Dec. 22, 1936. F. G. VON HOORN 2,065,356

CIRCUIT BREAKER

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Fig. 1.

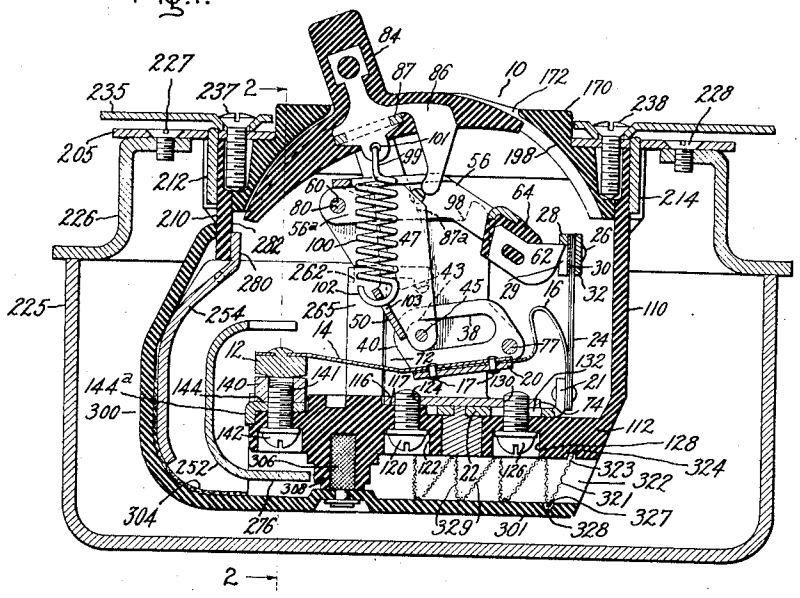


Fig. 2.

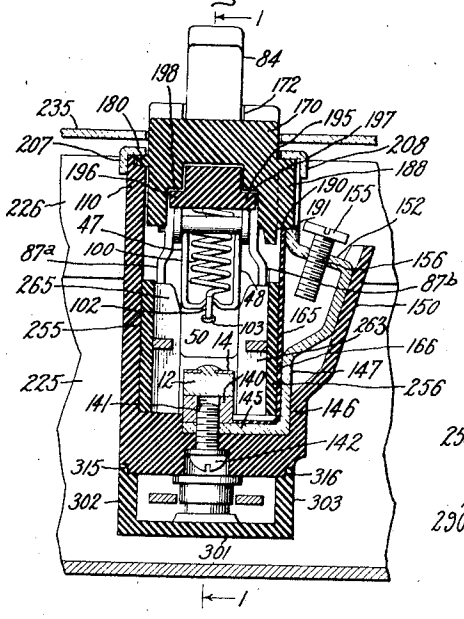
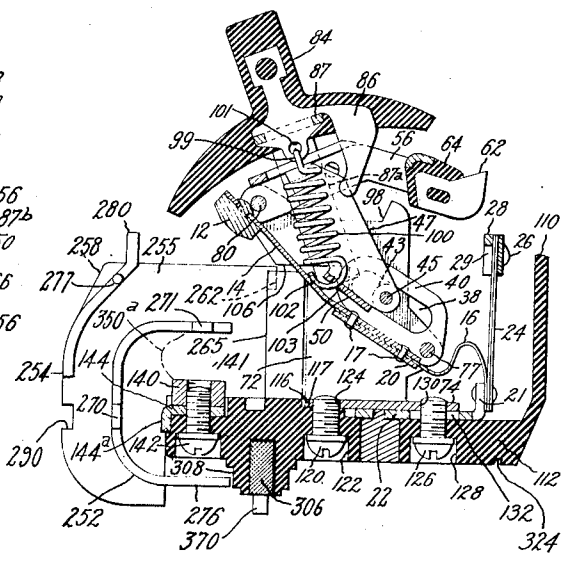


Fig. 3.



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Fig. 4.

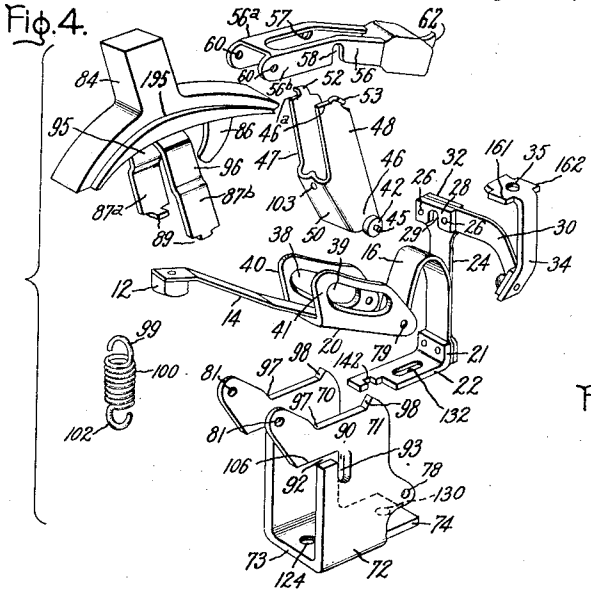


Fig. 5.

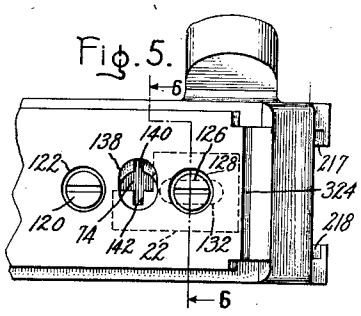


Fig. 6.

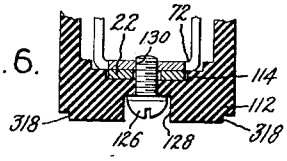


Fig. 7.

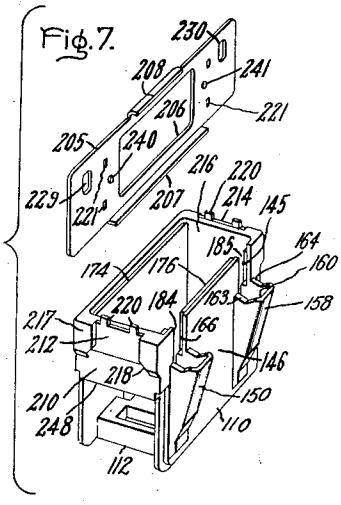


Fig. 9.

