July 6, 1965 J. S. HOLLYDAY 3,193,643

CIRCUIT BREAKER HAVING AN IMPROVED LINKAGE

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Fig. 1.

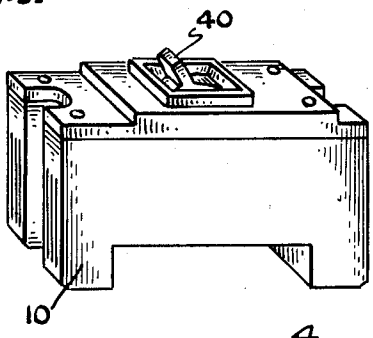


Fig. 14.

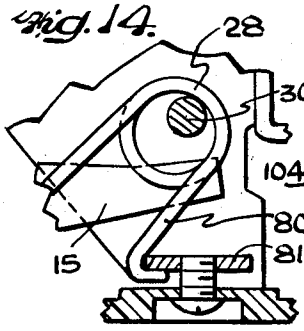


Fig. 7.

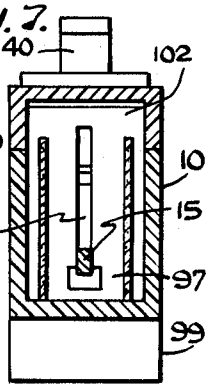
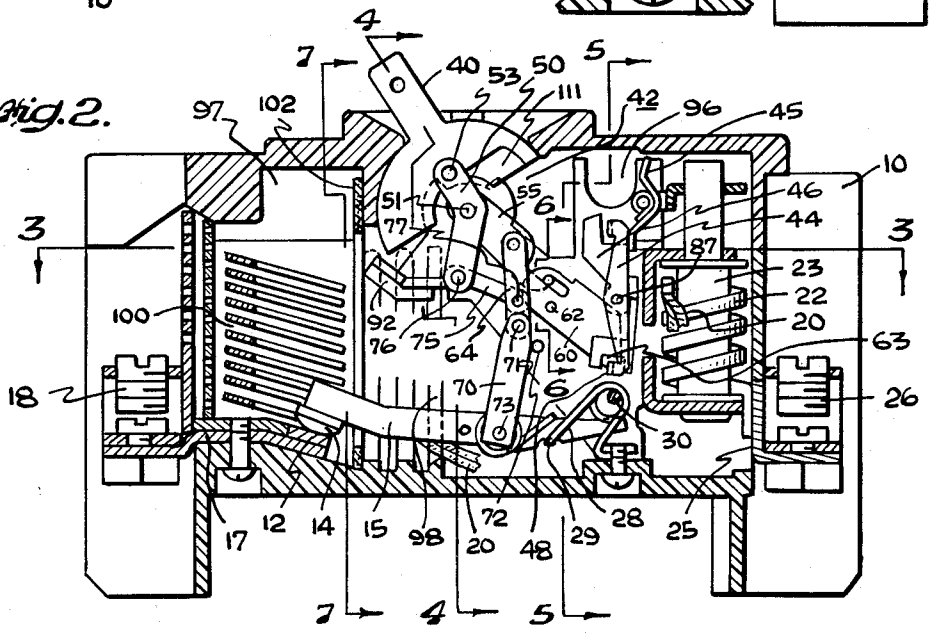


Fig. 2.



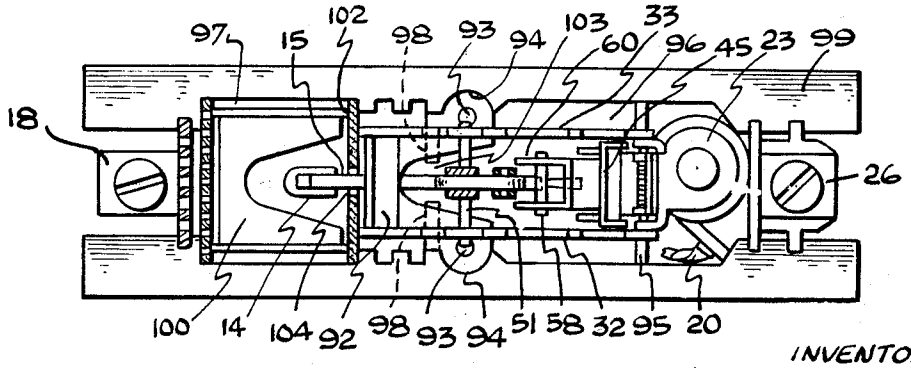


Fig. 3.

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Fig. 4.

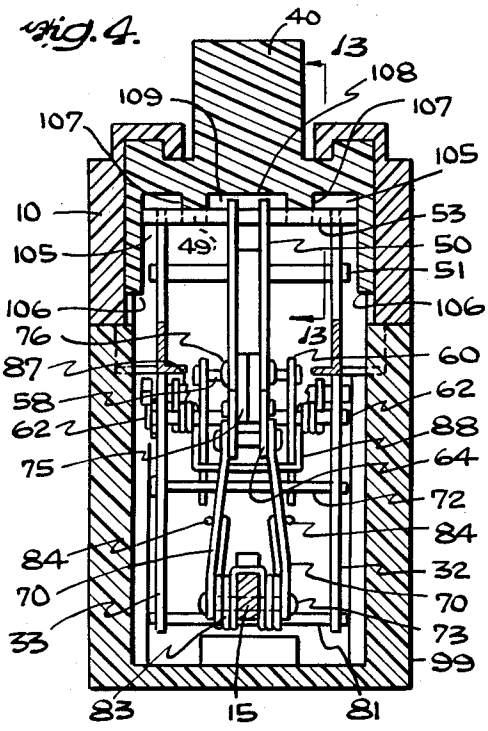
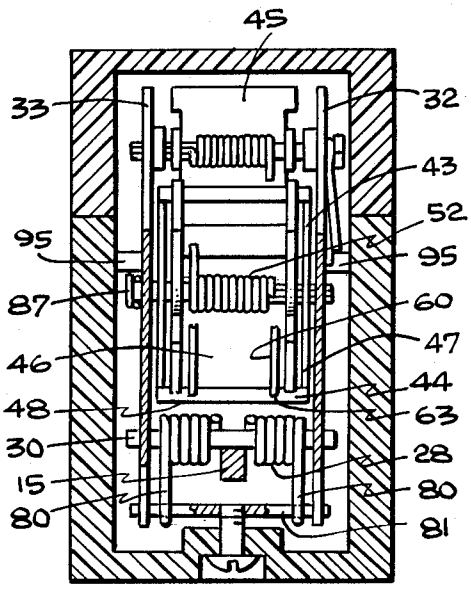


Fig. 5.



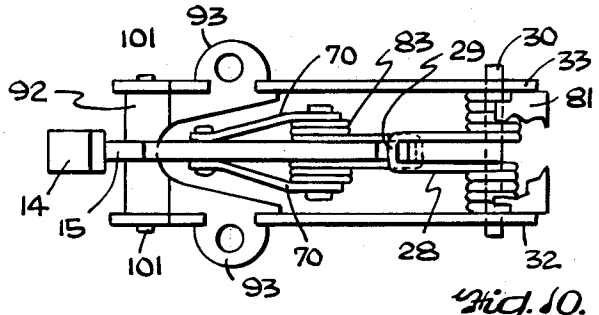


Fig. 10.

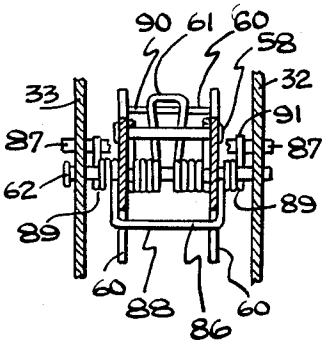


Fig. 6.

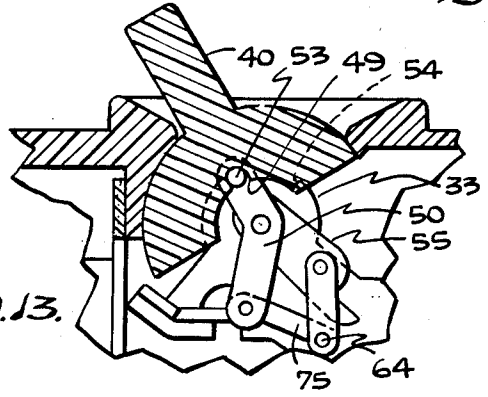


Fig. 13.

