Feb. 8, 1955 D. F. WELCH ET AL 2,701,831

ELECTRIC CIRCUIT BREAKER

Filed July 12, 1951

4 Sheets-Sheet 1

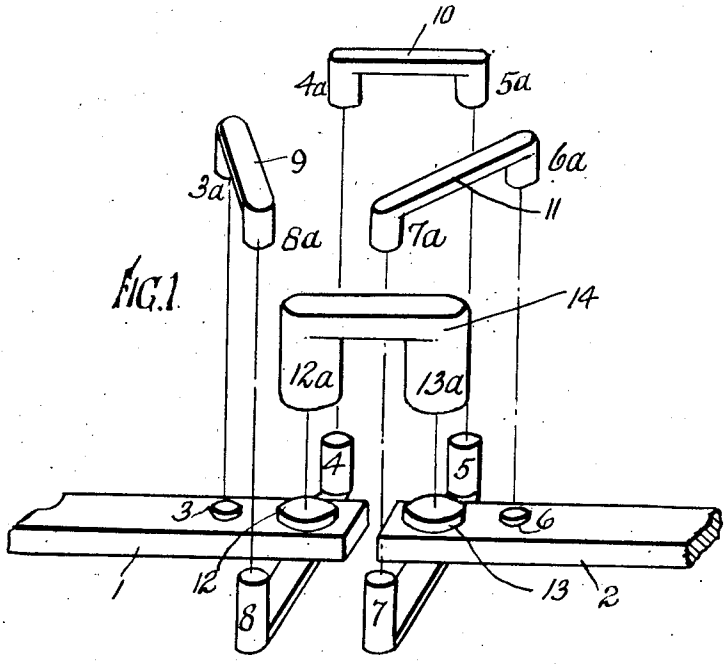


FIG. 1

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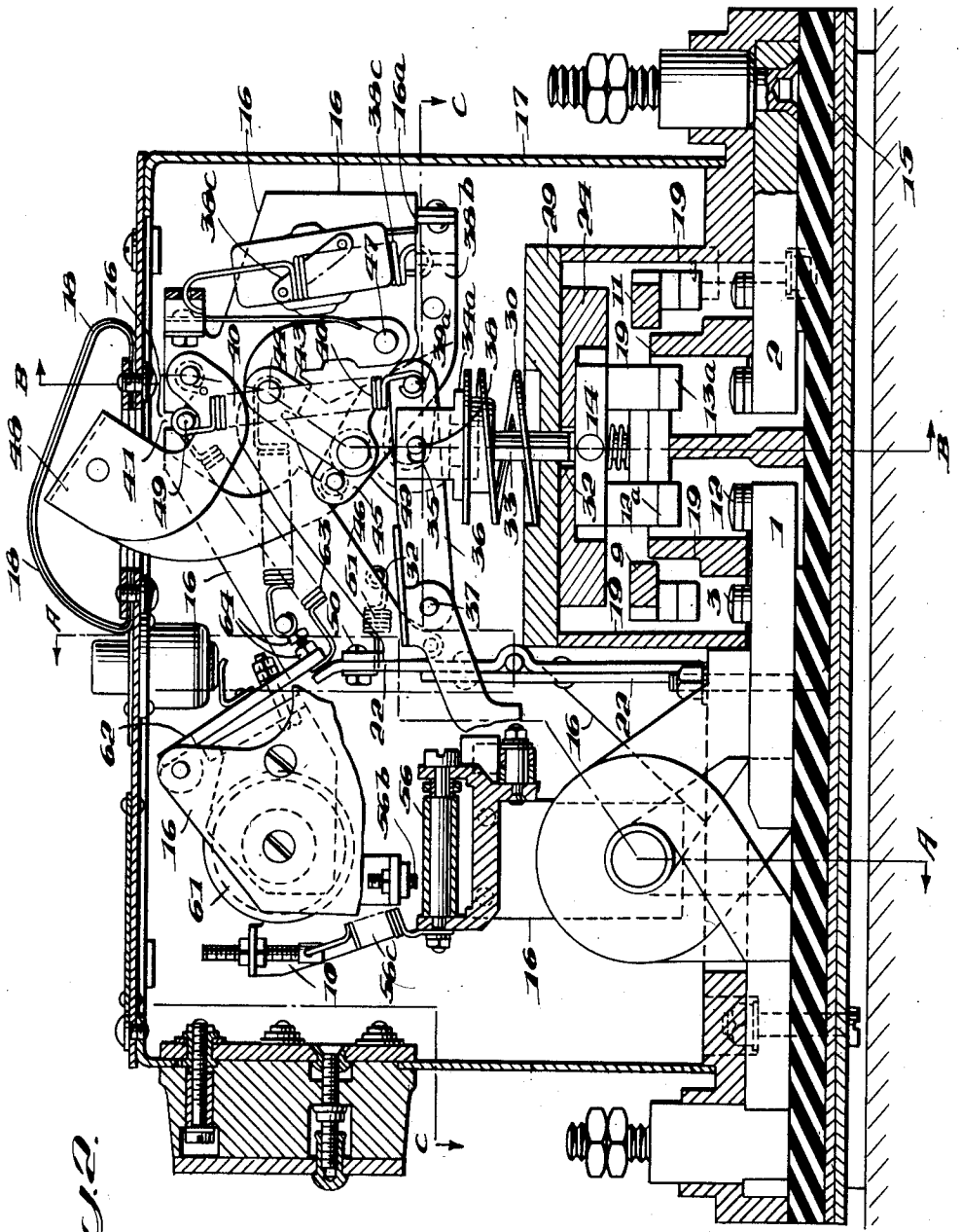


