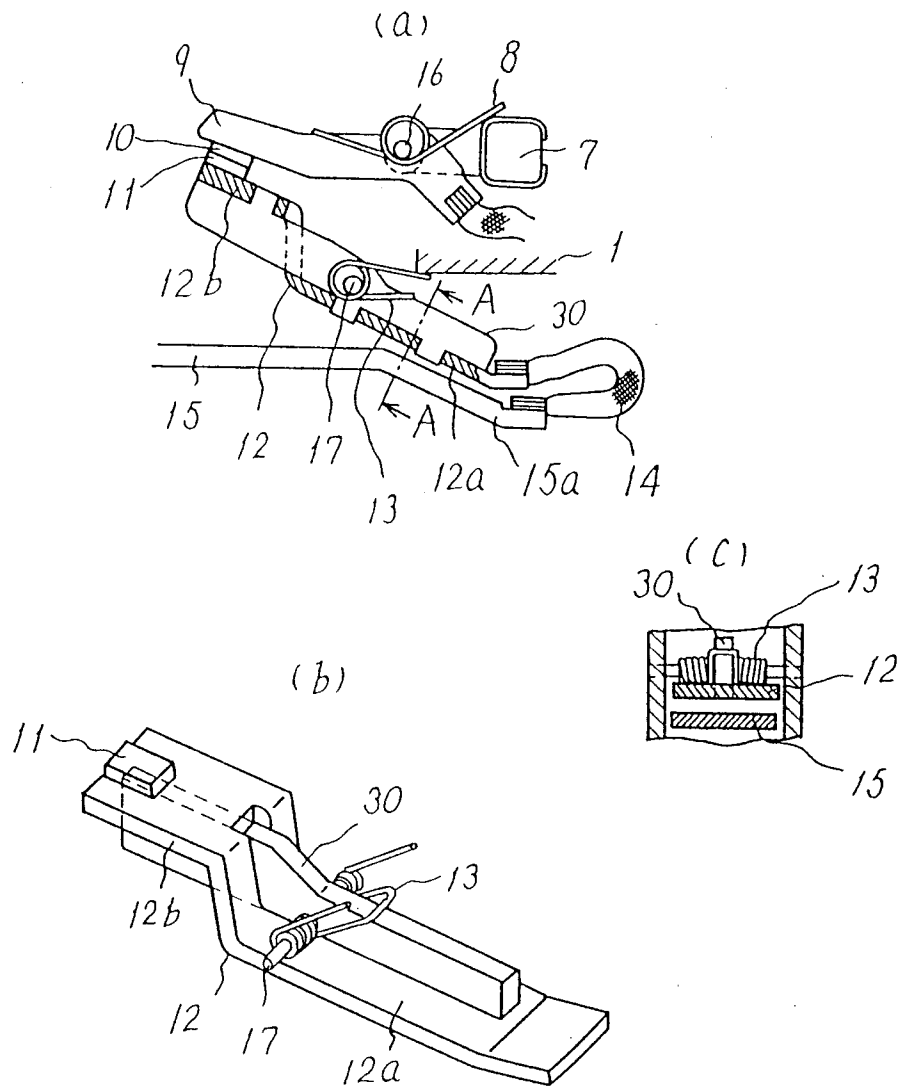
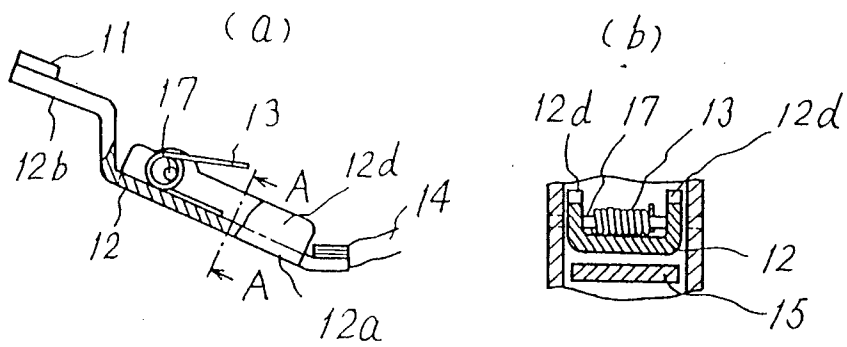


