Jan. 15, 1963 L. L. BAIRD 3,073,936

ELECTRIC CIRCUIT INTERRUPTER

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Fig. 2.

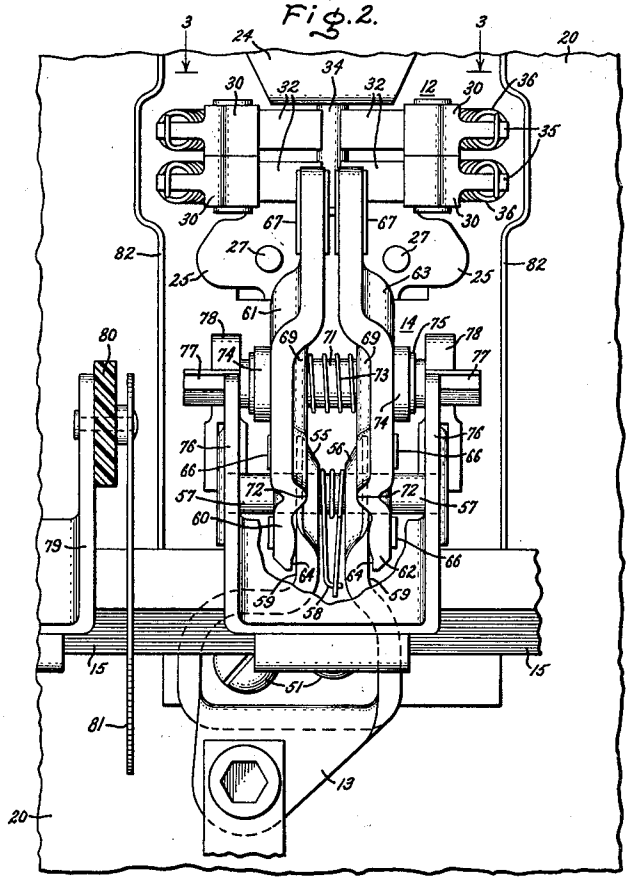


Fig. 1.

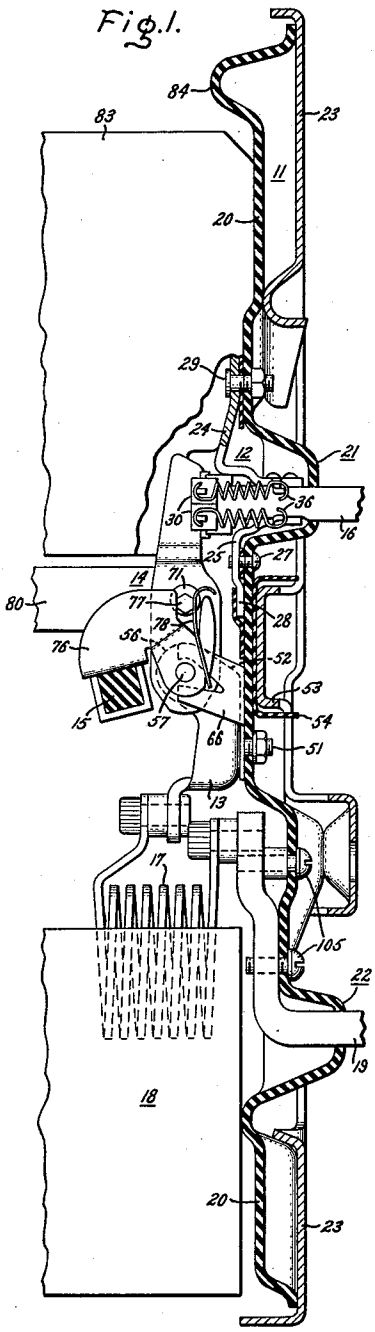


Fig. 4.

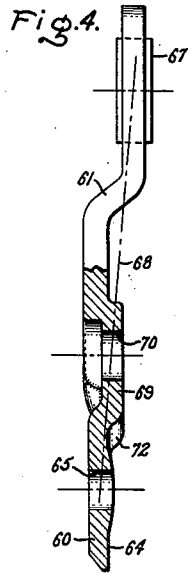
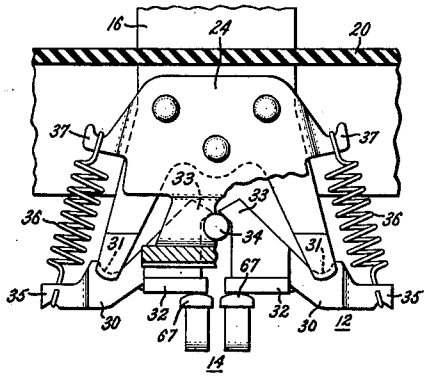


Fig. 3.



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Fig. 5.

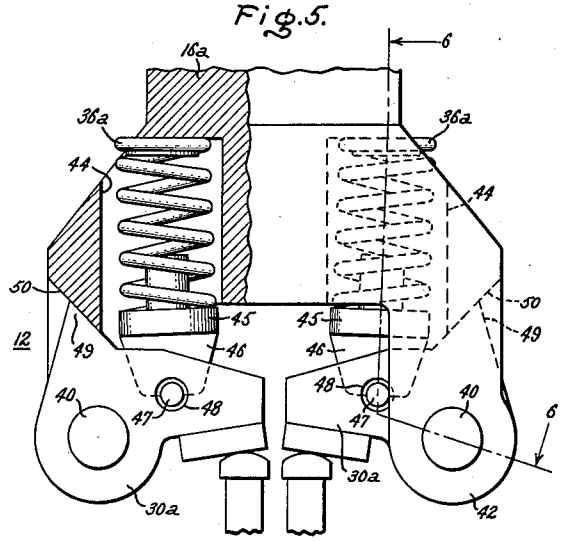
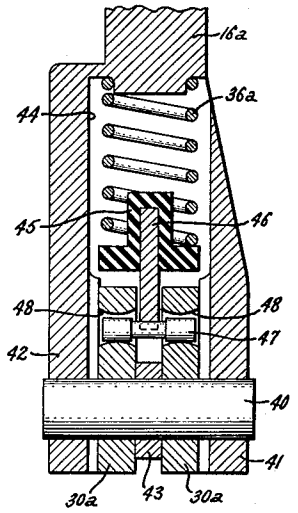


Fig. 6.



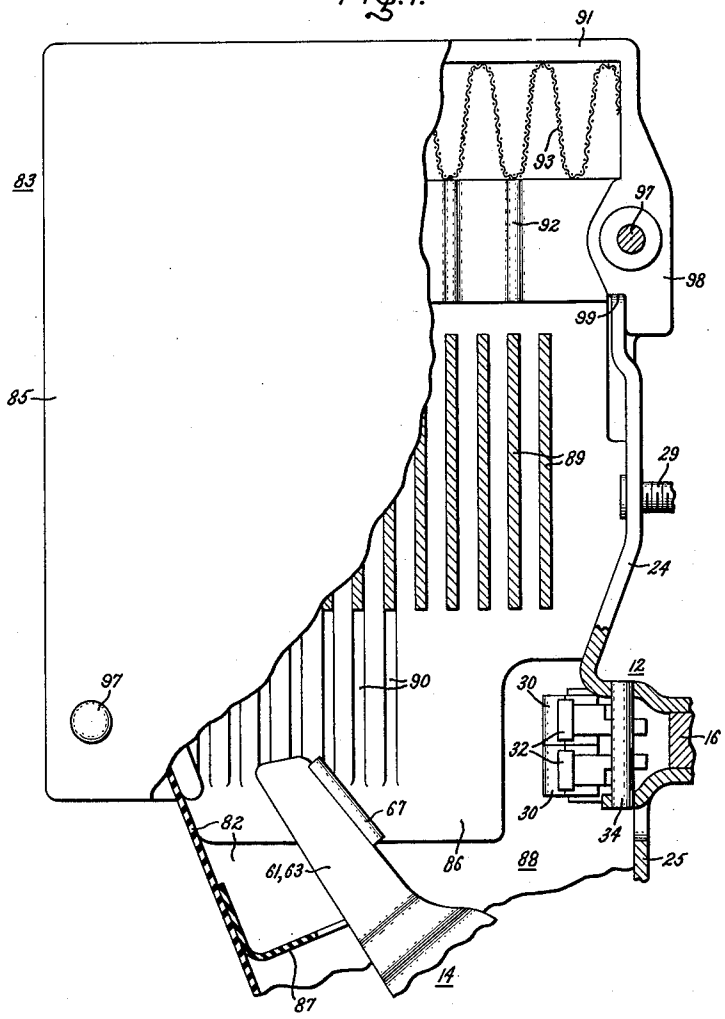
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Fig. 7.



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Fig. 8.

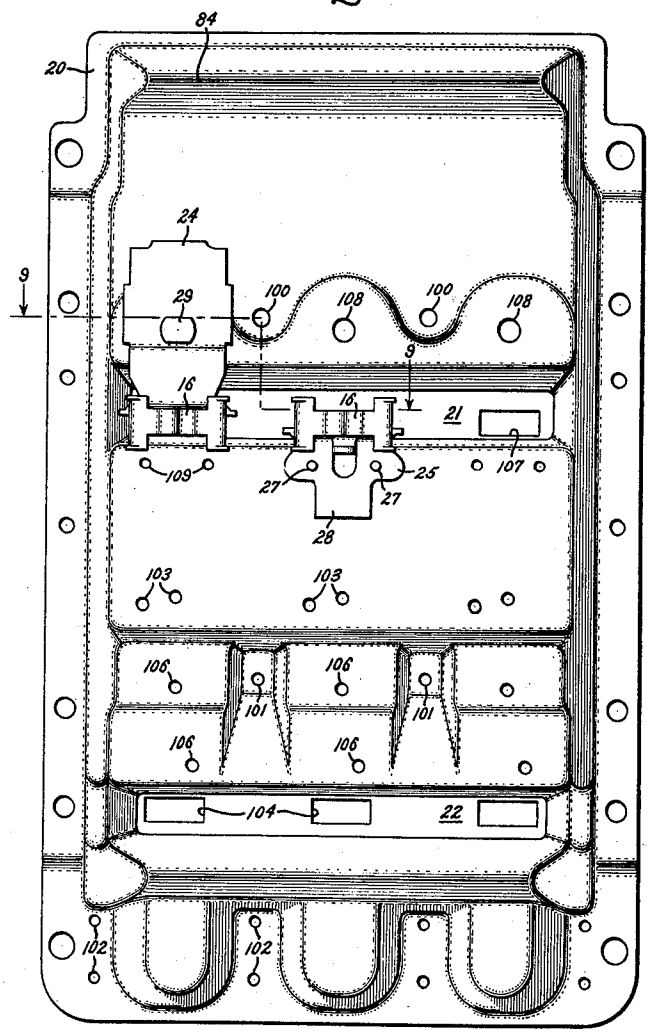
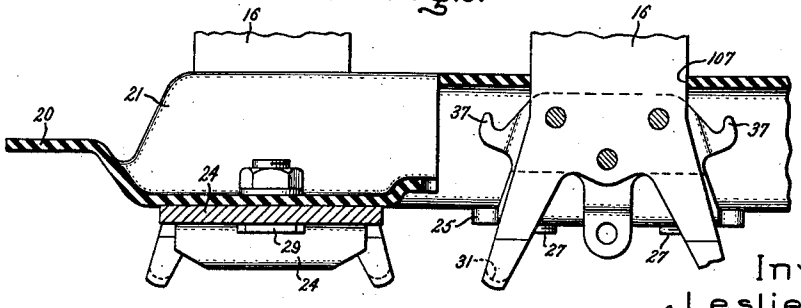


Fig. 9.