Fig. 2.

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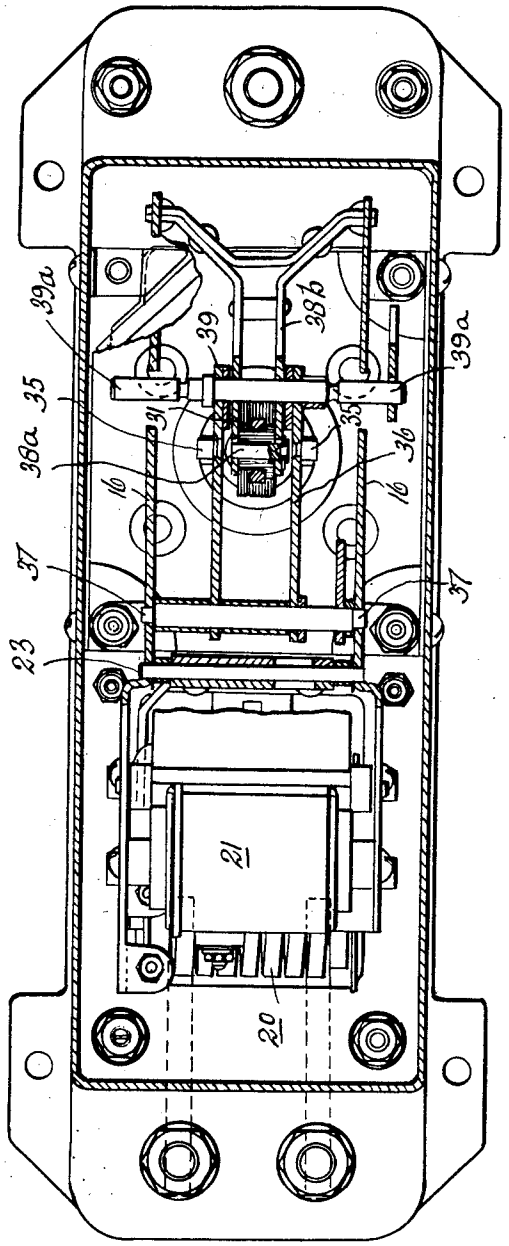
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ELECTRIC CIRCUIT BREAKER

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4 Sheets-Sheet 3

FIG. 3.



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ELECTRIC CIRCUIT BREAKER

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Fig. 4.

