Dec. 22, 1959 W. FUST 2,918,552

CIRCUIT INTERRUPTERS

Filed Oct. 14, 1957 3 Sheets-Sheet 1

FIG. 1

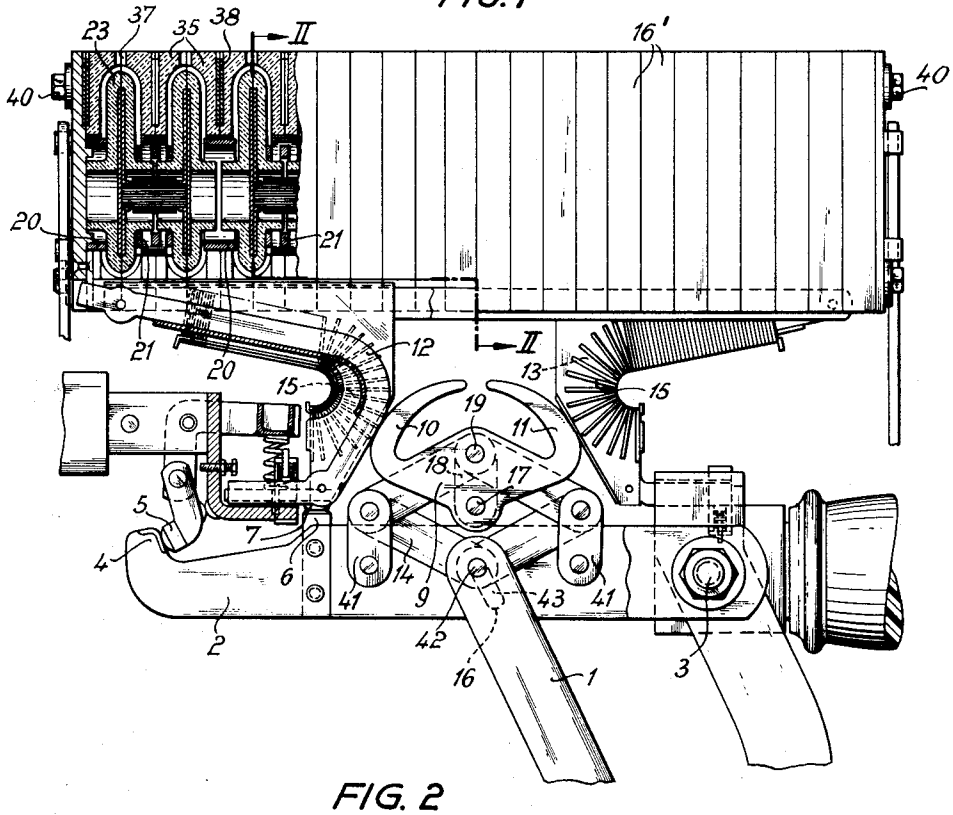
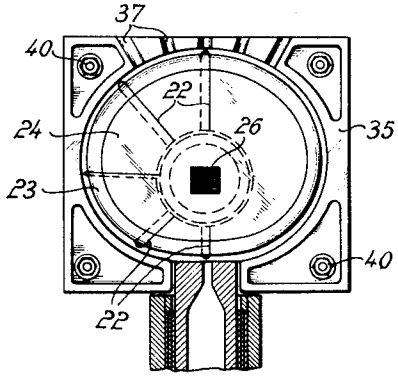



FIG. 2




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CIRCUIT INTERRUPTERS

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FIG. 3

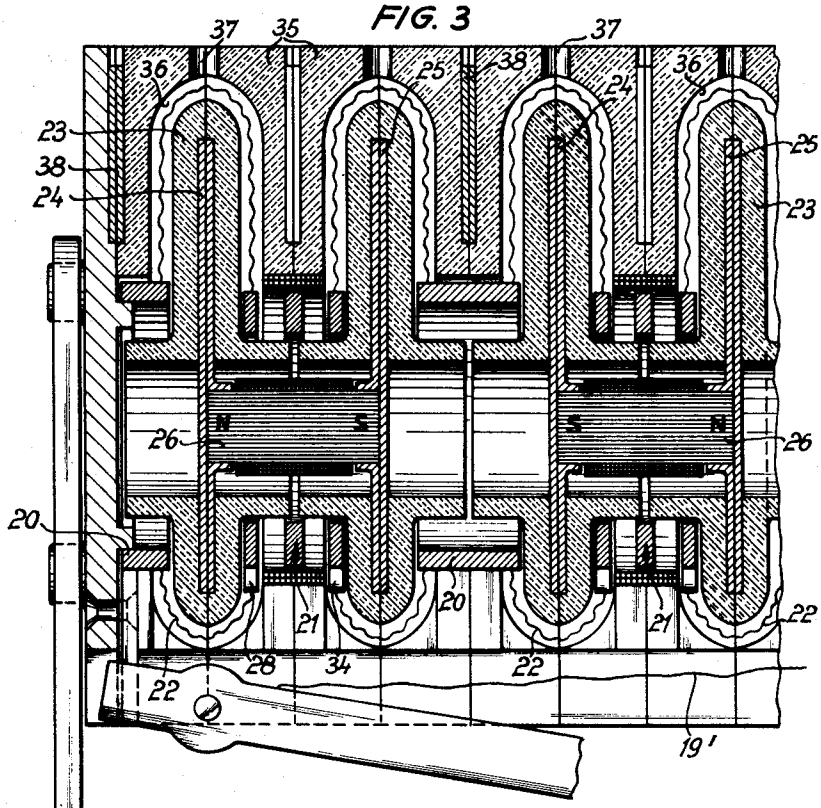
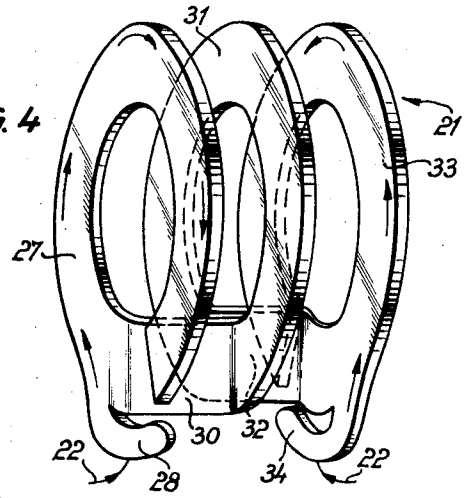