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United States Patent Office 3,073,936 Patented Jan. 15, 1963

3,073,936

ELECTRIC CIRCUIT INTERRUPTER

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Filed Oct. 1, 1958, Ser. No. 764,642
33 Claims. (Cl. 200—168)

This invention relates to electric circuit interrupters or breakers, and more particularly it relates to improvements in the contact structure and in the mounting base of a low voltage air circuit breaker.

One object of the invention is the provision of a relatively simple, lightweight and compact circuit interrupter contact structure having abutting movable and relatively stationary contact members so oriented with respect to each other that a plurality of stationary contact elements can conveniently be associated with each movable contact member.

It is another object of the invention to provide in an electric circuit interrupter the combination of an arc chute of the type including arc-chopping metal plates and improved contact structure including a plurality of cooperating contact surfaces arranged to provide at least two parallel paths for current flow, all of the contact surfaces being disposed within the arc chute for substantially simultaneous separation during a circuit interrupting operation.

Another object of this invention is the provision, in a circuit interrupter contact structure, of a pivotally mounted, substantially torsion-free contact arm connected to an actuating member and having an axially offset contact surface disposed for movement into and out of circuit making engagement with a cooperative contact surface of a relatively stationary contact member.

Still another object is the provision, in a contact structure including a relatively stationary bracket having a removable pivot pin for pivotally supporting a movable contact arm, of inexpensive and expedient releasable clamping means associated with the pivot pin intermediate its ends for preventing removal thereof.

A further object of the invention is to provide a circuit breaker mounting base comprising a sheet of substantially uniformly thick insulating material supporting the breaker studs and formed in a manner to provide unusually great strength and rigidity in the areas between adjacent breaker studs.

It is a general object of the invention to provide an improved circuit breaker of the character described hereinafter.

In carrying out my invention in one form, an electric circuit breaker is mounted on a base member comprising a sheet of electric insulating material of substantially uniform thickness. For improved rigidity, the insulating sheet is molded in the form of channel-shaped sections in the areas where the current-conducting studs of the breaker are supported by the base. Mounted on the base is a relatively stationary contact comprising: an electroconductive member electrically joined to one of the breaker studs, at least one contact finger pivotally supported by the electroconductive member, and spring means for biasing the contact finger and permitting deflection thereof. A bracket is mounted on the base in spaced relation to the stationary contact, and a movable contact member is pivotally connected to the bracket for rotation about an axis oriented approximately perpendicular to the pivotal axis of the relatively stationary contact finger. The movable contact member is electrically connected to another breaker stud, and it has a transverse contact surface disposed for circuit making engagement with a co-operative abutting contact surface of the finger. An actuating member is connected to the movable contact member for angularly moving the latter member and its contact surface into abutting engagement with the cooperative contact surface of the finger, thereby deflecting said finger.

In one aspect of the invention, the bracket includes a pair of upstanding lugs supporting a removable pivot pin to which the movable contact member is pivotally connected. Axial movement and hence removal of the pivot pin is prevented by means of a releasable clamp connected to the pin intermediate the upstanding lugs. The releasable clamp comprises a resilient coil encircling and firmly grasping the pin, the ends of the coil being arranged for cooperative movement to expand the coil circumference and thereby release the pivot pin.

In another aspect of the invention, the movable contact member comprises an elongated arm, and the portion of the arm that carries the contact surface is axially offset with respect to the pivotal connection between arm and bracket. This movable contact arm is constructed and arranged so that the lines of action of the resultant forces acting on the arm at its pivotal connection, at its connection to the actuating member, and at the contact surface when in circuit-making engagement with the cooperative contact surface of the relatively stationary contact finger all lie in a common plane, whereby substantially no twisting moment is established in the contact arm.

In still another aspect of the invention, the axially offset end of the movable contact arm and the portion of the relatively stationary contact finger that carries the cooperative contact surface are disposed in an arcing chamber of an arc chute. The arc chute encloses the electric arc drawn between the respective contact surfaces when separated during a circuit breaking operation, and the arc is extinguished in the chute with the aid of a plurality of spaced-apart, arc-chopping metal plates. To increase the current rating of the breaker, a second contact finger is conveniently disposed adjacent the first-mentioned finger, and the second finger is provided with a contact surface disposed in the arcing chamber for abutting engagement with the contact surface of the movable arm. Thus two parallel points of circuit-making engagement are provided between the movable and relatively stationary contacts.

My invention will be better understood and its various objects and advantages will be more fully appreciated from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevation of a circuit breaker contact structure and mounting base embodying a preferred form of my invention, with the base member in section and the movable contact member of the contact structure shown in its closed circuit position;

FIG. 2 is an enlarged front elevation of the contact structure illustrated in FIG. 1, with the movable contact member moved to its open circuit position;

FIG. 3 is a plan sectional view of the contact structure of FIG. 2 taken along the line 3—3 and showing the stationary contact member with the cooperating movable contact member in an intermediate position;

FIG. 4 is a profile view of one arm of the movable contact member shown in FIGS. 1 and 2;

FIG. 5 is a plan view, partly in section, of an alternative embodiment of the stationary contact member;

FIG. 6 is a sectional view of the FIG. 5 embodiment along the line 6—6;

FIG. 7 is an enlarged side elevation, partly in section, of the arc chute shown in block form in FIG. 1;

FIG. 8 is a front elevation of a preferred embodiment of the base member illustrated in section in FIG. 1, two breaker studs being shown secured to the base member by representative supporting angles; and

FIG. 9 is an enlarged sectional view of the base member of FIG. 8 along lines 9—9.

Referring now to FIG. 1, I have shown an electric circuit breaker or interrupter comprising a base member 11,

a relatively stationary contact member 12 mounted on the base, an electroconductive bracket 13 mounted on the base in spaced relation to the stationary contact member, a movable contact member 14 pivotally supported by bracket 13 and disposed in cooperative relationship with the stationary contact member 12, and actuating means such as a crossbar 15 coupled to the movable contact member 14 for moving this member into and out of circuit-making engagement with the stationary contact member 12. The components 12, 13 and 14 comprise the contact structure of one pole unit of an alternating or direct current circuit breaker or interrupter. Although I do not wish to be limited thereto, the preferred embodiment of contact structure has been particularly designed for a 3-pole A.-C. circuit breaker, and for this purpose two other pole units (not shown) substantially identical to that shown in FIGS. 1 and 2 would be mounted for gang operation on the base member 11.

In the preferred embodiment, the stationary contact member 12 of the illustrated pole unit is connected to one phase of a 3-phase A.-C. electric power source or bus by means of an upper current-conducting stud 16; and by means of the bracket 13, an operating coil 17 of an overcurrent trip device 18 and a lower current-conducting stud 19, the movable contact member 14 is connected to a corresponding phase of a load circuit (not shown). The other two companion pole units of a 3-pole breaker are connected by corresponding means to the respective phases of the 3-phase A.-C. bus and load circuit. The electric power bus, not shown in the drawings, may be part of a 600-volt system that is capable of producing as much as 25,000 amperes short-circuit current at 600 volts, and the contact structure of the circuit breaker, which is designed to carry 600 amperes continuously without exceeding permissible limits of temperature rise, can successfully interrupt this maximum short-circuit current. Of course the circuit breaker may be applied in any electric power system to which its capabilities are suited, and the above-mentioned ratings have been set forth only for the purpose of illustrating one range of magnitudes specifically contemplated.

The base member 11 supports all of the current-conducting studs of the breaker and the other breaker parts connected directly to the studs. As illustrated in FIG. 1, the base member 11 in one embodiment of my invention comprises a single sheet 20 of electric insulating material of substantially uniform thickness. The sheet 20 is shaped to form two separate channel-shaped sections or depressions at 21 and 22, and the bottoms of these sections are provided with apertures for snugly admitting and partially supporting the breaker studs 16 and 19, respectively. For the purposes of the present description, the contact structure 12—14 will be considered mounted on the front of the base 11, and the bus and load circuits to which the breaker studs are respectively connected are located behind or to the rear of the base (in other words, on the opposite side of the base member from the circuit breaker). In order to provide extra sturdiness and rigidity, the base member 11 may include a metal frame 23 disposed behind the insulating sheet 20 for supporting the sheet adjacent its outer edges. The base member will be described hereinafter in greater detail in connection with FIGS. 8 and 9.

The stationary contact member 12 is mounted on a portion of upper breaker stud 16 emerging from within the channel shaped base member section 21. As can be seen in FIG. 1, the emergent portion of the stud 16 is secured to the sheet 20 of base member 11 by suitable support means such as generally L-shaped angles 24 and 25. The angles 24 and 25 are respectively disposed above and below stud 16 and are fastened thereto by three copper rivets or the like. The lower angle 25 is provided with a pair of tapped holes, and a pair of appropriate bolts 27 is used to secure this angle to the base member 11 below the lower lip of its depressed section 21. As can be seen in FIG. 1, an integral part 28 of the supporting angle 25 is disposed adjacent the front surface of the sheet of insulating material 20 intermediate the channel-shaped sections 21 and 22. The supporting angle 24, which extends above the breaker stud 16 as is shown in FIG. 1, serves as an arc runner in cooperation with the stationary contact member 12. This angle is provided with a stud 29 for securing it to the insulating sheet 20 adjacent to the upper lip of the depression 21 formed therein.