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CIRCUIT BREAKER HAVING AN IMPROVED LINKAGE

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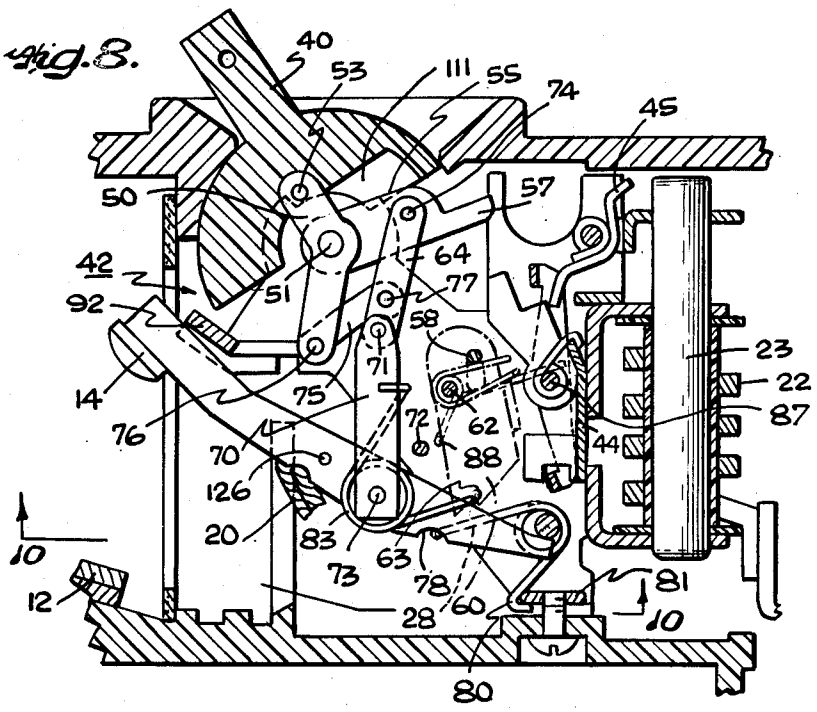
Fig. 8.



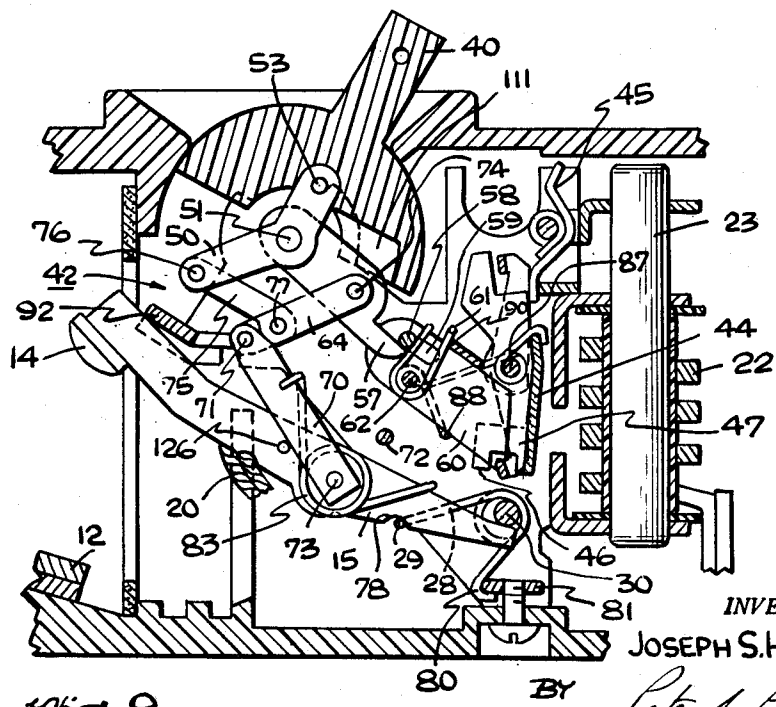


Fig. 9.

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Fig. 11.

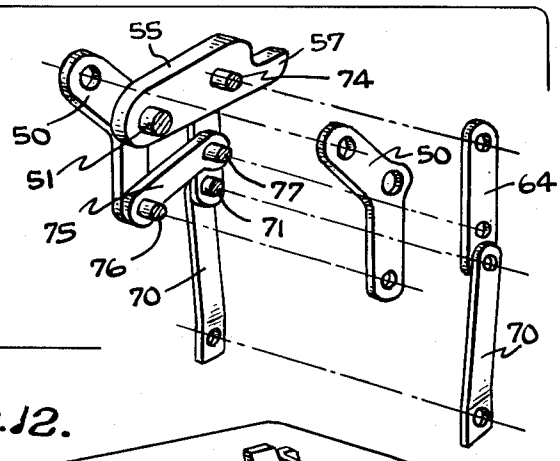


Fig. 23.

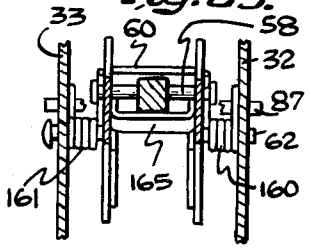


Fig. 24.

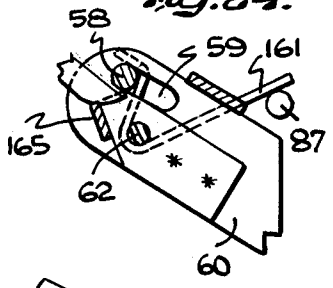
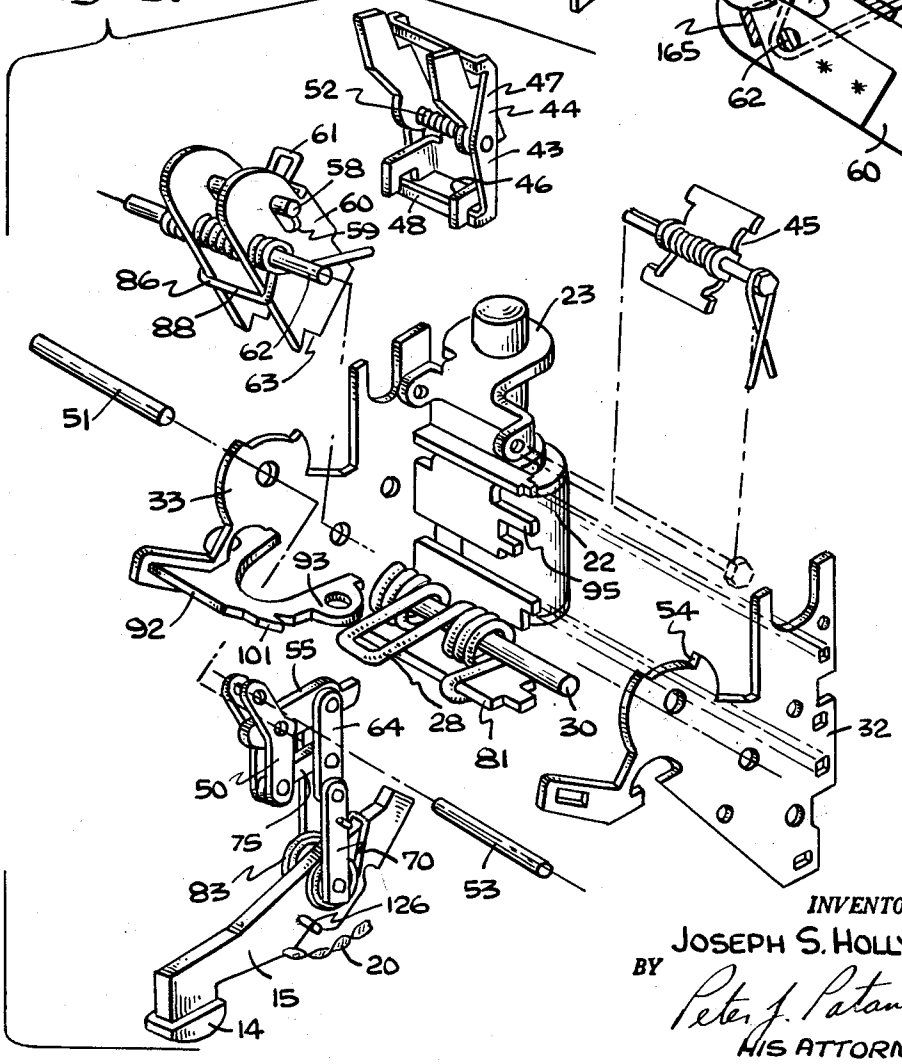


Fig. 12.