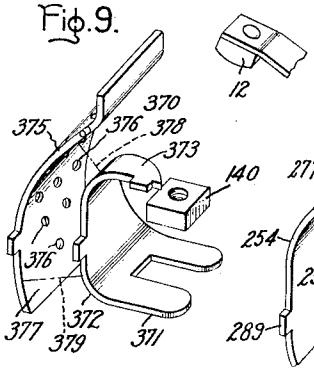


Fig. 8.

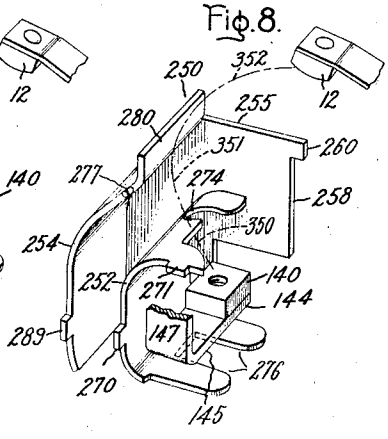


Fig. 10.

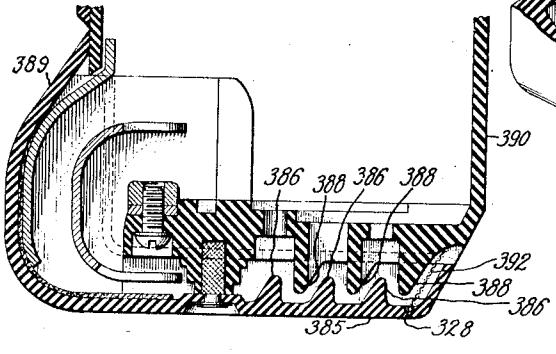
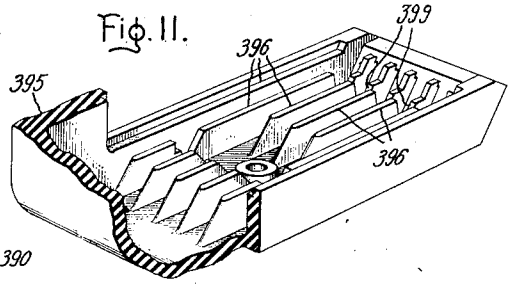


Fig. 11.



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UNITED STATES PATENT OFFICE

2,065,356

CIRCUIT BREAKER

Fred G. von Hoorn, Bridgeport, Conn., assignor to General Electric Company, a corporation of New York

Application April 5, 1934, Serial No. 719,125

27 Claims. (Cl. 200—144)

My invention relates to circuit breakers, more particularly to circuit breakers of the type sometimes known as branch-circuit circuit breakers which provide the protective features under overload and short circuit conditions supplied by a fuse as well as the additional advantages of a manually operable switch, and has for an object the provision of a compact circuit breaker which will be simple and inexpensive in construction, dependable in operation, and adapted for installation in a switch box or other enclosure, either individually or in combination with similar units classified generally as wiring devices, for the protection and control of wiring systems and apparatus connected thereto.

Heretofore branch-circuit circuit breakers have been provided with a thermal release arranged to trip the circuit breaker upon the occurrence of an overload or short circuit and with a manually operable handle for opening and closing the circuit breaker independently of the thermal release. However, much is yet to be desired in reducing the size of circuit breakers hitherto proposed to replace fuses, while retaining the ability of the circuit breaker to meet the requirements of such service. For example, it is required by the Underwriters' Laboratories that the circuit breaker shall interrupt the short circuit current flowing in a circuit capable of delivering 5,000 amperes of alternating or direct current at 125 volts.

In carrying out my invention in one form thereof, I provide a circuit breaker which is capable of interrupting overload currents of large magnitude by sub-dividing the arc and generating a gas pressure by the heat of the arc thereby to produce a rapid flow of air through the arc to cool it and to aid in more rapidly extinguishing the arc. More specifically, I provide a mechanism for both opening and closing the circuit breaker contacts with a snap action as well as one which opens the contacts with a snap action in response to a predetermined flow of overload current. The mechanism is mounted in a substantially air-tight housing provided with an opening leading into a passageway which extends from the opening along the full length of the housing so that the pressure generated by the gases heated by the arc causes a forced draft across the arc path and through the passageway. The portion of the passageway directly adjacent the contacts is divided into two parts by magnetizable plates, which plates serve the function of sub-dividing and cooling the arc without diminishing the flow of air through the passageway.

For a more complete understanding of my invention, reference should now be had to the accompanying drawings wherein I have shown in Fig. 1 a sectional elevation of my invention taken on the lines 1—1 of Fig. 2; Fig. 2 is an end view of the invention taken on the lines 2—2 of Fig. 1 with certain parts omitted; Fig. 3 illustrates a sectional elevation of the operating mechanism after the circuit breaker has opened its contacts in response to an overload current; Fig. 4 is an exploded perspective view of the operating mechanism; Fig. 5 is a fractional view of the base of the circuit breaker with the arc chute removed; Fig. 6 is a sectional elevation taken on the line 6—6 of Fig. 5; Fig. 7 is a perspective view showing the switch box and a metal supporting strap; Fig. 8 is a perspective view of a portion of the arc extinguishing device; Fig. 9 illustrates in perspective a modified form of the magnetizable plates; while Figs. 10 and 11 illustrate modifications of the arc chute or closure member.

While not limited thereto, I have shown my invention in one form as applied to a branch-circuit circuit breaker 10 of extremely small size, embodiments of which have repeatedly interrupted the short circuit current flowing in a constant voltage circuit capable of delivering 10,000 amperes of direct current at 125 volts.

It is believed that the manner in which the circuit breaker achieves the successful interruption of such large values of current will be best understood by a description of the operation of the circuit breaker as a whole. Therefore, the construction and the assembly of the component parts will be first described in detail.