Fig. 8



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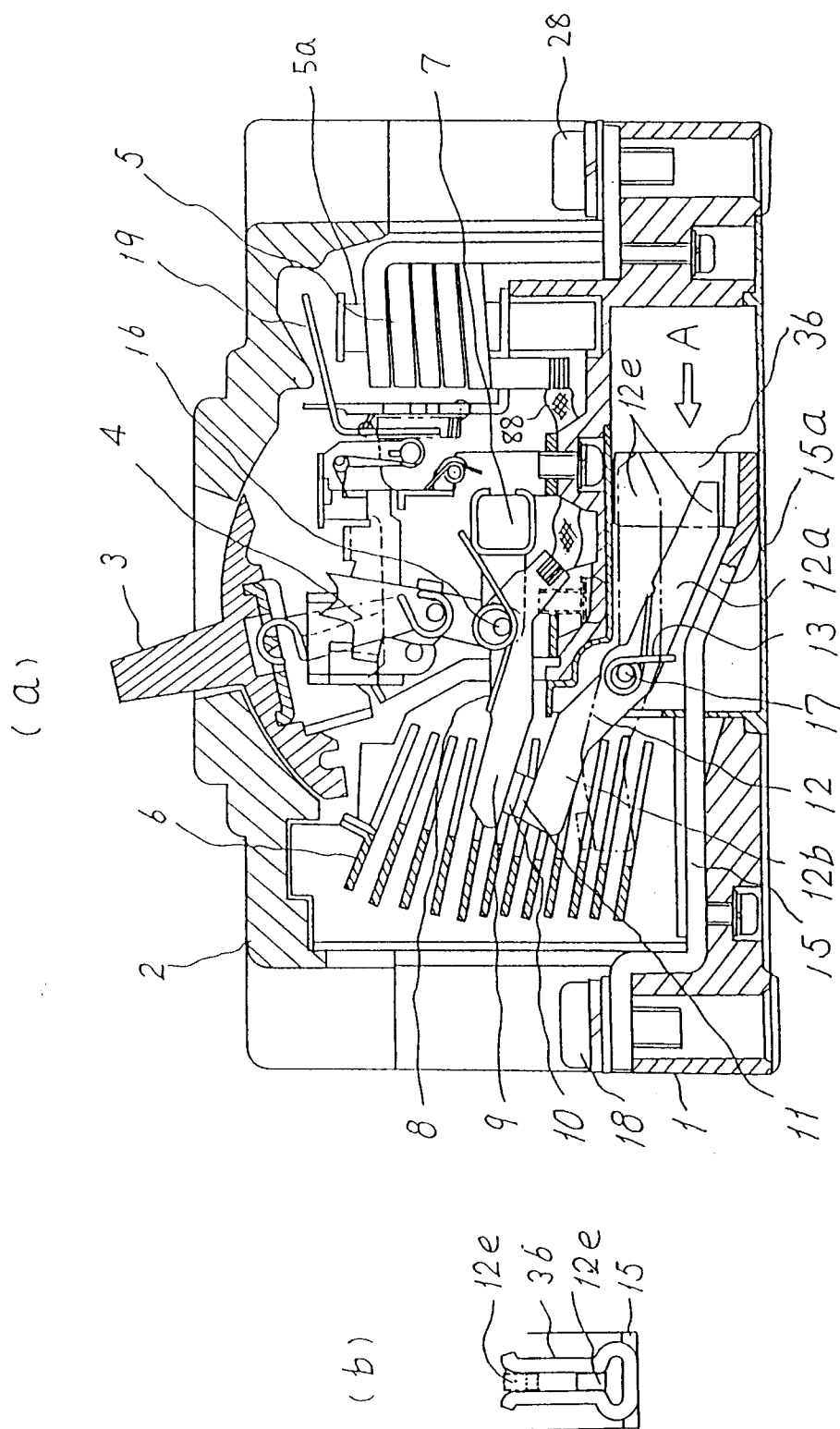