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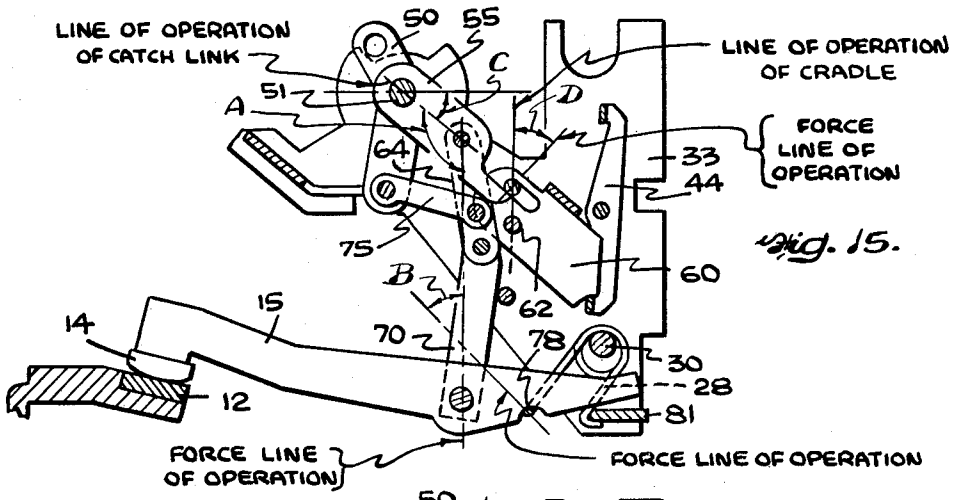

Fig. 15.

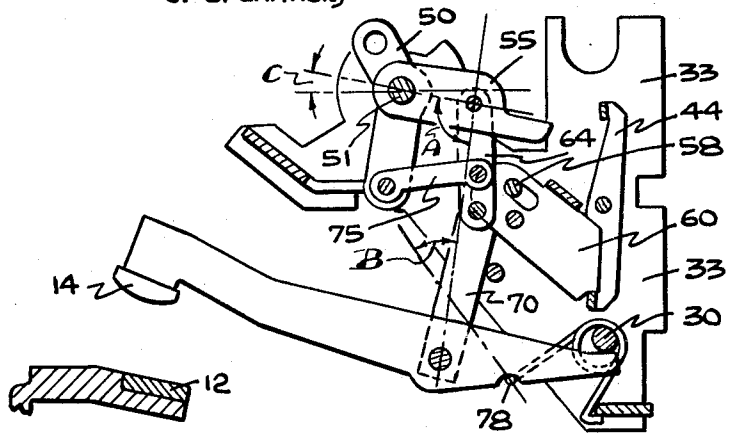

Fig. 16.

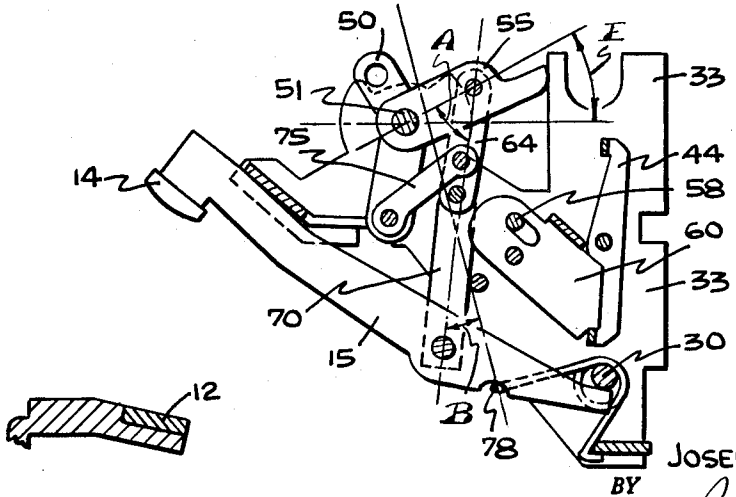

Fig. 17.

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Fig. 18.

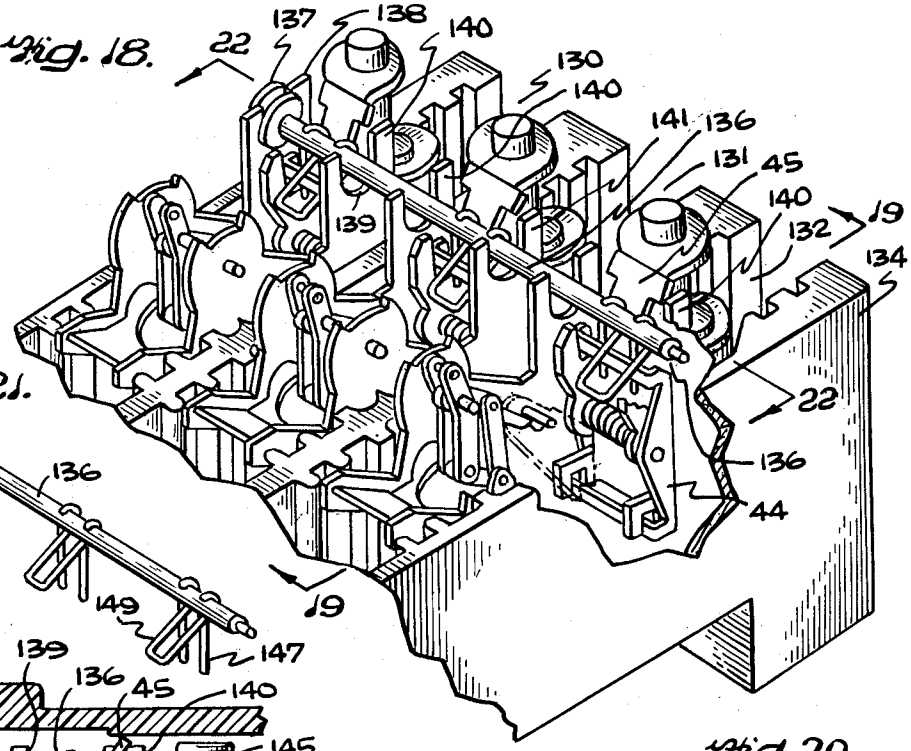


Fig. 21.

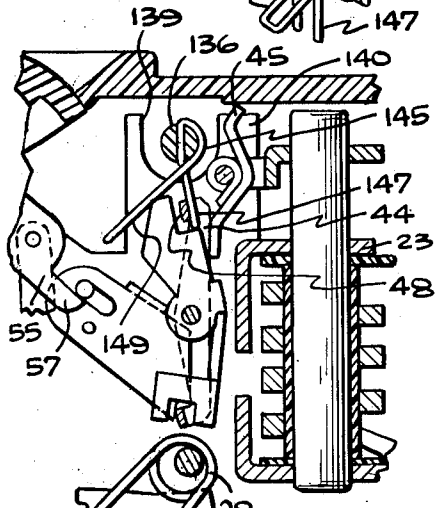


Fig. 19.

Fig. 20.

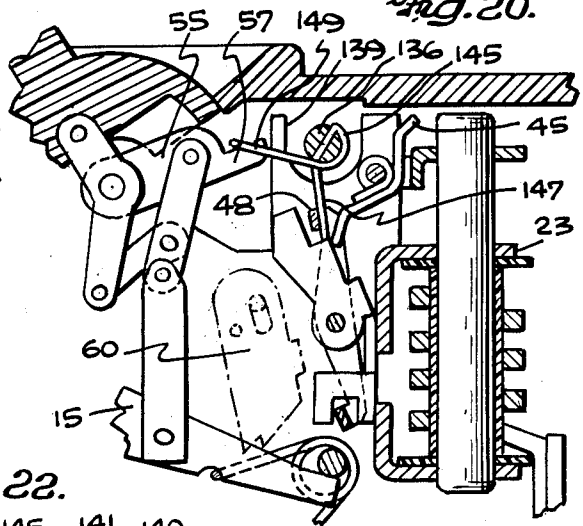
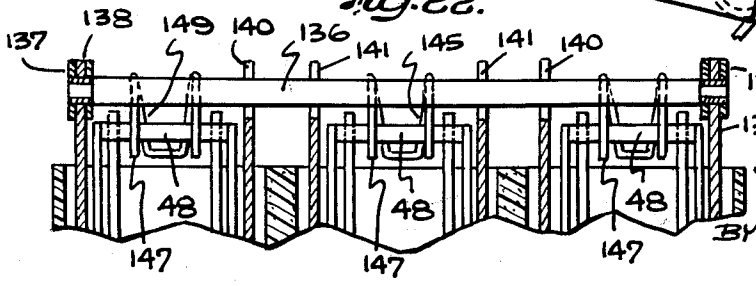


Fig. 22.