FIG. 4




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CIRCUIT INTERRUPTERS

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FIG. 5

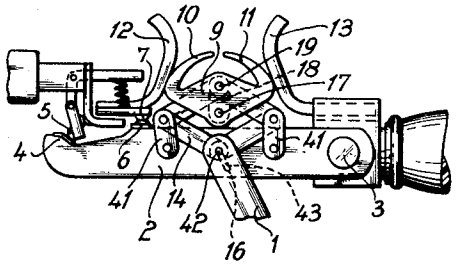



FIG. 6

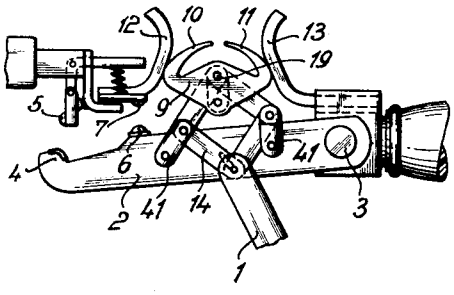



FIG. 7

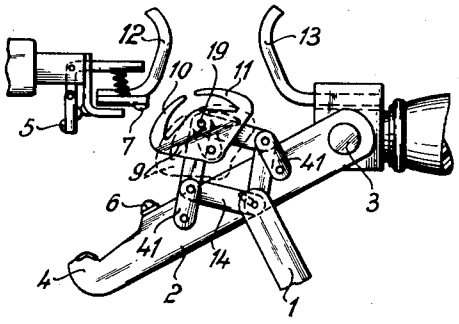
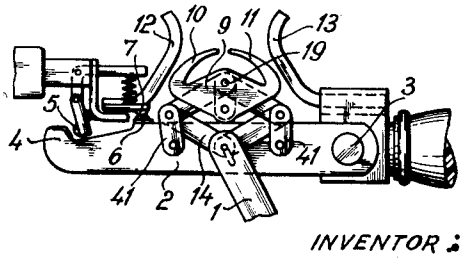



FIG. 8




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United States Patent Office 2,918,552 Patented Dec. 22, 1959



2,918,552

# CIRCUIT INTERRUPTERS

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Application October 14, 1957, Serial No. 690,160

Claims priority, application Germany October 20, 1956

17 Claims. (Cl. 200—147)

This invention refers to circuit interrupters, or circuit breakers.

It is one object of this invention to provide a family of circuit interrupters, i.e. a basic design for circuit interrupters, applicable for a wide range of voltage ratings, current ratings and interrupting capacity ratings.

Another object of the invention is to provide improved magnetic blow-outs, or improved magnetic arc extinguishing means, for circuit interrupters.

Another object of the invention is to provide air magnetic circuit breakers comprising means for elongating an arc, means for subdividing the relatively long arc into a plurality of shorter partial arcs, and means for rotating said plurality of partial arcs by the action of magnetic fields which circuit breakers have more effective arc-extinguishing means, or arc chutes, than prior art circuit breakers answering this description, and are therefore capable of having higher voltage ratings, current ratings and interrupting capacity ratings than comparable prior art circuit breakers.

Another object of the invention is to provide arc-extinguishing means capable of effecting progressive elongation of partial arcs while such arcs are caused to rotate by the action of magnetic fields.

Another object of the invention is to provide arc-extinguishing means capable of forming substantially U-shaped arcs and of progressively increasing the size and the length of substantially U-shaped arcs concomitant with a rotary motion thereof.

Another object of the invention is to provide simple and effective arc-extinguishing means in stack-form capable of generating high arc voltages by simultaneous rotation and elongation of electric arcs.

Another object of the invention is to provide improved electric circuit interrupters wherein the opening, closing and normal current carrying duty is assigned to three different pairs of cooperating contacts.

Still another object of the invention is to provide improved electric circuit interrupters precluding excessive generation of heat between cooperating pairs of arcing contacts during initial separation of a pair of main current-carrying contacts.

Further objects, advantages and features of this invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to, and forming part of, this specification.

For a better understanding of the invention reference may be had to the accompanying drawings, wherein

Fig. 1 is mainly a front view of a circuit interrupter, or circuit breaker, embodying the invention showing some of the constituent parts, including a portion of the arc chute, in vertical section;

Fig. 2 shows a portion of the arc chute structure sectioned along II—II of Fig. 1;

Fig. 3 shows the left upper portion of Fig. 1 on a larger scale;



Figs. 5 to 7 are front views showing the contact structure of the circuit breaker illustrated in the previous figures in three different operating positions, Fig. 5 showing the closed contact position, Fig. 6 showing a position intermediate the closed contact position and the open contact position (the main current-carrying contacts being open and the arcing contacts being still closed), and Fig. 7 showing the open contact position resulting in complete cessation of current flow; and

Fig. 8 is a modification of the structure shown in Figs. 5 to 7 wherein the arcing contacts are separated when the current-carrying contacts are in their normal closed current-carrying position.