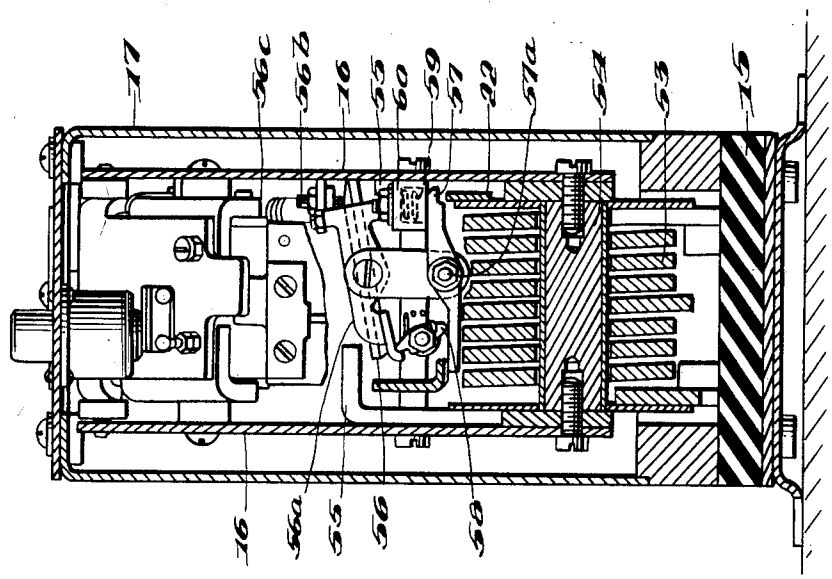
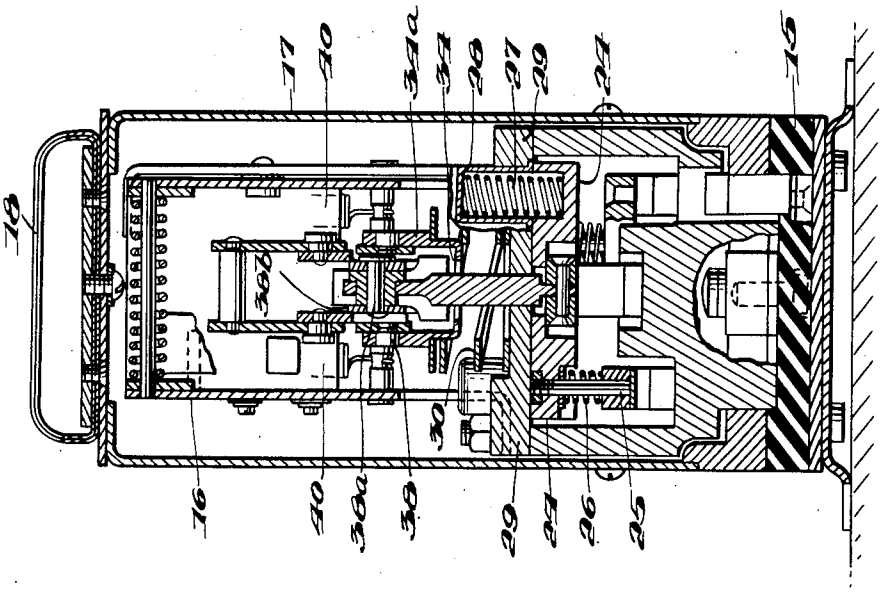


Fig. 5.



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2,701,831

ELECTRIC CIRCUIT BREAKER

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Application July 12, 1951, Serial No. 236,308

13 Claims. (Cl. 200—145)

This invention relates to circuit breakers for interrupting relatively heavy currents at voltages not exceeding 500 volts in which contact separation takes place in air and the conditions in which the circuit breaker operates are such as to render the provision of arc extinguishing devices inadvisable on account of space, or other considerations. The invention is particularly, although not exclusively, applicable to circuit breakers intended for operation on aircraft where generators supplying considerable amounts of power are designed to operate at voltages which are customarily of the order of 100 and direct current is the usual form in which such power is utilized.

In such conditions, the duty of extinguishing arcs between the contacts when the breakers operate on heavy fault currents becomes somewhat eroneous, since there is no current zero at which the switching arc is normally extinguished and control over the arcing space and deionisation of the arcing space becomes possible, and a new approach to the problem of circuit breaking is thus essential.