The end of breaker stud 16 extending forward from the base member is divided into two horizontally diverging branches, whereby this emergent portion of the stud in plan view has a generally Y-shaped appearance. In the preferred embodiment of my invention illustrated in FIGS. 1, 2 and 3, the stationary contact member 12 comprises a plurality of elongated contact elements or fingers 30 each pivotally supported intermediate its ends on the outer end of one of the diverging branches of the breaker stud 16. For this purpose, the outer end of each diverging branch is provided with a generally cylindrical bearing surface 31, the axis of this surface being oriented in a vertical direction as seen in side and front views, FIGS. 1 and 2. The length of the bearing surface 31 can be made sufficient to accommodate two contact fingers 30 in side-by-side relation, and the surface 31 is recessed so that a shoulder is formed at each of its ends to prevent movement of the adjacent contact fingers in a vertical or axial direction with respect to the bearing surface.

Each of the two bearing surfaces 31 of the breaker stud 16 provides a fulcrum for a set of two parallel contact fingers 30, and the pivotal connection between each contact finger and the breaker stud forms a current-conducting joint. As can be clearly seen in FIGS. 2 and 3, the contact fingers 30 are arranged in adjacent pairs. The fingers of each pair are respectively supported on opposite bearing surfaces in opposing relationship with respect to each other, the opposing fingers of each pair being pivotally movable in a common horizontal plane. The opposing or inner ends of the contact fingers of each pair move in separate, relatively short arcuate paths which are respectively parallel to the arcuate paths of movement of the corresponding ends of the adjacent pair of fingers. The opposing ends of the fingers 30 are respectively provided with generally flat, complementary contact surfaces 32 normally disposed in a common vertical plane as viewed in FIGS. 1 and 2.

The inner end of each contact finger 30 is also provided with an extension 33 disposed to engage a common stop 34 for determining the limit of the arcuate movement of the contact surface 32 in one direction. The stop 34, as has been shown in FIGS. 2 and 3, comprises a pin vertically disposed intermediate the divergent branches of the breaker stud 16 and fixedly connected to the upper and lower supporting angles 24 and 25.

Associated with the outer end 35 of each contact finger 30 is suitable spring means, for example, the illustrated tension spring 36 which may be anchored at one end to a fixed member such as provided by the laterally extending lugs 37 of the supporting angles 24 and 25. Thus, spring means 36 establishes a biasing torque in the contact finger 30 tending to move the contact surface 32 along an arcuate path in a forward direction away from the base member 11, and as is clearly shown in FIG. 3, such movement by the finger is limited by stop pin 34. As a result of this arrangement, relatively limited deflection of each contact finger in a rearward direction is permitted.

The biasing torque is opposed and overcome and each contact finger 30 of the relatively stationary contact member 12 is tilted slightly on its fulcrum 31 by the action of the movable contact member 14. As will be fully explained hereinafter, the movable contact member 14 includes a pair of arms respectively provided with contact surfaces 67 which move in parallel planes disposed approximately perpendicular to the planes defined by the parallel arcuate paths of the contact surfaces 32 of each

set of adjacent fingers 30. The actuating means 15 provides actuating force for moving each contact surface 67 of member 14 into and out of circuit-making abutting engagement with adjacent contact surfaces 32 of two parallel contact fingers. During a circuit making operation, the contact surfaces 67 are jointly carried rearwardly from their open circuit position into substantially simultaneous engagement with all of the cooperating contact surfaces 32. FIG. 3 shows the relative positions of the parts when circuit-making engagement is initially established, and further rearward movement of the contact surfaces 67 to their fully closed position forces spring means 36 to stretch as the yieldably supported contact fingers 30 tilt on fulcrums 31. In this manner conventional contact wiping action is obtained.

As is most clearly seen in FIG. 3, the relatively stationary contact member 12 is arranged so that the arcuate path of the portion of each contact surface 32 engaged by a contact surface 67 of the movable contact member is spaced from the fulcrum 31 a distance greater than the length of the moment arm of the line of action of the tension spring 36 with respect to fulcrum 31. In other words, the line of action of the biasing spring force is placed relatively close to the fulcrum, and the force exerted by the contact finger 30 on fulcrum 31 will be more than twice the amount of force applied to contact surface 32 by the movable contact member 14. This results in sufficient force at the fulcrum to ensure a good current-conducting joint between fingers 30 and breaker stud 16.

The details of the above-described relatively stationary contact member 12 have been more fully disclosed and are claimed in Patent 3,033,964-Titus, issued on May 8, 1962. An alternative embodiment of this member is shown herein in FIGS. 5 and 6. Here the opposing contact fingers 30*a* are yieldably supported on breaker stud 16*a* by means including two pivot pins 40. Each pivot pin 40 extends between spaced-apart walls 41 and 42 of each diverging branch of the breaker stud 16*a*, and two adjacent contact fingers 30*a* are disposed on each pivot pin between walls 41 and 42. Suitable spacing means such as a washer 43 may be located between the contact fingers 30*a*. Biasing torque is established in each pair of contact fingers 30*a* by means of a helical compression spring 36*a* disposed in a well 44 located in the breaker stud 16*a*. The compression spring 36*a* acts against a disk-like insulating member 45 which supports and guides a force transmitting link 46. The link 46 is recessed at one end for receiving the midportion of an equalizer pin 47, and the respective ends of pin 47 extend on opposite sides of link 46 into cooperating holes 48 located in the contact fingers 30*a*. It should be apparent from inspection of FIG. 6 that this structure ensures that substantially equal biasing torque is established in the adjacent contact fingers 30*a* by the single compression spring 36*a*. The insulating member 45 is used to prevent current conduction by the spring 36*a*. Pivotal movement of each contact finger 30*a* under the influence of the biasing torque is limited by an extension 49 of the finger which is disposed to engage an inclined stop surface 50 of the breaker stud 16*a*.

Returning now to FIGS. 1 and 2, it can be seen that the electroconductive bracket 13 for supporting the movable contact member 14 is mounted on base member 11 by means of a pair of suitable bolts 51 or the like. An integral part 52 of the bracket 13 is disposed adjacent the front surface of the insulating sheet 20 of base member 11 intermediate the channel-shaped sections 21 and 22. A rigid reinforcing member 53 is disposed adjacent the opposite surface of the sheet 20 intermediate the channel-shaped sections 21 and 22 in overlapping relationship with the integral parts 28 and 52 of the supporting angle 25 and the bracket 13, respectively. The reinforcing member 53 may be part of the metal frame 23, and it is provided so that the loading of the insulating sheet 20 in this area will be in compression rather than in flexure. In other words, the reinforcing member 53 provides a backing for the sheet 20 in an area that would otherwise be stressed in flexure whenever the circuit breaker is closed due to the force of actuating means 15 applied to the movable contact member 14 and hence to the supporting bracket 13 and to the cooperating stationary contact member 12 and its supporting angle 25. A channel 54 of insulating material is disposed intermediate the reinforcing member 53 and the rear of sheet 20 to provide additional electrical insulation between the sides of member 53 and the fastening bolts 27 and 51.

The bracket 13 includes a pair of spaced-apart upstanding lugs 55 and 56 projecting in front of base member 11. A removable pivot pin 57 is supported by the lugs 55 and 56, the axis of the pivot pin extending in a horizontal direction generally parallel to the plane of the base member 11 as viewed in FIGS. 1 and 2. The pivot pin 57, which projects beyond the outwardly facing side of each lug, is retained in place by a releasable clamp 58 connected to the pin intermediate lugs 55 and 56. The clamp 58 comprises a resilient helical coil loosely encircling pin 57, the length of the helix corresponding approximately to the span between the lugs. The opposite ends of the coil of clamp 58 extend tangentially therefrom and are arranged for movement between first and second cooperating positions. In FIG. 2 the ends are shown in a position wherein they releasably engage each other, and in this self-locked position the circumference of the coil is contracted for firmly grasping the encircled pin and preventing axial movement and removal thereof. By separating the ends and permitting them to assume their other position in accordance with the resilience of the coil, the circumference of the coil can be expediently expanded for assembling or disassembling purposes. It will, of course, be understood that this arrangement of the releasable clamp 58 could be reversed, that is, the resilient coil could be designed normally to grasp the pivot pin 57, the coil circumference being expanded to release the pin by forcing the coil ends away from each other.

The outwardly facing side of each upstanding lug 55, 56 is provided with a substantially flat slide surface 59. Disposed adjacent the slide surface 59 of lug 55 and rotatably mounted on pivot pin 57 is one end 60 of an elongated contact arm 61; and disposed adjacent the slide surface 59 of lug 56 and rotatably mounted on the pivot pin 57 is one end 62 of an elongated contact arm 63. The contact arms 61 and 63 are arranged in generally parallel relation for joint operation and comprise the movable contact member 14.

The connection between each movable contact arm 61, 63 and the electroconductive bracket 13 is arranged to provide three separate current-conducting joints. The first such joint is provided by the bearing surfaces between the contact arm and the pivot pin 57 on which it rotates, that is, between pin 57 and the periphery of a hole 65 which has been located in the one end 60, 62 to accommodate the pin 57. The surface of the pivot pin 57 and the periphery of hole 65 may be silver plated and burnished to ensure a wear-resistant, low electric resistance current-conducting path.

The pivoted end 60, 62 of each movable contact arm 61, 63 has a pertaining slide surface 64 on its relatively broad inner side, i.e., on the side of the contact arm facing the companion contact arm. The slide surface 64 is disposed generally parallel to the adjoining slide surface 59 of the lugs 55, 56 of the supporting bracket 13. Both slide surfaces 59 and 64 are disposed substantially perpendicular to the axis of pivot pin 57 which corresponds to the axis of rotation of the movable contact arms 61 and 63. In accordance with the teachings of Patent 2,962,573-Scully, issued on November 29, 1960, the slide surface 64 includes a raised section which, as can best be seen in the FIG. 4 profile view of contact arm

61, preferably comprises a portion of a cylinder. The crest of this raised section is oriented so that it extends in a direction substantially perpendicular to the longitudinal centerline of the contact arm, and it is intersected by the hole 65 provided for pivot pin 57. The crest of the raised section of slide surface 64 is contiguous with slide surface 59 of bracket 13, and pivotal movement of the contact arm or pin 57 causes the crest to slide over the surface 59. The contiguous portions of the slide surfaces 59 and 64 define a line contact which provides the second current-conducting joint between each movable contact arm and the supporting bracket. Of course, as an alternative to the specific arrangement illustrated in FIGS. 2 and 4 and described above, a raised section could be located on slide surface 59 and the slide surface 64 could be made substantially flat.