Referring now to the drawings, numeral **1** has been applied to indicate an operating rod for operating a contact arm **2** which is pivotally mounted at **3** and supports all the movable contacts of the circuit breaker. Contact arm **2** is provided with a four bar or pantograph linkage **14**. Linkage **14** comprises four links shown in Fig. 1 to be arranged in the form of a parallelogram, and pivotally connected to each other at the ends thereof. Pantograph linkage **14** is pivotally supported by two links **41** pivotally mounted on contact arm **2**. Contact arm **2** is provided with an oblique slot **43** receiving a guiding pin **42** of pantograph linkage **14**. Pin **42** is hingedly mounted on the upper end of operating arm **1** to transmit the pull and push of arm **1** to pantograph linkage **14**. It will be apparent that slot **43** and pin **42** jointly form a lost motion connection between parts **1** and **2**, and parts **2** and **14**, respectively. Reference numeral **19** has been applied to indicate the upper pin of pantograph linkage **14**. A link **18** suspended on pin **19** supports at **17** a movable arcing contact **9** which includes the arc horns **10** and **11**. Contact arm **2** supports the movable closing contact **4** adapted to engage the fixed closing contact **5**, and contact arm **2** supports also the movable main current-carrying contact **6** adapted to engage the fixed main current carrying contact **7**. The arc horns **10**, **11** of movable arcing contact **9** are adapted to engage two arc runners **12**, **13** which are also in the shape of arc horns. Arc runners **12**, **13** transfer the arc from the point of its initiation into an arc chute arranged at a point remote from the point of arc initiation and generally indicated by reference numeral **16'**. Any means known to be useful for the transfer of an arc from the point of its initiation into an arc chute may be used to move the arc extending between divergent arc runners **12**, **13** into the arc chute **16'**. One such means has been shown in the form of a family of magnetic plates **15** associated with each of the two arc runners **12**, **13**. Arc transfer may also be expedited by pneumatic puffers, as is well known in the art. By virtue of the divergent arrangement of runners **12**, **13** the arc is considerably elongated during its travel to and into arc chute **16'**. Arc chute **16'** is adapted to subdivide relatively long arcs into a plurality of serially related relatively short arcs, frequently referred to as partial arcs. Arc chute **16'** is made up of a plurality of arc extinguishing parts arranged substantially in the form of a stack. These parts include solid arc runner rings **20** and arc runner windings generally indicated by reference numeral **21**. The parts referred to as arc runner rings are circular electrodes along which terminals of the partial arcs are caused to move in substantially circular paths. The parts referred to as arc runner windings are windings for establishing magnetic fields substantially at right angles to some portion of the length of the partial arcs to cause circular rotary motions of the partial arcs. Windings **21** which are substantially circular are also used as electrodes along which terminals of the partial arcs are caused to move in circular paths. In other words, windings **21** establish arc-propelling magnetic fields, and the surfaces thereof form arc runners providing circular paths for

arc terminals. Each winding **21** comprises three turns **27, 31, 33.** Each partial arc **22** extends between one of the arc runner rings **20** and one of the axially outer turns of one of the arc runner windings **21.** An arc-elongating barrier **23** of appropriate insulating material is arranged between each arc runner ring **20** and each arc runner winding **21.** Each barrier **23** projects radially outwardly beyond the periphery of arc runner rings **20** and arc runner windings **21.** Reference numeral **19'** in Fig. 3 indicates the path of the arc upon being elongated by the action of the arc runners **12, 13** but prior to being subdivided into a plurality of partial arcs. There is a point on the periphery of barrier **23** where its distance from the common axis of parts **20** and **21** is a minimum and another point where this difference is a maximum (Fig. 2). The distance barrier **23** projects radially outwardly beyond the periphery of parts **20** and **21** increases progressively along the periphery of parts **20, 21** and **23.** As shown in Fig. 2 barrier **23** comprises two symmetrical portions for elongating partial arcs rotating in clockwise direction as well as for elongating arcs rotating in counterclockwise direction as will more clearly appear from what follows below. The long arc **19'** engages barriers **23** substantially at the point thereof where the distance said barrier projects radially outwardly beyond parts **20** and **21** is a minimum. At this point the arc enters from the space between arc runners **12, 13** through the throat shown at the bottom of Fig. 2 into a plurality of arcing chambers **36** formed inside of arc chute **16'.** The relatively slight distance barrier **23** projects forwardly at the point of initial engagement thereof by long arc **19'** is sufficient to bend arc **19'** at said point of initial engagement substantially in the shape of a relatively small or short U, as clearly indicated in the lower portion of Fig. 3. The lateral portions of the U-shaped partial arcs, i.e. the portions thereof situated immediately adjacent the arc terminals formed on parts **20** and **21,** are substantially at right angles to magnetic fields produced by windings **21,** and hence subject to magnetic action tending to impart a rotary motion to the partial arcs **22** as will be shown below more in detail. As the partial arcs **22** are caused to rotate, their terminals move along the periphery of parts **20** and **21,** and the portions intermediate their terminals move along the edges of barriers **23.** This causes progressive elongation of the partial arcs **22** by virtue of the progressive increase of the distance the arc-stretching periphery of each barrier **23** projects radially outwardly beyond the periphery of parts **20** and **21** or, in other words, beyond the common axis of parts **20** and **21.**

Each magnet winding **21** is provided with a magnetic core **26** arranged along the axis of winding **21** substantially in the center thereof. Cores **26** are energized by the arc current flowing through windings **21.** The axially outer ends of cores **26** are provided with pole plates **24** and **25** made of a suitable magnetic metal. Pole plates **24** and **25** are arranged inside of insulating barriers **23** and the shape of their periphery is similar to the shape of the periphery of barriers **23,** a predetermined margin being left between the periphery of the former and that of the latter. The magnetic fields formed between pole plates **24** and **25** are substantially at right angles to pole plates **24** and **25,** and at right angles to the portions of the partial arcs **22** which extend substantially radially outwardly from the arc terminals or arc roots on parts **20** and **21.**