It is known that the current that can be ruptured by a pair of contacts is mainly a function of the supply voltage and if the voltage is below the ionisation potential of the gas or vapour between the separation contacts, the current that may be broken approaches infinity. In practice the rate of separation and the distance between the contacts at the moment when any inductive energy of the system has been dissipated influence the maximum supply voltage across the contacts for large but finite currents. The supply voltage across any pair of contacts during separation should not greatly exceed the ionisation potential of the medium between the contacts, the actual amount by which the supply voltage may exceed the ionisation potential being governed by the magnitude of the current to be broken such that the higher the current the lower the supply voltage per contact pair.

This known condition is utilised in a circuit breaker according to the invention, by employing a plurality of three or more breaks in series, operating substantially simultaneously the number of breaks being so chosen having regard to the supply voltage that the voltage appearing across each break does not exceed 40, the exact voltage being determined by the current ruptured, the speed and separation of the contacts comprising the break.

Since for any given maximum distance of contact separation and speed of movement of the contacts, the number of contact pairs is dependent on the maximum current to be interrupted and the system voltage, it has been found that for a supply voltage to be interrupted of 120 volts D. C. and a contact separation of 3 mm., a minimum of six breaks in series are necessary for interrupting a current of up to 25,000 amps. However, the introduction of a large number of contacts into the circuit may produce a total contact resistance which is greater than it is advisable to permit.

It is a feature of the invention that in a circuit breaker as above noted the supply voltage exceeds the ionising potential of the medium by an amount governed by the magnitude of the current broken per contact pair, the voltage being in inverse relation to the current ruptured.

It is a further feature of the invention that the interrupting path consisting of the plurality of breaks in series may be bridged by one or more extraneous bridging contact pairs, the number of which is determined

by the voltage that occurs across the interrupting breaks as a result of circuit current and contact resistance. The voltage per break of the extraneous bridging contacts should not exceed the value of 40 volts above-mentioned or that value below 40 volts determined by the current to be broken, so that the number of extraneous bridging contact pairs may itself become excessive if the supply voltage to be interrupted is towards the upper limit, viz., 500 volts, to which the invention is restricted. Thus, the extraneous bridging contacts themselves may be bridged by at least one additional extraneous bridging contact pair.

In operating such a circuit breaker it is essential for the plurality of circuit breaking series breaks to be closed first and opened last to ensure that the circuit is both made and broken at the series breaks. The arrangement will, therefore, be such that the further extraneous bridging contact breaks will close after, and open before, the plurality of series breaks; and if the further extraneous bridging contacts are themselves bridged by additional extraneous bridging contacts, these latter contacts will close last and open first.

It is yet a further feature of the invention that the plurality of breaks in series is achieved by compounding units each comprising two contact pairs, the said pairs comprising butt contacts, one of which is fixed and the other adapted to move axially into and out of engagement with its complementary fixed contact, the contact surfaces being normal to the said axial movement, further the fixed contacts of the contact pairs may be geometrically arranged to lie in substantially one plane and preferably but not necessarily at the corners of a polygonal configuration, adjacent pairs of contacts being insulated one from the other yet so connected electrically to other fixed contacts as to form a plurality of breaks in series between supply conductors. The said supply conductors may be adapted to cross the polygonal configuration of fixed contacts and lie substantially in the plane thereof, the conductors being electrically separated at their inner ends within the polygonal configuration near its centre and adapted to carry a contact on each of the inner ends capable of being bridged by an extraneous bridging contact pair, the conductors being electrically connected to certain of the fixed contacts such that the interrupting path is between the plurality of breaks in series.

It is yet a further feature of the invention that the cross-bars may be all secured to an insulating member in the form of an insulating plate located in a plane parallel to the plane of the fixed contact pairs and mounted for movement about an axis perpendicular to the said plane of the fixed contact pairs, the cross-bars being adapted to form a polygonal configuration, so that the contacts secured at each end of the cross-bars are aligned with the individual contacts of the fixed contact polygonal configuration. The insulating plate may be spring-loaded in a direction tending to urge it toward the plane of the fixed contacts and arrested from so doing by abutment with the extraneous bridging contact pair which is spring-urged away from the plane of the fixed contacts by a main spring means possessing a total force in excess of the force which tends to move the said insulating plate toward the plane of the fixed contacts.