Contact pressure at the joint formed by the contiguous slide surfaces is maintained by means of an electroconductive spring member 66 which preferably comprises a U-shaped spring clip, the upstanding legs of the clip 66 being split for respectively bearing against the relatively broad outer sides of each contact arm 61, 63 at points disposed on opposite sides of the pivot pin 57. See FIGS. 1 and 2. The electroconductive spring member 66 is secured to the bracket 13, and since it also is in engagement with each movable contact arm it provides the third current-conducting joint. In addition, spring member 66 supplies a force which maintains contact pressure between the contiguous slide surfaces 59 and 64. This force is supplemented by an electromagnetic force whenever the movable contact member 14 is conducting current. Whenever the parallel contact arms 61 and 63 conduct alternating current, a magnetic force is established tending to reduce the spacing between these two arms and thereby establishing additional contact pressure at the contiguous slide surfaces 59 and 64, the magnitude of this force being proportional to the square of the current magnitude.

The diameter of hole 65 in the movable contact arms is made slightly greater than the diameter of pivot pin 57. This arrangement permits the contact arms 61 and 63 to rock on pivot pin 57. The crest of the raised section of slide surface 64 provides a fulcrum for the rocking movement of the arms. This arrangement allows for a certain degree of misalignment of the various parts and a liberal manufacturing tolerance without adversely affecting the positiveness of the electric contact between the movable members and the supporting bracket. By utilizing three parallel current-conducting joints for each of the two parallel arms, the overall electric resistance of the pivotal connection is lowered thereby decreasing temperature rise. In this manner it is possible to obtain a successful contact structure without the conventional flexible braids or conductors.

The corresponding free ends of the contact arms 61 and 63 are provided respectively with elongated, transverse contact surfaces 67 disposed for abutting engagement with the contact surfaces 32 of the relatively stationary contact fingers 30. Each contact surface 67 preferably is generally cylindrically shaped and defines with the abutting surface 32 of each cooperating finger 30 a relatively narrow area of contact engagement. The length of this thin area of engagement or line contact between each movable contact arm and cooperating finger is less than the length of the contact surface 67, as is apparent in FIGS. 1 and 2, and the curved contact surface 67 extends beyond the generally flat contact surface 32 at both ends of the line contact.

Rotary movement of the contact arms 61 and 63 on pivot pin 57 carries both contact surfaces 67 through arcuate paths which define vertical planes intersecting at approximately right angles the parallel planes defined by the arcuate paths of the relatively stationary contact surfaces 32, as viewed in FIGS. 1–3. In other words, each movable contact arm is disposed to move in a plane generally perpendicular to the longitudinal centerline of a stationary contact finger—the axis of rotation of the movable arm being oriented parallel to the plane of movement of the relatively stationary contact finger and the axis of rotation of the relatively stationary contact finger being oriented parallel to the plane of movement of the movable contact arm. This arrangement permits the convenient utilization of two separate stationary contact fingers for each movable contact arm, whereby four separate points of circuit-closing engagement are provided between the movable contact member 14 and the relatively stationary contact member 12.

By utilizing the structure and orientation of the movable and relatively stationary contact members described above, I am able to realize a number of important advantages and improvements over prior art circuit breakers. The desirability of a multi-point contact arrangement is, of course, recognized by those skilled in the art. Since the electric resistance of any single-point contact cannot practically be reduced below a finite minimum value regardless of the contact force applied, total contact resistance is most efficiently reduced by providing parallel points of engagement between the cooperating contact surfaces, substantially the same amount of contact force being applied at each point. In this manner the temperature rise of the contact structure is decreased so that significant economies can be realized in the required minimum sizes of the various current-carrying parts. Two parallel points of contact will enable the breaker successfully to carry at least 225 amperes continuously while four parallel points of contact enable the breaker successfully to carry 600 amperes continuously at 600 volts A.C. By means of the specific orientation of the movable and relatively stationary contact members 14 and 12 of the present invention, I obtain the four points of contact between the abutting contact surfaces 67 and 32 with only two movable contact arms having only one transverse contact surface each. This relatively simple and compact arrangement permits a reduction in the mass of the moving parts thus permitting higher operating speeds while lessening impact stresses and thereby prolonging the mechanical life of the contact structure.

The cooperating contact surfaces 32 and 67 preferably are made of silver tungsten carbide material which will successfully perform not only the continuous current-carrying function of the contacts but also the required circuit making and breaking duty without appreciable contact erosion or pitting or contact welding as a result of electric arcing. Therefore it is not necessary to provide separate arcing and main contacts, and as a result the complexity of the contact structure as well as the necessity for and problems of maintenance are minimized. Due to the particular orientation of the respective elements of the cooperating contact members 12 and 14, all contact surfaces 32 and 67 can be conveniently located in a common arcing chamber of a single arc chute for the purpose of interrupting the electric arc drawn between these cooperating contact surfaces during a circuit opening operation thereof. This latter point will be discussed in greater detail hereinafter.

In order to obtain a compact arrangement at the cooperating contact surfaces 32 and 67, the contact arms 61 and 63 are spaced closer together at their corresponding free ends than at the pivot pin 57. As is shown in FIG. 2, this has been accomplished by axially offsetting the free ends of the contact arms with respect to the pivotally connected ends 60 and 62, respectively. In other words, each free end is disposed inside a plane normal to the pivot pin 57 that intersects the bearing area providing the pivotal connection between the associated movable contact arm (the periphery of hole 65) and pin 57. Thus, the center of the circuit-making surface area of the contact surface 67, that is, the center of the area of surface 67 which engages the contact surfaces 32 of the stationary contact fingers 30, defines with the center of the

pivotal connection to pivot pin 57 a straight line 68 which intersects the axis of rotation (the axis of pivot pin 57) at an oblique angle. See FIG. 4.

In accordance with my invention, the contact arms are oppositely offset at intermeidate portions 69. As indicated in FIG. 4 the offset portion 69 of each arm is provided with a transverse hole 70 the centerline of which is oriented parallel to the pivot pin 57. An actuating member such as a cylindrical impelling shaft 71 is rotatably disposed in hole 70, and by this means actuating force is applied to the movable contact member 14 for jointly moving the contact arms 61 and 63 between open and closed circuit positions. The offset portion 69 of each of the contact arms is so arranged that the line of action of the resultant actuating force intersects the straight line 68. In other words, a common plane of action and reaction is defined by the center of the bearing surface between the impelling shaft 71 and the offset portion 69 of the contact arm, the center of the pivotal connection between pivot pin 57 and the pivoted end of the arm, and the center of the engaging area of contact surface 67. This plane will include the intersection of the respective planes of movement of the cooperating movable and relatively stationary contact surfaces 67 and 32. As a result, there is not net component of actuating force having a moment arm with respect to the straight line 68, and there is substantially no torsion or twisting tendency in the contact arm in its closed circuit position. Such a tendency would be undersirable because it would cause uneven forces along the length of the crest of the raised section of slide surface 64 with respect to the continguous slide surface 59, whereby the effectiveness of this current-conducting joint between the movable contact member 14 and the supporting bracket 13 would be seriously impaired. By substantially eliminating torsion in each of the contact arms 61 and 63, the current-conducting integrity of the area contact joint formed between the pivot pin 57 and the proximate end of each arm is also preserved.

In the vicinity of the offset portions 69 of the contact arms 61 and 63, protrusions 72 are formed. These protrusions 72, which preferably are in the form of curved embossments on the inner sides of the contact arms, are respectively disposed to extend in overhanging relationship with the lugs 55 and 56 of bracket 13. In this manner, the current-conducting joints formed by the contiguous slide surfaces 59 and 64 are shielded from the electric arc and arc products which may be produced during circuit breaking action of the contact structure. The protrusions 72 will prevent particles of foreign matter produced during circuit breaking action from entering these joints by straight-line paths from the area of arc interruption. Such foreign matter, if permitted to enter a joint, could cause excessive wear and increased contact resistance. The shielding arrangement just described is the subject matter of Patent 3,023,292-Stewart issued on February 27, 1962.

The impelling shaft 71 fits relatively loosely in the holes 70 in the offset portions 69 of the movable contact arms 61 and 63, whereby each arm can slide on shaft 71 while rocking on pivot pin 57. Thus the contact surface 67 of each arm is free to move in a lateral or transverse direction, and such lateral movement is controlled by resilient means associated with the contact arm. As is shown in FIG. 2, the resilient means preferably comprises a helical spring 73 disposed on impelling shaft 71 intermediate the contact arms 61 and 63. The spring 73 applies a transverse force to each contact arm and establishes in the arm a relatively weak biasing torque with respect to the pivot provided by the line contact at the joint formed formed by the contiguous slide surfaces 59 and 64. This biasing torque is in a direction tending to spread apart the contact arms. Such movement of each contact arm is stopped and its normal position is determined by a bushing 74 disposed on shaft 71 between a retaining ring 75 or the like and the circular outer side of the offset portion 69 of the arm.

During circuit making action of the contact structure, contact surface 67 comes into abutting engagement with contact surface 32 of a relatively stationary contact finger 30, and as the cooperating contact surfaces wipe the contact finger 30 is tilted on fulcrum 31 in opposition to its biasing torque. The arrangement is such that a transverse force is supplied to contact surface 67 by contact surface 32 as the contact finger 30 moves pivotally on fulcrum 31. Due to the resilient means 73, the movable contact arm yields to this transverse force and the contact surface 67 is able to move laterally while following the arcuate path of contact surface 32. As a result, the relative movement between the cooperating contact surfaces 32 and 67 is reduced thereby reducing the amount of friction between these cooperating surfaces and improving the performance of the contact structure. Such an arrangement is in accordance with the teachings of Patent 2,938,986, Baskerville et al. issued on May 31, 1960.

