

July 15, 1958

J. A. OPPEL

2,843,706

ELECTRIC CIRCUIT BREAKER

Filed Sept. 23, 1955

2 Sheets-Sheet 1

Fig. 1.

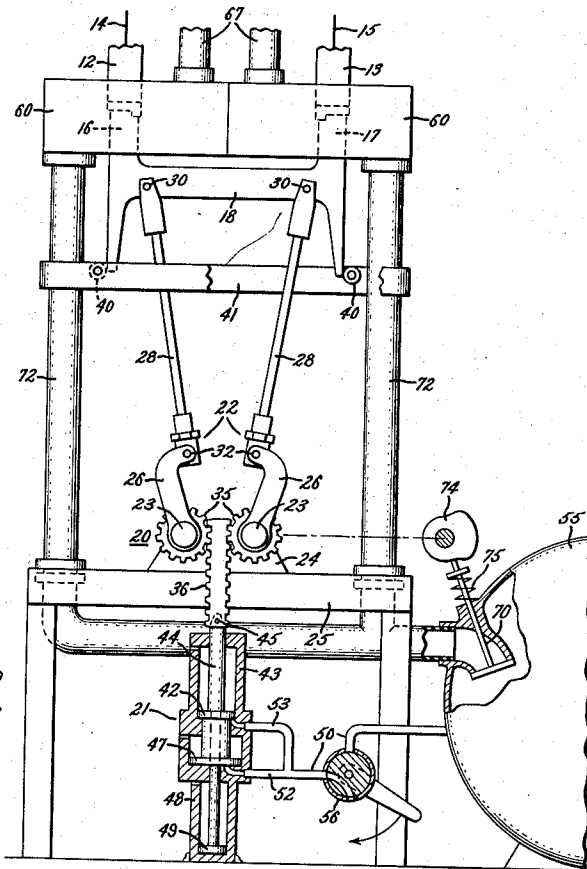
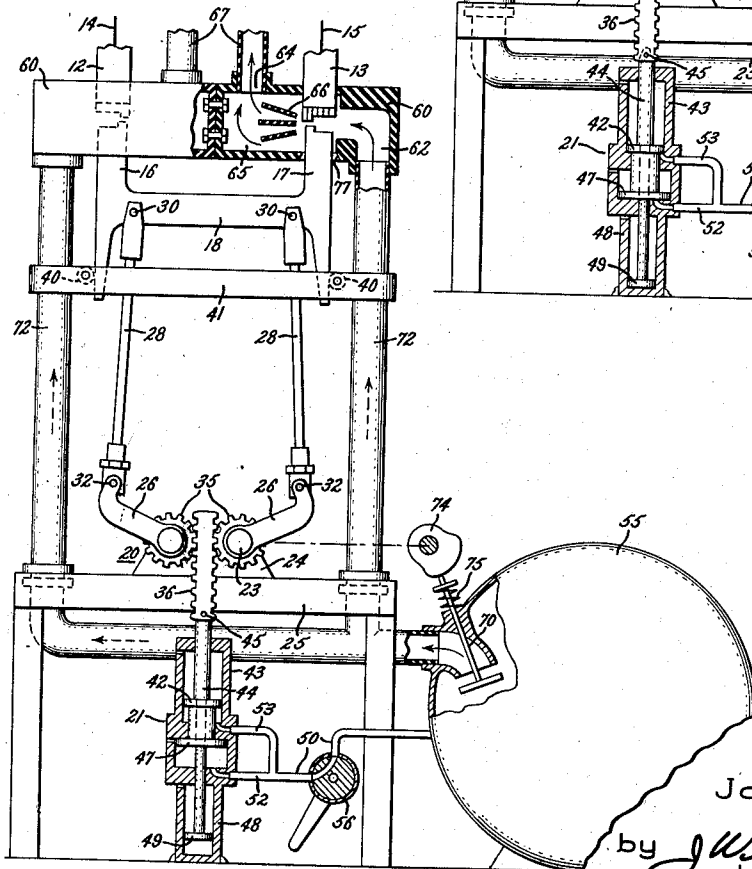


Fig. 2.