Fig. 10

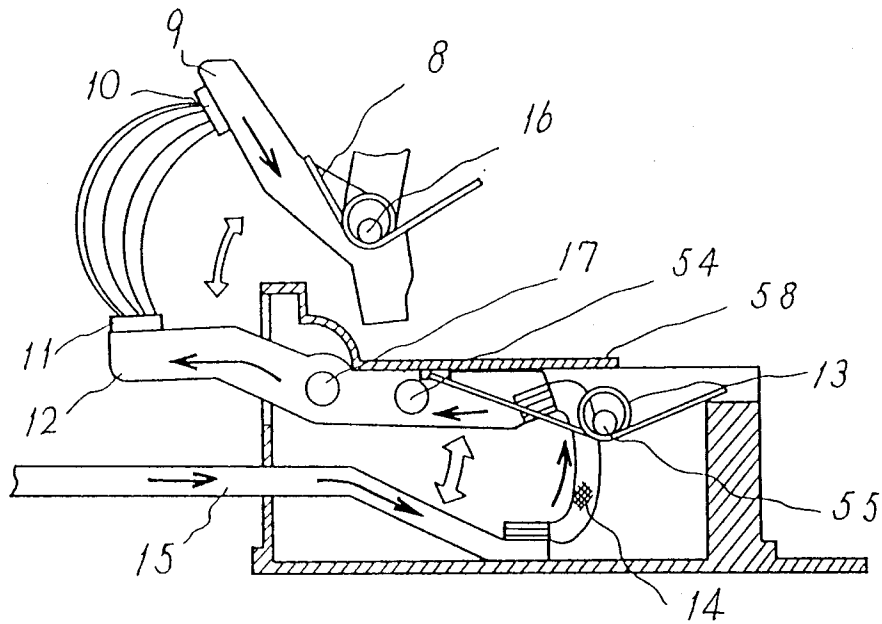


Fig. 11

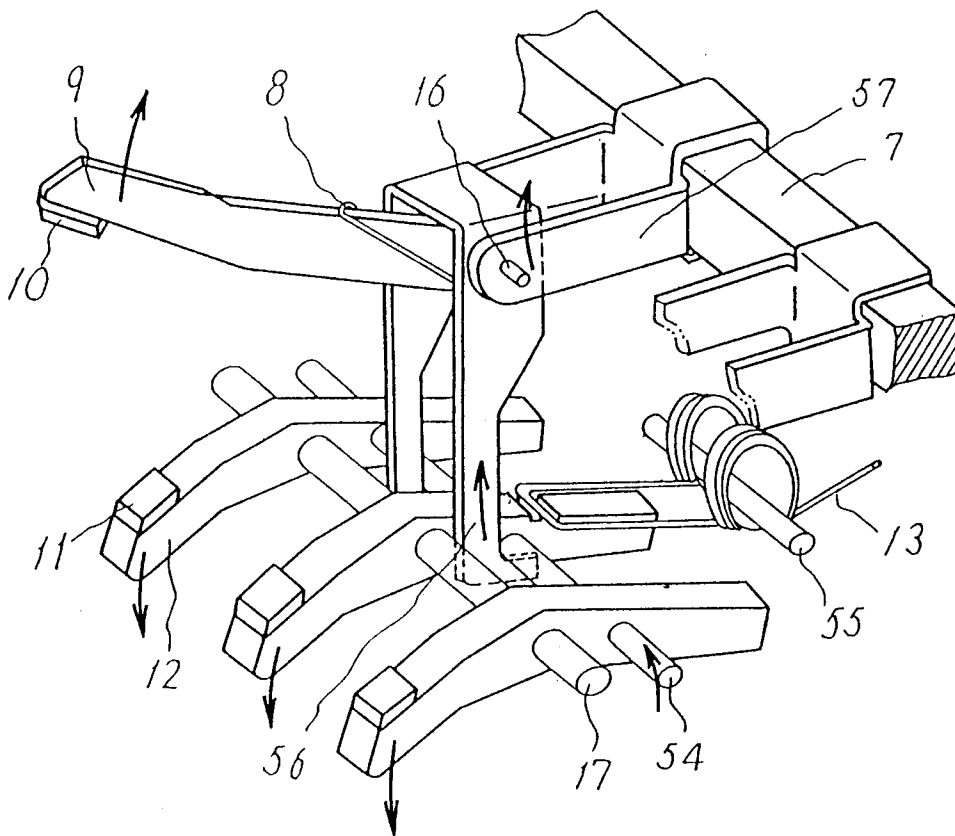
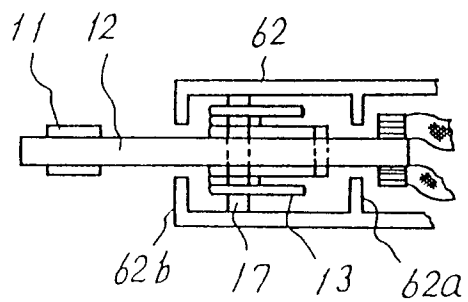
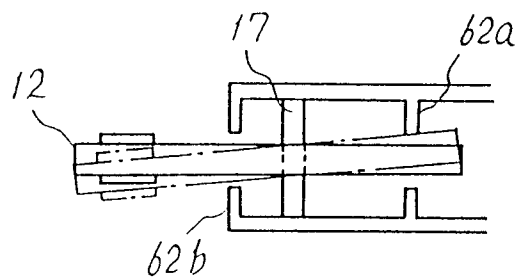


Fig. 12

(a)



(b)



(c)