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United States Patent Office 3,193,643 Patented July 6, 1965

3,193,643

CIRCUIT BREAKER HAVING AN IMPROVED LINKAGE

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Filed May 15, 1961, Ser. No. 109,914
13 Claims. (Cl. 200—106)

This invention relates to electrical circuit breakers and, more particularly, to an improved mechanical linkage for connecting the control handle to the movable contact arm.

It is an object of this invention to provide an improved trip free, automatically resettable linkage mechanism for a circuit breaker, which retains the characteristics of dependability and reliability of certain previous circuit breakers. The relationship between the catch link and its restraining lock pin is such, in this invention, that the close tolerances required in certain previous devices are no longer needed. Also, the number of sensitive adjustments required during manufacture and final assembly are reduced by the use of the linkage and the arrangement of the present invention.

Another object of the present invention is to provide an improved fast opening mechanical linkage for separating the contacts of the circuit breaker. In accomplishing the foregoing, the linkage comprises a four bar linkage connected to the movable arm by a fifth link, one of the links of the four bar linkage and the fifth link together forming a toggle.

Also, in this linkage, the angle between the line of action of the force (transmitted to the catch link by the toggle) biasing the catch link to the open position of the contacts, and the line between the pivot point of the catch link and the point at which the force is applied to the catch link, is closer to perpendicular than in catches of certain other mechanisms.

In this invention, the four bar linkage is constructed and arranged so that at certain times different links are fixed with respect to the other links, and at another time none of the four links are fixed.

The catch link is restrained from movement, when the handle is in the position corresponding to the closed or open positions of the contacts, by the lock pin which is carried by a rockable cradle, the latter being controlled by an armature device. The cradle is biased toward the position where it will restrain the catch and the linkage is provided with an automatic reset spring means which moves the catch link into restrainable engagement with the lock pin after the contacts are electrically tripped open.

A component of the force of the opening spring tending to bias the contacts to the open position, which is transmitted to the catch link by the toggle, is applied by the catch link against the lock pin. Due to the varying angle between the operating line of the toggle and the operating line of the catch link, as the catch link pivots to allow the movable contact to separate from the stationary contact, this force component increases from an initial amount, when the contacts are closed, to a maximum and then decreases as the contacts move to the fully open position. Thus, fast opening is insured because the force available to pivot the catch link at the start of the movement of the linkage is large and this force increases subsequent to the initial release of the catch link. Also, the subsequent decrease insures that no undue load is placed on the linkage when its movement is abruptly stopped due to the abutment of the movable arm with its stop plate.

The movable contact arm utilized in this invention is biased against and pivoted about a fixed abutment by the contact opening spring eliminating the need for a pintle bearing in the movable contact arm. The opening spring biases the movable arm against the abutment and allows the movable contact arm to wipe, or slide along the stationary contact, during the opening and closing of the contacts.

The foregoing and other objects of my invention, the principles of my invention, and the best modes in which I have contemplated applying such principles will more fully appear from the following description and accompanying drawings in illustration thereof.

In the drawings:

FIG. 1 is a perspective view of a circuit breaker embodying this invention;

FIG. 2 is a view partly in section and partly in elevation of a circuit breaker incorporating my invention with the linkage illustrated in the closed position of the contacts;

FIGS. 3, 4, 5, 6 and 7 are sectional views taken along the lines 3—3, 4—4, 5—5, 6—6, and 7—7, respectively, in FIG. 2;

FIG. 8 is a view of the circuit breaker illustrated in FIG. 1, which is similar to FIG. 2, but this view illustrates the linkage in the tripped position of the contacts before automatic resetting;

FIG. 9 is a view of the circuit breaker illustrated in FIG. 1, which is similar to FIG. 2, but this view illustrates the linkage in the open position of the contacts;

FIG. 10 is a view taken along the line 10—10 in FIG. 8;

FIG. 11 is an exploded view of the five links comprising the linkage;

FIG. 12 is an exploded view of the mechanism illustrated in FIG. 2, omitting the handle;

FIG. 13 is a partial view, partly in elevation and partly in section, taken along the line 13—13 in FIG. 4;

FIG. 14 is a partial view, partly in elevation and partly in section, illustrating one end of the movable contact arm, the abutment about which it pivots and the opening spring;

FIGS. 15, 16 and 17 are elevational views illustrating the linkage, the movable arm and the opening spring in which various lines of operation and lines of force have been indicated corresponding to the contacts closed position, the momentary partial trip position and the momentary trip position, respectively;

FIG. 18 is a partial perspective view illustrating three circuit breakers constructed as illustrated and described in connection with FIGS. 1 to 17 but incorporating a feature for tripping all the circuit breakers upon an overload in any one;

FIG. 19 is a partial view, partly in elevation and partly in section, taken along the line 19—19 in FIG. 18, illustrating the closed position of the contacts;

FIG. 20 is a view similar to FIG. 19 but illustrating the tripped position after initial engagement of the catch link with the trip rod and the rotation thereof in the direction to trip the associated circuit breakers;

FIG. 21 is a perspective view of the trip rod and its trip fingers;

FIG. 22 is a rear elevation view, partly in section, of the trip rod, frames and casing;

FIG. 23 is a front elevation view, similar to FIG. 6, but illustrating a modified cradle and spring arrangement; and

FIG. 24 is a side elevation view of the modification illustrated in FIG. 23, partly in section.

This invention is embodied in a circuit breaker comprising a circuit breaker mechanism mounted within an insulating case 10. The case 10 encloses a stationary contact 12 having a flat contact face, and a movable contact 14 having a curved contact face, the contact 14 being secured to a movable arm 15. The stationary contact 12

is connected by suitable terminal structure 17 to a connector 18 to which an external circuit conductor may be secured. The movable contact arm 15 is connected by a flexible conductor 20 to a coil 22 of an electromagnet 23, the coil 22 having its other end connected to a terminal structure 25 and a connector 26 to which a second external circuit conductor may be secured.

The movable contact arm 15 is biased by a spring 28 toward the open position of the contacts. The opening spring 28 biases the movable arm against the stationary abutment or shaft 30 which has its ends secured to similar, parallel, and spaced frame plates 32 and 33, intermediate which is disposed the mechanism for operating the circuit breaker. The movable arm 15 is connected to (and manually operable by) a handle 40 through a linkage mechanism 42, hereinafter described in detail, the linkage mechanism 42 being electrically controlled by the electromagnet 23 and armature devices 44 and 45, upon predetermined electric currents.

The armature device 44 is a two piece mechanism comprising a pivotal magnetizable inner body 46 (having interconnected side arms) for pivoting an outer latch 47, the latter comprising side plates 43 and top and bottom interconnecting bars 48. The lock or lower bar 48 (FIG. 2) of the latch plate 47 restrainably engages the lock tip 63 of a cradle 60, the lower latch bar 48 being rotated counterclockwise out of engagement with the lock lip 63 upon predetermined overload currents by suitable engagement of the inner body 46 and the pivotal latch, the cradle 60 being pivotal about pintle 62 whose ends are carried by plates 32 and 33. Since the electromagnet 23, the armature devices 44 and 45 are the subject of copending patent application Serial No. 137,488, they are not described in greater detail herein.

The linkage mechanism 42 connects the operating handle 40 to the movable contact arm 15 by five links, constructed and arranged as illustrated in the drawings. Referring to FIG. 2 which illustrates the closed position of the contacts 12 and 14, the handle 40 is illustrated in its leftwardmost or contacts closed position having pivoted the associated handle link 50 to its most counterclockwise position, about the pintle 51, the latter having its ends carried in suitable openings in the frames 32 and 33. The handle link 50 is connected to the handle 40 by a pintle 53 carried by the upper end of the link 50 and pivotally disposed in a notch 49 formed in the handle 40, FIGS. 4 and 13. The mechanism includes a catch link 55, pivotally connected to the pintle 51 at one end, between the two members forming the link 50, provided with a straight nose portion 57 at the other end for engaging a lock pin 58 carried in slots 59 of the cradle 60. The lock pin 58 is biased to the top of the slots 59 by a spring 61, FIGS. 6 and 9, for restrainably engaging the nose portion 57.

