Feb. 28, 1967 L. E. COOPER 3,307,002

MULTIPOLE CIRCUIT BREAKER

Filed Feb. 4, 1965 6 Sheets-Sheet 1

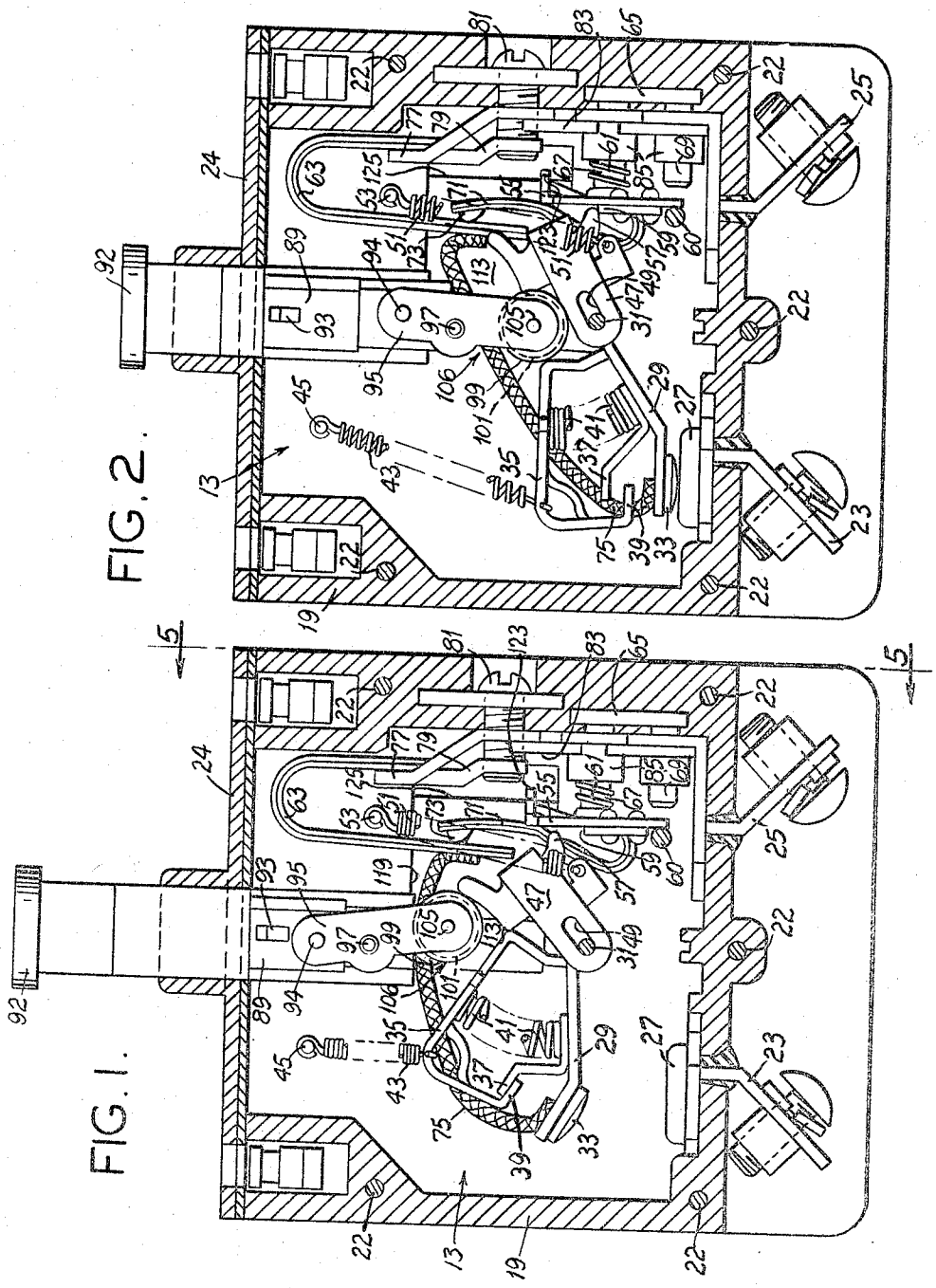


FIG. 2.

FIG. 1.

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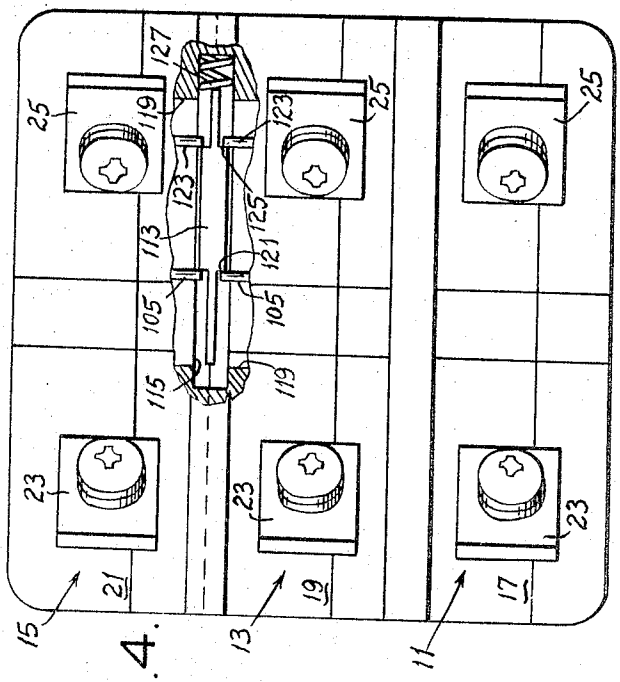


FIG. 4.