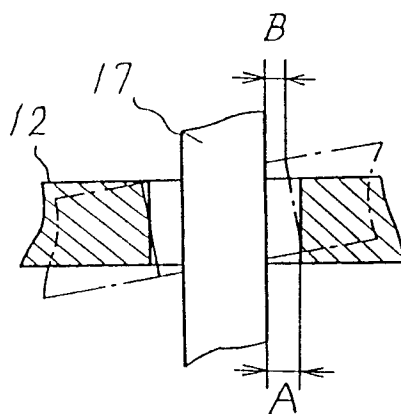


Fig. 13

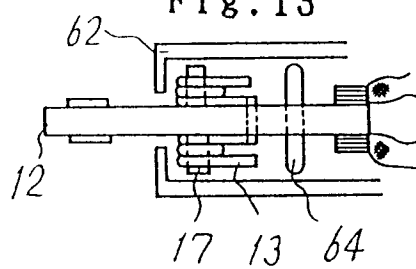


Fig. 14

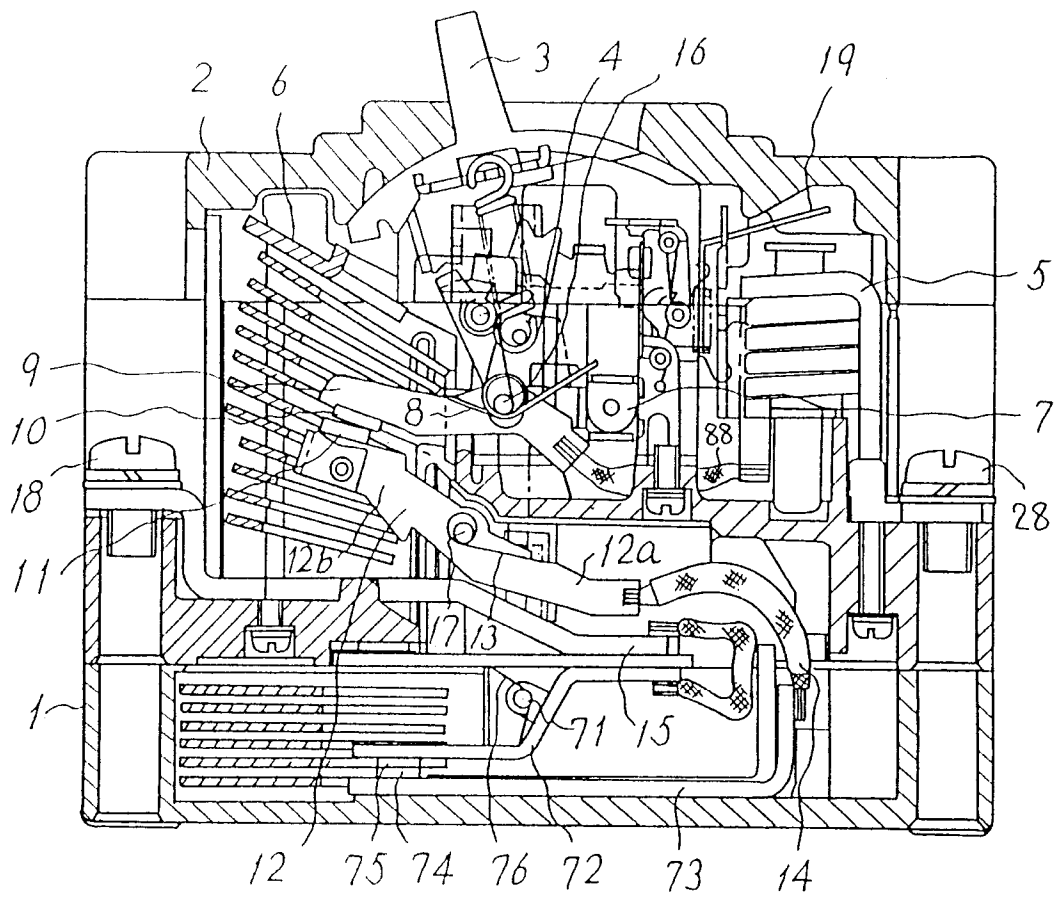


Fig. 15

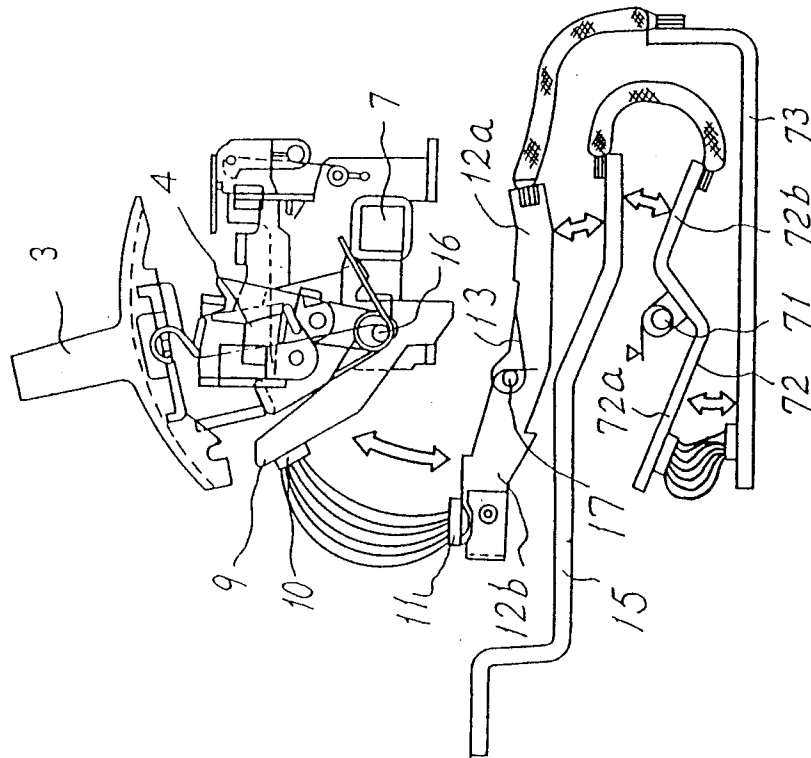
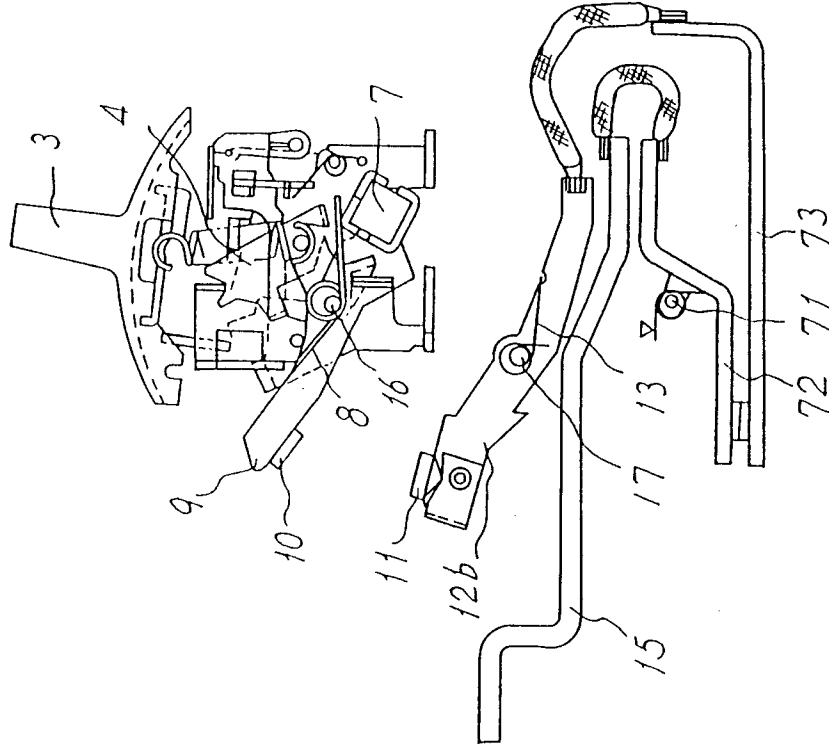