The geometry of winding **21** can best be seen from **Fig.** 4 clearly showing the axially inner turn **31** and the two axially outer turns **27** and **33.** Each turn is situated in a plane parallel to the planes of the other turns, i.e. the three constituent turns of winding **21** are not helical. As seen in Fig. 4 the left turn **27** is conductively connected to the intermediate turn **31** by a length of conductor **30** substantially at right angles to the planes of turns **27** and **31.** Similarly, the intermediate turn **31** is conductively connected to the right turn **33** by a length of conductor **32** substantially at right angles to the planes of turns **31** and **33.** As indicated in Fig. 3 adjacent windings **21** are wound in opposite directions, resulting in the formation of magnet poles of the same polarity at the juxtaposed ends of adjacent magnet cores **26.** Reference letter S in Fig. 3 indicate a pair of juxtaposed magnet poles of the same polarity (south poles) on adjacent magnet cores **26.** Reference letters N have been applied in Fig. 3 to indicate a pair of magnet poles of the same polarity (north poles) formed at the remote ends of immediately adjacent magnet cores **26.** Reference numerals **28** and **34** indicate two arc horns, the former being an integral part of turn **27** and the latter being an integral part of turn **33.** Arc horn **28** of turn **27** projects beyond the beginning of turn **27** and arc horn **34** of turn **33** projects beyond the end of turn **33.** A long arc **19'** rising into arc chute **16'** engages initially winding **21** at the two points where arc horns **28, 34** are situated. As a result, the portion of the arc situated between arc horns **28** and **34** is being shunted by winding **21.**

The arc chute **16'** further comprises a plurality of chamber-forming units **35** made of an appropriate arc resistant insulating material. Units **35** are superimposed, or stacked, as shown in Fig. 3. Units **35** are provided with complementary recesses at some of their contiguous surfaces. These recesses form the arching chambers **36** of which each accommodates one of the arc-elongating insulating barriers **23.** The arcing-chamber-forming stack units **35** are adapted to receive, and to house, the arc runner rings **20** and the arc runner windings **21.** The portions of arcing-chamber-forming stack units **35** situated most remotely from the zone where the arc enters the arc chute define venting ducts to which reference numeral **37** has been applied (Figs. 2 and 3). The abutting sides of units **35** opposite the arcing-chamber-forming recesses are provided with recesses forming pockets adapted to receive arcuate plates **38** of magnetic material. Plates **38** are arranged in every second plate receiving pocket, i.e. the magnetic plates are inserted into the pockets which are situated directly above the runner rings **20** but are not inserted into the pockets which are situated directly above the arc runner windings **21.** Reference numeral **40** (Figs. 1 and 2) has been applied to indicate screws and studs projecting transversely across all the chamber-forming units **35** of the stack by which arc chute **16'** is being made up. It will be apparent from the foregoing that all constituent parts of the arc chute **16'** such as arc runners **20** and **21,** insulating barriers **23** and magnet cores **26** are properly positioned by parts **35** and **40.** The barriers **23** are formed by transverse projections of tubular members on which parts **20** and **21** are mounted and which house the magnet cores **26.** The aforementioned tubular members, cores **26** and parts **20, 21** are arranged in coaxial relation inside of a passage or tunnel defined by the stack units **35.**

The contact arm may be rocked by operating lever **1** about fulcrum **3** in clockwise or counterclockwise direction (Fig. 1). Rocking of arm **2** in counterclockwise direction results in parting of cooperating pairs of contacts, drawing of an arc and eventual interruption of the circuit. Rocking of arm **2** from the open position shown in Fig. 7 in clockwise direction results in engagement of cooperating pairs of contacts and closing of the circuit which is controlled by the circuit breaker. A downward pull of operating lever **1** causes sliding of pin **42** inside slot **43** formed in contact arm **2.** As a result, pantograph, linkage **14** is being moved from the position shown in Figs. 1 and 5 to approximately the position shown in Fig. 6. To be more specific, initial motion of operating lever **1** causes stretching of linkage **14** in a direction substantially transversely to that of arm **2** and a clockwise motion of the left link **41** supporting pantograph linkage **14.** As a result of stretching linkage **14,** contacts **10, 12** and **11, 13** remain in engagement

while contacts 4, 5 and 6, 7 are caused to part. The aforementioned link 41 and the immediately adjacent upper link of pantograph linkage 14 form jointly a toggle which is collapsed in the closed position of the circuit breaker (Figs. 1 and 5) and which is being drawn during the initial phase of the opening stroke of the circuit breaker, as indicated in Fig. 6. The aforementioned stretching of pantograph or four bar linkage 14 increases the spacing between arcing contact 9 and its arc horns 11, 12, on the one hand, and contact arm 2, on the other hand. The lower end of slot 43 forms an abutment 16 for pin 42. Upon engagement of abutment 16 by pin 42 arcing contact 9, 10, 11 and contact arm 2 move jointly about fulcrum 3. As a result of the aforementioned mode of operation the contact pressure between arc horns 10 and 11 of movable arcing contact 9 and fixed arc runners 12, 13 may be increased during the initial phase of the opening stroke of operating lever 1, since the downward movement of pin 42 results in an upward thrust of contact 9 and arc horns 10, 11. Upon engagement of abutment 16 by pin 42 contact arm 2 is moved downwardly at a considerable speed, resulting in parting of arcing contacts 9, 10, 11 from arc runners 12, 13 subsequent to parting of contacts 4, 5 and 6, 7. The small arclets initially formed between arc horn 10 and arc runner 12 and between arc horn 11 and arc runner 13 merge instantly into a larger arc, extending between the lower ends of arc runners 12, 13. That arc is propelled into arc chute 16' by thermal and magnetic effects or by auxiliary air blast action and thus reaches the position indicated in Fig. 3 by the reference character 19'. In that position the arc is situated at the entrance of the arc chute 16' proper. It has been stretched to a relatively long arc by virtue of the divergence of arc runners 12 and 13. That long arc is now about to be subdivided into a plurality of relatively short serially related partial arcs.