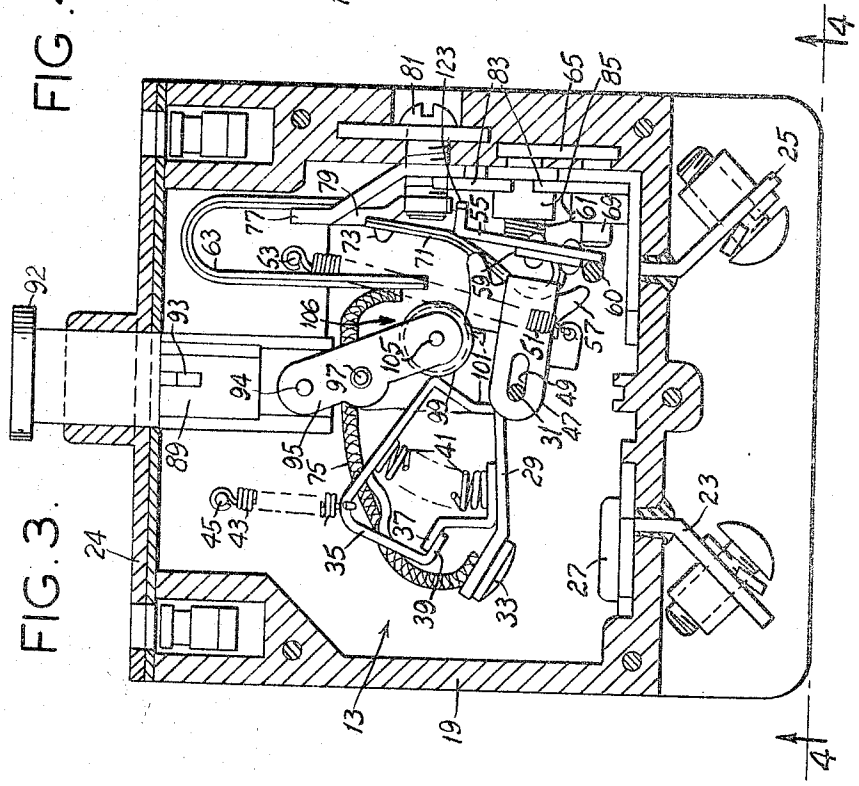


FIG. 3.

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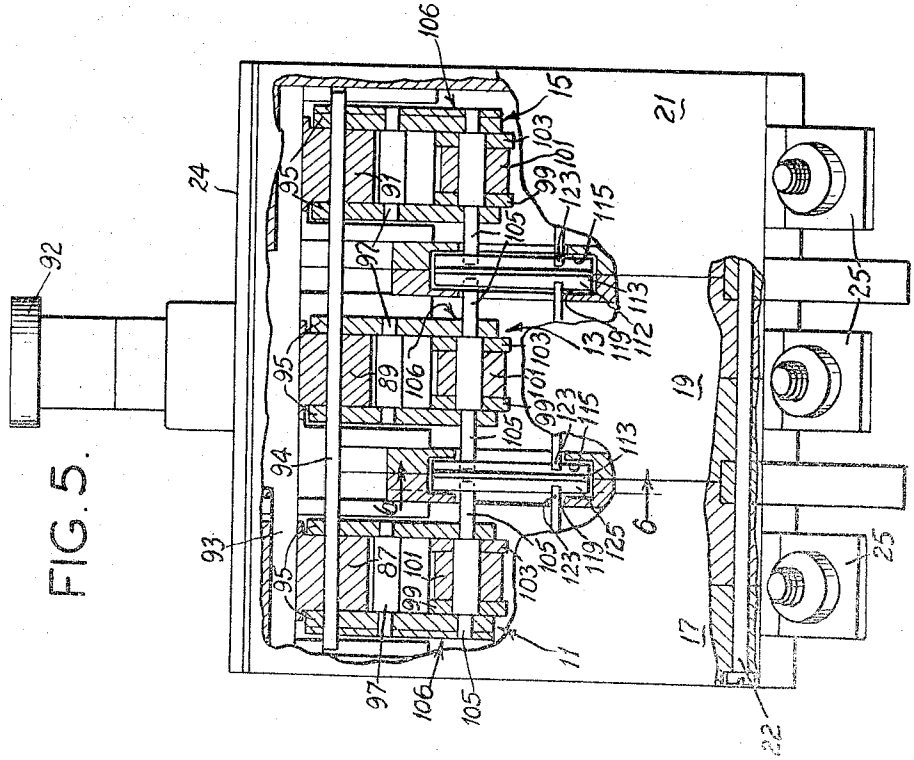


FIG. 5.

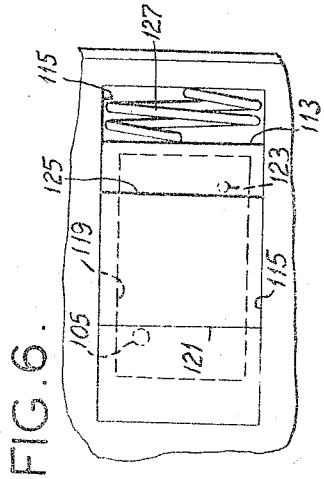


FIG. 6.

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FIG. 9.

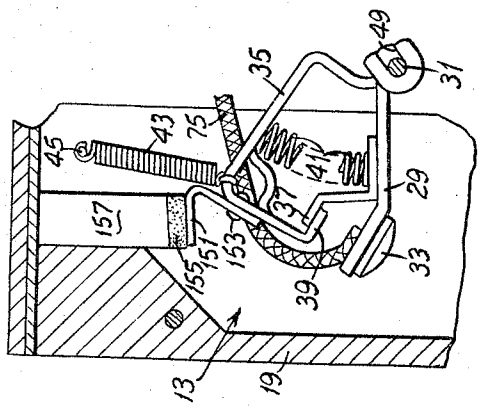


FIG. 8.

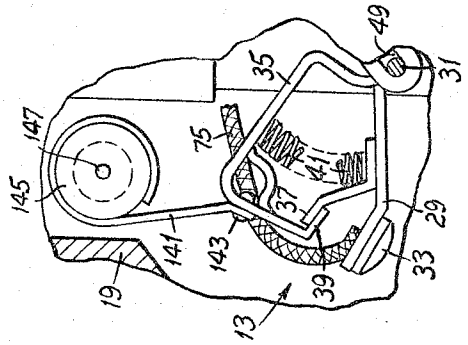
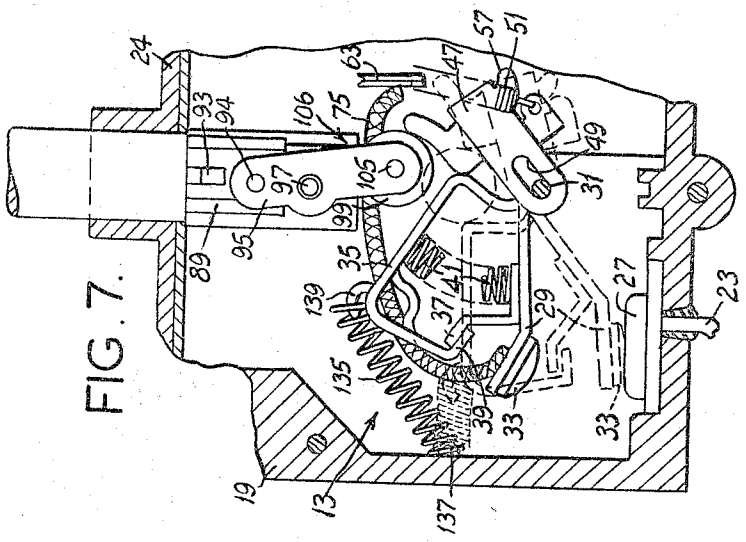


FIG. 7.