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Fig. 3.

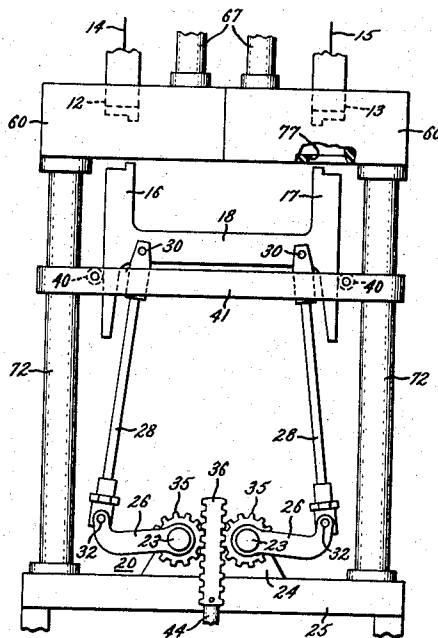
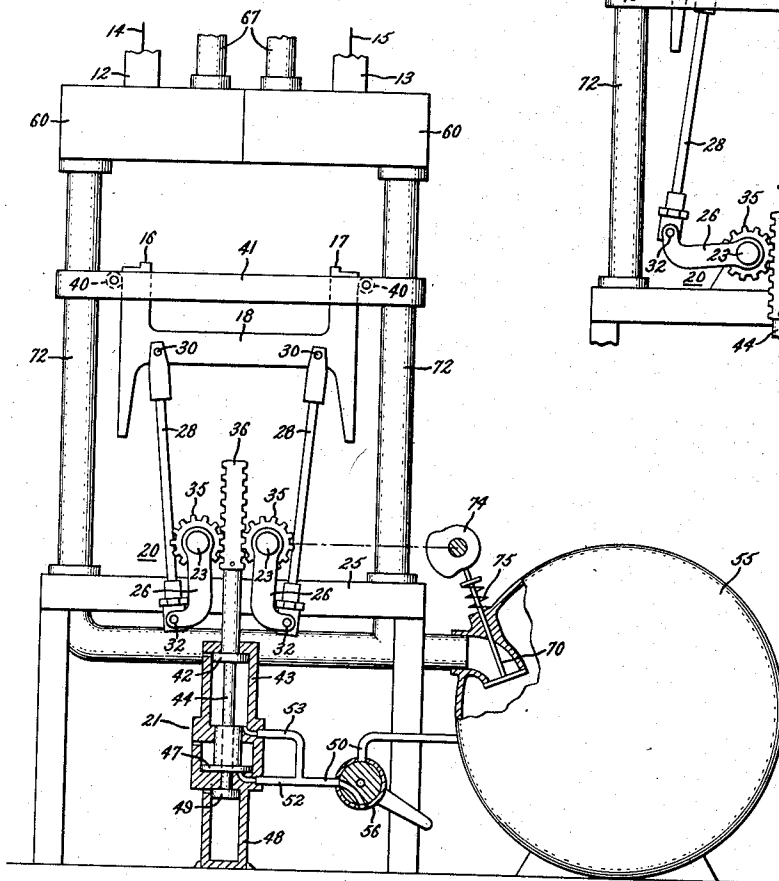


Fig. 4.



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2,843,706

ELECTRIC CIRCUIT BREAKER

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9 Claims. (Cl. 200—148)

This invention relates to an electric circuit breaker and, more particularly, to an operating mechanism which is capable of driving the movable contacts of the breaker in an essentially straight-line path.