It appears from the foregoing that the contact pressure between arcing contact 9 and arc runners 12, 13 may be greatly increased during the time of initial separation of contacts 4, 5 and 6, 7 or, in other words, during the time when the entire current under interruption must be carried by arcing contact 9 only (Fig. 6). The pressure between arcing contact 9 and arc runners 12, 13 increases in proportion to the friction at the hinge 3 of contact arm 2 and in proportion to the inertia of contact arm 2.

When contact arm 2 is being moved in clockwise direction from the open position shown in Fig. 7 to the closed position shown in Fig. 5 arcing contact 9 is the last to engage its cooperating contacts 12, 13 and thus relieved from carrying heavy inrush currents occurring upon closing the circuit breaker against a heavy fault or solid short-circuit. When operating lever 1 is being raised and contact arm 2 rocked in clockwise direction, pantograph linkage 14 is being compressed, as a result of which the contacts to first re-engage are the closing contacts 4, 5. The contacts to engage thereafter are the main current-carrying contacts 6, 7, and the contacts to close last are the arcing contact 9, 10, 11 and arc runners 12, 13. Closing of contacts 6, 7 and 9, 10, 11, 12, 13 may occur in a very rapid sequence, or even simultaneously, as long as closing contacts 4, 5 have been closed first.

Upon engagement of a relatively long arc by the elements situated at the entrance of arc chute 16' proper, the long arc is subdivided into relatively short substantially U-shaped arcs 22 which are connected in series by means of arc runner rings 20 and arc runner windings 21. Immediately upon engagement by the partial arcs 22 of arc horns 28, 34 on arc runner winding 21 but the intermediate turn 31 of winding 21 is being energized by the arc current. At this point of time, the arc terminals or arc roots being situated on arc horns 28, 34, the current flows from the left arc horn 28 (Fig. 4) directly through conductor 30 to the intermediate turn 31, through the intermediate turn 31, and from the intermediate turn 31 through conductor 32 directly to the right arc horn 34. The magnetic fields resulting from current flow through turns 31 of windings 21 and concomitant energization of the magnet systems 24, 25, 26, is substantially at right angles to the portions of the partial arcs situated directly adjacent arc horns 28, 34. As a result, these portions of the arcs 22 are subjected to magnetic action tending to rotate these portions along circular paths. The partial arcs 22 are arranged edgewise with respect to the insulating arc-elongating barriers 23, and the curved portion of the partial arcs 22 engage the edges or the peripheries of barriers 23. This causes heat to be abstracted from the partial arcs 22. Since the distance barriers 23 project radially outwardly beyond the periphery of parts 20 and 21 increases progressively, the length and the arc voltage of partial arcs 22 are being progressively increased as these arcs are caused to rotate under the action of the magnetic fields which are established by winding 21. The length of the partial arcs increases as the arc terminals are moved in circular paths along the periphery of parts 20 and 21 away from their initial positions on arc horns 28, 34. Since the magnetic action upon a conductor is proportional to its length and since the length of partial arcs 22 increases progressively when moving along their circular paths, there is a tendency toward arc movement at progressively increasing speeds. The configuration of the spaces 36 defined between barriers 23 and arcing-chamber-forming stack units 35, i.e. the configuration of the arcing chambers is another significant factor in the process of arc extinction. Parts 23 and 35 may be designed to define spaces 36 which have drastic de-energizing effects upon the partial arcs 22 moving therein by virtue of intense cooling action resulting from an intimate contact of the arc 22 with parts 23 and 35, and resulting from an arc constricting action of these parts.

It will be apparent from the geometry of the magnetic structures and that of the magnetic fields as indicated in Fig. 3 that immediately adjacent partial arcs 22 rotate in opposite directions rather than in the same direction. The direction of rotation of the arc terminals or arc roots has been indicated by arrows in Fig. 4. It will be seen that arc terminals formed on arc horns 28 of axially outer turns 27 are caused to rotate clockwise, while the arc terminals formed on the arc horn 34 of axially outer turns 33 are caused to rotate counter-clockwise.

As mentioned above, no current flows through the axially outer turns 27, 33 during the initial stage of arc rotation. The more remote the arc terminals from arc horns 28 and 34, the larger the portions of turns 27 and 33 connected in series with turn 31 to produce the arc-rotating magnet field. This tends to cause a progressive increase of the action of the magnetic field upon the rotating partial arcs 22. Upon completion of each revolution the arc terminals rotating along the surfaces of parts 20 and 21 are transferred back to arc horns 28 and 34 respectively. At the instant of the transfer of the arc terminals back to the arc horns 28, 34 the axially outer turns 27, 33 are again cut out of the circuit which then comprises but parts 30, 31 and 32. Arc horns 28 and 34 preclude the erosion of the surfaces of turns 27 and 33 on which the arc terminals move. Such erosion tends to impede the desired high-speed rotary motion of the terminals of the partial arcs 22 along parts 27, 33.

As a general rule, the various partial arcs 22 do not rotate in phase and synchronism along their rotary paths. This has been found to be beneficial to the arc-extinguishing action of arc chute structure 16'.