The extraneous bridging contact pair spring-urged away from the plane of the fixed contacts may be actuated from a linkage mechanism which permits the said extraneous bridging contact pair to be moved toward the plane of the fixed contacts against the spring force of the main spring means and make contact with the said conductors; incident upon the movement of the extraneous bridging contact pair is the movement, toward the plane of the fixed contacts, of the spring-loaded insulating plate carrying its cross bars and contacts to make contact with the said fixed contacts. The actual making of contact between these said contacts being adapted to take place in time, earlier than that of the extraneous bridging contact pair with the supply conductors, so that the circuit is made first through the fixed contacts and the contact pairs of the cross-bars constituting the breaks in series and finally through the extraneous bridging contact pair and the supply conductors.

The linkage mechanism may comprise a second-order lever arm fulcrumed at one end upon a support plate and freely connected intermediate its ends by trunnions to a forked spring plate which is adapted to bear upon the main spring means. A plunger is provided which mechanically links the said extraneous bridging contact pair to the end of a spring-loaded dual fulcrum lever pivoted intermediate its ends to the end of the said second-order lever arm (remote from the end which is fulcrumed on the support plate) and adapted, under certain conditions, to fulcrum about its end remote from the second-order lever arm sometime in abutment with the frame, while under other conditions to fulcrum about its other end fixed to the plunger. The said spring-loaded dual fulcrum lever is adapted to apply pressure on the abutting faces of the contacts of the extraneous bridging contact pair and to compensate for contact wear. The point intermediate the dual fulcrum lever which is pivoted to one end of the second-order lever is also connected to one end of a toggle mechanism and powerful extension spring means, anchored to the frame. The other end of the said toggle is pivotally secured to a latch lever pivoted per se on the frame. Depression of a handle mechanism, pivoted about the frame, is adapted to act upon a roller at the centre of the toggle, causing the toggle to increase its effective length about its fixed end on the latch lever and extend the said extension spring means also causing the said second-order lever arm to be depressed against the action of the main spring. The extremity of the second-order lever arm remote from its fulcrum moves downward carrying with it the pivot of the dual fulcrumed lever, now adapted to fulcrum about its end remote from the second-order lever arm in abutment with the frame. This general movement permits movement, toward the plane of the fixed contacts, of the insulating plate carrying its cross-bars and contacts which are adapted to make contact with the said fixed contacts. Consequently, the extraneous bridging contact pair is brought against its contacts on the supply conductors which arrests further movement of the plunger, and any further movement of the second-order lever causes the dual fulcrum lever to fulcrum about the plunger and apply contact pressure. The reaction to these movements causes the latch lever to abut with a pivoted latch plate. Tripping action of the said latch plate is adapted to remove the said reaction force and permit the extraneous bridging contact pair and the said insulating plate to move away from the plane of the fixed contacts at high speed under the said main spring means and the powerful extension springs.

The invention will be more readily appreciated from the following description, reference being had to the several figures of the accompanying drawings, wherein Fig. 1 is a schematic arrangement of the contact assembly of the circuit breaker; Fig. 2 is a sectional side elevation of a typical circuit breaker; Fig. 3 is a sectional plan in first angle orthographic projection on the section stations C—C; and Figs. 4 and 5 are sectional end elevations in first angle orthographic projection taken, respectively, on the section stations A—A and B—B.

Referring now specifically to Fig. 1, there are shown two supply conductors **1** and **2** lying substantially in the plane of fixed contacts **3**, **4**, **5**, **6**, **7** and **8** arranged geometrically at the corners of a polygonal configuration, adjacent pairs of contacts being insulated one from the other, yet so connected electrically to other fixed contacts as to form a plurality of breaks in series between the supply conductors **1** and **2**. In the arrangement shown, contacts **3** and **6** are electrically common with supply conductors **1** and **2**, contacts **4** and **8** are electrically common one with the other, and contacts **5** and **7** are electrically common one with the other. Contacts **3** and **8**, **4** and **5**, **6** and **7**, are adapted to be bridged by bridging members **9**, **10** and **11**, each of the said bridging members comprising a cross-bar having a contact secured at each end thereof and extending parallel to one another. For ease of terminology the contacts on the bridging members are denoted by the numerals used to refer to the fixed contacts with which they come into abutment and a suffix letter, for example the contacts on bridging member **9** are denoted by **3***a* and **8***a* respectively. The supply conductors **1** and **2** are each provided with contacts **12** and **13** and these are adapted to be bridged by an extraneous bridging contact pair **14** comprising a cross-bar and contacts **12***a*, **13***a*. It will be appreciated that the plurality of