The invention has special application to the type of operating mechanism in which reciprocatory motion is imparted to the movable contact structure by means of a rotatable crank and a connecting rod pivotally connected between the crank and the movable contact structure. Such a mechanism is shown in U. S. Patent No. 2,436,190, issued to A. C. Boisseau et al. and assigned to the assignee of the present invention. In order to produce straight-line motion for the contact structure in such a mechanism, it has been necessary to provide guide means, coacting with the contact structure, which extends along an appreciable length of the path of movement for the contact structure. In order to allow for guides of a length sufficient to provide adequate guiding action, it has been necessary to provide contact structure of a much greater length than would otherwise be required. This is frequently disadvantageous because any increase in the length of the contact structure reflects itself in increased overall height for the breaker, and there are many applications where space factors limit the permissible overall height of the breaker.

Thus, a primary object of my invention is to provide an improved circuit breaker operating mechanism which is capable of driving the breaker contact structure in an essentially straight-line path without the need for long guides coacting with the contact structure.

Another object is to provide a straight-line operating mechanism which has its highest degree of stability during that portion of the breaker stroke at which precise guidance of the contact structure is most required. For example, with reference to a breaker having a contact member movable into and out of a highly-restricted opening in the wall of an arc chute, it is an object of my invention that the mechanism have its highest degree of stability in the region just ahead of the point at which the contact member enters the opening, so as to insure that the contact member is precisely guided into the opening without harmfully engaging the adjacent wall.

Another object is to provide for a fluid-blast breaker an arc-chute assembly which is so arranged that the high-velocity flow of fluid therethrough produces substantially no harmful resultant forces external to the assembly.

In accordance with a preferred form of my invention, the contact structure for the breaker is mounted on a crosshead which is guided for movement in an essentially straight-line path. For driving the cross-head along this path, there is provided operating mechanism comprising a pair of relatively rotatable driving shafts which are driven simultaneously in opposite directions of rotation about stationarily-located axes at substantially the same speed. Mounted on said shafts is a pair of cranks of equal effective lengths which are symmetrically located with respect to a reference plane which is equi-distant from the axes of said shafts and which extends parallel to

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the path of movement of said crosshead. The outer ends of the cranks are pivotally coupled to the crosshead by means symmetrically located on opposite sides of the reference plane.

In accordance with another feature of my invention, the above mechanism is utilized for contact structure which moves into and out of a highly restricted opening in a wall of an arc-confining device, and the cranks are so arranged that their outer ends are spaced apart to about the maximum extent during the portion of the breaker stroke just ahead of the point at which the contact structure enters the opening. This relationship of the cranks renders the mechanism most stable at the instant when precise guidance of the contact structure is most needed and thereby insures that the contact structure is precisely guided into the opening without harmfully engaging the adjacent wall.

For a better understanding of these features as well as other features of my invention, reference may be had to the following specification taken in connection with the accompanying drawing, wherein: Fig. 1 is a side elevational view, partly schematic, showing a circuit breaker constructed in accordance with my invention. The breaker is illustrated in closed position. Fig. 2 is a view similar to that of Fig. 1 showing the breaker in a position through which it passes shortly after an opening operation has been initiated. Fig. 3 shows a portion of the breaker later in the opening stroke, whereas Fig. 4 shows the position of the breaker parts when the opening operation has been completed.

Referring now to Fig. 1, the circuit breaker shown therein comprises a pair of spaced-apart stationary contacts 12 and 13 which are respectively connected to opposite terminals 14 and 15 of the breaker. Coacting with the stationary contacts and connecting them in series circuit relationship are a pair of simultaneously movable contact blades 16 and 17, which are electrically interconnected by means of a conductive crosshead 18. This crosshead 18 is shown integral with the contact blades 16 and 17 but can be rigidly connected to the blades in any suitable manner. In Fig. 1, the cooperating contacts are shown in the closed-circuit position.