The movable contact 12, preferably formed of an arc resistant high melting point metal, such as nickle or molybdenum is mounted on one end of a resilient member or contact arm 14 formed of phosphor bronze, the opposite end of which is secured in intimate electrical engagement with one end of a flexible conductor 16 by rivets 17 extending through one side of a U-shaped contact operating member 20. The opposite end of the flexible conductor 16 is riveted between an upturned end 21 of a slidably adjustable member 22 and one end of a bimetallic thermal element 24 formed of alloys having different coefficients of expansion, i. e., alloys of nickel steel and nickel copper. On the opposite end of the thermal element there is secured, as by rivets 26, a latching member 28 provided with a recess 29, one end of a flexible conductor 30, and a backing plate 32.

The opposite end of the conductor **30** is secured to one end of a terminal strap **34**, (Fig. 4) the opposite end of which is provided with a threaded opening **35** arranged to receive a terminal fastening screw (not shown).

That part of my invention relating to the operating mechanism is an improvement over the invention of the Schmitt Patent 2,006,966 issued July 2, 1935, entitled Electric switch and assigned to the same assignee as the present invention. No claim is herein made to the operating mechanism per se which is described and claimed in my copending application Serial No. 50,907, filed November 21, 1935, entitled "Circuit breaking", which application is a continuation of the present application.

As shown in Fig. 4, the operating mechanism includes inclined slots **38** and **39** respectively provided in the arms **40** and **41** of the U-shaped contact operating member **20**, which are arranged to receive, respectively, the rollers **42** and **43** supported on the respective ends of a pin **45** carried by one end of a U-shaped operating link **46**, having arms **47** and **48** connected by a cross member **50**. The arms **47** and **48** are arranged to nest between the arms **40** and **41** of the contact operating member **20** so as to prevent the inward movement of the rollers out of their respective slots.

A pair of outwardly extending projections **52** and **53** formed respectively on the arms **47** and **48** pivotally support the link **46** in cooperation with a channel-shaped tripping bar **56** having a hole **57** arranged to receive the projection **52**, and a slot **58** arranged to receive the projection **53**. To provide for the pivotal support of the tripping bar **56** apertures **60** are arranged at one end to receive a pivot pin, while its opposite latching end supports a latching member or tip **62** by means of insulating material **64** (Figs. 1 and 3) molded between the latching end of the channel-shaped bar **56**.

In assembling the parts together, the projection **52** is inserted in the hole **57** provided in one side **56***a* of the channel-shaped tripping bar. The upper end of the arms **47** and **48** of the operating link **46** then being slightly pressed together until the projection **53** will slide into the slot **58** provided in the opposite side **56***b* of the tripping bar. The opposite end of the operating link **46** is then placed between the arms **40** and **41** of the contact operating member **20**, the pin **45** inserted in the operating link, and the rollers **42** and **43** mounted on the respective ends of the pin. This partial assembly of parts is then placed between two arms **70** and **71** of a U-shaped frame **72** (Fig. 4), the two arms being connected together by a cross member **73** provided with an extension **74**. The inner side of the arms **70** and **71** receive in nesting relationship, the contact operating member **20** thereby preventing the dislodgment of the rollers **42** and **43** from their respective slots **38** and **39**. A pivot pin **77** extending through the holes **78** and **79**, provided respectively in the frame **72** and the contact operating member **20** pivotally supports the contact operating member **20**. Similarly, a pivot pin **80** extending through the holes **81** provided in the upper ends of the respective arms **70** and **71** and through the holes **60** provided in the tripping bar, pivotally supports the tripping bar on the frame. The slidable plate **22** is placed on the side of the extension **74** opposite the arms **70** and **71**.

As shown in Figs. 1, 3, and 4, an operating member **84**, formed of molded insulating material, includes a pair of metallic inserts **86** and **87**, Figs. 1 and 4, riveted together. The metallic insert **87** is U-shaped, the respective legs **87***a* and **87***b* of which pivotally support the operating member **84** in the frame **72** by means of a pair of L-shaped slots **90** provided in the respective arms **70** and **71** of the frame. The respective arms **87***a* and **87***b* are provided with inwardly extending projections **89** which can be moved through the horizontal portions **92** of the slots **90** and into their vertical portions **93**. The pivotal movement of the operating member **84** is limited by the cooperation of the inwardly extending portions **95** and **96** of the legs **87***a* and **87***b* and the projections **97** and **98** provided on the upper portion of the frame **72**. One end **99** of an overcenter spring **100** is hooked into a hole **101** provided in the insert **86** while the opposite end **102** is hooked into a hole **103** provided in the upper portion of the cross member **50** of the operating link **46**. I have found it convenient to utilize the portion **106** of the frame as a fulcrum for a pair of pliers or similar instrument by means of which the end **102** of the spring is easily placed in the opening **103**, it being understood, of course, that the spring is placed under substantial tension when it is mounted in the position shown in Fig. 3.

The assembly of the circuit breaker is completed by lowering the frame **72** and its associated parts into a housing **110** formed of insulating material. The size of the circuit breaker will be appreciated by saying that the outside dimensions of the housing as viewed in Fig. 1 may be but 2¾" across, 2" high and 1⅛" deep. The lower end wall **112** of the housing, as shown in Fig. 6, is provided with a channel **114** having a depth and width substantially equal to that of the sliding member **22**. The channel **114** guides the slidable member **22** for longitudinal movement beneath the frame, the frame resting at one portion **116**, against a ledge **117** of the housing, as shown in Figs. 1 and 3. The portion **116** of the frame is rigidly held on the ledge **117** by means of a screw **120** extending through a countersunk hole **122** formed in the lower end wall **112** and into screw threaded relationship with a threaded hole **124** provided in the cross member **73** of the frame **72**. A second screw **126** is mounted in a countersunk opening **128** and into screw threaded relationship with the threaded opening **130** provided in the end of the extension **74** of the frame **72**, the screw passing through an elongated slot **132** provided in the slidable adjustable member **22**.