The movable contact member 14 is coupled to the actuating means or crossbar 15 by means of the impelling shaft 71 and an actuating member 76 preferably comprising a generally U-shaped connecting link securely fastened to the crossbar. Each leg of the connecting link 76 is provided with an extension which, as is clearly seen in FIG. 1, is connected to the pivot pin 57. Thus, the crossbar 15 is supported for pivotal movement on pin 57. The end portions 77 of impelling shaft 71 extend laterally from the contact arms 61 and 63 and are made eccentric with respect to the cylindrical body of this shaft. The end portions 77 are coupled to the connecting link 76 in a manner permitting controlled rotation of the shaft 71. This has been done by providing each end portion 77 with flat sides forming a hexagon, parallel sides of the hexagon being positively but resiliently locked between a shoulder of the connecting link 76 and a cooperating cantilever flat spring 78 carried by link 76. See FIG. 1.

By means of a conventional open-end wrench applied to the hexagonal end portion 77, the shaft 71 may be rotated to any one of six angular positions. In each of these six positions, the movable contact member 14 is located in a different relative angular position with respect to the crossbar 15 and with respect to the relatively stationary contact member 12. The purpose of this adjustment is to accurately establish the fully closed position of the movable contact member regardless of liberal manufacturing tolerances, whereby the desired amount of contact wipe can be precisely obtained. The illustrated contact wipe adjusting means has been more fully disclosed and is claimed in Patent 2,938,095-Baskerville issued on May 24, 1960.

The crossbar 15 is connected to a circuit breaker operating mechanism by means of another link 79 and a connecting member 80. The operating mechanism, which has not been shown, may be of any suitable type for moving the connecting member 80 in a generally horizontal direction (as viewed in FIGS. 1 and 2) and thereby reciprocally carrying the crossbar 15 about its pivot between first and second relatively fixed positions.

The crossbar 15 may be extended across the width of the circuit breaker for connection in a similar manner to other pole units of a multipole circuit breaker. An isolating barrier 81 of insulating material is shown mounted on the crossbar 15 in FIG. 2. Other barriers 82 are provided for the purpose of isolating the various current-conducting parts of the illustrated pole unit from the corresponding parts of adjacent pole units and from ground. A suitable arc chute 83, shown in block form in FIG. 1, is used for the conventional purpose of arc extinction. At a point above the arc chute 83, as viewed in FIG. 1, a ridge 84 is formed in the insulating sheet 20 of the base member 11. The ridge 84 shields the upper edge of the metal frame 23 from the direct blast of ionized arc gases

during circuit interruption, thereby preventing ground currents in this area.

An arc chute 83 particularly well suited for use in combination with the above-described contact structure has been shown partly in section in FIG. 7. This arc chute comprises a pair of spaced sidewalls 85 and 86 of electric insulating material such as porcelain. The arc chute is constructed so that the sidewalls 85 and 86 nest between and extend above the isolating barriers 82 of the illustrated pole unit. The sidewalls define a relatively narrow arcing chamber adjacent the lower end of the chute, as seen in FIG. 7, and a suitable barrier 87 disposed adjacent the lower end of the chute provides a relatively restricted opening 88 therein.

The restricted opening 88 in chute 83 admits the corresponding free ends of arms 61 and 63 of the movable contact member 14 and the opposing ends of each pair of fingers 30 of the relatively stationary contact member 12. Thus all of said ends are enclosed by the spaced sidewalls 85 and 86 which are disposed generally parallel to the arcuate paths of movement of the free ends of arms 61 and 63. Accordingly, all of the cooperating contact surfaces 32 and 67 are disposed in the narrow arcing chamber. The disposition of the contact surfaces to provide as many as four parallel points of abutting engagement within a common arcing chamber of practical width has been made possible by the particular orientation of the movable and relatively stationary contact members 14 and 12 described in detail hereinbefore. When the actuating means 15 moves the movable member 14 to effect substantially simultaneous separation or disengagement of the cooperating contact surfaces during a circuit opening operation of the breaker, an electric arc is initiated within the arcing chamber of arc chute 83.

Located intermediate the upper and lower ends of the arc chute 83 are a plurality of spaced-apart metal plates 89 transversely extending between the sidewalls 85 and 86 and disposed generally perpendicular to the path of the electric arc drawn between the cooperating contact surfaces 32 and 67. In a conventional manner, the arc is driven against the exposed lower edges of the plates 89, and these plates chop the arc into a family of serially related arclets which are subsequently deionized and extinguished as they move within the spaces between adjacent plates.

Such arc-chopping plates 89 contribute to the arc quenching process in several different ways. Their relatively cool surfaces reduce the temperature of the arc thereby enhancing deionization. In order to permanently extinguish the arc and thus interrupt the A.-C. circuit current, it is, of course, necessary to deionize the arc gases at a current zero thereby preventing the reestablishment or reignition of the arc which is periodically discontinued every half cycle as the alternating current goes through zero. The plates 89 further enhance deionization by causing a turbulent mixing of the hot arc gases and relatively cold air in the spaces through which the arclets move. Each arclet has its own anode and cathode voltage drop region adjacent the opposing surfaces of the associated pair of metal plates where the voltage gradient is relatively high, and at least a certain minimum potential difference between the associated plates is required to reestablish the arclet after a current zero. Accordingly, the cumulative effect of the plurality of spaced metal plates is to raise the reignition voltage of the circuit interrupter, that is the potential difference between the separated contact members 12 and 14 that is required to reignite the arc after a current zero, to a point where it exceeds permanently the circuit recovery voltage impressed upon the members 12 and 14 tending to reestablish the flow of current.

The spaced-apart metal plates 89 are held in place by means of appropriate vertical grooves 90 disposed in the opposing surfaces of sidewalls 85 and 86. As can be seen in FIG. 7, reduced-depth portions of some of the grooves 90 extend below the metal plates 89 in order to increase the length of the electrical creepage path over this part of the surface of the sidewalls. The inner portions of these groove extensions are shielded from the intense heat of the electric arc in the arcing chamber and hence are cooler than the remainder of the surface of the sidewalls. The electric resistance of insulating materials is known to decrease with increasing temperature, and accordingly the shielded portions of the surface of the sidewalls provided by the extensions of grooves 90 serve to improve the resistance of the surface. This construction significantly aids the rapid and permanent extinguishment of the arc drawn between the cooperating contact surfaces 32 and 67 as they separate.

The arc products generated in the arc chute 83 during a circuit interrupting operation are exhausted or vented through an outlet 91 provided by an opening between sidewalls 85 and 86 at the upper end of the chute. The hot arc products pass upward from the area of the metal plates 89 through spaces provided between insulating barriers or ribs 92 which extend across the arc chute above the metal plates. At outlet 91 the arc products must pass through a muffler 93 comprising a serpentine strip of perforated metal. The arc products impinge against the muffler 93 and are rapidly cooled thereby. This suppresses flame emisison from the arc chute during a circuit interrupting operation, which flame emission would otherwise result if incandescent arc products were exhausted.

The sidewalls 85 and 86 are assembled and held in spaced relation by a pair of rivets or bolts 97 extending through transverse members 98 of the arc chute 83. As is indicated in FIG. 7, the chute is conveniently mounted on base member 11 by means of an appropriate recess or notch 99 provided in transverse member 98. The notch 99 is disposed to receive an upwardly protruding portion of the supporting angle 24, and the supporting angle 24 is provided with a stud 29 for securing it to the insulating sheet 20 of the base 11. As has been mentioned hereinbefore, the supporting angle 24 also serves as an arc runner in cooperation with the stationary contact member 12.

Turning now to FIGS. 8 and 9, the insulating sheet 20 of the base member 11 will be described in detail. In the preferred embodiment of my invention, the insulating sheet comprises glass fiber laminae bonded with polyester resin. Preferably this material is made flame retardant, i.e., self extinguishing when burned. Manufacture of the insulating sheet is controlled so that it is substantially uniformly thick throughout, the thickness being preferably in the order of magnitude of ⅛ inch. The overall surface area of the illustrated sheet is in the order of magnitude of well over 180 square inches.

The material mentioned above has the following significant characteristics. Minimum physical strength: tensile strength—12,000 pounds per square inch; impact strength—10 foot-pounds per inch of notch (Izod). Minimum dielectric strength: 400 volts per .001 inch perpendicular to laminations; 40,000 volts per inch parallel to laminations. Dimensional stability: the amount of warp or twist of the material varies exponentially as a function of its length, the warp of a 36-inch length after 168 hours at 125 degrees centigrade being no greater than one percent of such length.

The insulating sheet 20 for a 3-pole circuit breaker is molded into the shape indicated in FIGS. 1 and 8. Referring to FIG. 8, the holes spaced along the vertical outer edges of the sheet are provided to receive bolts or other suitable fastening means for the purpose of connecting the sheet to the rigid metal frame 23 and for connecting the operating mechanism and other parts of the circuit breaker to the sheet 20 and frame 23. Holes 100 and 101 are also used in connection with fastening the sheet 20 to the frame 23, the holes 101 being located in the bottoms of depressions which have been formed in the sheet in order to improve its rigidity. By means of holes

102, the overcurrent trip devices 18 may be mounted on the base member. The bolts 51 for mounting the supporting bracket 13 of each pole unit on the base member extend through holes 103 in sheet 20.

The spaced apertures 104 in the bottom of channel-shaped section 22 of insulating sheet 20 admit and partially support the lower breaker studs 19, and the portion of each of these studs emerging from section 22 is secured to the sheet by means of a pair of bolts 105 extending through holes 106 located without this section. Apertures 107 are provided at spaced intervals along the bottom of the channel-shaped portion 21 of sheet 20 for partially supporting the upper studs 16. The stud 29 of the upper supporting angle 24 of each upper stud 16 extends through a hole 108 in sheet 20, and the bolts 27 for the lower supporting angle 25 of each upper stud 16 extend through holes 109 in the sheet. Thus each breaker stud is connected for support to sheet 20 at several points, one point of connection being made in a channel-shaped section of the sheet. The reinforcing member 53 of the metal frame 23 is disposed behind the insulating sheet 20 in the area between the holes 103 and 109. Sections 21 and 22 of the sheet are protruding on this side of the base member as is shown in FIG. 1.