Separation of the contacts to interrupt the circuit is achieved by driving the movable contact assembly 16, 17, 18 rapidly downwardly in an essentially straight-line path by means of an operating mechanism 20 constructed in accordance with my invention. This operating mechanism 20 comprises a motive device, such as the fluid motor designated 21, and an operating linkage 22 connected between the fluid motor 21 and the crosshead 18. The operating linkage 22 comprises a pair of spaced-apart driving shafts 23 which are rotatably mounted in stationary bearing structures 24 suitably fixed to an adjacent framework 25. Keyed or otherwise rigidly secured to each of the shafts 23 is a driving crank 26. Each of the cranks 26 is operatively connected to the crosshead 18 by means of an insulating connecting rod 28, one end of which is pivotally connected at 30 to the crosshead 18 and the other end of which is pivotally connected at 32 to the outer end of the crank 26. The crosshead pivot joints 30 are located in essentially the same horizontal plane and at locations spaced apart as widely as practicable. The two cranks 26 are of equal effective length and are symmetrically disposed with respect to a vertical extending reference plane located equidistant from the axes of shafts 23, which plane also includes the axis of the fluid motor 21. Likewise, the crosshead pivot joints 30 are equally spaced from this central reference plane. The importance of this symmetrical disposition of the parts of mechanism will soon appear more clearly.

Motion is transmitted to the driving shafts 23 by a pair of identical pinions 35, each of which is keyed to a dif-

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ferent one of the shafts. These pinions 35 cooperate with a double-sided rack 36 having teeth on its opposite sides which mesh with the teeth of the two pinions. When the rack 36 is driven upwardly, it rotates the pinions 35 and hence the cranks 26 in opposite directions at the same angular speed. As will be apparent from the various figures of the drawing, this crank movement, acting through the connecting rods 28, drives the movable contact assembly 16, 17, 18 vertically downward in an essentially straight-line path.

During this entire downward movement, the two halves of the linkage which are disposed on opposite sides of the centrally-located, vertically-extending reference plane remain symmetrical with respect to said plane. As a result of this symmetrical disposition throughout the stroke, the two crosshead pivot joints 30 move vertically downward at the same speed. Accordingly, operation of the mechanism produces essentially no tendency of the crosshead to rock out of its normal horizontally-disposed position. Another important result of the above-described symmetrical disposition is that the horizontal component of force transmitted to the crosshead through one connecting rod is balanced by the horizontal component transmitted to the crosshead through the other connecting rod. Accordingly, essentially no resultant horizontal force is imparted to the crosshead from the connecting rods.

Thus, since operation of the mechanism produces essentially no tendency of the crosshead 18 to rock and essentially no horizontal force component on the crosshead, guidance in a straight-line vertical path of the crosshead and hence the contact assembly becomes a relatively simple matter. It is no longer necessary to resort to guide means which extends, in the usual manner, over a substantial portion of the length of the contact assembly. Precise guidance can be obtained by utilizing guide means which extends over only a minimum length of the contact assembly. For example, I can provide adequate and precise guidance by utilizing only a single pair of horizontally aligned rollers 40 which, at any instant, engage the contact assembly generally along only a single horizontal line. These rollers 40 preferably are mounted on a horizontally-extending stationary brace 41.

Any slight freedom of motion which the crosshead might have as a result of clearance or play in the various pivot joints or backlash in the gears is effectively minimized in my linkage by virtue of the fact that the crosshead pivot joints 30 are located as near as practicable to the opposite ends of the crosshead. Hence, there is little tendency for any slight play in the linkage to become magnified at the ends of the crosshead, where the contact blades are located.

The disclosed rack and pinion arrangement 35, 36 is especially advantageous for several reasons. First, because the rack and pinion teeth which are located at opposite sides of the rack are subjected to substantially the same loads, these teeth will wear at essentially the same rate. This insures that the pinions will continue to move at essentially the same rate of angular motion, as is desired, throughout the life of the breaker. Secondly, the disclosed rack and pinion arrangement obviates the need for providing separate guides for the rack. The pinions themselves constitute guides which act to insure that the rack will always be held in proper meshing engagement with the pinion teeth. Thirdly, the downwardly-moving contact parts are largely counterbalanced by the upwardly-moving rack and its associated fluid motor parts, and, as a result, there is no substantial mass movement in any one direction during an opening or closing operation.