Referring to Fig. 5, it will be observed that a third countersunk opening **138** is provided intermediate the holes **122** and **128**, a recess **140** forming a portion of the hole **138** being arranged directly opposite a recess **142** formed in the end of the slidable member **22**. By inserting a screw driver, or the like, into the recesses **140** and **142**, it will be observed that the recess **140** will serve as a fulcrum for the screw driver by means of which the slidable member **22** can be moved longitudinally to adjust the position of the thermal element **24** with respect to the latching member **62** of the tripping bar **56**. After the position of the thermal element **24** is determined, the screw **126** is tightened to bend the extension **74** into frictional engagement with the slidable member **22** and thus secure it.

Cooperating with the movable contact **12** is a stationary contact **140** of anti-welding material such as silver and lead oxide provided with a threaded opening **141** into which a threaded screw **142** extends, a conductor **144** being located be-

tween the stationary contact 140 and the lower end wall 112 of the housing through which the screw 142 extends. As shown in Fig. 2, the conductor 144 has one portion 145 which extends horizontally along the lower end wall 112 to the side wall 146 of the housing 110, thence vertically as shown at 147, the conductor then being formed to extend outwardly into a terminal housing 150 formed integrally with the side wall 146. The upper end 152 of conductor 144, substantially at right angles to the vertical portion, closes the opening of the contact housing. A terminal screw 155 is mounted in the threaded opening 156 of the conductor 152. The conductor, or terminal strap 34 connected to the bimetal element 24 (shown in Fig. 4) is substantially identical in shape with the upper portion of the terminal strap or conductor 144 and is arranged in contact with the housing 158 of identical shape with the housing 150. The strap 34 nests within a channel 160 (Fig. 7) formed in the outer wall of the contact housing 158 while two outwardly extending projections 161 and 162 are arranged to engage the upper ends 163 and 164 of the housing 158. As shown in Fig. 2, a member 165 of insulating material, such as fibre, nesting in the groove 166 formed on the inner side of the wall 146, serves to insulate the conductor 144 from the other parts of the switch as well as to prevent the escape of air or gas from the housing 110.

Referring to Figs. 2 and 7, a cover 170 made of insulating material, preferably molded, is provided for the housing 110, the cover being provided with a rectangular opening 172 through which the operating member 84 extends. In order to seal substantially air-tightly the housing, ledges 174 and 176 are located just below the upper end of the housing 110, a flange 180 formed integrally with the cover 170 resting upon the ledge 174 while a similar flange (not shown) rests upon the ledge 176. The cover 170 is also provided with a pair of projections identical in construction, only one of which, the projection 188, being shown in the drawings. The projection 188 lies in the opening 184 in the housing, the lower portion 190 of the projection 188 bearing against the outer end 191 of the conductor 144. In order substantially to prevent the escape of air through the rectangular opening 172 in the cover 170, the operating handle 84, as shown in Fig. 2, is provided with a pair of arcuate flanges 195 and 196 molded integrally with the handle and arranged to nest under arcuate ledges 197 and 198 formed on the cover 170.

The molded cover 170 is tightly secured into place by means of a metallic supporting strap 205 (Fig. 7) provided with a rectangular opening 206 and with flanges 207 and 208 arranged to overlap the side walls of the housing 110. The supporting strap 205 is secured in place by means of a pair of locking members 212 and 214 of identical construction. As shown in Figs. 5 and 7, the locking member 214 is provided with out-turned ends which nest against a pair of ledges 217 and 218 formed integrally with an end wall 216 of the housing 110. A pair of rectangular extensions 220 formed integrally with the locking members 212 project through rectangular openings 221 provided in the supporting strap 205 and are riveted to the outer face of the strap 205 as shown in Fig. 1.

The circuit breaker can be readily mounted as shown in Fig. 1 in a metallic connection box 225, provided with a cover 226 by means of fastening screws 227 and 228 extending through openings 229 and 230 provided in the supporting strap 205. A cover plate 235 is secured to the strap 205 by means of threaded screws 237 and 238 extending through the cover plate and into threaded openings 240 and 241 provided in the strap 205, as shown in Fig. 7.

Arc extinguishing device

Referring to Figs. 1, 7, and 8, it will be observed that the lower portion of the end wall 210 is cut away to form an opening 248 into which extends an arc extinguishing device 250 which can be constructed in various forms, once the principles of my invention are understood, although at the present time I prefer to construct it as shown in Figs. 1 and 8. The arc extinguishing device 250 comprises a magnetizable structure mounted in spaced relation with the stationary contact 140 and the movable contact 12 so as to form a continuous low reluctance path substantially throughout the extent of and adjacent the contact travel for first moving the arc outwardly from the contacts and then moving the arc at a substantial angle to its first movement. As shown the magnetizable structure consists of two magnetizable plates 252 and 254, preferably made of magnet core iron, mounted in spaced relation with each other by means of a pair of insulating supports 255 and 256 of identical shape and preferably formed of fibre. One end 258 of the fiber support 255 has the same vertical dimension as the opening 248 while a projection 260 formed on the upper end of the support 255 nests within a notch 262 (Fig. 3) formed in a post 265 molded integrally with the switch housing 110 to prevent the warping of the fibre away from the side wall of the housing. The other fibre support 256 is similarly mechanically interlocked with a notch provided in an insulating post 263 identical in construction with the post 265. The two posts 263 and 265 are spaced apart one from the other just enough to permit free movement of the movable contact 12 and the resilient member 14 between them.

The inner magnetizable plate 252 is provided with projections on each side which cooperate with the fibre supports 255 and 256, only the projections 270 and 271 of which are shown in Fig. 8. The projections fit tightly within holes provided in the fibre supports and hold the magnetizing plate 252 in the position shown in the drawings. The upper end of the magnetizable plate 252 is provided with an irregular shaped notch the deepest portion 274 of which is located adjacent the side of the plate remote from the vertically extending portion 147 of the conductor 144. The plate 252 is curved so that the lower notched end 276 is located below the stationary contact 140 as viewed in Fig. 1 and in spaced relation with the lower side of the bottom end wall 112.

The outer magnetizable plate 254 is arranged to pivot about a pair of projections 277, one in each side, extending into apertures provided for them in the fibre supports 255 and 256 so that the upper end 280 can be lowered sufficiently to permit the insertion and removal of the arc extinguishing device assembly 250 from the housing 110. After the arc extinguishing device is moved into the housing 110 the magnetizable plate 254 is rotated in a counterclockwise direction so that its upper end 280 strikes against the inner edge 282 of the end wall 210 clamping the arc extinguishing device 250 in position. Additional projections 289 are arranged to snap into

a pair of notches 290 (Fig. 3) provided in the fibre supports 255 and 256 when the magnetizable plate 254 has been moved to the position shown in the drawings.