It will be apparent that but a portion of the partial arcs 22 is situated inside of the magnetic fields established between pole plates 24 and 25. The portion of the partial arcs 22 immediately adjacent the parts 20 are not subjected to the action of the magnet field established be-

tween pole plates **24** and **25**. These portions of the partial arcs **22** are subjected to the action of magnetic fields established between pole plates **24** and **25** and the magnetic plate inserts **38**.

In the structure which has been described above the magnetic fields required for arc rotation are solely established by electromagnetic means. As an alternative such fields may also be established wholly, or partly, by the action of permanent magnets.

The contact mechanism shown in Figs. 5 to 7 may be modified in such a way as to cause arcing contact **9** not to engage its cooperating fixed contacts **12, 13** as long as the closing contacts **4, 5** and the main current-carrying contacts **6, 7** are in engagement. This modification has been illustrated in Fig. 8. In the structure shown in Fig. 8 contacts **9, 12, 13** are not normally carrying current. Contacts **9, 12, 13** are caused to engage only upon occurrence of a tripping impulse causing operating rod **1** to move in downward direction. This causes elongation of the four bar linkage **14**, concomitant increase of the spacing between arm **2** and contact **9**, and ultimate engagement of runner contacts **12, 13** by the arc horns of arcing contact **9**. Contacts **9, 12, 13** are caused to engage before either contacts **4, 5** or contacts **6, 7**, separate. At the time of engagement of contacts **9, 12, 13** these contacts are cool, not having been subjected to any previous current-carrying duty. No arcing occurs when contacts **9, 12, 13** are being closed since these contacts are then shunted by contacts **4, 5** and **6, 7**. The pressure of arcing contact **9** upon runner contacts **12, 13** tends to move contact arm **2** counterclockwise, or in circuit interrupting direction. This is true in regard to the embodiment of the invention shown in Fig. 8 as well as to that shown in Figs. 1 and 5 to 7.

It will be apparent from the foregoing that the arc chute or arc-extinguisher **16'** according to this invention comprises a plurality of stacked insulating units **35** having complementary arcing-chamber-forming recesses **36** at some contiguous sides thereof. The stack of units **35** defines also a passage or tunnel which extends transversely across the stack. The aforementioned passage or tunnel receives a plurality of substantially tubular coaxial members of insulating material, arranged in coaxial relation in regard to said passage or tunnel. Contiguous pairs of these tubular members are each provided with one of a pair of transverse, abutting barrier-forming projections **23**. Each of projections **23** extends from the outer surfaces of contiguous pairs of the tubular members into contiguous pairs of arc-chamber-forming recesses **36** in units **35**. The periphery or edge portion of each projection **23** comprises a point having a predetermined minimum distance or spacing from the axis of the aforementioned tubular members, and the periphery or edge-portion of each projection **23** further comprises a point having a predetermined maximum distance or spacing from said axis. The distance or spacing of intermediate points of said periphery or edge-portion from said axis increases progressively from said first mentioned point to said last mentioned point. The plates **24, 25** of magnetic material are arranged between some of the juxtaposed surfaces of barrier-forming projections **23**. The annular arc runners **20, 21** are mounted on the outside of the aforementioned tubular members, their inside forming housings for cores **26**. Each core **26** magnetizes plates **24, 25** and **38**. The magnetic fields established between plates **24, 25** and **38** rotate the partial arcs **22** formed in arcing chambers **36**. Rotation of arcs **22** in engagement with edges of barriers **23** results in progressive arc elongation, and ultimate arc extinction.

The arc as initially drawn is situated substantially in a predetermined plane, which is the plane of the paper on which Fig. 3 is drawn. Barriers **23** and their periphery (see Fig. 2) are symmetrical in regard to the plane in which the arc is initially drawn, the latter plane being at right angle to the plane of the paper on which Fig. 2 is drawn.

It will also be noted that magnetic plates **25** and **28** are situated in parallel planes.

Referring now to Fig. 8, the lost motion connection between arm **2** and the pantograph linkage which is supported by said arm defines two limit positions for the pantograph linkage relative to arm **2**. The first of these two limit positions is illustrated in Fig. 8. In the limit position illustrated in Fig. 8 contacts **9, 12, 13** are out of engagement, while contacts **4, 5** and **6, 7** are in engagement. In the second limit position contacts **9, 12, 13** are in engagement, while contacts **4, 5** and **6, 7** are out of engagement.

It will be apparent to those skilled in the art that various changes and modifications may be made in the circuit breaker structure described and illustrated without departing from the spirit of the invention, as set forth in the appended claims.

I claim as my invention:

1. In a circuit interrupter the combination of means for drawing an arc, means for establishing a magnetic field at right angles to a portion of said arc to impart to said arc a rotary motion in a predetermined direction, a pair of spaced substantially coaxial electrodes providing substantially circular paths for the terminals of said arc, and an insulating barrier arranged in the space between said pair of electrodes edgewise with respect to said arc, said barrier projecting in said predetermined direction progressively farther outwardly from the axis of said pair of electrodes to progressively elongate said arc when rotating.

2. In a circuit interrupter the combination of means for drawing an arc, means including a pair of divergent arc runners for moving said arc away from the zone of arc initiation and for elongating said arc, a stack formed of hollow elements of insulating material defining a line of contiguous arcing chambers having arc entrances at the sides thereof adjacent said pair of arc runners, means for subdividing said arc when at said arc entrances into a plurality of serially related partial arcs, means including magnetic means for rotating each of said plurality of partial arcs inside one of said plurality of arcing chambers about a common axis, and a plurality of insulating barriers one in each of said plurality of arcing chambers, each of said plurality of barriers having an arc-stretching periphery, consecutive points of said periphery having progressively increasing spacings from said common axis.