MULTIPOLE CIRCUIT BREAKER

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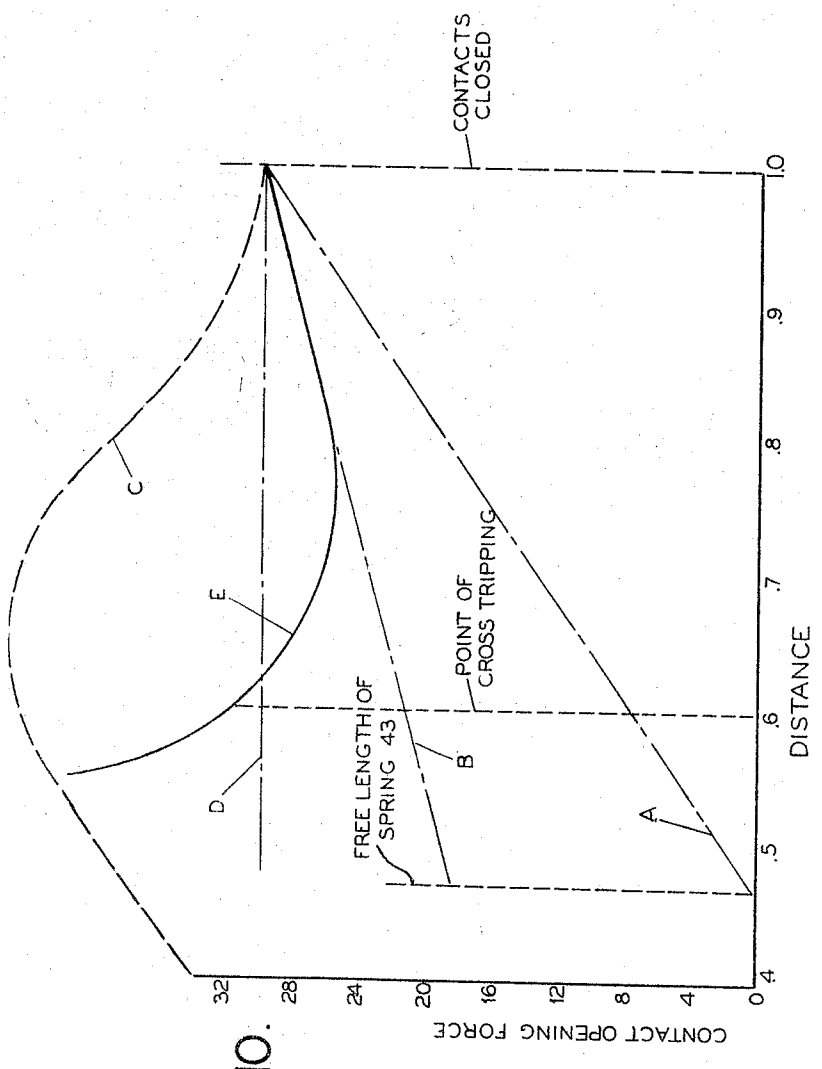


FIG. 10.

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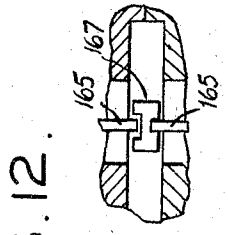


FIG. 12.

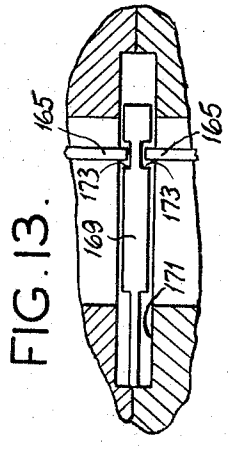


FIG. 13.

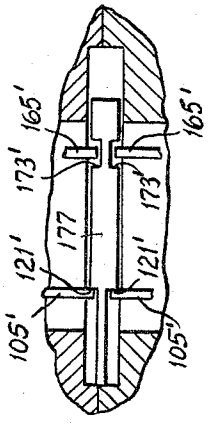


FIG. 14.

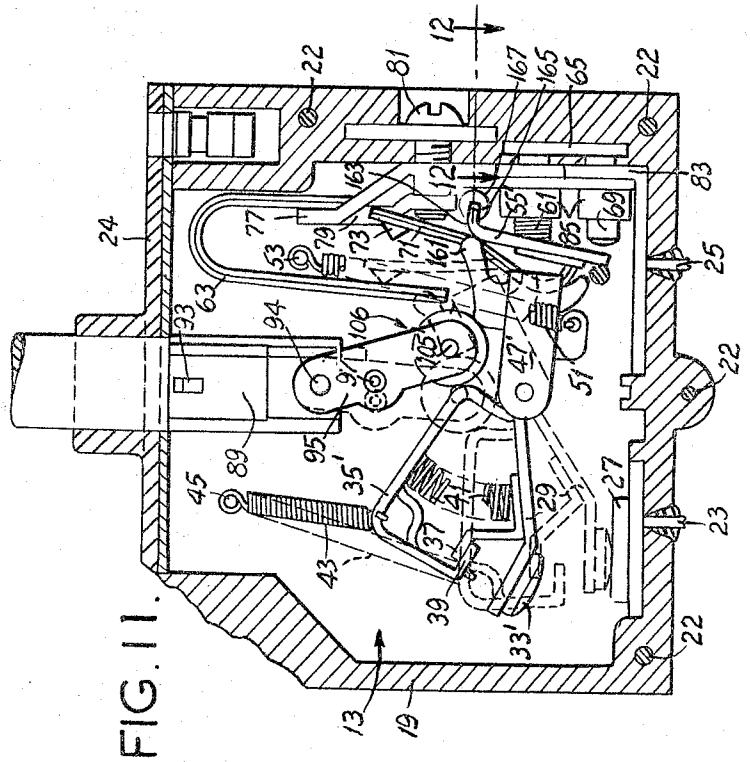


FIG. 11.

United States Patent Office 3,307,002 Patented Feb. 28, 1967

3,307,002

MULTIPOLE CIRCUIT BREAKER

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Filed Feb. 4, 1965, Ser. No. 430,423
16 Claims. (Cl. 200—116)

This invention relates to circuit breakers and more particularly to multipole circuit breakers which are responsive to an overload current passing through any one of the poles to open all of the circuits.

In the development of multipole circuit breakers, particularly those employing trip-free mechanisms such as that shown in U.S. Letters Patent 2,613,296 issued on October 7, 1952, to M. B. Wood, there has been a continuing problem in achieving complete independence in the sensitivities of the different mechanisms, that is, the current passing through one of the poles should not affect the trip point of the others. Complete independence is a highly desirable characteristic, particularly for circuit breakers used in polyphase A.C. circuits aboard aircraft. A related problem is that of insuring that all poles will open under so-called "hot-reclose" conditions in which an attempt is made to reset the circuit breaker while one or more of the poles is in a trip condition. It is highly desirable to render it impossible for any of the poles to be reset when one of them is in trip condition or, stated conversely, no fewer than all of the poles should ever be reset.