Although, in the preferred form of my invention shown in the drawing, full pinions 35 are utilized for driving the cranks 26, it will be apparent that toothed sectors could equally well be used since the cranks move through

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only a portion of a complete revolution. It will also be apparent that in certain applications the pinion, or sector, can be directly secured to, or formed integral with, its corresponding crank 26, in which case the shaft 23 would serve only as a support providing a pivot axis for the crank and pinion.

Operation of the fluid motor 21 to effect the above-described upward opening movement of rack 36 is produced by supplying pressurized fluid to the underside of a main piston 42 which is reciprocable in the cylinder 43 of the motor. The piston 42, which has a piston rod 44 connected to the rack 36, responds by driving the rack upwardly as desired. Preferably, the connection between the piston rod and the rack comprises a suitable pivot joint 45 which allows for slight misalignment between the piston rod and the rack.

To aid the main piston 42 during the initial portion of the opening stroke so that a fast initial opening impulse can be imparted to the movable contact structure, there is provided a booster piston 47, which is shown having a larger diameter than the main piston. As seen in Fig. 1, this booster piston 47 fits freely about a lower extension of the piston rod 44 and has an upwardly projecting sleeve portion which bears against the underside of the main piston 42. This booster piston is actuated by pressurized fluid supplied to its underside at the same instant that fluid is supplied to the main piston. Thus, the rack 36 is initially driven by both pistons 42 and 47. This continues until the booster piston reaches the end of its short opening stroke, as seen in Fig. 2, after which continued movement of the rack is produced solely by the main piston 42, as is apparent from Fig. 4. A suitable double-acting dashpot 48 having a piston 49, which is fixed to the lower extension of the piston rod 44, controls the speed of the mechanism in a conventional manner.

For supplying pressurized fluid simultaneously to the two pistons as described above, there is provided a supply line 50 terminating in a pair of parallel ducts 52 and 53 leading to the two pistons. This supply line 50 is connected to a suitable source 55 of pressurized fluid and contains a three-way control valve, shown schematically at 56. When this valve is actuated in the direction of the arrow in Fig. 1, either manually or by conventional electroresponsive means, it establishes communication between the source 55 and the parallel ducts 52 and 53, as seen in Fig. 2, and thereby produces operation of the fluid motor 21 in the manner above described.

For rapidly extinguishing the arcs which are drawn between the cooperating contacts when they are separated by the above-described opening action, I provide, for each pair of cooperating contacts, an arc chute 60 which is supplied with arc-extinguishing fluid from the source 55. Each of these arc chutes 60 is of a conventional form, such as is described in greater detail in Prince Patent 2,284,842, assigned to the assignee of the present invention. As shown in Fig. 2, each chute comprises an inlet or blast port 62, an exhaust port 64, and a main cross-blast passage 65 extending between these ports and transversely across the arc gap formed by separation of the contacts. Mounted within this main passage are suitable transverse baffles 66 having their edges adjacent the arc gap. When an arc is established between the separating contacts, pressurized fluid flowing from the blast port 62 drives the arc against the edge of the baffles, thereby extinguishing the arc in a well-known manner. The exhaust gases containing the arcing products are led from the chute through the exhaust port 64 and a suitable duct 67 extending therefrom to atmosphere.

For controlling the flow of fluid to each of the arc chutes 60, I provide a suitable biased-closed blast valve 70 which can be opened to permit pressurized fluid to flow from the source 55 through two vertically-extending conduits 72 to the blast ports of the arc chutes. The valve 70 is controlled by a suitable cam 74 coupled

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to one of the pinion shafts 23. When the breaker is in the closed position of Fig. 1, the valve 70 is maintained closed by source pressure thereon and by a suitable spring 75, but when the above-described opening action is initiated, as by movement of the mechanism through the position of Fig. 2, the cam is rotated to force the valve 70 open and to cause pressurized fluid to flow through the conduits 72 to the arc chutes 60. Such gas-blast action extinguishes the arcs and interrupts the circuit in the manner previously described. When the breaker has moved into its fully open position shown in Fig. 4, the cam 74 has rotated sufficiently to permit the blast valve 70 to return to its closed position under the bias of spring 74.