As shown in Figs. 1 and 2, a closure member 300 provided with an end wall 301 and side walls 302 and 303 forms a passageway along the base of the housing 110. Preferably a liner 304 of arc resistant material, such as asbestos, is cemented to the closure member 300 to protect the member 300 from the arc. The member 300 is secured to the housing 110 by means of a metallic insert 306 molded integrally with a post 308 on the bottom end wall 112 of the housing 110. The side walls 302 and 303 of the enclosure 300 are respectively provided with notches 315 and 316 arranged to receive the projecting ends 318 of the bottom end wall 112 shown in Fig. 6. It will be observed that the closure member 300 in conjunction with the walls of the housing 110 forms a passageway leading from the contacts 12 and 140 through the opening 249 in the housing and extending throughout the length of the circuit breaker housing 110. A wire screen 321 is mounted in the outer opening 322 of the passageway, one end 323 of which nests within a notch 324 formed in the bottom end wall 112 and a second portion 327 of which nests within a notch 328 provided in the end of the closure member 300, the remaining sections 329 of which are bent back and forth across the passageway.

Operation

It is now believed that a comprehensive understanding of the invention including the construction and arrangement of the various apparatus, as well as its operation under various conditions, will be facilitated by a description of the operation of the circuit breaker as a whole.

Referring to Fig. 1, it will be assumed that the circuit breaker is connected in a circuit capable of delivering large magnitudes of current although for normal operation the circuit breaker is called upon to interrupt current of low magnitude, for example, 15 to 30 amperes. The current path through the circuit breaker may be traced from the terminal strap 34, conductor 30, bimetal thermal element 24, conductor 16, resilient member 14, movable contact 12, stationary contact 140, conductor 144 and to the terminal screw 155.

In order to open the circuit manually the operating handle 84 is moved in a clockwise direction, as viewed in Fig. 1, carrying with it the upper end 99 of the over-center spring 100. As soon as the upper end 99 of the spring has been moved past its dead-center position, i. e. past the projections 52 and 53, a component of force is exerted on the operating link 46 in a direction to rotate it in a counterclockwise direction about its pivot. The rollers 42 and 43 operating against the upper sides of the inclined slots 38 and 39 quickly move the contact member 12 to the open circuit position. In case it is desired to close the circuit breaker, it will be obvious that the handle 84 is moved in a counterclockwise direction carrying the upper end 99 of the spring past its dead-center position thereby causing the operating link 48 to rotate in a clockwise direction so that the rollers 42 and 43 bear against the lower sides of the slots 38 and 39 to operate the movable contact 12 to the closed circuit position. As shown in Fig. 1 the resilient member 14 which supports the movable contact 12 is placed under a substantial tension during the closing of the circuit breaker thereby providing a substantial contact pressure and a wiping action as the contacts come together. The spring force due to the resilient member 14 of course tends to rotate the movable contact member 12 towards the open circuit position. The contact operating member 20 however is locked in the closed circuit position since the operating link 46 is substantially at right angles to the slots 38 and 39 so that there is not a sufficient component of force produced on the link 46 by the resilient member 14 to cause it to move from its closed circuit position. Furthermore, this locking means prevents rebound or chattering of the movable contact as it strikes the stationary contact 140.

It will now be assumed that a short circuit occurs with the parts shown in the position of Fig. 1. The resultant rush of current through the circuit breaker and the bimetal thermal element 24 quickly heats the thermal element, causing it to bend in a clockwise direction about its support 22 to disengage the member 28 carried on the upper end of the thermal element from the latching member 62. The full forces of the over-center spring 100 and the resilient member 14 are instantly effective to accelerate the movable parts to their open circuit positions shown in Fig. 3. The force of the spring 100 is applied to the tripping bar 56, through the projections 52 and 53, causing the tripping bar 56 to be rotated about its pivot 80 in a counter-clockwise direction. The movement of the contact 12 begins shortly after that of the tripping bar 56 since the resilient member 14 must first be relaxed and as the opening movement proceeds the rollers 42 and 43 move along the slots 38 and 39 by means of the engagement of the shoulders 46a with the channel-shaped tripping bar 56. The action is a transfer of the pivot for the operating link 46 from the projections 52 and 53 to the pivot pin 80, whereby the link 46 is rotated in a counter-clockwise direction, as viewed in Fig. 1. As viewed in Fig. 3, the final position of the movable contact 12 is directly adjacent the pivot pin 80 while the rollers are midway of the slots 38 and 39.

As the contact 12 is separated from its stationary contact 140 an arc is drawn between them. As the arc lengthens somewhat it is immediately blown against the inner magnetizable plate 252 by a blowout coil formed by the vertical portion 147 of conductor 144, the horizontal portion 145 and the vertical portion of the arc, the axis of the blowout coil being parallel to the axis of the opening 248, i. e., parallel with the plane of movement of the contact member 14. This blowout coil encircles the upper projecting end of the magnetizable plate 252 carrying the projection 271, whereby the effect of the blowout coil is intensified. I have found that there is a tendency for the arc to move to a position remote from the vertical portion 147 of conductor 144 and in order to minimize this effect the deeper notch 274 is provided.

In addition to the action of the blowout coil, the flux surrounding the resilient conductor 14 reacts with the flux surrounding the arc to cause the arc to bow towards the plate 252 and thereby lengthen it as is shown in Fig. 3 by the dotted line 350a. Furthermore, the effect of the low reluctance path provided by the plate 252 is to cause the arc to move to a position of minimum reluctance for the magnetic flux encircling it. Every flux linkage around the arc tends to take a path through the low reluctance plate 252, the

lines of force surrounding the arc being concentrated in the plate **252**, whereby an additional force is applied to the arc tending to bow it toward the plate. Since the magnetizable plate extends substantially along the path of the movable contact **12**, the bowing movement of the central portion of the arc to the plate is greatly accentuated by this additional force.