To connect the catch link 55 to the movable arm 15, a toggle is utilized comprising upper and lower links 64 and 70. The upper link 64 comprises two members having their ends connected between the ends of the members forming the latch link 55 by a pintle 74. The lower link 70 also comprises two members connected at their ends to the opposite sides of the movable arm 15 by another pintle 73. The knee of the toggle is formed by a pintle 71 and its overset (to the right) is limited by a pin 72 having its ends secured to the plates 32 and 33. The four bar linkage is completed by pivotally connecting the bottom portion of the handle link 50 to the upper link 64 by a cross link 75 by providing a pintle 76 for connecting the ends of the handle link 50 and the cross link 75 and, also, providing a pintle 77 for connecting the other end of the cross link 77 to the upper link 64 intermediate the ends of the latter.

Thus, the handle link 50, the catch link 55, the upper toggle link 64 and the cross link 75 together form a four bar linkage in which each of the links are pivotally connected to the other and one of the links, the upper toggle link 64, is connected to a fifth link, the lower toggle link 70. Rotation of the handle 40 rotates the handle link 50

which, through the linkage just described, moves the contact 14 to the closed position, illustrated in FIG. 2, at which time the knee of the toggle is over center to the right and the handle is at its leftwardmost position. The movement of the toggle to the right is limited by the stop pin 72, thus limiting movement of the handle 40 to the left and movement of the linkage 42; and movement of the handle 40 to the right is limited by abutment of the movable arm 15 with its stop 92 and movement of the linkage 42 by pin 126.

Referring to FIG. 4, between each of the members forming the link 70 and the arm 15 are disposed the legs of a generally U-shaped automatic reset spring 83 having the base of the U biased against the upper side of the arm 15 (opposite to the side in which the notch 78 is formed) the reset spring 83 having portions of its legs coiled about the pintle 73 on opposite sides of the arm 15. Also, the reset spring 83 has its ends 84 hooked over the two members forming link 70, as illustrated in FIG. 4. The reset spring 83 supplies the spring bias for automatically resetting the links after electromagnetic tripping and, also, tends to laterally position the toggle relative to the arm 15.

The cradle 60 is approximately of channel shape in cross section (FIG. 6) freely interfitting between the side arms of the inner armature body 46 as shown in FIG. 5, for instance, and the pintle 62 about which it pivots is disposed intermediate the ends of the slots 59 but adjacent the lower end thereof. The spring 61 which biases the lock pin 58 to the top of the slots 59 is of general U-shape with end portions coiled about the pintle 62. The mid-portion of the spring 61 adjacent the base of the U-shape is biased against the lock pin 58 while the opposite ends of the spring 61 are biased against the flat base 90 which connects the opposite cradle sides, FIGS. 4 and 9.

A U-shaped cradle spring 88 (FIG. 6) biases the cradle into engagement with the armature 44. The cradle spring 88 has portions 89 coiled about the opposite ends of the pintle 62 between the sides of the cradle 60 and the frame plates 32 and 33, and extreme end portions 91 resting upon the pintle 87 about which the armature device 44 rotates, and the spring base 86 engages the cradle sides for biasing the cradle about the pintle 62 in the counterclockwise direction.

The movable arm 15 is pivoted about the shaft 30 by the pressure of the opening spring, the latter positioning the arm 15 laterally and longitudinally. The arm 15 has a limited amount of freedom and may move a certain amount parallel and transverse to the axis of the shaft 30, FIGS. 5 and 10. The opening spring 28 is of approximate U-shape with the base of the U or loop 29 being disposed in a semi-circular notch 78 in the arm 15 between the pintle 73 and the shaft 30. The legs of the spring 28 closely but slidably contact the sides of the arm 15 and terminal portions of the legs are coiled about the shaft 30 on opposite sides of the arm 15 and between the arm 15 and the frame plates 32 or 33, FIGS. 5 and 10, with end portions 80 hooked over the cross piece 81, FIGS. 8 and 9 (connecting the frame plates 32 and 33), for establishing a suitable spring bias on the arm 15 tending to open the contacts.

The frame plates 32 and 33 are also interconnected by a plate 92 (FIGS. 8, 10 and 12) of approximate L-shape having lugs 101 for assembly to the plates 32 and 33 and laterally projecting semi-circular feet 93 extending through openings in the plates 32 and 33. The feet 93 are received in semi-circular grooves 94, FIG. 3, provided in the casing lower part 99 and rest upon suitable wall structures through which screws extend for engaging the feet 93 and securely fastening the frames 32 and 33 to the lower casing part 99. The cross piece 81 (about which the spring ends 80 are hooked) is spaced from the bottom of the casing lower part 99, FIGS. 8 and 9, and both are provided with openings through which another screw ex-

tends for aiding in securing the mechanism. Projections **95**, FIGS. 3 and 12, extending from the frame of the electromagnet and through the plates **32** and **33**, are provided to properly space the device from the casing walls by abutting therewith for preventing lateral movement of the device.

It will be noted that the entire mechanism is supported by and between the frame plates **32** and **33**. The impact of the contact arm **15** upon the stop plate **92** exerts a force tending to move the plates **32** and **33** about the screw extending into the cross piece **81** as a pivot. This force is resisted, near the point of impact, by the feet **93** disposed within the grooves **94** which are secured to the lower casing part by the screws mentioned, extending through the lower casing part.

The interior of the lower casing **99** is divided into two compartments **96** and **97** by a wall **98**. The compartment **96** generally houses the aforementioned mechanism and the compartment **97** houses an arc extinguishing device **100** including a vertical insulator **102**. The wall **98** and the insulator **102** of the arc extinguisher have aligned elongated slots **103** and **104**, respectively, through which the movable arm **15** extends and which accommodates pivotal opening and closing movements of the arm **15**.

The handle **40** is provided with recesses **105** (FIG. 4) defined partially by parallel, spaced walls **106** for accommodating the upper end of the frame plates **32** and **33**. The notches **49** (FIG. 13) for receiving the ends of the pintle **53** are formed by walls **107** (FIG. 4). Also, the walls **107** and **108** define a space **109** for accommodating the upper end of the link **50**. The handle **40** is further provided with a recess **111**, FIGS. 8 and 9, for receiving a portion of the link **55**.

While the walls **106** limit axial movement of the pintles **51** and **53**, the link **50** is slidable along the pintle **51** and the links **50** and **55** may move toward one or the other of the frame plates **32** or **33** during operation of the circuit breaker. Also, the movable arm **15** is positioned laterally between the plates **32** and **33**, only by the springs **28** and **83**. Hence, it is possible that the arm **15** and/or the linkage mechanism **42** will move toward one or the other of the plates **32** and **33**, out of the central position between the plates **32** and **33**, during operation of the circuit breaker. However, the nose **57** of the catch link **55** tends to remain stationary against the lock pin **58**, during manual closing of the contacts, due to the force being applied to the handle **40**. By making the spring **28** substantially close fitting with the movable arm **15**, as illustrated in FIG. 10, and sufficiently rigid, substantial lateral movement of the associated end of the movable arm **15** is limited. Also, by making the slots **103** and **104** only slightly wider than needed to accommodate the arm **15** this lateral movement is limited and by making the stationary contact **12** somewhat larger than the movable contact **14**, should any lateral movement occur, sufficient contact will still be made, due to the oversize stationary contact.

With the unit in the open position of the contacts, as illustrated in FIG. 9, if the handle **40** is manually engaged and turned counterclockwise, against the bias of the opening spring **28**, the force applied at the handle **40** will be transmitted by the handle link **50** to the cross link **75**. The cross link will move the upper link **64** (of the toggle) to the right and tend to move simultaneously the lower link **70** and the catch link **55**. Movement of the catch link is restrained, however, by the lock pin **58**, and continued movement of the cross link **75** closes the contacts **12** and **14** and oversets the toggle, to the right, against the stop pin **72**.