3. In a circuit interrupter the combination of means for drawing an arc initially situated substantially in a predetermined plane, a first substantially annular electrode having a predetermined outer radius and adapted to provide a circular path for one terminal of said arc, a second substantially annular electrode having a predetermined outer radius and adapted to provide a circular path for the other terminal of said arc, said second electrode being arranged in coaxial relation with respect to said first electrode and being in the form of a winding having more than one turn, a magnetic core inside said winding energized by electric current flowing through said winding, magnetic pole plates at the axially outer ends of said core establishing a magnetic field for rotating said arc about the axis of said first electrode and of said second electrode, and an insulating barrier arranged in the space between said first electrode and said second electrode substantially at right angles to said axis, the periphery of said barrier comprising two portions symmetrical in regard to said predetermined plane wherein said arc is initially situated, consecutive points of each of said portions having progressively increasing spacings from said axis, the minimum spacing of said portions from said axis exceeding the outer radii of said first electrode and of said second electrode, the point of said periphery having said minimum spacing being that point of said periphery situated nearest to said means for drawing an arc.

4. In a circuit interrupter means for drawing a pair of arcs, a pair of spaced substantially annular coaxial electrodes providing circular paths for two terminals of said pair of arcs, an additional substantially annular coaxial electrode arranged in the space between said pair of electrodes, said additional electrode being in the form of a winding having a pair of axially outer circular arc-path-forming turns and an axially inner turn connected in series with said two serially outer turns, a magnetic core inside said axially outer turns and said axially inner turn, a pair of insulating barriers each arranged in the space between one of said pair of electrodes and one of said pair of axially outer turns substantially at right angles to the axis of said pair of electrodes and of said additional electrode, each of said pair of barriers comprising an edge-like arc-stretching portion, consecutive points of said portion having progressively increasing spacings from said axis, and a pair of magnetic pole plates one inside of each of said pair of barriers, each of said pair of pole plates being in engagement with one of the axially outer ends of said core and establishing a magnetic field substantially parallel to said axis.

5. In a circuit interrupter a plurality of substantially tubular coaxially arranged members of insulating material provided with transverse radially outer barrier-forming projections having a predetermined periphery, consecutive points of said periphery having progressively increasing spacings from the axis of said plurality of members, a plurality of spaced magnetic cores arranged inside said plurality of members, pairs of magnetic pole plates on the axially outer ends of each of said plurality of cores, each of said pairs of pole plates extending into the inside of one of said barrier-forming projections, a plurality of spaced windings mounted on the outside of said plurality of members each for energizing one of said plurality of cores therein, each of said plurality of windings comprising a pair of axially outer turns adapted to form substantially circular arc runner surfaces, and a plurality of additional windings mounted on the outside of said plurality of members forming substantially circular additional arc runner surfaces, each of said barrier-forming projections separating one of said arc runner surfaces from one of said additional arc runner surfaces.

6. In a circuit interrupter means for drawing a relatively short arc, arc elongating means transferring said arc from the point of arc initiation to a point remote therefrom, arc-quenching means at said remote point, said arc-quenching means including a plurality of stacked insulating units having complementary arcing-chamber-forming recesses at contiguous sides thereof, said plurality of units also defining a passage extending transversely across said plurality of units, a plurality of substantially coaxial members of insulating material arranged inside said passage, contiguous pairs of said plurality of members each being provided with one of a pair of transverse abutting barrier-forming projections, each of said pair of barrier-forming projections extending from the outer surfaces of a contiguous pair of said plurality of members into a contiguous pair of said recesses, the periphery of each of said pair of barrier-forming projections comprising a point having a predetermined minimum distance from the axis of said plurality of members and further comprising a point having a predetermined maximum distance from said axis, the distance of intermediate points of said periphery from said axis progressively increasing from said first mentioned point to said last mentioned point, plates of magnetic material arranged between the juxtaposed surfaces of each of said pair of barrier-forming projections, a plurality of substantially annular arc runners mounted on the outside of said plurality of members, said plurality of arc runners being adapted to subdivide said arc into a plurality of partial arcs and to provide circular paths for the terminals of said partial arcs, and a plurality of spaced magnet cores mounted inside said plurality of members each adapted to energize a pair of said plates of magnetic material to establish magnetic fields between pairs of said plates to cause said plurality of partial arcs to rotate around said plurality of arc runners to thereby elongate said plurality of partial arcs.

7. A circuit interrupter as specified in claim 6 wherein some of said plurality of arc runners comprise several turns, and wherein each of said plurality of arc runners comprising several turns is mounted directly above one of said plurality of magnet cores to energize said one of said plurality of magnet cores, and wherein contiguous surfaces of said insulating units are provided with recesses adapted to receive additional plates of magnetic material situated in planes parallel to the planes defined by said plates of magnetic material.

8. In a circuit interrupter the combination of a pair of cooperating separable main current-carrying contacts, a pair of cooperating separable arcing contacts, joint contact separating means for one of said pair of main current-carrying contacts and one of said pair of arcing contacts, said joint contact separating means including means for causing separation of said pair of main current carrying contacts prior to separation of said pair of arcing contacts, and means tending to increase contact pressure between said pair of arcing contacts during initial separation of said pair of main current-carrying contacts preparatory to separation of said pair of arcing contacts.

9. A circuit interrupter as specified in claim 8 comprising a common support for one of said pair of main current-carrying contacts and for one of said pair of arcing contacts, separating means interposed between said common support and said one of said pair of arcing contacts to increase the spacing between said common support and said one of said pair of arcing contacts, an operating rod for operating said separating means to increase said separation, and a lost motion connection between said common support and said operating rod to enable said operating rod to effect joint opening movement of said one of said pair of main current-carrying contacts and of said one of said pair of arcing contacts in addition to increasing said separation.