Fig. 16



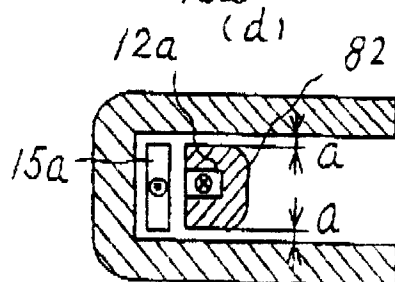
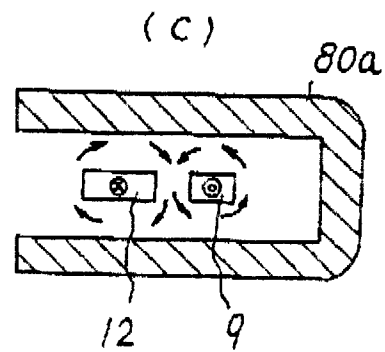
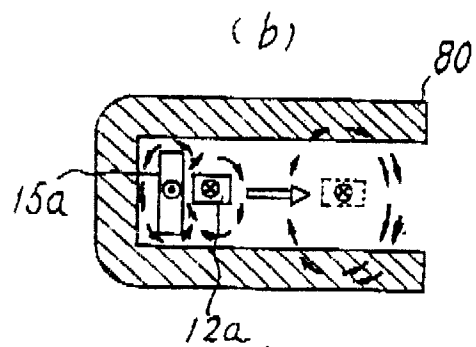
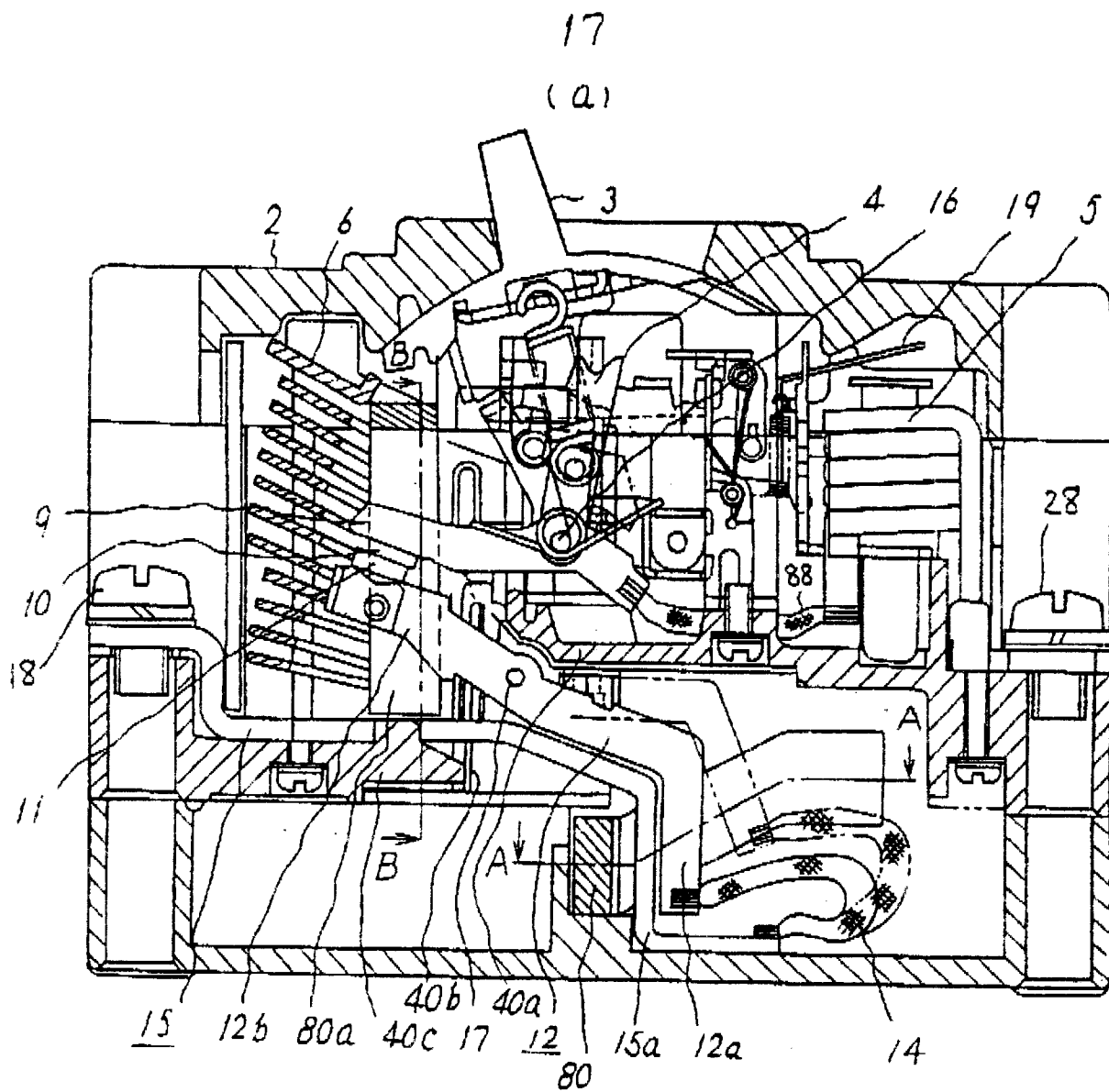