breaks in series between the supply conductors **1** and **2** are provided between the contacts **3**, **8**, **4**, **5**, and **7**, **6**.

The closing sequence for the contacts is as follows: Bridging members **9**, **10** and **11** with their contacts **3***a*, **8***a*, **4***a*, **5***a*, **6***a*, **7***a* close simultaneously on to the fixed contacts **3**, **8**, **4**, **5**, and **6**, **7**, followed by the extraneous bridging contact pair **14**, its contacts **12***a* and **13***a* making contact later in time with contacts **12** and **13** on supply conductors **1** and **2**. The opening sequence is as follows: The extraneous bridging contact pair **14** opens firstly, followed by the bridging members **9**, **10** and **11** simultaneously. Thus, the making and breaking of the circuit takes place through the plurality of breaks in series. The contacts **3**, **4**, **5**, **6**, **7** and **8** are suitably shielded by flame barriers (not shown in Fig. 1) made of arc resistant material, such as, for example, sindanyo.

Referring now to Figs. 2, 3, 4 and 5, the contact assembly of Fig. 1 is referred to by the same numerals, supply conductors **1** and **2** being mounted upon an insulating base **15** completely surrounded by a frame **16** and casing **17** with an aperture **17***a* completely masked by a rubber hood **18**. The flame barriers separating the contacts are shown generally at **19** and the entire circuit breaker in Fig. 2 will be seen to be divided into substantially two divisions, the circuit breaker per se on the right with its attendant toggle and spring mechanism, and on the left its trip mechanism, and this comprises, in the embodiment shown, a differential current trip shown generally at **20** and a remote controlled trip shown generally at **21**, these being adapted to co-operate with a latch plate **22** pivoted at the point **23**.

The extraneous bridging contact pair **14** is seen to be in abutment with an insulating plate **24** located in a plane parallel to the plane of the fixed contacts **3**, **4**, **5**, **6**, **7** and **8** and mounted for movement about an axis perpendicular to the said plane of the fixed contacts, the cross-bars **9**, **10** and **11** being attached thereto by screwed rods **25** and spring-loaded at **26**, thereby permitting a slight amount of tilting so that the contacts upon the cross-bars are rendered self-aligning with the contacts of the fixed contact pairs. The insulating plate **24** is spring-loaded by four separate spring means **27** (one only of which is shown in Fig. 5) in a direction tending to urge the insulating plate and its cross-bars and contacts towards the plane of the fixed contacts **3**, **4**, **5**, **6**, **7** and **8**, the reaction being provided by the cups **28** firmly secured to the insulating platform **29**. In the position of the contacts selected for illustration, the insulating plate **24** is arrested from moving in the said direction in that it is in abutment with the extraneous bridging contact pair **14**, which is spring-urged away from the plane of the fixed contacts by main spring means **30** possessing a total force in excess of the force which tends to move the insulating plate **24** towards the plane of the fixed contacts. The extraneous bridging contact pair **14** is provided with a plunger **31** secured thereto and adapted to pass through apertures **32** in the insulating plate **24** and **33** in the insulating platform **29**. The upper end of the plunger **31** passes through an aperture **34** in a fork spring plate **34***a* (Fig. 5) carrying the trunnions **35** on lever **36**. The said upper end of **31** is linked at **38***a* to a spring-loaded dual fulcrum lever **38***b* which abuts with frame **16** at **16***a* under the action of spring **38***c*. The dual fulcrum points are located at **16***a* and **38***a*. The said dual fulcrum lever **38***b* is also connected to a spindle **39***a*. The main spring means **30** is adapted to operate between the insulating platform **29** and the said spring plate **34***a*, the platform **29** providing a reaction member for the upward movement of the extraneous bridging contact pair **14**.