10. In a circuit interrupter the combination of a pair of cooperating relatively movable main current-carrying contacts, a pair of cooperating relatively movable arcing contacts, a support for one of said pair of main current-carrying contacts, a pantograph linkage supported by said support and supporting one of said pair of arcing contacts, pantograph linkage operating means for causing movement of said pantograph linkage and of said one of said pair of arcing contacts relative to said support to increase the spacing between said one of said pair of arcing contacts and said support, and a lost motion connection between said operating means and said support to enable said operating means to effect joint movement of said pantograph linkage and said support upon initial movement of said pantograph linkage relative to said support.

11. In a circuit interrupter the combination of a pivotally mounted contact support, a movable main current-carrying contact supported by said support, a fixed main current-carrying contact adapted to cooperate with said movable main current-carrying contact, a fixed arcing contact, a movable arcing contact adapted to cooperate with said fixed arcing contact, a four bar linkage supporting said movable arcing contact supported by said support, said four bar linkage comprising a pin guided in a slot provided in said support and adapted upon operation thereof to vary the spacing between said movable arcing contact and said support, and an operating rod journaled to said pin.

12. In a circuit interrupter a pivotally mounted contact support, a movable circuit closing contact mounted on said support, a fixed circuit closing contact adapted to cooperate with said movable circuit closing contacts, a movable main current-carrying contact mounted on said support, a fixed main current-carrying contact adapted to cooperate with said movable main current-carrying contact,

a pair of fixed horn-shaped arc runners, a horn-shaped movable arcing contact adapted to cooperate with said pair of arc runners, a four bar linkage supporting said arcing contact, a pair of links pivotally mounted on said contact support supporting said linkage, cooperating abutment means on said linkage and on said support limiting realtive movement between said linkage and said support, and an operating rod pivoted to said linkage for operating said linkage and said support to cause movement of said linkage relative to said support and joint movement of said linkage and said support.

13. In a circuit interrupter a first pair of relatively movable contacts; a second pair of relatively movable contacts; a third pair of relatively movable contacts; contact opening means for said first, second and third pair of contacts adapted to open said third pairs of contacts subsequent to opening of said first pair of contacts and opening of said second pair of contacts; and contact closing means adapted to close said first pair of contacts prior to closing of said third pair of contacts, said contact opening means and said contact closing means including means for causing joint movement of one of said first pair of contacts, one of said second pair of contacts, and one of said third pair of contacts, and said contact opening means and said contact closing means further including means for causing relative movement between said one of said first pair of contacts and said one of said second pair of contacts.

14. In a circuit interrupter a fixed main current-carrying contact, a contact support, a movable main current-carrying contact fixedly mounted on said contact support and adapted to cooperate with said fixed main current-carrying contact, a fixed arcing contact, a movable arcing contact adapted to cooperate with said fixed arcing contact, a linkage supporting said movable arcing contact and being supported by said contact support, said linkage being adapted to vary the spacing between said movable arcing contact and said contact support, and operating means for said contact support and for said linkage including an operating rod hingedly connected to said linkage and a lost motion connection between said linkage and said contact support.

15. In a circuit interrupter a first fixed contact, a first movable contact adapted to cooperate with said first fixed contact, a support for said first movable contact, operating means for said support adapted to selectively exert a force upon said support in a first direction and in a second direction to separate said first movable contact from said first fixed contact and to engage said first fixed contact by said first movable contact, a second fixed contact, a second movable contact arranged a variable distance from said support and adapted to cooperate with said second fixed contact, contact supporting means supported by said support supporting said second movable contact, said contact supporting means being adapted to increase said distance when acted upon in said first direction and to decrease said distance when acted upon in said second direction, means for securing said operating means to said contact supporting means, and a lost motion connection between said contact supporting means and said support to enable relative and joint movement of said first movable contact and of said second movable contact by said operating means.

16. In a circuit interrupter a first fixed contact, a first movable contact adapted to cooperate with said first fixed contact, a support for said first movable contact, operating means for said support adapted to selectively exert a force upon said support in a first direction and in a second direction to separate said first movable contact from said first fixed contact and to engage said first fixed contact by said first movable contact, a second fixed contact, a second movable contact arranged a variable distance from said support and adapted to cooperate with said second fixed contact, means for varying said distance including a pantograph linkage supported by said support supporting said second movable contact, said linkage being adapted to increase said distance when acted upon in said first direction and to decrease said distance when acted upon in said second direction, means for securing said operating means to said pantograph linkage, and a lost motion connection between said support and said pantograph linkage to enable relative and joint movement of said support and of said pantograph linkage by said operating means.

17. In a circuit interrupter a fixed current-carrying contact, a movable current-carrying contact adapted to cooperate with said fixed current-carrying contact, a pivotally mounted arm supporting said movable current-carrying contact, an operating rod for said arm adapted to selectively exert a force upon said arm in a first direction and in a second direction to separate said movable current-carrying contact from said fixed current-carrying contact and to engage said fixed current-carrying contact by said movable current-carrying contact, a fixed arcing contact, a movable arcing contact adapted to cooperate with said fixed arcing contact, means for varying the spacing between said movable arcing contact and said arm including a pantograph linkage supported by said arm supporting said movable arcing contact, said pantograph linkage being adapted to increase said spacing when acted upon in said first direction and decrease said spacing when acted upon in said second direction, means for securing said operating rod to said pantograph linkage, and a lost motion connection between said arm and said pantograph linkage, said lost motion connection determining a first limit position of said pantograph linkage relative to said support wherein said movable arcing contact is separated from said fixed arcing contact while said movable current-carrying contact is in engagement with said fixed current-carrying contact, and said lost motion connection further determining a second limit position of said pantograph linkage relative to said support wherein said movable arcing contact is in engagement with said fixed arcing contact while said movable current-carrying contact is out of engagement with said fixed current-carrying contact.

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