Upon the occurrence of a predetermined overload, the contacts **12** and **14** will open, either simultaneously or at the end of a time delay period, depending upon the overload, as explained in detail in my copending patent application Serial No. 137,488, due to the magnetic flux and the pivoting of the armature device **44** in the counterclockwise direction, whereby the cradle **60** is released by the bar **48**, the armature **44** pivoting (about its supporting pintle **87**) against the bias of spirng **52**, the latter tending to urge the lower bar **48** into engagement with the cradle **60**. The cradle **60** rotates due to the spring force upon the lock pin **58** from the opening spring **28**, the spring bias being transmitted by the toggle links **64** and **70** to the catch link **55**.

The linkage moves to the momentary position illustrated in FIG. 8 and then automatically resets to the open contacts position illustrated in FIG. 9. Referring to FIG. 8, after the cradle **60** rotates sufficiently, illustrated in dot-dash lines, the toggle links **64** and **70** move the catch link **55** upwardly through an arc about pintle **51** and simultaneously the movable arm **15** moves to the fully open position abutting the stop plate **92**. Between the release of the catch link **55** by the lock pin **58** and the attainment of the position of the catch link **55** illustrated in FIG. 8, the cradle **60** (due to the bias of the spring **88**) returns toward the position illustrated in FIG. 9, that is, toward latching engagement with the lower bar **48**, and the lock pin **58** returns to the top of the slots **59** due to the spring **61**. After the linkage moves upwardly its maximum amount and the movable arm **15** comes to rest against the stop **92**, the reset spring **83**, moves the link **70** toward the movable contact **14**, pivoting about the pintle **73**. This pivotal motion causes the catch link **55** to rotate downwardly clockwise about pintle **51**, and the handle link **50** to be pivoted by the cross link **75** so that the handle **40** is carried to the right or to the off position of the contacts. The back, rounded part of the nose **57** depresses the lock pin **58** (against the bias of the spring **61**) and slips behind the lock pin **58**, at this time. If desired, the bias of the spring **83** may be made sufficient to maintain the nose **57** spaced from the pin **58** until a sufficient force is applied at the handle **40** forcing the nose **57** against the pin **58**, in closing the contacts, or a stop pin **126** may be added to the movable arm for limiting movement of the link **70** and holding the nose **57** against the pin **58** in the off position. If the nose **57** does come to rest in the off position spaced from the lock pin **58**, it follows that the counterclockwise bias of the spring **88** on the cradle **60** keeps the right hand upper edge portions of the cradle **60** abutting the coils of the armature spring **52**, which is wrapped about the armature pintle **87**, as it does after electromagnetic tripping and prior to automatic resetting of the nose **57** in this situation and in the situation where the nose **57** comes to rest engaging and below the lock pin **58**. But the aforementioned locking engagement between the lips **63** and the lower bar **48** nevertheless takes place, as illustrated, because of the open ended form of the lips **63** and the sufficiently large vertical surface thereof, relative to the surface of the lower bar **48**, which the lips **63** are intended to engage, although at this time the upper generally horizontal surfaces of the lips may be spaced from the upper horizontal surface of the lower bar **48**.

It should be noted that from the closed position of the contacts to the trip position thereof, the toggle links **64** and **70** act substantially as one rigid member. However, just prior to the abutment of the movable arm **15** with its stop **92**, that is, just prior to the most upward or trip position of the linkage, the cross link **75** pulls the toggle links overcenter to the left. Thereafter, the reset spring **83** is able to automatically reset the linkage and move the handle to the off position.

Referring to FIGS. 15, 16 and 17, the various links are arranged in the illustrated embodiment, so that in the closed position of the contacts, FIG. 15, the line of operation of the force transmitted by the toggle links **64** and **70** intersects the line of operation of the catch link, angle A, at approximately and included angle of between 125° and 135°. The force of spring **28** is applied at the notch **78** at an angle with the line of operation of the toggle, angle B, of between 40° and 50°, and this force

decreases from the maximum at the contacts closed position as the movable arm moves to the contacts open position. Since the angle between the horizontal line illustrated and the line of operation of the catch link, angle C, is between 35° and 40°, in the closed position of the contacts, it is seen that the component of the opening spring force available to turn the catch link **55** (and start the various links and the cradle **60** moving) when the circuit breaker is tripped electromagnetically, is the portion obtained by multiplying the cosin of angle B by the cosine of angle C.

The catch link **55** rotates upwardly and above the horizontal line drawn through the pintle **51**, to an angle E, for a total angular rotation of between 65° and 75°, and returns downwardly through the same angle during automatic resetting. Due to the relative angular movement of the various parts, the angles A and B decrease progressively as the contacts move to the off position, as illustrated in FIGS. 16 and 17, and the available spring force at the catch link **55**, for rotating the latter, increases from its starting value to a maximum and decreases to a value above the starting value just before automatic resetting, in the illustrated embodiment.

However, the force on the catch link is applied radially to the lock pin **58** by the nose **57**, FIG. 15. The component of this force, tending to pivot the cradle **60**, is the radial force so applied, multiplied by the cosine of angle D, the angle between the radial force and the line of operation of the cradle, between 40° and 50° in the embodiment illustrated. Hence, in FIG. 15, the maximum force available at the lock pin **58** to turn the cradle **60** is the force on the catch link multiplied by the cosine of angle D.

The catch link **55** frees itself of the lock pin **58** in about the first 8 to 12% of the time period in which the contacts open after electromagnet tripping takes place, so that the inertia of the cradle **60** is removed from the subsequent sequnce.

Since acceleration is proportional to the force imposed, the acceleration of the catch link **55** increases as it pivots from the contacts closed position to the trip position, facilitating the separation of the contacts and the extinguishment of the arcs that tend to be drawn between the contacts.

Of all the piovtal connections, hence, provided by the pintles **51**, **53**, **71**, **73**, **74**, **76** and **77**, only the pintle **51** is fixed, its ends being carried by the frame plates **32** and **33**, whereas all of the others are capable of floating or shifting, as required.

With the four links arranged as heretofore described, namely links **50**, **55**, **64** and **75**, it is seen that in different positions of the mechanism, different links drive the link arrangement, while other links are driven. For instance, when turning the circuit breaker manually to the on or off position of the contacts, the handle link **50** is the driver link and the upper and lower toggle links **64** and **70** are the driven links, the cross link **75** being the coupling link between the links **50** and **64**, and the catch link **55** is a fixed link. Thus, during movement of the handle **40** between the on and off positions the upper toggle link **64** pivots through an arc about the pintle **74**.

When the contacts are closed and the circuit breaker is tripped electromagnetically, the functions of certain links change. The handle **50** remains fixed in the position illustrated in FIGS. 2 and 8, the driving link is the lower link **70** of the toggle, the upper link **64** acts as a couple to transmit the force of the driving link to the driven catch link **55**. The cross link **75** at this time, pivots about the pintle **76** connecting it to the handle link **50**.

When the circuit breaker mechanism resets automatically after tripping, by moving from the momentary trip position illustrated in FIG. 8, to the open position illustrated in FIG. 9, due to the spring **83**, the linkage

mechanism has no fixed link, and all of the links now pivot. The handle link **50**, which was fixed during movement of the mechanism from the on position (illustrated in FIG. 2) to the trip position (illustrated in FIG. 8), now pivots about the pintle **51** due to the bias of the spring **83**, transmitted to the link **50** by the links **64**, **70** and **75**. Simultaneously, the link **64** causes the catch link **55** to pivot downwardly (from the position of FIG. 8 to that of FIG. 9) until the nose portion **57** of the link **55** depresses and passes behind the lock pin **58**.

Thus, it is seen that a trip free mechanism has been provided because if an attempt is made to keep the contacts closed while a predetermined overload persists requiring the contacts to be open, the armature device **44** will remain in the position to release the cradle **60** and, thus, the lock pin **58** is out of restraining engagement with the catch link **55**. With the lock pin **58** not restraining the catch link **55**, the opening spring **28** collapses the toggle formed by links **64** and **70** even if the handle **40** is manually kept in the position corresponding to the closed position of the contacts, FIG. 2. Of course, during the usual electromagnetic tripping of the circuit breaker, the position of the linkage illustrated in FIGS. 8, 17 and 20 is not fully attained, because (referring to FIG. 8) once the pin **71** passes to the left of a line extending between pins **73** and **74** the force of spring **83** acts upon the linkage to move it toward the position illustrated in FIG. 9.