The linkage mechanism for the closing and opening of the breaker is now to be described and it is seen to comprise a second-order lever arm **36** fulcrumed at **37** upon the frame **16** and freely connected at **38** intermediate its ends to a fork spring plate **34***a*, which is adapted to bear upon the main spring means **30**, and tending to move the extraneous bridging contact pair **14** away from the plane of the fixed contacts. The other end **39** of the second-order lever arm **36** is secured by means of a spindle **39***a* to one end of each of a pair of powerful extension springs **40**, the other ends of the said springs being anchored at **41** to a part of the frame **16**. A toggle system comprising levers **42** and **43** pivoted at **39***a* and **44**, respectively is so arranged that a force upon a roller **45** pivoted on lever **42** causes the toggle system **42** and **43** to increase its effective length between the pivot points **39***a* and **44**, **44**

being arranged to lie upon a latch lever **46** arranged to pivot about a point **47** which is attached to the frame. The force upon the roller **45** is applied through a handle mechanism **48** pivoted about the frame at **49**.

From Fig. 2 it will be appreciated that a downward movement of handle mechanism **48** applied through the rubber hood **18** will, as already mentioned, cause the toggle system to increase its effective length between the points **39** and **44** thereby causing the second-order lever arm **36** to move in a clockwise direction about the point **37**, thereby compressing the main spring means **30** and lowering point **39** and spindle **39***a* which in turn lowers point **39** of lever **36** and the dual fulcrum lever **38***b* about its pivot **16***a*. The insulating plate **24** is permitted to close with its attendant contacts towards the plane of the fixed contacts **3**, **4**, **5**, **6**, **7** and **8**, while the contacts of extraneous bridging contact pair **14** close and point **38***a* comes to rest, dual fulcrum lever **38***b* now moves about point **38***a* under toggle action from handle mechanism **48** and lever **38***b* makes further motion in a clockwise direction depressing still further point **39** and lever **38***b* against spring **38***c* to load contacts **12**, **12***a*, **13**, **13***a* and compensate for contact wear.

The sum total of the combined spring forces through the lever mechanism causes an upward movement of the latch lever **46** which abuts with the latch plate **22** at the stop mechanism **50** and this provides a reaction member, the latch plate **22** being spring-urged about its pivot **23** by a small extension spring **51** secured to the frame at **52**.

Considering now the trip mechanism of the circuit breaker, the differential current trip (Figs. 2 and 4) shown generally at **20** comprises a divided coil **53** upon a core **54** of a magnetic circuit **55** which is adapted to actuate a balanced armature **56** and a ratcheted lever **56***a*, whilst the armature abuts with stop screw **56***b* under spring force due to spring **56***c*. A lever **57** pivoted at **57***a* and spring-loaded by spring **59** in spring cup **60**, forces upon the spring-urged pawl **58** tending to rotate it against its spring in the anti-clockwise direction but this is prevented by ratchet lever **56***a*. When an out-of-balance current flows in the coil **53** the armature **56** is moved and with it ratchet lever **56***a* and the pawl **58** is then free to move under the action of lever **57** and spring **59** in an anti-clockwise direction. The lever **57** is then free to move in a clockwise direction and this movement of the lever **57** causes the latch plate **22** to move about its pivot **23** and release the latch lever **46** from under the stop mechanism **50**. The distant trip mechanism shown generally at **21** comprises a coil **61** which, when carrying current, provides a magnetic field which actuates the armature **62** against the extension spring **63**, and thus the adjusting screw **64** at the end of the said armature is brought into abutment with the extremity of the latch plate **22** and moves it about its pivot **23** thereby releasing latch lever **46** from under the stop mechanism **50**.

While the foregoing is related to one embodiment it will be appreciated that other means of tripping a circuit breaker of this construction are envisaged. For example, we have provided a reverse current trip mechanism comprising a single heavy section conductor which is able to influence a balanced armature to trip the latch plate **22**. Further, bi-metallic overload mechanism has been effectively used to press upon the trip plate **22** and these means may be incorporated to suit varying applications.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges connecting said conductors, and an auxiliary contact breaker bridge separately connecting said conductors.

2. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges connecting said conductors, an auxiliary contact breaker bridge separately connecting said conductors, and an actuator for reciprocating all of said bridges.

3. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges connecting said conductors, an auxiliary contact breaker bridge separately connecting said conductors, and means for simultaneously closing or opening said plurality of bridge contact breakers.

4. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges connecting said conductors, an auxiliary contact breaker bridge separately connecting said conductors, means for simultaneously closing or opening said plurality of bridge contact breakers and for closing said auxiliary bridge after said plurality of bridges is closed and for opening said auxiliary bridge before said plurality of bridges is opened.

5. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of contacts positioned in the configuration of the points of a polygon whose plane substantially contains the inner ends of said conductors, said inner ends being electrically separated and positioned within said polygon near the center thereof, one of said contacts electrically connected to one of said conductors a second of said contacts electrically connected to said second conductor, a plurality of bridges serially connecting all of said contacts electrically, and an auxiliary contact bridge separately connecting said conductors electrically.

6. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of contacts positioned in the configuration of the points of a polygon whose plane substantially contains the inner ends of said conductors, said inner ends being electrically separated and positioned within said polygon near the center thereof, one of said contacts electrically connected to one of said conductors, a second of said contacts electrically connected to said second conductor, a plurality of bridges serially connecting all of said contacts electrically, and an insulated carrier plate resiliently connected to each of said bridges.

7. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges connecting said conductors, an auxiliary contact breaker bridge separately connecting said conductors, an insulated carrier plate mechanically connected to each of said plurality of bridges, resilient means urging said bridges to closed position, and means carried by said auxiliary bridge to releasably retain said bridges in open position.

8. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, an insulated carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said plurality of bridges toward said conductors, an auxiliary contact breaker bridge separately connecting said conductors electrically, and positioned between said plate and said conductors, a reciprocating actuator mechanically connected to said auxiliary bridge, and means for reciprocating said actuator.

9. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, a carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said bridges toward said conductors, a stop plate positioned adjacent said carrier plate, an auxiliary contact breaker bridge separately connecting said conductors electrically and positioned between said carrier plate and said conductors, an actuator connected to said auxiliary bridge, and means for reciprocating said actuator.

10. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, a carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said bridges toward said conductors, a stop plate positioned adjacent said carrier plate, an auxiliary contact breaker bridge separately connecting said conductors electrically and positioned between said carrier plate and said conductors, an actuator connected to said auxiliary bridge, and a toggle linkage connected to said actuator for reciprocating said actuator.

11. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, a carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said bridges toward said conductors, a stop plate positioned adjacent said carrier plate, an auxiliary contact breaker bridge separately connecting said conductors electrically and positioned between said carrier plate and said conductors, an actuator connected to said auxiliary bridge, a second resilient means connected to said actuator and biasing all of said bridges away from said conductors, and means for reciprocating said actuator.

12. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, a carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said bridges toward said conductors, a stop plate positioned adjacent said carrier plate, an auxiliary contact breaker bridge separately connecting said conductors electrically and positioned between said carrier plate and said conductors, an actuator connected to said auxiliary bridge, a second resilient means connected to said actuator and biasing all of said bridges away from said conductors, a snap action toggle linkage mechanically connected to said actuator, and a mechanical lever system connected to

said toggle linkage, whereby movement of said lever system will close all of said bridges.

13. An electric circuit breaker for interrupting relatively heavy current comprising in combination, two electrical conductors, a plurality of serially connected contact breaker bridges electrically connecting said conductors, a carrier plate connected to each of said plurality of bridges, resilient means urging said plate and said bridges toward said conductors, a stop plate positioned adjacent said carrier plate, an auxiliary contact breaker bridge separately connecting said conductors electrically and positioned between said carrier plate and said conductors, an actuator connected to said auxiliary bridge, a second resilient means connected to said actuator and biasing all of said bridges away from said conductors, a snap action toggle linkage mechanically connected to said actuator, a mechanical lever system connected to said toggle linkage, a latch for retaining said lever system and toggle linkage in bridge-closing position, and an electromagnetic trip mechanism connected to said latch.

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