When the upper end of the arc strikes the upper end of the magnetizable plate **252**, the flux surrounding the arc and concentrated in the plate causes the end of the arc to move downward along the inner surface of the plate **252** to a position of minimum reluctance for the flux, the arc during this movement, swinging about the face of the contact **140** as a center, i. e. the arc swings in a vertical plane, as viewed in Fig. 1, taken through the contact **140**, the contact serving as a hub or center of rotation. This movement, of course, greatly assists in cooling the arc and hastens its extinction. The force exerted on the arc by its attraction to the plate disappears as the flux encircling the arc finds a path of uniform reluctance surrounding the arc. In Fig. 8 the position of minimum reluctance is obtained when the arc moves to the center of the plate **252**, i. e. when the arc strikes that point of the plate which is surrounded by substantially uniform amounts of the magnetic material of the plate.

As the contact **12** moves above the upper end of the plate **252** an arc is drawn between the plate **252** and the outer plate **254**, as indicated by dotted line **351**. It will be observed that the plate **254** extends substantially throughout the length of the contact travel. The arc **351** also moves downwardly over the surface of the plate **254** until it occupies a position of minimum reluctance, this movement being caused, as in the case of plate **252**, by the tendency of all of the flux linkages around the arc **351** to go through the low reluctance path provided by the magnetizable plate **254**. The section of the arc **352** between the upper end **280** of the plate **254** and the contact **12** remains substantially stationary. However, there is little burning at the movable contact **12** or at the upper portion **280** of the plate **254**. Even under the extreme overload condition of 10,000 amperes direct current, mentioned above, an embodiment of my invention repeatedly interrupted the current without showing excessive burning at these points, due to the fact that circuit interruption was completed at about the time the movable contact reached its limit of travel.

A further important action takes place as soon as the arc is drawn between the contacts. It will be remembered that all of the parts of the housing **110** are arranged in interlocking engagement so as to provide a substantially air-tight housing with the exception, of course, of the opening **248** and the passageway which extends along the base of the circuit breaker. Consequently, the heat due to the arc and the current flow through the circuit breaker heats and causes an expansion of the air within the circuit breaker, the resultant substantial pressure of which causes a rush of escaping gases over both sides of the inner plate **252** and across the arcs. This rush of gases contributes to the downward movement of the arcs **350** and **351** over the plates **252** and **254** and assists in moving them around the curved portion of the plates until they are expelled into the passageway **322**, the entrance opening **249** to the passageway of course extending at right angles to the path of the contact travel so that the arc is blown into the passageway. A downturned end **144***a* of the conductor **144** serves as an arcing tip and protects both the end of the housing wall **112** as well as the stationary contact **140** from burning.

It will be remembered that the flanges **195** and **196** provided on the operating member **84** (Fig. 2) cooperate with the ledges **197** and **198** formed integrally with the cover **170**. The action of the gas pressure can, when of sufficient magnitude, move the operating member **84** bodily outward until the flanges strike against the ledges to form an air-tight seal around the operating member. This movement is permitted by reason of the vertical portions **93** of the slots **90** into which the pivoting arms **87***a* and **87***b* of the operating member are pivoted, and by reason of the spring connection of the operating member **84** with the remaining parts of the circuit breaker.

In actual tests I have found that this flow of escaping gases is quite appreciable and contributes substantially to the successful operation of the circuit breaker. I deem it an essential feature of my invention to have the plates **252** and **254** placed sufficiently far apart so that the flow of air and arc gases is not impeded in any way. I prefer to space the plates apart approximately ¼ inch although it will be understood that this spacing will depend somewhat on the size of the circuit breaker.

The rush of the gases over the walls of the plates cools the gases, this cooling effect being increased by the screen **329** located in the passageway **322**, the screen serving the additional function of arresting any particles of hot metal. I have found that the housing **110** can be completely surrounded with cotton during the interruption of the exceedingly high currents, for example 10,000 amperes direct current, the effectiveness of the plates, of the passageway and of the screen being sufficient to prevent the ignition of the cotton even directly at the open end **322** of the passageway. The absence of external or visible flame or the emission of hot arc gases or molten metal particles is exceedingly important since it will be remembered that circuit breakers may be mounted in a gang box where a large number of wires are required in the wiring gutter adjacent the circuit breakers. Often inflammable insulation is used on these wires and if hot arc gases or flame were emitted the wires would have to be located carefully so that the flame would not come into contact with them. However, with my circuit breaker there is no danger of injury to the insulation since there is no emission of flame or hot arc gases.

It will be understood that for overload current of small magnitude, for example 150 percent of the rating of the circuit breaker, the thermal element **24** will deflect to release the tripping bar **56** to cause the opening of the circuit breaker in exactly the same manner as described for the overload currents under short circuit conditions. The deflection of the thermal element required to trip the breaker depends on the overlap of the latching member **28** with the latching tip **62** of the tripping bar **56**. This overlap is preferably determined at the factory and in order to provide a tamper-proof locking means the opening **138** (Fig. 5) is filled with suitable material, such for example as solder, the solder flowing into the recesses **140** and **142** and into the cavity between the base member **112** and the extension **74** forming a rigid connection or key between the base member

112 and the slidable member 22. Consequently even if the fastening screws 120 and 126 should be loosened somewhat any movement of the sliding members 22 and the bimetal element 24 is prevented. The holes 122 and 128 preferably are filled with suitable insulating compound. The closure member 300 is secured to the base by spinning over the end 310 of the metallic insert 306. To gain entry to the circuit breaker the end 310 of the insert must be destroyed making it apparent that the circuit breaker has been tampered with.