As will be evident from Fig. 2 of the drawing, the two arc chutes 60 are connected together in back-to-back relationship with their main passages 65 in general alignment. This is an especially advantageous arrangement in that it enables me to minimize the horizontal component of the forces produced by the high-velocity blasts of arc-extinguishing fluid as they flow into and out of the chutes. Since the two arc-extinguishing blasts flow through their respective chutes substantially simultaneously and in generally opposite directions, the horizontal force component produced by diverting one of the blasts from the inlet port 62 into the main arc passage 65 of one chute is balanced by an equal and opposite force component similarly produced in the other chute. Likewise, the horizontal force component produced in one of the chutes by diverting the exhaust gases from the main passage 65 into the exhaust duct 67 is balanced by an equal and opposite force component similarly produced in the other chute. The result is that substantially no resultant horizontal force is produced external to the two chutes. This is a highly desirable feature in the type of breaker such as shown, i. e., one which has arc chutes mounted at its top, since any external horizontal forces produced in this region could easily establish objectionably high cantilever stresses in parts such as the relatively-long, vertically-extending insulating conduits 72.

Because of their resulting high degree of stability, the conduits 72 form an ideal support on which to locate the guide rollers 40. To this end, the brace 41, which carries the guide rollers 40, is suitably anchored at its opposite ends to the two conduits 72. This arrangement assures that the rollers will remain stationarily located during all phases of breaker operation, thereby assuring that the rollers 40 will contribute in the intended manner to straight-line motion of the contact structure 16, 17, 18.

For higher voltage applications, it may be advantageous to tie the arc chutes 60 together through, say, a porcelain insulator, instead of directly back-to-back as shown.

For returning the breaker from the fully-open position of Fig. 4 to the closed position of Fig. 1, all that is required is that the piston 42 be driven in a reverse direction to that previously-described, i. e., from its elevated position of Fig. 3 to its lower position shown in Fig. 1. This moves the mechanism through the various illustrated positions in reverse sequence to that described for opening, thereby closing the breaker. Driving the piston in this reverse direction is accomplished by supplying fluid from the source 55 to the top side of the piston 42, as by a separate duct leading from the source 55 to the top of the cylinder and a suitable closing control valve. Neither this duct nor the closing control valve is shown since they can be of any suitable conventional type and since they form no part of the present invention.

An important feature of my invention is that at the instant during the closing stroke when precise guidance of the moving contact structure is most needed, my mechanism is in its most stable position and therefore

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can provide the required precise guidance. This instant is illustrated in Fig. 3 where the contact blades 16 and 17 are shown just as they are about to enter their respective arc chutes through contact-receiving openings 77 provided therein. These openings 77 must have only slight clearance with respect to the contact blades in order to insure against wastage of arc-extinguishing fluid and in order to maintain the arc and its incandescent vapor products confined within the chute. With such limited clearance, it will be apparent that even slight deviation of the blades 16, 17 from their preselected path can cause undesirable contact between the end of the blades and the walls of the chutes. The likelihood that any such deviation will occur is minimized in my mechanism by virtue of the fact that at this particular instant the mechanism is in a position of maximum stability, where it can best resist any forces tending to produce such deviation. More particularly, the cranks 26 are then disposed in essentially horizontal relationship with the pivot pins 32 at the outer end of the cranks spaced apart to the maximum possible extent. Since these pivot pins 32, in effect, define the width of a base through which opposing forces applied to the contact structure react, the base is widest at this instant. Such a wide base structure is most stable and is highly resistant to forces tending to produce deviation of the contact structure. Thus, correct entry of the blades into the openings is assured. As the closing operation continues and the pivot pins 32 approach each other, the mechanism may, due to pin clearance, become slightly less stable, but then the walls of the openings 77 are available to provide any additional guiding action which might be required.