Among the several objects of the invention may be noted the provision of a multipole circuit breaker which is responsive to an overload current passing through any one of the poles to open all of the circuits; the provision of such a circuit breaker in which the trip threshold for each pole is independent of the current level passing through any other pole; the provision of such a circuit breaker in which no fewer than all of the poles can be reset; the provision of such a circuit breaker which is extremely reliable; the provision of such a circuit breaker which operates quickly; and the provision of such a circuit breaker which is of relatively simple and inexpensive construction. Other objects and features will be in part apparent and in part pointed out hereinafter.

In one aspect a circuit breaker according to the present invention involves a plurality of trip-free circuit breaking mechanisms which are arranged side by side and are resettable by means of a common manually operable member. Each of the mechanisms includes a fixed contact and a movable contact member having a movable contact adapted for engagement with the fixed contact. The contact member is movable between a first position in which the contacts are separated and a second position in which the fixed and movable contacts are in conductive engagement. A biasing means normally urges the movable contact member towards the first position. Each mechanism also includes a displaceable reaction force bearing member, a latch for restraining movement of the reaction member, and current responsive means for releasing the latch. A driving or wedging member is provided which is adapted to be driven against the reaction member for moving the contact member to its second position when the latch is not released.

When one of the mechanisms is tripped by a current overload, the other mechanisms are tripped substantially simultaneously by coupling means, operative between each pair of adjacent mechanisms and responsive to movement of either of the contact members thereof upon tripping of the respective mechanism, which transmits the movement of the driving member of the tripped mechanism to the latch of any untripped adjacent mechanism. In order to provide a sufficient force for tripping adjacent

mechanisms upon hot reclose conditions, the biasing means for each mechanism has a rate characteristic providing a contact opening force at the point of cross tripping which is greater than 18/30 of the force exerted when the contacts are closed.

The invention accordingly comprises the construction hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings in which several of various possible embodiments of the invention are illustrated,

FIG. 1 is a side view of a three pole circuit breaker in which three single pole circuit breaking mechanisms are arranged side by side, parts being broken away to show the components of the middle mechanism, the components being in a normal contact open configuration;

FIG. 2 is a similar view with the parts in contact closed position;

FIG. 3 is a similar view with the parts in trip-free position;

FIG. 4 is a view substantially on the line 4—4 of FIG. 3, the casing being partially broken away to show a slide for coupling one mechanism to another;

FIG. 5 is a view substantially on the line 5—5 of FIG. 1, the casing being broken away at different levels to show various components of the individual breaker mechanisms;

FIG. 6 is a section on the line 6—6 of FIG. 5;

FIG. 7 is a side view similar to FIG. 1 showing a modification employing a toggle lever spring arrangement;

FIG. 8 is a similar view showing another modification which employs a tape-like linear spring;

FIG. 9 is a similar view showing another modification employing magentic biasing;

FIG. 10 is a graph illustrating the rate characteristics of the different biasing means employed in the various modifications of FIGS. 1–9;

FIG. 11 is a side view with parts broken away of an embodiment in which the latches of adjacent mechanisms are coupled together with a lost motion connection;

FIG. 12 is a section substantially on the line 12—12 of FIG. 11;

FIG. 13 is a view essentially similar to FIG. 12 showing a modification; and

FIG. 14 shows a further modification.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to the drawings, the multipole circuit breaker illustrated in FIGS. 1–6 is made up of three complete single pole circuit breaking mechanisms **11**, **13** and **15**, each of which is assembled in a respective casing **17**, **19** and **21**. These casings are molded of a suitable insulating plastic material with appropriate recesses and the like for retaining the parts of the mechanism described hereinafter. Casings **17**, **19** and **21** are assembled in a side-by-side relationship with cross pins **22**. A common face plate **24** covers all three casings. In FIGS. 1–3 the casings and the nearest mechanism **11** are broken away so that the components of the middle mechanism **13** are visible. The construction of this middle unit is explained in the following description of the arrangement of the individual mechanisms, the other two mechanisms being essentially similar.

Extending through the bottom of each casing, as viewed in FIGS. 1–3, are two terminals **23** and **25**. Each terminal **23** is connected to a fixed contact **27** within the respective casing. An arm **29**, which is pivotally mounted on a pin **31** fixed within the respective casing, carries a movable contact **33** for movement from a first position in which the contacts **33** and **27** are separated to a second position in which they are in conductive engagement. A suitable arc chute (not shown) can be incorporated if de-

sired. Also pivotally mounted on pin 31 is a cam member 35. By means of facing lip portions 37 and 39 on contact arm 29 and cam member 35 respectively, a lost motion connection for rotation is established between these elements. This lost motion connection is biased by a coiled compression spring 41, cam member 35 and contact arm 29 being urged away from each other.

A coiled tension spring 43 has one end fixed relative to the respective casing by attachment to a pin 45. The other end of spring 43 is attached to the cam member 35 and urges the rotating assembly, which includes the movable contact 33, to the first position in which the movable contact is separated from fixed contact 27. It should be noted that a plurality of springs 43 may be used in each mechanism and that such a multiple spring construction may be useful in obtaining various spring rate characteristics for the purposes described hereinafter.

A displaceable reaction force bearing member 47 constitutes a third element which is pivotally mounted relative to the casing on pin 31. Bearing member 47 is mounted on pin 31 by means of a slotted aperture 49 so as to provide room for lost motion. Reaction member 47 is normally urged in a counterclockwise direction, as viewed in FIGS. 1–3, by a tension spring 51 whose fixed end is mounted relative to the casing on a pin 53. Rotation of reaction member 47 in the clockwise direction is selectively limited by a latch member 55, reaction member 47 including a projection 57 for engagement with an abutment 59 on latch member 55. Latch member 55 is pivotally mounted on a pin 60 and is normally urged into engagement with reaction member 47 by a compression spring 61.

In the embodiment illustrated, there are provided two separate current responsive means for releasing the latch, a U-shaped bimetal element 63 and a generally U-shaped electromagnet structure 65. The electromagnetic structure 65 includes a pair of poles 67 and 69 which project into a magnetically coupled relationship with latch member 55. Pole 67 serves also as a guide for spring 61. Latch member 55 includes an arm portion 71 which is constructed of a bimetal laminate to provide ambient temperature compensation. The arm includes a projection 73 adapted to be engaged by bimetal element 63. Bimetal element 63 is constructed so that, when it is heated, its free end moves to the right into engagement with the projection 73 on arm 71, thereby rotating the latch member 55 in a clockwise direction and releasing reaction member 47. If the ambient temperature is high the projection 73 is moved away from bimetal element 63 by bimetal arm 71 so that the net heating which must be applied to element 63 to trip the mechanism remains substantially constant.