The apertures 104 and 107 in the insulating sheet 20 are preferably located in the bottoms of the two spaced-apart channel-shaped depressions 21 and 22. The channel-shaped depressions, which have been referred to hereinbefore, are provided to improve the structural characteristics of the base. The centerlines of these trough-like portions of the insulating sheet 20 extend in a horizontal direction, and the depressed portions run nearly the entire width of the base member. See FIG. 8.

It will be observed in the sectional view shown in FIG. 9 that corresponding breaker studs 16 of adjacent pole units are disposed in generally close proximity in parallel relationship with respect to each other. Whenever a substantial amount of current is being conducted by these breaker studs, such as during a severe short-circuit condition, strong sidewise magnetic forces will interact thereon. While such current is flowing in the same direction in both of the parallel studs, the magnetic force will act to reduce the spacing therebetween. The same magnetic force will reverse direction and tend to force the studs apart whenever the current reverses in only one stud. Lateral movement of each stud is restricted by the vertical walls of the aperture 107 in the channel-shaped portion 21 and also by the fastening means 27 and 29 which secure the supporting angles 25 and 24, respectively, to the insulating sheet 20 adjacent the channel shaped portion. The sidewise magnetic force is exerted uniformly per unit length of stud, and since the breaker studs 16 extend behind the base member for a greater distance than in front of it, it is evident that opposing bending moments are established in the channel-shaped portion 21 at the centerlines of these studs.

The channel-shaped construction of the insulating sheet 20 in the area of the breaker studs enables the relatively thin sheet 20 to successfully withstand the above-mentioned bending moments. The use of a channel-shaped or trough-like configuration greatly increases the moment of inertia and the section modulus of the portion of the insulating sheet being stressed, thereby significantly increasing its flexural rigidity and decreasing the deformation produced in this portion by the bending moments. Those skilled in the art will understand that the specifically illustrated configuration of base 11 in FIGS. 1, 8 and 9 is not the only configuration enabling these desirable results to be realized. I contemplate, for example, that instead of the three breaker studs 16 (or 19) being supported in the elongated channel-shaped portion or depression 21 (or 22) of constant depth as shown, an oval or round-shaped depression might be formed of the insulating sheet 20 with the portions thereof between studs having reduced depth. The expression "channel-shaped section" as used herein is intended to include such equivalent configurations wherein a cross-section taken through a depressed portion of the base is generally channel or U-shaped.

While I have shown and described a preferred form of my invention by way of illustration, many modifications will occur to those skilled in the art. Therefore, I contemplate by the concluding claims to cover all such 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. An electric circuit interrupter contact structure comprising: a base member; a relatively stationary contact member mounted on the base member; a pair of spaced-apart lugs mounted on the base member in spaced relation to the stationary contact member; a pivot pin supported by the lugs to span the space therebetween; a releasable clamp connected to the pivot pin intermediate the lugs to prevent axial movement of said pin, the clamp comprising a resilient coil encircling the pin and having tangentially extending opposite ends disposed in a cooperating releasably self-maintained position wherein the circumference of the coil is contracted so that the coil is firmly grasping the encircled pin, said opposite ends being movable relative to each other to a different cooperating position wherein the coil circumference is expanded and the pin thereby released for purposes of removal from said lugs; a movable contact arm rotatably mounted on the pivot pin and disposed in cooperative relationship with the stationary contact member; and actuating means coupled to the movable contact arm for moving said arm into and out of circuit making engagement with the stationary contact member.

2. An electric circuit interrupter contact structure comprising: a base member; a relatively stationary contact member mounted on the base; a pair of spaced-apart lugs mounted on the base in spaced relation to the stationary contact member; a pivot pin supported by the lugs to span the space therebetween and projecting outwardly from each lug; a releasable clamp connected to the pivot pin intermediate the lugs to prevent axial movement of said pin, the clamp comprising a resilient helical coil encircling the pin in the space between said lugs and having tangentially extending opposite ends arranged for movement between a normal position and a releasable self-locked position, the coil being disposed whenever said coil ends are in said releasable self-locked position to firmly grasp the encircled pin; a movable contact member rotatably mounted on the outward projections of the pivot pin adjacent the outwardly facing sides of both of said lugs, said movable contact member being disposed in cooperative relationship with the stationary contact member; and actuating means coupled to the movable contact member for moving said member into and out of circuit making engagement with the stationary contact member.

3. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base member; a bracket mounted on the base member in spaced relation to the stationary contact member; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm having at least one contact surface disposed for movement into and out of circuit making engagement with at least one cooperative contact surface of the stationary contact member, said one end being axially offset with respect to the pivotal connection between arm and bracket so that the center of the circuit making surface area of said one end defines with the center of said pivotal connection a straight line intersecting the axis of rotation at an oblique angle; and actuating means connected to the movable contact arm for moving said arm about said axis, said arm being constructed and arranged so that the line of action of the

resultant actuating force applied to the arm intersects said straight line.

4. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base; a bracket mounted on the base in spaced relation to the stationary contact member; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm having at least one contact surface disposed for movement into and out of abutting engagement with at least one cooperative contact surface of the stationary contact member, said one end being axially offset with respect to the pivotal connection between arm and bracket so that the center of the engaging surface area of said one end defines with the center of said pivotal connection a straight line intersecting the axis of rotation at an oblique angle; and actuating means connected to the movable contact arm for supplying actuating force to move said arm about said axis, said arm being constructed and arranged so that the actuating force applied to the arm produces no net moment with regard to said straight line.

5. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base; a bracket mounted on the base in spaced relation to the stationary contact member, said bracket including a pivot pin; a movable contact member comprising a pair of generally parallel, spaced-apart elongated arms connected to the pivot pin for rotation about its axis, said arms having contact surfaces at corresponding ends disposed for movement into and out of abutting engagement with cooperating contact surfaces of the stationary contact member, said pair of arms being spaced closer together at said corresponding ends than at the pivot pin; and actuating means comprising a shaft disposed in parallel relation to the pivot pin and connected to both of the movable contact arms for jointly moving said arms about the axis of said pivot pin, said arms being oppositely offset at their respective points of connection to said shaft, whereby said arms are substantially torsion-free while engaging the stationary contact member.

6. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base member; an electroconductive bracket mounted on the base member in spaced relation to the stationary contact member; an elongated movable contact arm pivotally connected to the bracket for rotation about an axis, one end of the arm having at least one contact surface disposed for movement into and out of abutting engagement with at least one cooperative contact surface of the stationary contact member, said one end being axially offset with respect to the pivotal connection between arm and bracket so that the center of the engaging surface area of said one end together with the center of said pivot connection lie in a common plane of reaction which intersects the axis of rotation at an oblique angle, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint, one of said slide surfaces being substantially flat and the other having a raised section defining with the flat surface a line contact; and an actuating member connected to the movable contact arm for moving said arm about said axis, the center of the connection between arm and actuating member being disposed substantially in said plane of reaction.

7. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base and a contact finger pivotally supported by said electro-conductive member for movement in an arcuate path; an electroconductive bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm being arcuately movable in a plane intersecting the plane defined by the arcuate path of the contact finger and having at least one contact surface disposed in circuit making and breaking relationship with at least one cooperative contact surface of said finger, said one end being axially offset with respect to the pivotal connection between arm and bracket so that the center of the circuit making surface area of said one end defines with the center of said pivotal connection a straight line which intersects the axis of rotation at an oblique angle, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint, one of said slide surfaces being substantially flat and the other slide surface having a raised section; and actuating means connected to the movable contact arm for moving said arm about said axis, said arm being constructed and arranged so that the bearing surface between the actuating means and the arm is intersected by said straight line.

8. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base and a contact finger pivotally supported by said electro-conductive member for movement in a first plane; an electroconductive bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm being axially offset with respect to the pivotal connection, the axially offset end being arcuately movable in a second plane intersecting said first plane and having at least one contact surface disposed for abutting engagement with at least one cooperative contact surface of said finger, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint, one of said slide surfaces being substantially flat and the other slide surface having a raised section defining with the flat surface a line contact; and actuating means connected to the movable contact arm to apply actuating force for rotating said arm on said axis, the center of the connection between arm and actuating means being disposed so that the line of action of the resultant actuating force for rotating the arm together with the center of the contact engaging area of said axially offset end and the center of the pivotal connection between arm and bracket define a third plane including the intersection of said first and second planes.

9. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base and disposed to provide a fulcrum, a contact finger pivotally supported intermediate its ends on the fulcrum, spring means associated with one end of the contact finger for establishing a biasing torque in the finger, the spring means being disposed so that the moment arm between its line of action and the fulcrum is a predetermined length, the contact finger having at its other end a contact surface movable in an arcuate path spaced from the fulcrum a distance greater than said predetermined length, and stop means disposed to engage said other end to determine the limit of its arcuate movement caused by the biasing torque; an electroconductive bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm being arcuately movable in a plane disposed substantially perpendicular to the plane of movement of said other end of the contact finger and having at least one contact surface disposed for abutting engagement with the contact surface of said finger, said one end of the arm being axially offset with respect to the pivotal connection between arm and bracket so that the center of the engaging surface area of said one end defines with the center

of said pivotal connection a straight line which intersects the axis of rotation at an oblique angle, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint, one of said slide surfaces being substantially flat and the other slide surface having a raised section defining with the flat surface a line contact; and actuating means connected to the movable contact arm for moving said arm about said axis, said arm being constructed and arranged so that the resultant actuating force applied to the arm is directed along a line of action intersecting said straight line.

10. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base and a contact finger pivotally supported by said electroconductive member for movement in an arcuate path; an electroconductive bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket for rotation about an axis, one end of the arm being arcuately movable in a plane generally perpendicular to the plane defined by the arcuate path of the contact finger and having a transverse contact surface disposed in circuit making and breaking relationship with an abutting contact surface of said finger, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint; and actuating means coupled to the movable contact arm for pivotally moving said arm.

11. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base, at least one elongated contact finger pivotally supported by the electroconductive member, and spring means for biasing the contact finger and permitting limited deflection thereof; a bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket, one end of the arm being arcuately movable in a plane generally perpendicular to the longitudinal centerline of said contact finger and having a transverse contact surface disposed in circuit making and breaking relationship with an abutting contact surface of said finger; and actuating means coupled to the movable contact arm for pivotally moving said arm.

12. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base and including at least two separate contact fingers respectively disposed for relatively limited pivotal movement in generally parallel planes, said fingers having adjacent contact surfaces, respectively; a bracket mounted on the base in spaced relation to the stationary contact member; an elongated movable contact arm pivotally connected to the bracket, one end of the arm being arcuately movable between open and closed circuit positions in a plane intersecting the respective planes of movement of the contact fingers and having at least one transverse contact surface disposed in abutting relation to the adjacent contact surfaces of said fingers for substantially simultaneously engaging and disengaging both of said adjacent surfaces as said one end is moving respectively into and out of its closed circuit position; and actuating means coupled to the movable contact arm for pivotally moving said arm.

13. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base and including at least one pair of opposing contact fingers disposed for relatively limited pivotal movement in a common plane, each finger of said pair having a contact surface; a bracket mounted on the base in spaced relation to the stationary contact member; a movable contact member comprising a pair of arms pivotally connected to the bracket and having corresponding ends respectively disposed for arcuate movement in generally parallel planes which intersect said common plane, said corresponding ends having transverse contact surfaces disposed in abutting relation to the contact surfaces of said fingers, respectively; and actuating means coupled to the movable contact member for jointly moving said arms and their contact surfaces into and out of circuit making engagement with the respective contact surfaces of said fingers.

14. In the contact structure of an electric circuit interrupter; a base member; a relatively stationary contact member mounted on the base comprising adjacent pairs of contact fingers and spring means for biasing the fingers and permitting relatively limited movement thereof, the fingers of one of said pairs having opposing ends disposed for movement in separate paths respectively parallel to separate paths of movement of opposing ends of the adjacent pair of contact fingers, the opposing ends of each pair of fingers being respectively provided with contact surfaces; a cooperating movable contact member pivotally supported on the base comprising a pair of arms having corresponding ends disposed for joint arcuate movement between open and closed circuit positions, each of said corresponding ends being provided with at least on contact surface disposed in cooperative relationship with the contact surfaces of two of said contact-finger ends having parallel paths of movement for substantially simultaneously engaging and disengaging the contact surfaces of both of said two ends as the corresponding end is moved respectively into and out of its closed circuit position, whereby at least four separate points of circuit-closing engagement are provided between the movable and relatively stationary contact members; and actuating means coupled to the movable contact member for jointly moving said arms.

15. In a multipole electric circuit breaker, a base member for supporting generally parallel current-conducting studs of the breaker which studs are provided for interconnecting the breaker and an electric circuit located on the opposite side of the base member from the breaker, with the studs extending through the base member for this purpose, said base member comprising a rigid sheet of electric insulating material of substantially uniform thickness shaped to form at least one channel-shaped section protruding on the electric circuit side of the base member, said section having a pair of spaced-apart apertures therein for admitting, respectively, two corresponding breaker studs of adjacent breaker poles with portions of said two studs emerging from said section for connection to the breaker, said two studs having strong sidewise magnetic forces interacting thereon whenever currents of relatively high magnitudes are being conducted thereby, and a plurality of supporting members respectively disposed to secure said emergent portions of the studs to the sheet immediately adjacent to said channel-shaped section, whereby each of said two studs is supported by the insulating sheet at points within and without its channel-shaped section and the sheet can withstand said strong sidewise forces without undesirable deformation.

16. In a multipole electric circuit breaker connected between source and load circuits, a base member for supporting in parallel spaced relation two pairs of current-conducting breaker studs connected to the source and load circuits, respectively, said base member comprising a single sheet of rigid electric insulating material of substantially uniform thickness molded to form at least two spaced-apart channel-shaped sections protruding on the opposite side of the base member from the breaker, portions of both source studs being disposed within a first one of said channel-shaped sections and being connected thereto for support, portions of both load studs being disposed within a second one of said channel-shaped sections and being connected thereto for support, and a plurality of supporting members connect-

ing the respective studs to the breaker side of the base member adjacent to a channel-shaped section thereof for additionally supporting the studs without said channel-shaped sections, whereby said insulating sheet is able to withstand strong magnetic forces acting on the studs when relatively high currents are flowing therein.

17. In an electric circuit breaker, a base member supporting all of the current-conducting studs and other breaker parts directly connected to the studs, said base member comprising a metal frame and at least one rigid sheet of electric insulating material of substantially uniform thickness attached to said frame, the sheet being molded to form a channel-shaped depression for partially supporting at spaced intervals along the bottom of the depression at least two of the current-conducting studs, said two studs respectively having portions thereof emerging from the depression which portions are subject to strong lateral magnetic forces when currents of relatively high magnitudes are being conducted thereby, and separate means for further supporting each of said two studs from non-depressed portions of the sheet, each of said means comprising a supporting member disposed rigidly to secure the emergent portion of a stud to a portion of the sheet adjacent to the lip of the depression therein, whereby said strong lateral forces are withstood by the sheet without undesirable deformation thereof.

18. In an electric circuit breaker: a base member comprising a sheet of substantially uniformly thick electric insulating material formed to define two spaced-apart trough-like portions; at least one pair of current-conducting studs respectively connected for partial support to the trough-like portions of said sheet; a relatively stationary contact member connected to one stud of said pair; support means secured to the sheet for supporting said stationary contact member and having an integral part disposed adjacent one surface of the sheet intermediate the trough-like portions; a bracket mounted on the sheet and having an integral part disposed adjacent said one surface of the sheet intermediate the trough-like portions in spaced relation to said support means; a movable contact arm pivotally supported by the bracket and connected to the other stud of said pair, said arm being disposed for movement into abutting engagement with the relatively stationary contact member; actuating means coupled to the movable contact arm for pivotally moving said arm; and a rigid reinforcing member disposed adjacent the opposite surface of the sheet intermediate the trough-like portions in overlapping relationship with the integral parts of said support means and bracket.

19. An electric circuit interrupter: a base member comprising a single sheet of substantially uniformly thick electric insulating material formed to define two spaced-apart trough-like portions having apertures in the bottoms thereof; a pair of current-conducting studs extending from the rear to the front of the sheet, each of said studs being disposed in an aperture of a different trough-like portion; a relatively stationary contact connected to one of said studs; support means secured to the sheet for supporting said stationary contact and having an integral part disposed adjacent the front surface of the sheet intermediate the trough-like portions; a bracket mounted on the sheet and having an integral part disposed adjacent the front surface of the sheet intermediate the trough-like portions in spaced relation to said support means; a movable contact arm pivotally supported by the bracket and connected to the other stud of said pair, said arm being disposed for rearward movement into abutting engagement with the stationary contact; actuating means coupled to the movable contact arm for pivotally moving said arm; and a rigid frame for supporting the sheet adjacent its outer edges and including at least one reinforcing member disposed adjacent the rear surface of the sheet intermediate the trough-like portions in overlapping relationship with the integral parts of said support means and bracket.

20. In an electric circuit breaker: a base member for supporting a pair of current-conducting studs of the breaker, said base member comprising a unitary sheet of electric insulating material of substantially uniform thickness molded to form a pair of spaced-apart channel-shaped sections, the breaker studs being connected for support to the sheet at a plurality of points, at least one point of connection of each stud being made in a different one of said channel-shaped sections; a contact finger supported by one of the current-conducting studs for pivotal movement in a first plane; spring means for biasing the contact finger and permitting limited deflection thereof; a bracket mounted on the sheet in spaced relation to the contact finger; an elongated movable contact arm pivotally connected to the bracket and electrically connected to the other current-conducting stud, one end of the arm being arcuately movable in a plane intersecting said first plane and having a transverse contact surface disposed in circuit making and breaking relationship with an abutting contact surface of said finger; and actuating means coupled to the movable contact arm for pivotally moving said arm.

21. In an electric circuit breaker: a metal frame; a base member comprising a unitary sheet of not more than ¼-inch thick electric insulating material mounted adjacent its outer edges on the metal frame, the sheet being disposed to form a pair of channel-shaped portions the bottoms of which have apertures for admitting and restricting lateral movement of the current-conducting studs of the breaker; a contact finger pivotally supported by one of the current-conducting studs for movement in an arcuate path; a bracket mounted on the sheet in spaced relation to the contact finger; an elongated movable contact arm pivotally connected to the bracket, one end of the arm having a transverse contact surface disposed for arcuate movement in a plane intersecting the plane defined by the arcuate path of the contact finger; and actuating means coupled to the movable contact arm for moving said transverse contact surface into and out of circuit making engagement with an abutting contact surface of said contact finger.

22. In an electric circuit breaker: a base member supporting the current-conducting studs and other breaker parts directly connected to the studs, said base member comprising a single sheet of electric insulating material of substantially uniform thickness shaped to form at least one channel-shaped depression having at least one aperture in its bottom for admitting one of the current-conducting studs; a contact finger pivotally connected to said one stud for movement in an arcuate path; an electroconductive bracket mounted on the sheet in spaced relation to the contact finger and connected to another current-conducting stud; an elongated movable contact arm pivotally connected to the bracket for rotation on an axis, one end of the arm being arcuately movable in a plane generally perpendicular to the plane defined by the arcuate path of the contact finger and having a transverse contact surface disposed in circuit making and breaking relationship with an abutting contact surface of said finger, the connection between bracket and arm including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint; and actuating means coupled to the movable contact arm for pivotally moving said arm.

23. In an electric circuit interrupter: a base member comprising a sheet of substantially uniformly thick electric insulating material, two spaced-apart trough-like depressions being formed of the sheet; at least one pair of current-conducting studs respectively connected for partial support to the trough-like depressions of said sheet; support means secured to the sheet for partially supporting one of the studs and having an integral part disposed

adjacent a front surface of the sheet intermediate the trough-like depressions; at least one contact finger connected to said one stud for relatively limited pivotal movement in a first plane; a bracket mounted on the sheet and having an integral part disposed adjacent the front surface of the sheet intermediate the trough-like depressions in spaced relation to said support means; a movable contact arm connected to the other stud of said pair and supported by the bracket for pivotal movement in a plane intersecting said first plane, one end of said arm having a transverse contact surface disposed for rearward movement in circuit making relationship with an abutting contact surface of said finger; actuating means coupled to the movable contact arm for pivotally moving said arm; and a rigid reinforcing member disposed adjacent a rear surface of the sheet intermediate the trough-like depressions in overlapping relationship with the integral parts of said support means and bracket.