Due to the movable contact arm **15**, the spring **28**, abutment **30**, and the notch **73**, a wiping or sliding action is provided during the opening and closing of the contacts. When the circuit breaker is open (FIG. 9), the loop **29** of the spring **28** biases the movable contact arm longitudinally to the left and upwardly toward the shaft **30**. When the handle **40** is turned to pivot the arm **15** about the shaft **30**, toward the closed position of the contacts, the force transmitted through the pintle **73** turns the arm **15** about the shaft **30** against the bias of the spring **28**, while the arm **15** contacts the shaft **30**. The movable contact face engages the stationary contact face before the throw of the handle **40** is completed, that is, before the toggle links **64** and **70** go over center to the right. Since the stationary contact prevents further downward movement of the movable contact, the continued application of force from the handle **40** through the pintle **73** moves the pintle **73** below the shaft **30** and rocks and shifts the movable arm so that the arm is moved longitudinally to the right and below the shaft **30**, simultaneously with the links **64** and **70** going over center. The movable contact face is thus given a wiping movement over the stationary contact face and at the completion of the movement, the movable contact face is biased yieldingly against the stationary contact face, the end of the movable arm **15** nearest the shaft **30** being spaced therefrom.

When the circuit breaker is moved to the contacts open position either electromagnetically or by moving the handle **40** clockwise, the loop **29** shifts the arm **15** longitudinaly to the left relative to the stationary contact **12** and the shaft **30** (compare FIGS. 15, 16 and 17), imparting a sliding and wiping movement to the movable contact **14** relative to the stationary contact **12**. For instance, on electromagnetic tripping, as soon as the nose **57** is released by the lock pin **58** the right hand end of the movable arm **15** impinges forcefully on the shaft **30** while the loop **29** tends to open the contacts. Also, the positions of contact between the coils of the spring **28** and the shaft **30**, also shift, as illustrated in the drawings. When the contact arm **15** is fully open, the left hand end abuts the stop **92**.

In summary, in movement from the open position (FIG. 9) of the contacts to the closed position (FIG. 2), the force applied at the handle **40** is transmitted by the handle link **50** to the driven upper link **64** by the coupling

cross link 75, while the catch link 55 is maintained stationary by the lock pin 58. In movement of the movable contact manually from the closed positions (FIG. 2) to the open position (FIG. 9), the applied force is transmitted by the handle link 50, through the cross link 75, to the upper link 64 to break the toggle formed by links 64 and 70 by moving the knee thereof to the left (FIG. 2), allowing the opening spring 28 to move the arm against the stop plate 92, the catch link 55 remaining substantially stationary.

With the contacts in the closed position (FIG. 2) if the circuit breaker is subjected to an electrical overload, the functions of certain links change. The handle link 50 now remains stationary and the opening force of the spring 28 is transmitted from the arm 15 and lower toggle link 70 by the upper link 64 to the catch link 55 which now functions as the driven link. During the automatic resetting of the mechanism from the tripped position (FIG. 8) to the open position (FIG. 9) all of the links 50, 55, 64, 70 and 75 move simultaneously and they pivot to the position illustrated in FIG. 9.

Referring to FIGS. 18 through 22, inclusive, there is illustrated a multi-pole circuit breaker unit comprising three circuit breaker mechanisms 130, 131 and 132 within the insulating case 134, each of the three circuit breaker mechanisms being constructed substantially the same as the circuit breaker mechanism illustrated and described in connection with FIGS. 1 through 17, inclusive. However, in the multi-pole circuit breaker unit, an interconnecting rod 136 of insulating material is provided for tripping all of the circuit breakers upon the occurrence of predetermined electrical conditions in one or more of the circuit breaker poles.

The ends of rod 136 are pivotally supported in bearings 137 connected to the end, opposed frame plates 138 provided on the end circuit breaker mechanisms 130 and 132. Only the bearings 137 and the plate 138 for the circuit breaker mechanism 130 is illustrated in FIG. 18, but it is to be understood that the mechanism 132 is similarly provided. The other frame plates 140 of the end mechanisms 130 and 132 and both plates 141 of the middle mechanism 131 are similar to each other and each is provided with suitable U-shaped notches 139 through which the rod 136 passes. Each of the circuit breaker mechanisms comprise a linkage mechanism 42 and armature devices 44 and 45, as previously described. The rod 136 is provided with three U-shaped fingers 145 having end portions 147 behind the upper bar 48 and rotatable into engagement with the upper bar 48 of the armature device 44 by engagement of loop portions 149 with the nose portion 57 of the catch link 55. FIG. 19 illustrates the relative position between one catch link 55 and one finger 145 during the closed position of the contacts. Rotation of the finger ends 147 counterclockwise is limited by the interference which would result with the armature device 45 so that the loop 149 is always in the path of movement of the nose 57.

Upon a predetermined overload in one of the coils 22 (of one of the circuit breakers), the associated cradle 60 is released by the armature 44, and the lock pin 58 releases the catch link 55 whereupon the nose 57 pivots counterclockwise upwardly and forcefully engages the loop 149, causing the rod 136 to rotate from the position corresponding to the closed position of the contacts, FIG. 19, to that corresponding to the trip position, FIG. 20. This causes each of the finger end portion 147 of the mechanisms of the non-overloaded circuit breakers to rotate their associated armature devices 44 in the direction to release their associated cradles.

The release of the associated cradles, releases the corresponding catch links of the associated linkages, and in this manner, all of the movable arms of the three circuit breaker mechanisms move substantially simultaneously to the contacts open position upon a predetermined overload in any one of the three coils.

The spring which biases the armature device 44 clockwise, so that the armature device 44 always tends to engage the cradle 60, is made strong enough to also rotate the rod 136, due to the abutting relation between the finger end portions 147 and the armature device 44, after the catch link 55 moves from the trip position, FIG. 20, to the contacts open position, similar to FIG. 9, whereupon the rod 136 is automatically reset as are all the linkages 42, as previously described.

FIGS. 23 and 24 illustrate a cradle with a modified spring arrangement wherein two similar springs 160 and 161 are utilized instead of the springs 61 and 88. The springs 160 and 161 are disposed, as illustrated, one between each of the side plates of the cradle and the frame plates 32 and 33. The springs 160 and 161 are coiled about the cradle pintle 62 and have ends disposed against the lock pin 58 and the armature pintle 87 for both biasing the lock pin 58 to the top of the slot 59 and for biasing the lip 63 of cradle 60 into locking engagement with the bottom bars 48 of the armature device 44.

Also, as illustrated in FIGS. 23 and 24 the inner sides of the cradle are interconnected by a U-shaped stop 165 below the pin 58. The stop 165 is positioned so that upon the return movement of the catch link 55, the bottom of the nose portion 57 will strike the stop 165 and tend to rotate the cradle 60 toward the lower bar 48, aiding the springs 160 and 161 in this respect. Also, the stop 165 with the stop 92 limits the movement of the linkage toward the off position of the contacts and holds the nose portion 165 in close proximity to the lock pin 58 so that when the circuit breaker is in the off position, and the handle is turned toward the on position, the linkage responds immediately because the nose 57 is close to the lock pin 58 or in abutment therewith. When the stop plate 165 is utilized, the stop pin 126, previously mentioned is omitted.

While specific ranges of angles and other numerical values have been stated, it is to be understood that the invention may be practised with an arrangement of parts resulting in different values.

From the foregoing it is seen that a four bar linkage has been provided, one of which forms with a fifth link a toggle and another link of which is engageable with a lock carried by a rockable cradle controlled by an armature device in an improved arrangement to provide a fast opening circuit breaker mechanism.

Having described this invention, I claim:

1. In a circuit breaker the combination comprising stationary and movable contacts, a frame plate, a case, a stationary arm carrying said stationary contact and mounted to said case; a four bar linkage comprising a handle link, a catch link, a connecting link and a fourth link; the handle link, the catch link, the connecting link and the fourth link being pivotally connected to define a four-bar linkage; a cradle restraining movement of said catch link when the circuit breaker is in the contacts closed position, a handle connected to said handle link, said stationary contact being engageable by said movable contact, a fifth link forming with said fourth link a toggle, said frame plate being secured to said case, a pintle to which are pivotally connected said handle and said catch link, said catch link and said handle link being pivotal on said pintle, a lock yieldingly carried by said cradle and engageable with said catch link, a spring biasing said lock and said cradle toward a position in which said lock is engageable by said catch link, a movable arm to which is secured the movable contact, said movable arm being connected to said fifth link and controlled thereby, an electromagnetic means to release said cradle from said catch link, stop means limiting overtravel movement of said toggle when the contacts are closed, and an opening spring means having a portion mounted to said frame plate, said spring means engaging and biasing said movable contact arm to the contacts open position, said links being proportioned relative to each other to permit said

toggle to act as a rigid strut to transfer the opening spring pressure to said catch link as the movable arm moves to the contacts open position.