Referring to Fig. 9, I have shown a modified form of the magnetic structure, one magnetizable plate 371 of which is provided with a relatively wide base portion 372 terminating at its upper end in a relatively narrow end portion 373. By gradually increasing the cross-sectional area of the plate 372 from the upper end 373 to the lower end 371 the position of the arc with a minimum reluctance path for the flux linkages surrounding the arc is much farther from the upper face of the fixed contact 140 than in the case of the magnetizable plate 252 shown in Fig. 8, because more of the magnetizable plate is concentrated below the center of the plate than in the case of the plate 252. The second magnetizable plate 375 of the magnetic structure 370 is provided with a plurality of holes 376, the major number of the holes being located on the upper half of the plate so that there is a much greater mass of magnetic material located at the lower end 377 of the plate. The result, of course, is to cause the arc to move to a lower position on the plate 375. In addition, the plate 375 is formed so that the distance between the plates gradually increases from top to bottom. For example, the distance between the upper ends of the plates as indicated by the dotted line 378 is much less than the distance between the lower ends of the plates as indicated by the dotted line 379. Similarly, the plate 372 can be curved so that the arc from the stationary contact to it gradually lengthens as the arc moves downward along the surface. Where space requirement permits the gradual lengthening of the arc as it moves over the surface of the plate can be utilized to advantage.

Referring to Fig. 10, I have shown a modified form of the lower end wall 385 of the circuit breaker, the end wall being provided with a plurality of baffles 388 arranged between a plurality of baffles 386 molded integrally with an enclosure member 389 provided for the circuit breaker housing 390. The baffles 386 and 388 provide a sinuous path for the arc gases, thereby presenting a greater cooling area to them. As before, I provide a metal screen 392, which may be of one or more thicknesses, only one thickness being shown in the drawings.

A further modification of my invention shown in Fig. 11 comprises an enclosure member 395 having a plurality of cooling fins 396 extending vertically from the end wall 397, the cooling fins increasing the cooling surface provided by the enclosure member. Several thicknesses of wire mesh work or screening (not shown) can be placed in notches 399 formed in the cooling fins.

It will be understood that the switch may be mounted in various positions and in the appended claims I refer to the switch as viewed in the drawings, the term "below" being applied to the switch when in the position indicated in drawings.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I, therefore, contemplate by the appended claims to cover any 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. In an arc-extinguishing device, the combination of a pair of contacts, means for moving one of said contacts relatively to the other between open and closed circuit positions, and magnetic means including a magnetizable member forming a low reluctance path for first moving the arc drawn between the contacts outwardly from the contacts and then moving the arc at a substantial angle to said first movement, said last-mentioned means including means for mounting said member in spaced relation with said contacts and at one side of said contacts so as to extend along the path of movement of said movable contact whereby the lines of flux surrounding said arc are concentrated in said member.

2. In an arc-extinguishing device, the combination of a stationary contact and a movable contact operable through a predetermined travel from a closed circuit position to an open circuit position, and a magnetizable plate formed so that one end of said plate is located on one side of said stationary contact at a predetermined distance therefrom, the middle portion of said plate having a substantially uniform curvature and extending along a portion of said movable contact travel to provide a gradually increasing distance between said plate and said stationary contact while the opposite end of said plate is located on another side of said stationary contact at a predetermined maximum distance therefrom.

3. An arc-extinguishing device for a circuit breaker provided with a pair of contacts one of which is movable relatively to the other between open and closed circuit positions, comprising means including a plate formed of magnetizable material mounted in spaced relation with said contacts with one portion of said plate forming a low reluctance path extending substantially along a portion of the contact travel for elongating said arc in the direction of said plate and means including another portion of said plate forming a lower reluctance path substantially beyond the limits of travel of said contacts for thereafter bodily moving said arc along said plate at a substantial angle with respect to said direction of elongation until said arc occupies a position of minimum reluctance with respect to said plate.

4. An arc extinguishing device for a circuit breaker provided with a fixed contact and a movable contact operable into and out of engagement with one face of said fixed contact, comprising means including a curved plate formed of magnetizable material for elongating and bodily moving said arc, said plate being positioned adjacent said contacts with a preponderance of its material located in spaced relation with said fixed contact and extending to one side thereof, said means also including a second curved plate of magnetizable material positioned in spaced relation with said first plate, said plates forming substantially parallel low reluctance flux paths so that the arc moves towards said plates and is subdivided by them, the subdivisions of said arc then being moved along the surface of said plates at a substantial angle to the direction of movement towards said plates.

5. An arc-extinguishing device for a circuit breaker provided with a pair of contacts, means

for moving one of the contacts relatively to the other between open and closed circuit positions, a plate formed of magnetizable material, means mounting said plate in spaced relation with said contacts to form a low reluctance path for the flux surrounding the arc drawn between the contacts, said low reluctance path extending in a plane substantially parallel to the direction of contact travel and substantially throughout the length of the contact travel, and a second plate formed of magnetizable material, means mounting said second plate between said first plate and said contacts and in spaced relation with said contacts and said first plate, a preponderance of said magnetizable material being located to one side of the closed circuit position of said contacts whereby said arc is caused to move over the surface of said plates.

6. An arc-extinguishing device for a circuit breaker provided with a pair of contacts, means for moving one of said contacts relatively to the other between open and closed circuit positions, a magnetizable plate mounted in spaced relation with said contacts, a portion of said plate extending partly along the travel of said contacts, the remaining portion of said plate being located below said contacts, said plate being formed so that the distance between said contacts and said plate gradually increases towards said remaining portion of said plate, a second plate mounted in spaced relation with said first plate and extending substantially throughout the extent of said contact travel, said second plate being formed so that the distance between said first plate and said second plate gradually increases from adjacent ends of said plates to the opposite adjacent ends of said plates whereby the arc drawn between said contacts is elongated by attraction to said plates, and is divided by said plates, each division of the arc thereafter being moved along the surfaces of said plates at a substantial angle to its movement towards said plates and being elongated by the increased spacing of said plates.

7. An arc extinguishing device for a circuit breaker provided with a stationary contact and a movable contact operable into and out of engagement with one of said fixed contacts, comprising means including a plate formed of magnetizable material for swinging the arc drawn between said contacts about said stationary contact, one end of said plate being positioned above said stationary contact, the major portion of said magnetizable plate extending below said fixed contact, said plate being curved around said fixed contact and in spaced relation thereto the curvature of said plate being substantially uniform to provide for gradual elongation of said arc.

8. In combination with a circuit breaker provided with separable contacts between which an arc is drawn, arc extinguishing means comprising walls forming an enclosure for said contacts and a passageway extending from said enclosure to a point a substantial distance from said contacts, and a magnetizable structure located in said passageway for attracting the arc into said passageway, said passageway having an opening remotely located with respect to said structure and said contacts.