Fig. 18

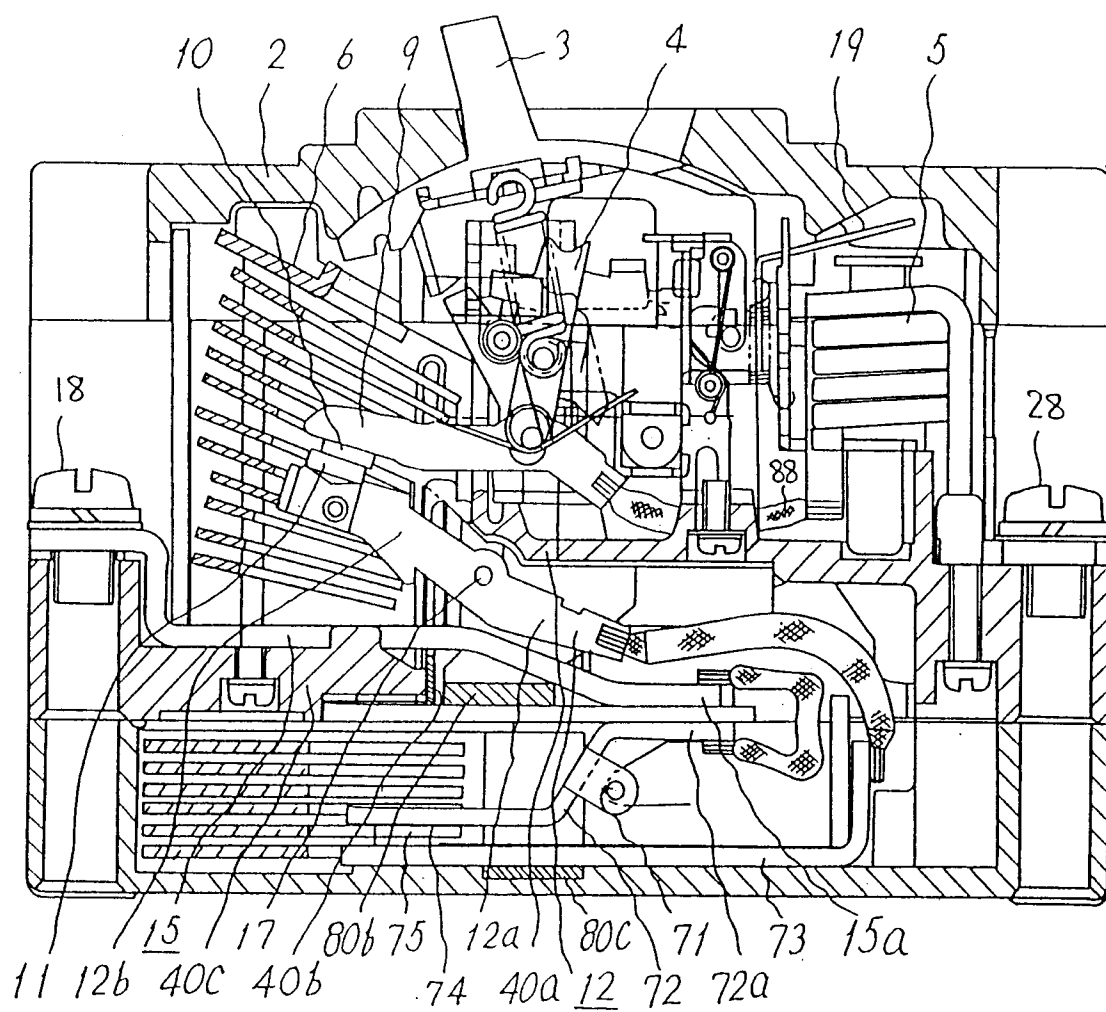
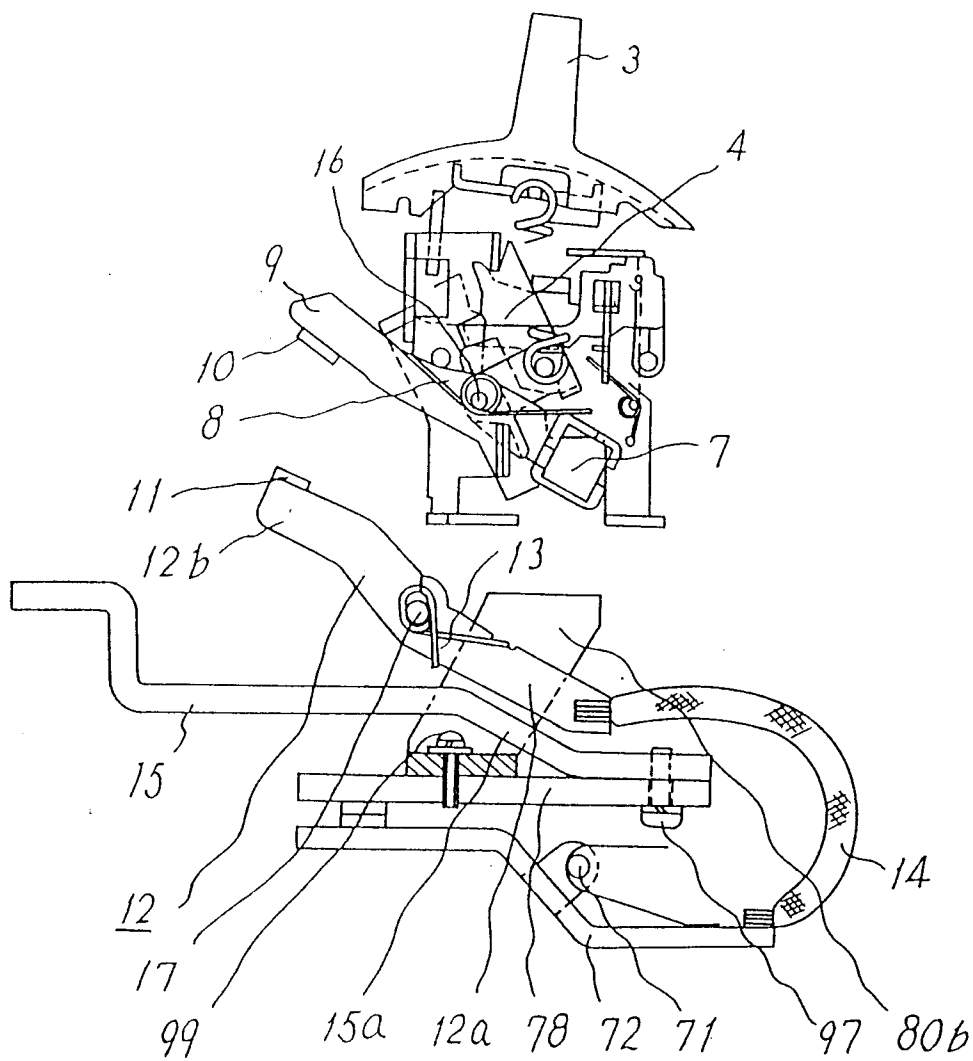