Bimetal element 63 and magnet 65 are connected for energization in a circuit joining the movable contact 33 to the terminal 25 as follows: movable contact 33 is connected to the free end of bimetal element 63 by a flexible braid lead 75 which does not restrict the movement of either element. The fixed end of bimetal element 63 is welded to an electrically conductive mount 77. The mount includes an arm 79 into which is threaded a screw 81. The head of the screw rotates freely within a recess in the casing. By means of this screw the nominal position of bimetal element 63 can be adjusted for calibration of the trip threshold in conventional manner. Mount 77 is in turn welded to a bus bar 83. Bus bar 83 is a metal stamping of convoluted form which, as viewed in FIGS. 1–3, passes under pole 67 and over pole 69 so that the magnetic fields created in these poles by a current passing through the bus bar will aid each other in attracting latch member 55. Bus bar 83 is insulated from the poles 67 and 69 by plastic collars 85. The bus bar 83 is welded at its lower end to the terminal 25.

Each of the mechanisms 11, 13 and 15 includes a respective operating plunger 87, 89 and 91 which is, as viewed in FIGS. 1–3, slidingly mounted in the respective

casing for movement on a vertical axis passing through pin 31. The plunger 89 for the middle one of the three circuit breaker mechanisms extends through the cover plate 24 and terminates in a push button 92 for the manual operation of the breaker. The plungers 87 and 91 for the outer mechanisms are coupled to the center plunger 89 by a cross bar 93 (FIG. 5). Each plunger 87, 89 and 91 has pivotally attached thereto, by means of a pin 94, a pair of swinging links 95. The links 95 in each mechanism are maintained parallel to one another by a cross-brace pin 97 which is rigidly connected to each link. Between each such pair of links 95 are mounted three rollers 99, 101 and 103 on an axle pin 105. The middle roller 101 in each mechanism is of smaller diameter than the outside rollers 99 and 103 which are of equal diameter. The rollers and the links in each mechanism constitute a driving or wedging member 106 adapted to be driven against reaction member 47 and between it and the respective cam member.

The operation of each of the mechanisms 11, 13 and 15 is essentially as follows, the center mechanism 13 visible in FIGS. 1–3 again being taken as an example. In FIG. 1 the parts are shown in their normal open positions, the button 92 being retracted and the movable contact 33 being pulled to its first position away from the fixed contact 27 by spring 43. To close the contacts the push button 92 is depressed so that the rollers 99 and 103 engage the surface of cam member 35 while the middle or smaller roller 99 engages the reaction force bearing member 47. Assuming that the bimetal element 63 is cool, the clockwise movement of the reaction member 47 is limited by the engagement of projection 57 against the abutment 59 of the latch member 55. Thus, the continued downward movement of operating plunger 89 will cause the rollers 99, 101 and 103 to wedge between reaction member 47 and cam member 35 thereby rotating the cam member, with its associated movable contact 33, in a counterclockwise direction against the tension of spring 43. It should at this point be noted that the force exerted by spring 43 is transmitted through driving member 106 to reaction member 47 and the reaction member applies this force to the latching surface between projection 57 and abutment 59. The total force applied to the latching engagement is a parameter affecting the force required to release the latch and hence it also affects the sensitivity or trip threshold of the mechanism. Accordingly, the force exerted by springs 43 at the contacts' closed position is not arbitrarily variable but is, in large extent, dictated by the overall design of the breaker and particularly of the current responsive components which initiate the tripping operation.

When movable contact 33 initially engages fixed contact 27, the cam member 35 can continue to move by compressing spring 41 until the parts reach the positions shown in FIG. 2. It should be noted that the configuration shown in FIG. 2 is stable because the cam member 35 and reaction member 47 are so shaped that they cooperate in retaining the rollers, there being no net upward force applied through links 95 to plunger 89. With the parts so positioned a current can be passed through the breaker mechanism from terminal 23 to terminal 25.

If a current somewhat greater than a preselected value is passed through one of the mechanisms, the respective bimetal element 63 will gradually heat and, due to the bimetal construction, its free end will gradually move to the right coming into engagement with projection 73 on arm 71. The latch member 55 will thus be rotated clockwise around to the pin 60 thereby releasing the reaction member 47. Latch 55 can also be tripped to release reaction member 47 by the application of a current which is so much greater than the preselected ultimate trip threshold that the electromagnet 65 is sufficiently energized to attract latch member 55. This feature provides a very rapid release in case of suddenly

applied currents which greatly exceed the ultimate trip threshold.

Upon the release of the latch member **55**, spring **43** will cause the cam member **35**, the rollers **99**, **101** and **103**, and the reaction member **47** to rotate, substantially as a unit, in a clockwise direction around pivot pin **31**. After the first bit of rotation has taken up the lost motion permitted by lips **37** and **39**, contact arm **29** will be picked up by cam member **35** so that the movable contact **33** is moved out of engagement with the fixed contact **27**. It should be noted that the separation of the contacts is initiated by the impact of lip **39** coming into engagement with lip **37** so that a very rapid contact opening is provided.

If the push button **92** is held down, the elements rotating about pin **31** continue substantially to the positions shown in FIG. 3. This is the trip-free position in which the contacts are open even though the button is depressed. It may be seen that the rollers **99**, **101** and **103** are somewhat withdrawn from their position between cam member **35** and reaction member **47** since their path of movement is restrained by the limited length of the links **95**.

It should be noted that, when the parts are in the position shown in FIG. 3, there is an upward force applied to plunger **89**, through the rollers and links **95**, by spring **51**. Accordingly, if push button **92** is not restrained, the elements rearrange themselves into the positions shown in FIG. 1 so that the protruding button gives a visual indication that the breaker has been tripped and so that the breaker is ready to be reset. In returning to the position shown in FIG. 1, the reaction member **47** does not have to displace latch member **55** or compress spring **61** in order for the projection **57** to clear latch abutment **59**. Rather, the clearance is provided by taking up the lost motion permitted by slotted aperture **49**.

As discussed previously, it is an object of the present invention to open all of the circuits if any one of them is overloaded and yet allow each of the mechanisms to operate independently in the manner just described so that the trip threshold for each circuit is independent of the magnitude of current flowing through any of the other circuits. The latch member **55** of each of the mechanisms normally operates at relatively low force levels. Thus loading of these elements before tripping should therefore be avoided since it would cause a shift in the trip threshold. In the embodiment of the invention illustrated in FIGS. 1–6, energy for tripping the untripped circuits is obtained from the driving or wedging member **106** of the tripped pole. The driving member operates at relatively high force levels. Upon tripping, it is moved to the right (clockwise around pin **31**) under the influence of the spring **43** which opens the contacts.