It should be apparent from the drawing that each of the cranks 26 forms with its corresponding connecting rod 28 a toggle mechanism. When the breaker approaches the closed position shown in Fig. 1, the toggle 26, 28 approaches its dead center position, and, as a result, can apply maximum forces to overcome any magnetic opposing forces established as a result of closing on an energized, or even short-circuited, line. Preferably, the toggle 26, 28 is driven into a slightly overcenter position, as shown in Fig. 1, coincident with completion of the closing stroke so that the contacts are then prevented from accidentally opening under the influence of magnetic forces, or from creeping out from this sustained closed position. Thus, it will be apparent that my mechanism retains the usual advantages of a toggle-type linkage without in any way impairing its ability to produce the precision straight-line motion described hereinabove.

For simplicity, this description has been directed to a single-phase circuit breaker, but it will be obvious to those skilled in the art that my invention is equally applicable to a multi-phase breaker. In this latter type of breaker, a separate operating linkage corresponding to the linkage 22 described would be provided for each phase of the breaker, and the cranks 26 of each linkage would be appropriately secured to extensions of shafts 23.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In a circuit breaker comprising movable contact structure mounted on a crosshead which is guided for motion in an essentially straight-line path, operating mechanism for driving the crosshead along said path comprising a pair of spaced-apart shafts having stationarily-located axes, a pair of cranks of substantially equal effective length each of which is mounted for pivotal movement on a different one of said shafts, said cranks being symmetrically located with respect to a reference plane

which is disposed midway between said shafts and extends parallel to the path of movement of said crosshead, means coupling the outer end of each of said cranks to said crosshead, and means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed.

2. In a circuit breaker comprising movable contact structure mounted on a crosshead which is guided for motion in an essentially straight-line path, operating mechanism for driving the crosshead along said path comprising a pair of spaced-apart, relatively-rotatable driving shafts, a pair of spaced-apart toothed arcuate members each of which is arranged to drive a different one of said shafts, a pair of cranks of substantially equal effective length each of which is mounted on a different one of said shafts and is arranged to be driven by its respective shaft, said cranks being symmetrically located with respect to a reference plane which is disposed midway between said shafts and extends parallel to the path of movement of said crosshead, means coupling the outer end of each of said cranks to said crosshead, and means for simultaneously driving said shafts in opposite directions of rotation at substantially the same speed comprising a double-sided rack located between said toothed members and having teeth on its opposite sides for drivingly engaging said members.

3. In a circuit breaker comprising movable contact structure mounted on a crosshead which is guided for motion in an essentially straight line path, operating mechanism for driving the crosshead along said path comprising a pair of cranks of substantially equal effective length respectively mounted for angular movement about spaced-apart, stationarily-located pivot axes, said cranks being symmetrically located with respect to a reference plane which is equidistant from said axes and which extends parallel to the path of movement of said crosshead, a pair of connecting links each respectively pivoted at one end to the outer end of a corresponding one of said cranks, the opposite ends of said links being pivotally connected to said crosshead at spaced-apart points thereon, and means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed.

4. In a circuit breaker comprising movable contact structure mounted on a crosshead which is guided for motion in an essentially straight-line path, operating mechanism for driving the crosshead along said path comprising a pair of spaced-apart shafts, a pair of cranks of substantially equal effective length each of which is mounted on a different one of said shafts, a pair of toothed arcuate members each of which is arranged to drive a different one of said cranks, said cranks being symmetrically located with respect to a reference plane which is disposed midway between said shafts and extends parallel to the path of movement of said crosshead, means coupling the outer end of each of said cranks to said crosshead, and means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed comprising a double-sided rack located between said toothed members and having teeth on its opposite sides for drivingly engaging said members.

5. In a circuit breaker comprising movable contact structure mounted on a crosshead which is guided for motion in an essentially straight line path, operating mechanism for driving the crosshead along said path comprising a pair of cranks of substantially equal effective length respectively mounted for angular movement about spaced-apart pivot axes, said cranks being symmetrically located with respect to a reference plane which is equidistant from said axes and which extends parallel to the path of movement of said crosshead, a pair of connecting links symmetrically located on opposite sides of said reference plane for pivotally coupling the outer ends of said cranks to spaced-apart points on said crosshead, and

means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed.