Fig. 19



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00835

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶												
According to International Patent Classification (IPC) or to both National Classification and IPC												
Int. Cl ⁵ H01H71/43, H01H73/36												
II. FIELDS SEARCHED												
Minimum Documentation Searched ⁷												
Classification System	Classification Symbols											
IPC	H01H71/43, H01H73/36											
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸												
Jitsuyo Shinan Koho	1926 - 1990											
Kokai Jitsuyo Shinan Koho	1971 - 1990											
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹												
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³										
X	JP, A, 58-154114 (Toshiba Corp.), 13 September 1983 (13. 09. 83), Pages 2 to 3	1										
Y	JP, U, 53-49057 (Hitachi, Ltd.), 25 April 1978 (25. 04. 78), Page 1	2 - 9										
Y	JP, B1, 46-8356 (Terasaki Denki Sangyo K.K.), 2 March 1971 (02. 03. 71), Pages 2 to 5	10, 11, 12										
Y	JP, B1, 46-8358 (Terasaki Denki Sangyo K.K.), 2 March 1971 (02. 03. 71), Pages 2 to 4	10, 11, 12										
Y	JP, A, 55-53840 (Westinghouse Electric Corp.), 19 April 1980 (19. 04. 80), Pages 3 to 5 & DE, A1, 2940781 & FR, A1, 2439470 & US, A, 4245203	13										
¹⁰ Special categories of cited documents: <table border="0"> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"E" earlier document but published on or after the international filing date</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"E" earlier document but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	"P" document published prior to the international filing date but later than the priority date claimed	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention											
"E" earlier document but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step											
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art											
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family											
"P" document published prior to the international filing date but later than the priority date claimed												
IV. CERTIFICATION												
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report											
September 13, 1990 (13. 09. 90)	September 25, 1990 (25. 09. 90)											
International Searching Authority	Signature of Authorized Officer											
Japanese Patent Office												

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y JP, A, 55-56329 (Westinghouse Electric Corp.),
25 April 1980 (25. 04. 80),
Pages 3 to 5 & FR, A1, 2439472
& US, A, 4259651 & DE, A1, 2940692

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V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers, because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claim numbers, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claim numbers, because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ²

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.