The energy for cross tripping is transmitted between adjacent mechanisms by slides **113** which are supported for transverse movement in channels **115** formed into the abutting side walls of adjacent casings. The slides are best seen in FIGS. 4, 5 and 6, although they can also be seen in back of the mechanism components in FIGS. 1–3 through a window **119** which opens from each of the channels **115** into the main chamber of each of the adjacent casings and through which access may be had from each mechanism to the slide. It may be noted that FIG. 6 shows the slide from the same side as FIG. 1 but with the breaker mechanism components removed from view. For transmitting lateral movement of the driving or wedging members **106** to each adjacent slide **113**, the respective axle pin **105** extends through the respective window **119** so as to be engageable with a shoulder **121** on the slide **113**. It should be noted that the shoulders **121** extend vertically for the entire height of the slide so that the vertical excursions of the wedging member can be accommodated. For receiving the cross tripping movement, each of the latch members **55** includes a projection **123** extending laterally through each adjacent window **119** so as to be engageable by a shoulder **125** on slide **113**. The slides **113** are normally biased to the left, that is away from engagement with the latch projection **123**, by springs **127**. This bias tends to prevent tripping of the breakers by vibration acting on the slides.

When one of the mechanisms is tripped, its wedging member **106** moves to the right as explained previously. The respective axle pin **105** will drive the slide **113** to the right and, if the adjacent mechanism is not already tripped, the slide will release the untripped latch. Since either of the adjacent mechanisms can drive one of the slides **113** by means of the respective axle pin **105** and since the slide can engage and release the latch **55** of either of the adjacent mechanisms, it can be seen that the tripping of any one of the mechanisms will trip any previously untripped adjacent mechanism. It can also be seen that, since either latch extension **123** can freely move away from the respective slide shoulder **125**, the latches **55** are not loaded in any way by the slides **113**. Thus each of the mechanisms **11**, **13** and **15** will truly operate independently of the others and the trip threshold for each will not be influenced by the level of current passing through any of the other circuits.

In achieving proper operation upon current overload conditions, it is necessary that the springs **43** exert a force which is sufficient not only to open the contacts of the respective breaker but also to trip any previously untripped adjacent mechanisms. In particular, the center mechanism **13** of the three must develop sufficient force to trip both of the side mechanisms **11** and **15**. This requirement is not particularly severe under overload conditions when the breaker mechanisms trip from a closed circuit position since, in that case, the components of the tripped mechanism are in rapid movement when the point of cross tripping of adjacent mechanisms is reached. The latches of the adjacent mechanisms are thus displaced with an impact and not merely under the influence of the contact opening springs **43** of the tripped mechanism. However, it has been found that this requirement is significantly more severe under so-called hot-reclose conditions, that is, when an attempt is made to reset the circuit breaker while one of the mechanisms is still in a tripped condition. In this situation, the reaction member **47** of the tripped mechanism is not restrained by its respective latch **55**. Therefore when button **92** is depressed, the elements of the tripped mechanism proceed directly from the configuration shown in FIG. 1 to the positions shown in FIG. 3, without the respective contacts ever being closed. In other words, as the wedging member **106** is driven between cam member **35** and reaction member **47**, it is the reaction member rather than the cam member which is primarily displaced.

As the wedging rollers move down the surface of cam member **35**, they and their axle pin **105** will move to the right, as seen in FIGS. 1–3, thereby displacing the adjacent slides **113**. When the point of cross tripping for adjacent mechanisms is reached, it is essential that it be the reaction member rather than the cam member **35** which is displaced by the continued downward movement of the wedging member. Otherwise the adjacent breakers will not be tripped and their contacts will be closed even though the contacts of the one breaker are not closed. In order for cam member **35** to resist movement under these conditions, it is necessary that the springs **43** exert a force which is sufficient, when transmitted through wedging member **106**, to displace the slides **113** and to trip all previously untripped adjacent mechanism. In the popular form of trip-free mechanism illustrated, it has been found that, to insure satisfactory operation under hot-reclose conditions, the force exerted by springs **43** at the point of cross tripping of adjacent mechanisms should be greater than $18/30$ of the force exerted when the contacts are closed.

One way of obtaining such a rate characteristic using a linear coil spring would be to use a relatively long spring so that the ratio of the spring extensions in the two significant positions is substantially equal to the desired force ratio. However, as a practical matter, such an approach cannot be used if the casings are to be kept within conventional established dimensions.

In the embodiment illustrated in FIGS. 1–6, the springs 43 have been given the desired rate characteristics by winding the coils under torsion so that the spring exhibits a substantial force preload which must be overcome before any extension at all is obtained. The rate characteristic of this preloaded spring is shown in the graph of FIG. 10 as line B. The length of the spring when fully extended, that is in contacts closed position, is taken as unity on the horizontal scale while the free or unextended length of the spring is approximately 0.47. The ratio of these lengths is of course in large extent determined by the space available within the pre-established dimensions of the casing. The point of cross tripping of adjacent mechanisms occurs when springs 43 are extended only slightly so that their length is 0.6 of the length of the fully extended spring. It will be noted that the force exerted by this spring at the point of cross tripping is slightly greater than $^{18}/_{30}$ of the force exerted when the contacts are closed. This rate characteristic may be compared with that of a conventional coil spring having no preload as illustrated in FIG. 10 by the line A in which the force applied rises linearly from zero starting at the free length of the spring.

The desired rate characteristic for the contact opening force can also be provided by employing the modified construction illustrated in FIG. 7. In this arrangement, the contact carrying cam member 35 is urged in a clockwise direction around pin 31 by a compression spring 135 rather than a tension spring as illustrated in the previous example. The spring 135 extends from a locating boss 137 on a side wall of the casing to a projection 139 on arm 35. The attachments at each end of spring 135 are arranged, in cooperation with the natural flexibility of the spring, so that a substantially pivotal connection is established. It can thus be seen that spring 135 and cam member 35 essentially constitute a toggle linkage. With such an arrangement, spring 135 operates on a varying moment arm to rotate cam member 35 around pin 31. Accordingly a highly nonlinear force characteristic is obtained which tends to offset the decreasing force available from spring 135 as it extends. The net contact opening force obtained with this arrangement is illustrated in FIG. 10 by the line C. It will be noted that this curve exhibits a peak at about 0.65 on the horizontal scale where the product of the spring force and the effective moment arm reach a maximum. The rate characteristic for this arrangement and for the following modifications have been plotted on the graph of FIG. 10 in terms of equivalent contact positions so that comparisons can be easily made.