6. In a circuit breaker comprising a pair of contact members mounted at opposite ends of a crosshead which is guided for motion in an essentially straight line path, a pair of cranks of substantially equal effective length respectively mounted for angular movement about spaced-apart pivot axes, said cranks being symmetrically located with respect to a plane which is equidistant from said axes and which extends parallel to the path of movement of said crosshead, a pair of connecting links, each of said links being pivotally connected to the outer end of a corresponding one of said cranks, pivot joints symmetrically disposed with respect to said reference plane and located adjacent the opposite ends of said crosshead for coupling said links to said crosshead, and means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed.

7. In a circuit breaker having contact structure movable along an essentially straight line path into and out of a highly restricted opening in a wall of an arc confining device, operating mechanism for driving said contact structure along said path comprising a pair of cranks of substantially equal effective length each of which is mounted for angular movement about a pivot axis, said cranks being symmetrically located with respect to a reference plane which is equidistant from said axes and which extends parallel to the path of movement of said contact structure, means symmetrically located on opposite sides of said reference plane for pivotally coupling the outer ends of said cranks to said crosshead, and means for simultaneously driving said cranks in opposite directions of rotation at substantially the same speed, the outer ends of said cranks being spaced apart to about the maximum extent during the portion of the breaker stroke just ahead of the point at which the contact structure enters said opening.

8. In a fluid blast circuit breaker of the type comprising a plurality of pairs of separable contacts and a movable crosshead on which one contact of each of said pairs is mounted, a pair of arc chutes for confining the arcs which are drawn between said contacts upon separation thereof, each of said arc chutes comprising an exhaust port, a blast port, and a blast passage extending generally horizontally between said ports for directing an arc extinguishing blast through said chute, means for mounting said arc chutes in rigid relationship with respect to each other and with said blast passages disposed generally in axial alignment, the blast and exhaust ports of each of said arc chutes being so located that flow through one of said blast passages is in an opposite direction to flow through the other of said blast passages, means including a pair of spaced-apart generally vertically-extending conduits for supplying pressurized arc-extinguishing fluid simultaneously to said blast ports, and guide means supported on said conduits for engaging said crosshead and guiding it in an essentially straight-line path.

9. In a fluid blast circuit breaker of the type comprising a plurality of pairs of separable contacts and a movable crosshead on which one contact of each of said pairs is mounted; a pair of arc chutes for confining the arcs which are drawn between said contacts upon separation thereof, each of said arc chutes comprising an exhaust port, a blast port, and a blast passage extending generally horizontally between said ports for directing an arc-extinguishing blast through said arc chute, each of said chutes including an opening for permitting movement of said one contact of a corresponding one of said pairs into or out of said arc chute; means for mounting said arc chutes in rigid relationship with respect to each other and with said blast passages disposed generally in axial alignment, said blast and exhaust ports of each of said arc chutes being so located that flow through one of said blast passages is in an opposite direction to flow through the other of said blast passages; means including a pair

of conduits for supplying pressurized arc-extinguishing fluid simultaneously to said blast ports; and guide means including said openings for engaging and guiding said crosshead in an essentially straight-line path as said crosshead-mounted contacts are moved into or out of said arc chutes. 5

References Cited in the file of this patent

UNITED STATES PATENTS

681,625 Cowles ----- Aug. 27, 1901 10 737,431

Sines ----- Apr. 15, 1919
 Dellagala ----- Jan. 18, 1927
 Grosse ----- Apr. 7, 1942
 Boisseau et al. ----- Feb. 17, 1948
 Amer ----- Nov. 23, 1948
 Matthews ----- July 14, 1953
 McNeill et al. ----- June 26, 1956

FOREIGN PATENTS

France ----- Oct. 3, 1932