24. In an electric circuit interrupter: a base member comprising a rigid frame and a single sheet of substantially uniformly thick electric insulating material mounted on the frame, said sheet being formed to include a pair of spaced-apart trough-like portions having openings in their bottoms; a pair of current-conducting studs extending from the rear to the front of the sheet, each of said studs being disposed in an opening of a different trough-like portion; a relatively stationary contact member connected to one of said studs for pivotal movement in a first plane; support means secured to the sheet for supporting said stationary contact and having an integral part disposed adjacent the front surface of the sheet intermediate the trough-like portions; an electroconductive bracket mounted on the sheet and having an integral part disposed adjacent the front surface of the sheet intermediate the trough-like portions in spaced relation to said support means; at least one reinforcing member affixed to said rigid frame and disposed adjacent the rear surface of the sheet intermediate the trough-like portions in overlapping relationship with the integral parts of said support means and bracket; an elongated movable contact arm pivotally supported by the bracket and connected to the other stud of said pair, said arm being disposed for rotation on an axis oriented generally parallel to the longitudinal centerlines of the trough-like portions of the sheet, one end of the arm being arcuately movable in a second plane intersected by said first plane and having at least one contact surface disposed for abutting engagement with at least one cooperative contact surface of said relatively stationary contact member, said one end being axially offset with respect to the pivotal connection between arm and bracket, the bracket and arm respectively including contiguous slide surfaces disposed generally perpendicular to the axis of rotation to form a current-conducting joint; and actuating means connected to the movable contact arm to apply actuating force for rotating said arm on said axis, the center of the connection between arm and actuating means being disposed so that the line of action of the resultant actuating force for rotating the arm together with the center of the contact engaging area of said one end and the center of the pivotal connection between arm and bracket define a third plane including the intersection of said first and second planes.

25. In the contact structure of an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base member; an electroconductive bracket mounted on the base member in spaced relation to the stationary contact member and including a removable pivot pin; a movable contact arm rotatably mounted on said pivot pin for arcuate movement at one end into and out of circuit making engagement with the stationary contact member, the arm and the bracket having contiguous slide surfaces disposed generally perpendicular to the axis of the pivot pin to form a current-conducting joint, one of said surfaces being substantially flat and the other surface having a raised section defining with the flat surface a line contact; spring means for maintaining contact pressure between the contiguous surfaces forming the joint as the movable contact arm rotates; a releasable clamp connected to the pivot pin to prevent axial movement of said pin, the clamp comprising a resilient coil encircling and firmly grasping the pin to prevent removal thereof from the bracket, the opposite ends of the coil being arranged for cooperative movement to expand the coil circumference and thereby release the pivot pin to permit removal thereof; and actuating means coupled to the movable contact arm for rotating said arm on the pivot pin.

26. In an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base and including a pair of opposing contact fingers disposed for relatively limited pivotal movement in a common plane, the opposing ends of said fingers having complementary contact surfaces, respectively; a bracket mounted on the base in spaced relation to the stationary contact member; a movable contact member comprising a pair of arms pivotally connected to the bracket and having corresponding ends respectively disposed for arcuate movement in generally parallel planes which intersect said common plane, said corresponding ends having transverse contact surfaces disposed in abutting relation to the complementary contact surfaces of said fingers, respectively; actuating means coupled to the movable contact member for jointly moving the contact surfaces of both of said arms into and out of circuit making engagement with the respective complementary contact surfaces; and an arc chute mounted on the base comprising a pair of spaced sidewalls defining an arcing chamber adjacent one end of the chute, an outlet at another end of the chute and a plurality of spaced-apart, arc-chopping metal plates disposed substantially perpendicular to the sidewalls at a location intermediate the outlet and said one end of the chute, said arc chute having at its one end a relatively restricted opening for admitting the opposing ends of said fingers and the corresponding ends of said arms, whereby all of said contact surfaces are disposed in the arcing chamber.

27. In an electric circuit interrupter: a base member; a relatively stationary contact member mounted on the base comprising two adjacent pairs of opposing contact elements, the opposing ends of the elements of each pair being respectively provided with complementary contact surfaces disposed in a common plane; a bracket mounted on the base in spaced relation to the stationary contact member; a movable contact member pivotally connected to the bracket comprising a pair of arms having corresponding ends respectively disposed for joint arcuate movement between open and closed circuit positions in generally parallel planes intersecting said common plane, each of the corresponding ends of said arms being provided with at least one contact surface disposed in cooperative relationship with the contact surfaces of two different contact elements for substantially simultaneously engaging the contact surfaces of both of said two elements during a circuit closing operation of the circuit interrupter, whereby at least four separate points of circuit-closing engagement are provided between the movable and relatively stationary contact members; an arc chute mounted on the base comprising a pair of spaced sidewalls disposed generally parallel to the respective planes of movement of the corresponding ends of said arms and enclosing said corresponding ends and the opposing ends of both pairs of contact elements thereby to enclose and extinguish the electric arc drawn upon disengagement of the cooperating contact surfaces during a circuit opening operation of the circuit interrupter, said arc chute including an outlet for exhausting the arc products and a plurality of spaced-apart metal plates transversely extending between the sidewalls at a location intermediate said outlet and said cooperating contact surfaces, said metal plates being disposed generally perpendicular to

the path of the electric arc for chopping said arc into a family of serially related arclets; and actuating means coupled to the movable contact member for jointly moving said arms to obtain circuit opening and closing operations.

28. In an electric circuit interrupter: a base member; an arc chute mounted on the base comprising a pair of spaced sidewalls defining an arcing chamber adjacent one end of the chute, an outlet at another part of the chute, and a plurality of spaced-apart, arc-chopping metal plates disposed substantially perpendicular to the sidewalls at a location intermediate the arcing chamber and outlet of the chute; means for initiating an electric arc within said arcing chamber comprising movable and relatively stationary contact members supported on the base and extending into the arc chute at said one end, the contact members being provided with cooperating contact surfaces respectively disposed in said arcing chamber for relative movement into and out of circuit making engagement, at least one of the contact members having at least two separate contact surfaces for establishing parallel points of engagement between the cooperating contact surfaces; and actuating means coupled to the movable contact member for moving said member to effect substantially simultaneous disengagement of all of said cooperating contact surfaces.

29. In an electric circuit breaker: a base member; a relatively stationary contact comprising an electroconductive member mounted on the base, at least one elongated contact finger pivotally supported by the electroconductive member, and spring means for biasing the contact finger and permitting limited deflection thereof; a bracket mounted on the base in spaced relation to the stationary contact; an elongated movable contact arm pivotally connected to the bracket, one end of the arm being movable in an arcuate path defining a plane generally perpendicular to the longitudinal centerline of said contact finger and having a contact surface disposed in circuit making and breaking relationship with a cooperating contact surface of said finger; an arc chute mounted on the base comprising a pair of sidewalls disposed generally parallel to and on opposite sides of the arcuate path of movement of said one end for enclosing the electric arc drawn between said cooperating contact surfaces during a circuit breaking operation thereof, said arc chute including an opening for exhausting the arc products and a plurality of spaced-apart metal plates transversely extending between the sidewalls at a location intermediate said opening and said cooperating contact surfaces, said metal plates being disposed generally perpendicular to the electric arc for chopping the arc into a family of serially related arclets; and actuating means coupled to the movable contact arm for moving said arm to obtain circuit making and breaking operations of said cooperating contact surfaces.

30. In an electric circuit breaker: a base member; a relatively stationary contact member mounted on the base comprising a pivotally supported contact finger disposed for relatively limited deflection in a first plane; an elongated movable contact member pivotally supported on the base for movement in a second plane perpendicular to the first plane, said movable contact member having a contact surface disposed for movement along an arcuate path into and out of circuit making engagement with a cooperating contact surface of said finger; an arc chute mounted on the base comprising a pair of sidewalls disposed generally parallel to said second plane on opposite sides of said arcuate path for enclosing the electric arc initiated upon disengagement of the cooperating contact surfaces, said arc chute including an outlet for exhausting the arc products and a plurality of spaced-apart arc-chopping metal plates disposed between the sidewalls intermediate said outlet and the area of arc initiation, the opposing surfaces of said sidewalls being respectively provided with a plurality of grooves for receiving said metal plates and said grooves being extended beyond the metal plates along portions of the sidewalls adjacent the area of arc initiation; and actuating means coupled to the movable contact member for pivotally moving said member and thereby effecting engagement and disengagement of the cooperating contact surfaces.

31. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact member mounted on the base comprising a pivotally supported contact finger disposed for relatively limited deflection in a first plane; an electroconductive supporting bracket mounted on the base in spaced relation to the stationary contact member; an elongated movable contact member pivotally connected to the bracket for movement in a second plane perpendicular to the first plane, the connection between supporting bracket and movable contact member including contiguous slide surfaces disposed generally parallel to the second plane to form a current-conducting joint, one of said surfaces being substantially flat and the other being raised so that the contiguous portions of the surfaces define a straight line oriented at approximately a right angle with respect to the longtudinal centerline of the movable contact member; abutting contact surfaces respectively disposed on said contact finger and said movable contact member in circuit making and breaking relationship; and actuating means coupled to the movable contact member to move said member.

32. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact member mounted on the base comprising a yieldably supported element having a generally flat contact surface; a bracket mounted on the base in spaced relation to the stationary contact member; an elongated movable contact arm supported near one end by the bracket and having at its other end a transverse contact surface disposed for movement in a direction generally perpendicular to said flat contact surface into circuit-making abutting engagement therewith, said transverse surface being curved to define with the abutting surface of said element a straight-line contact oriented generally parallel to the longitudinal centerline of the arm, the cooperating contact surfaces being constructed and arranged so that the curved transverse surface extends beyond the flat surface at opposite ends of said straight-line contact; and actuating means coupled to the movable contact arm for moving said arm.

33. In the contact structure of an electric circuit breaker: a base member; a relatively stationary contact member mounted on the base comprising a yieldably supported element having a first contact surface; a bracket mounted on the base in spaced relation to the stationary contact member; a movable contact arm pivotally connected to the bracket and having an elongated contact surface disposed for movement into and out of circuit-making abutting engagement with the first contact surface, the elongated surface being movable along an arcuate path which intersects the first surface substantially perpendicular thereto and the elongated surface being oriented with its lengthwise dimension in the plane of said arcuate path of movement; one of said surfaces being curved relative to the other to establish between the surfaces when in abutting engagement a straight-line contact the length of which is shorter than the length of said elongated surface; and actuating means coupled to the movable contact member for pivotally moving said member.

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