Another modification, which is capable of providing a substantially uniform contact opening force, is shown in FIG. 8. In this embodiment the cam member 35 is urged upwardly by a tape-like spring member 141 attached thereto by a rivet 143. The tape-like spring member 141 is given a preset so that, when it is unstressed, it returns to an arcuate or coiled configuration. The upper end of spring member 141 is permitted to coil around a freely turning guide wheel 145 journaled in the casing on a pin 147. Accordingly, as the cam arm 35 is moved downwardly in closing the circuit, progressive portions of the tape-like spring member are straightened. The force necessary to so straighten progressive portions of the tape-like spring member is only that necessary to overcome the preset of the naturally arcuate spring at the point where it leaves guide wheel 145. Since this force is substantially constant in a tape-like spring member of uniform width and thickness, a substantially constant contact opening force is obtained. This rate characteristic is illustrated on the graph FIG. 10 by the line D.

A fourth method of obtaining adequate force at the point of cross tripping is to supplement the spring characteristics with magnetic attraction as illustrated in FIG. 9. In this embodiment, the cam arm 35 is urged upwardly by a spring 43 as in the example shown in FIG. 1. However, cam arm 35 also carries an armature piece 151 secured thereto by rivet 153. A permanent magnet 155 is mounted on a post 157 extending from the casing toward the path of the armature. As cam arm 35 passes through the point of cross tripping and approaches the fully open position, the magnetic attraction between the magnet 155 and armature 151 will increase rapidly thereby causing the net contact opening force to increase nonlinearly as illustrated by the line E in the graph of FIG. 10.

It will be noted that, in each of the examples whose contact opening force characteristics are illustrated by the lines B through E, the force available at the point of cross tripping of adjacent breakers is greater than $^{18}/_{30}$ of the force provided when the contacts are closed, the curves being referenced to unity at this point for comparison purposes. In the embodiments shown in FIGS. 7, 8 and 9, the force characteristics are such that, as illustrated by the lines C, D and E, the force at the point of cross tripping is essentially not less than the force exerted when the contacts are closed.

FIGS. 11 and 12 illustrate a modification in which the force for tripping adjacent mechanisms is obtained from the reaction force bearing member of a tripped mechanism rather than its driving or wedging member. In this embodiment the reaction force bearing member 47′ includes a projection 161 which is adapted to strike a surface 163 on latch 55′ when the mechanism is tripped. Each of the latch members 55′ includes a projection 165 extending laterally toward the adjacent mechanisms. The projections extending toward each other on a pair of adjacent breakers are coupled by a lost motion connection constituted by a collar 167 which is fixedly attached to one of the projections 165 and which loosely confines the movement of the other (FIG. 12).

Since there is lost motion in the connection between adjacent latches 55′, the current responsive elements in each of the mechanisms needs only to deflect the respective latch, the lost motion being sufficient to accommodate the motion necessary for the independent tripping of either of the adjacent mechanisms. The latch in each mechanism is thus not loaded by the latches of any of the others and the trip thresholds for each mechanism are not affected by conditions in the others. However, upon tripping of one mechanism, the projection 161 on the respective reaction member 47′ will strike the already tripped latch member 55, driving it further in the direction of tripping. This additional movement takes up the lost motion travel and causes movement to be transmitted from the tripped latch to the latch of any untripped adjacent mechanism. Accordingly these adjacent mechanisms will be tripped substantially simultaneously with the mechanism in which the original tripping current overload occurs.

In place of using a collar 167 which is attached to one of the latches 55′ the lost motion connection can also be provided by a slide similar to that used in the embodiment of FIG. 1. In the modification illustrated in FIG. 13 a slide 169 is mounted for lateral movement in a channel 171 formed in the casing walls between adjacent mechanisms. The slide includes a pair of back-to-back slots 173 for receiving the adjacent latch projections 165. The slots 173 are of such width that sufficient lost motion is provided in the connection between the projections 165 so that each latch 55′ can be operated completely independently by its respective current responsive components. Upon tripping, however, the additional displacement of the tripped latch caused by the impact of the respective reaction member will cause a tripping motion

to be transmitted through the slide to the untripped latch.

The modification illustrated in FIG. 14 represents a combination of the coupling arrangement illustrated in FIG. 13 with that employed in the embodiment of FIGS. 1–6. In FIG. 14 there is shown a slide **177** mounted for lateral movement as in the previous examples. The slide includes a pair of shoulders **121'** adapted for engagement by the driving member axles **105'** of a pair of adjacent breakers as well as slots **173'** providing a lost motion connection between adjacent latch projections **165'**. In this way the latch of an untripped mechanism, which is adjacent a mechanism being tripped, can be tripped by movement transferred from either the driving member of the tripped mechanism or by the movement of the respective reaction force bearing member as transmitted through the respective latch and the slots **173'**. This arrangement thus provides redundant means of cross tripping for increased reliability.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member including a movable contact adapted for engagement with said fixed contact, said member being movable between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, biasing means urging said contact member toward said first position, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and a driving member adapted to be driven against said reaction member thereby to move said contact member to said second position when said reaction member is restrained by said latch, the force of said biasing means being transmitted through said driving member to said latch; and

a slide operative between each pair of adjacent breaker mechanisms, each being slidable generally transversely of the direction of movement of said driving members which moves said contact members to said second positions, each said slide having first surface means engageable by and responsive to movement of either of the respective driving members upon tripping of the respective mechanism and second surface means engageable with either of the respective latches for transmitting movement from the driving member of a tripped one of said mechanisms to the latch of any untripped adjacent mechanism thereby to trip such untripped mechanism, the position of the contact member which produces tripping of adjacent mechanisms constituting a point of cross tripping for the member, said biasing means having rate characteristics providing a contact opening force at said point which is greater than $18\%_{00}$ of the force exerted when the contacts are closed whereby, if said driving members are driven against the respective bearing members while one mechanism is still in tripped condition following an overload, the spring means of said one mechanism will possess sufficient force to permit the respective driving member to trip all adjacent mechanisms substantially simultaneously thereby preventing closing of any of the mechanisms until all of them can be closed.

2. A multipole circuit breaker as set forth in claim **1** including spring means for biasing said slide against movement caused by vibration.

3. A multipole circuit breaker as set forth in claim **1** in which said biasing means includes a coiled tension spring, the coils of which are wound under torsion whereby said spring exhibits a rate characteristic having a substantial force preload which must be overcome before any extension is obtained.

4. A multipole circuit breaker as set forth in claim **1** in which said biasing means includes a tape-like spring member which, when unstressed, returns to an arcuate configuration, one end of said tape being connected to said contact member so that movement of said contact member toward said second position straightens progressive portions of said tape-like member.