2. The structure recited in claim 1 and further including a spring carried by said movable arm and the fifth link to reset the catch link with the lock of the cradle by automatically, pivotally moving, in the direction to return the catch link toward restraining engagement with said lock, the handle link, connecting link, and the fourth and fifth links after the movable arm has moved sufficiently toward the contacts open position.

3. In a circuit breaker the combination comprising stationary and movable contacts, a stationary arm carrying said stationary contact and mounted to said case, a movable arm carrying said movable contact, a linkage pivotally connected to said movable arm and comprising two toggle links pivotally connected to each other by a first pintle to form a knee, one of said toggle links being pivotally connected to said movable arm by a second pintle, a catch link pivotally connected by a third pintle to the other of said toggle links, a handle link pivotally connected by a fourth pintle to said catch link, a case, two frame plates secured to said case, a connecting link pivotally connected by a fifth pintle to said handle link and pivotally connected to said toggle, frame plates supporting the ends of said fourth pintle and between which said linkage is mounted, all of said links depending from said fourth pintle, all of said pintles other than said fourth pintle being movable between the two frame plates, a fixed abutment having its ends connected to said frame plates, said abutment being engageable with the end of the movable arm remote from the movable contact, an opening spring biasing said movable arm to the contacts open position, said opening spring being mounted on said abutment on opposite sides of said movable arm and having a portion in engagement with said movable arm to laterally position said movable arm and, hence, laterally position the links depending from said fourth pintle with respect to the frame plates, a pin secured to said frame plates to limit overcenter travel of the toggle knee in the contacts closed position of the movable arm, a lock restraining said catch link below predetermined current values, the force of said opening spring being transmitted by said toggle links to said catch link by the toggle links, said connecting link retaining said toggle link in force transmitting relationship until the contacts are sufficiently open, at which time the knee is moved overcenter away from its contacts closed position, a reset spring carried by said movable arm and one of said toggle links, whereupon sufficient movement of the movable arm toward the contacts open position said reset spring automatically moves the toggle links, the connecting link and the handle link in the direction to return the catch link toward restraining engagement with said lock.

4. The structure recited in claim 3 and further including a pivotal cradle mounted to said frame plates, said cradle carrying said lock, said cradle including wall structure toward one part of which said lock is yieldingly biased whereby upon the return movement of the catch link, the catch link depresses the lock to return to its locking position.

5. The structure recited in claim 3 wherein said movable arm is provided with a stop limiting movement of the toggle link that is pivotally connected to the movable arm to thereby terminate the resetting movement of the links after electromagnetic opening of the contacts.

6. The structure recited in claim 4 wherein the cradle carries a stop limiting movement of the catch link after the catch link returns into restraining engagement with said lock to thereby terminate the resetting movement of the links after electromagnetic opening of the contacts.

7. In a circuit breaker the combination comprising, a case, a handle, stationary and movable contacts, a stationary arm carrying said stationary contact and mounted to said case, a movable contact arm carrying said movable contact and biased to the open position of the contacts, a frame mounted to said case, an automatically resettable linkage mechanism pivotally secured to said frame, said linkage mechanism comprising a plurality of force transmitting elements connected to said handle and to said movable arm, said linkage mechanism including a catch link automatically returned to its latching position after unlatching, an automatically resettable restraining means fixed against movement in one direction but yieldable in another direction to latch the catch link and automatically relatch said catch link after unlatching, a cradle means carrying said restraining means, said cradle means being independent of said linkage mechanism in that it is not a force transmitting element between said handle and said movable arm, said cradle means being pivotal from a first position in which it latches said catch link toward a second position during which it unlatches said catch link and back toward said first position before said catch link returns to its latching position, said cradle means being pivotally secured to said frame, and biasing means engaging said cradle means to bias said cradle and restraining means toward the position of said catch link in which said restraining means latches said catch link.

8. In a circuit breaker the combination comprising, a handle, a case through which said handle extends, stationary and movable contacts, said stationary contact being mounted to said case, a movable contact arm carrying said movable contact and biased to the open position of the contacts, a frame mounted to said case, an automatically resettable linkage mechanism pivotally secured to said frame, said linkage mechanism comprising a plurality of force transmitting elements connected between said handle and said movable arm, said linkage mechanism including a catch link automatically returned to its latching position after unlatching, an automatically resettable restraining means fixed against movement in one direction but yieldable in another direction to latch the catch link and automatically relatch said catch link after unlatching, a cradle means carrying said restraining means, said cradle means being pivotal from a first position in which it latches said catch link toward a second position during which it unlatches said catch link and back toward said first position before said catch link returns to its latching position, said catch link depressing said restraining means during resetting of the linkage mechanism to relatch said catch link, said cradle means being independent of said linkage mechanism, said cradle means being pivotally secured to said frame, and biasing means engaging said cradle means to bias said cradle means and restraining means toward the position of said catch link in which said restaining means latches said catch link.

9. The structure recited in claim 8 and further including a pivotal lock bar engageable with said cradle means to restrain rotation of said cradle means under pressure from said catch link, a spring biasing said movable arm to the contacts open position and through said elements of the linkage mechanism biasing, when the movable arm is in the contacts closed position, said catch link against said restraining means which in turn is then biased against said lock bar, and electromagnetic means responsive to the electrical current to pivot and disengage said lock bar from said cradle means upon a predetermined current, whereby said cradle means rotates about its pivot to release said catch link, said electromagnetic means being responsive to the electrical current and comprising a solenoid and an armature device, said armature device including said lock bar.

10. In a circuit breaker, a case, stationary and movable contacts enclosed by said case, said stationary contact being mounted to said case, a frame mounted to said case, said frame including an abutment, a movable contact arm carrying said movable contact and engageable with said abutment at the end portion of the movable arm remote from said movable contact for rotation of

said movable contact arm about said abutment, a handle extending through said case, a linkage mechanism connected to said handle and to said movable contact arm, said linkage mechanism being pivotally mounted to said frame, a spring means mounted to said frame and said movable contact arm to bias said movable contact arm to the contacts open position, said linkage mechanism including a catch link latched to prevent movement of said movable contact arm to the contacts open position under the bias of said spring means, said movable contact arm being mechanically connected only to said linkage mechanism, electromechanical means to latch said linkage mechanism and unlatch said catch link on predetermined currents, said movable contact arm engaging said abutment only in the contacts open position of the movable arm and otherwise being spaced therefrom, said spring means slidably and pivotally moving said movable contact arm about said abutment.

11. In a circuit breaker, a case, stationary and movable contacts, said stationary contact being mounted to said case, a movable contact arm carrying said movable contact, a fixed abutment engageable with a portion of said movable contact remote from said movable contact, spring means biasing said movable arm to the contacts open position and toward said abutment, said arm having a notch, said spring means having a portion thereof lodged in said notch, a latched linkage mechanism connecting said movable arm to a handle for manual operation of the circuit breaker, and additional spring means connected to said linkage mechanism and directly to said movable arm tending to laterally position said movable arm and to automatically relatch said linkage mechanism after said linkage mechanism is unlatched.

12. In a circuit breaker, a case, stationary and movable contacts, said stationary contact being mounted to said case, a movable arm carrying said movable contact, a linkage mechanism to actuate said movable arm, a frame carrying said linkage mechanism, a casing of insulating material, said frame including a stop abutment upon which said movable arm impinges to limit the movement thereof in the opening direction, said stop abutment having feet adjacent the zone of impact between the movable arm and said stop abutment securing the frame to the casing.

13. A circuit breaker comprising a linkage mechanism, a case, stationary and movable contacts opened and closed by said linkage mechanism, said stationary contact being mounted to said case, said linkage mechanism comprising multiple links, a frame secured to said case, a pintle carried by said frame, two of said links being pivoted about said pintle while the others depend therefrom laterally unsecured to said frame, a movable contact arm carrying said movable contact and connected to one of said depending links, a spring for biasing said movable arm to the contacts open position, a fixed abutment against which an end portion of said movable arm remote from said movable contact is biased by said spring and about which said movable arm is pivotal, said depending links and movable arm being restrained from freely moving laterally with respect to said stationary contact by said spring.

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