5. A multipole circuit breaker as set forth in claim **1** in which said biasing means includes permanent magnet means exerting a nonlinear force tending to hold said contact member in said first position.

6. A multipole circuit breaker as set forth in claim **1** in which said contact member is movable about a pivot and said biasing means includes a compression spring one end of which is pivotally mounted at a fixed pivot and the other end of which is attached to said contact member, said spring and said contact member constituting a toggle linkage providing a nonlinear contact opening force.

7. A multipole circuit breaker as set forth in claim **1** in which said biasing means provides a contact opening force at said point of cross tripping which is not less than the force exerted when the contacts are closed.

8. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member including a movable contact adapted for engagement with said fixed contact, said member being movable between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, a tape-like spring member for urging said contact member toward said first position, said spring member being preformed to normally assume an arcuate configuration, one end of said spring member being connected to said contact member so that movement of said contact member toward said second position straightens progressive portions of said spring member, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and a driving member adapted to be driven against said reaction member thereby to move said contact member to said second position when said reaction member is restrained by said latch, the force exerted by said spring member being transmitted through said driving member to said latch; and

means, operative between each pair of adjacent breaker mechanisms and responsive to movement of either of the respective contact members thereof upon tripping of that mechanism, for transmitting movement from the driving member of that one of said mechanisms to the latch of any untripped adjacent mechanism thereby to trip each mechanism whereby, when one of said mechanisms is tripped by a current overload, all of the contacts will be opened.

9. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member in-

cluding a movable contact adapted for engagement with said fixed contact, said member being pivotally mounted for movement between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, a compression spring one end of which is pivotally mounted at a fixed pivot and the other end of which is pivotally connected to said contact member, said spring and said contact member constituting a toggle linkage which produces a nonlinear contact opening force, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and a driving member adapted to be driven against said reaction member thereby to move said contact member to said second position when said reaction member is restrained by said latch, the force of said spring being transmitted through said driving member to said latch; and

means, operative between each pair of adjacent breaker mechanisms and responsive to movement of either of the respective contact members thereof upon tripping of that mechanism, for transmitting movement from the driving member of that one of said mechanisms to the latch of any untripped adjacent mechanism thereby to trip such mechanism whereby, when one of said mechanisms is tripped by a current overload, all of the contacts will be opened.

10. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member including a movable contact adapted for engagement with said fixed contact, said member being movable between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, a spring urging said contact member toward said first position, a magnet exerting a nonlinear force tending to hold said contact member in said first position, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and a driving member adapted to be driven against said reaction member thereby to move said contact member to said second position when said reaction member is restrained by said latch, the force exerted by said spring being transmitted through said driving member to said latch; and

means, operative between each pair of adjacent breaker mechanisms and responsive to movement of either of the respective contact members thereof upon tripping of that mechanism, for transmitting movement from the driving member of that one of said mechanisms to the latch of any untripped adjacent mechanism thereby to trip such mechanism whereby, when one of said mechanisms is tripped by a current overload, all of the contacts will be opened and if said driving members are driven against the respective bearing members while one mechanism is still in tripped condition following an overload, the magnet will exert sufficient force to permit the respective driving member to trip all adjacent mechanisms thereby preventing closing of any of the mechanisms until all of them can be closed.

11. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member including a movable contact adapted for engagement with said fixed contact, said member being movable between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, biasing means urging said contact member toward said first position, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and means for moving said contact member to said second position when said reaction member is restrained by said latch, said reaction member including a portion which, upon release of said reaction member by said latch, engages and drives said latch further in the direction of release; and

means for establishing a lost-motion connection between the latches of adjacent mechanisms whereby each of said latches functions independently within the limits of the lost motion in tripping the respective mechanism but, upon tripping thereof, is driven beyond the limits of the lost motion by the respective reaction member and thereby trips the latches of any untripped adjacent mechanisms.

12. A multipole circuit breaker comprising:

a plurality of trip-free circuit breaking mechanisms arranged side by side each of which includes

a fixed contact, a movable contact member including a movable contact adapted for engagement with said fixed contact, said member being movable between a first position in which said contacts are separated and a second position in which said contacts are in conductive engagement, biasing means urging said contact member toward said first position, a displaceable reaction force bearing member, a latch for restraining movement of said reaction member, current responsive means for releasing said latch upon passage through said contacts of a current greater than a predetermined level, and a driving member adapted to be driven against said reaction member thereby to move said contact member to said second position when said reaction member is restrained by said latch, said reaction member including a portion which, upon release of said reaction member by said latch, engages and drives said latch further in the direction of release; and

means for establishing a lost-motion connection between the latches of adjacent mechanisms whereby each of said latches functions independently within the limits of the lost motion in tripping the respective mechanism but, upon tripping thereof, is driven beyond the limits of the lost motion by the respective reaction member and thereby trips the latches of any untripped adjacent mechanisms.

13. A multipole circuit breaker as set forth in claim 12 in which each of the latches includes a projecting portion extending laterally toward each adjacent mechanism and in which the connection means includes a coupler member positioned between each pair of adjacent mechanisms, said coupler member being fixed to one of the laterally opposing projecting portions and loosely confining the other of said projecting portions in the direction of release thereby to provide said lost-motion connection between the respective latches.

14. A multipole circuit breaker as set forth in claim 12 in which each of the latches includes a projecting portion extending laterally toward each adjacent mechanism and in which said mechanisms are enclosed in a housing and the connection means comprises a slide mounted in said housing between each pair of adjacent mechanisms,

said slide including recesses on opposite sides thereof for loosely engaging the laterally opposed projecting portions extending from said pair of breakers thereby to provide said lost-motion connection between the respective latches.

15. A multipole circuit breaker as set forth in claim **14** in which said slide is also adapted to be engaged by the driving member of either of said pair of mechanisms upon tripping thereof thereby to release the latch of the other of said pair of mechanisms.

16. A multipole circuit breaker as set forth in claim **12** further comprising means, operative between each pair of adjacent mechanisms and responsive to tripping of that mechanism, for transmitting movement from the driving member of that one of said mechanisms upon tripping to the latch of any untripped adjacent mechanism thereby to trip such mechanism.

References Cited by the Examiner

UNITED STATES PATENTS

2,503,409	4/1950	Platz et al.	200—116
2,613,296	10/1952	Wood	200—116
2,686,241	8/1954	Straub et al.	200—116
2,813,169	11/1957	Mascioli et al.	200—116 X
2,958,749	11/1960	Brackett	200—116
2,960,587	11/1960	Wood	200—116
3,142,737	7/1964	Brackett	200—116
3,171,931	3/1965	Powell	200—116
3,171,932	3/1965	Beaudoin	200—166

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