9. In combination with a circuit breaker provided with separable contacts between which an arc is drawn, arc extingushing means comprising walls forming an enclosure for said contacts and a passageway extending from a point adjacent to said contacts to a point a substantial distance from said contacts, magnetizable structure located in said passageway for attracting the arc into said passageway, said passageway having an opening remotely located with respect to said structure and said contacts, and a screen located adjacent said opening and extending across said passageway.

10. In combination with a circuit breaker provided with separable contacts between which an arc is drawn, enclosing walls for the circuit breaker providing a substantially air-tight housing having an opening adjacent said contacts and a passageway extending from said opening along the side of one of said enclosing walls, and means for moving the arc drawn between said contacts through said passageway to extinguish quickly the arc.

11. A circuit breaker provided with a stationary contact and a movable contact operable into and out of engagement with one face of said stationary contact, a curved plate formed of magnetizable material a minor portion of which extends in spaced relation with the contact travel and a major portion of which extends below said stationary contact so as to cause the arc drawn between said contacts to move against said plate and to move the end of said arc engaging said plate downwardly over the surface of said plate, a substantially air-tight housing for said circuit breaker provided with a passageway extending from said housing adjacent said contacts and including said curved plate so that the rise in pressure in said housing created by the heat of the arc causes a quick movement of air over said plate and through the arc to assist in quickly extinguishing the arc.

12. A circuit breaker comprising a substantially air-tight housing having an aperture in one wall, a pair of contacts operable between open and closed circuit positions, means mounting said contacts adjacent said one wall of said housing, and walls forming a passageway extending from the aperture adjacent said contacts and along said wall and then along an adjacent one of the outside walls of the housing for the flow of gas produced by the heat of the arc drawn between said contacts.

13. A circuit breaker comprising a substantially air-tight housing, a pair of contacts operable between open and closed circuit positions, means mounting said contacts adjacent one wall of said housing, walls forming a passageway extending from the portion of said housing adjacent said contacts and along one of the outside walls of the housing for the flow of gas produced by the heat of the arc drawn between said contacts, and an arc-extinguishing device located in said passageway and in spaced relation with said contacts.

14. A circuit breaker comprising a substantially air-tight housing, a pair of contacts operable between open and closed circuit positions, means mounting said contacts adjacent one wall of said housing, walls forming a passageway extending from the portion of said housing adjacent said contacts and along one of the outside walls of the housing for the flow of gas produced by the heat of the arc drawn between said contacts, and a magnetizable member located in said passageway and in spaced relation with said contacts for attracting the arc into said passageway.

15. A circuit breaker including a substantially air-tight housing, a fixed contact located adjacent one wall of the housing, a movable contact operable into an out of engagement with said stationary contact, said one wall being provided with an opening one dimension of which is sub-

stantially equal to the travel of said movable contact and the other dimension of which is somewhat greater than the width of said contacts, and walls forming in conjunction with the walls of said housing a passageway along said one wall of said housing and along said adjacent side wall so that the pressure due to the heat of the arc drawn between said contacts produces a rapid flow of gas from said housing across said arc path and into said passageway.

16. An arc extinguishing device for a circuit breaker provided with a fixed contact and a movable contact operable into and out of engagement with one face of said stationary contact, a pair of supports formed of insulating material mounted on opposite sides of said contacts and in spaced relation therewith, a curved plate formed of magnetizable material mounted between said supports, said plate being provided with a notched end located to one side of and in spaced relation with said face, the remainder of said plate extending substantially along the direction of movement of said movable contact in spaced relation with said stationary contact with a preponderance of said plate being located below said face, a second curved plate formed of magnetizable material mounted between said supports and in spaced relation with said first plate, the distance between said first plate and said stationary contact being approximately equal to the distance between said first plate and said second plate.

17. A circuit breaker comprising a substantially air-tight housing, a fixed contact located adjacent one corner of the housing, a movable contact, means for operating said movable contact into and out of engagement with one face of said stationary contact, said housing being provided with an opening adjacent said contacts, a plate formed of magnetizable material, one end of said plate being positioned in said opening, the remainder of said plate extending below said face whereby the magnetic field due to the arc drawn between said contacts causes said arc to move downwardly over the surface of said plate, and walls forming in conjunction with said housing a passageway extending from said opening and along one side of said housing so that the gas pressure produced due to the heat of the arc causes a rapid flow of gas from said housing across the arc to assist in extinguishing the arc.

18. A circuit breaker including a fixed contact and a movable contact, means mounting said movable contact for operation into and out of engagement with one face of said stationary contact, walls forming a substantially air-tight housing for said contacts and said operating means, said housing being provided with an opening in the wall adjacent said stationary contact, a pair of ledges each extending from an opposite wall of said casing adjacent said stationary contact, a pair of insulating supports provided with interlocking projections for cooperation with said ledges, a pair of magnetizable plates mounted by said supports in spaced relation with each other, one of said plates having one end positioned slightly above said face and said stationary contact, the remaining portion of said plate being curved downwardly so that the opposite end of said plate is located in spaced relation with said fixed contact and substantially below the same, and walls forming in conjunction with said housing a passageway extending from said opening downwardly along the lower wall of said housing so that gas pressures due to the heat of the arc drawn between said contacts causes a rapid flow of air through said plates to assist in quickly extinguishing the arc.

19. A circuit breaker including a fixed contact and a movable contact, means mounting said movable contact for operation into and out of engagement with one face of said stationary contact, walls forming a substantially air-tight housing for said contacts and said operating means, said housing being provided with an opening in the wall adjacent said stationary contact, a pair of ledges each extending from an opposite wall of said casing adjacent said stationary contact, a pair of insulating supports provided with interlocking projections for cooperation with said ledges, a pair of magnetizable plates mounted by said supports in spaced relation with each other, one of said plates having one end positioned slightly above said face and said stationary contact, the remaining portion of said plate being curved downwardly so that the opposite end of said plate is located in spaced relation with said fixed contact and substantially below the same, and walls forming in conjunction with said housing a passageway extending from said opening downwardly along the lower wall of said housing so that gas pressures due to the heat of the arc drawn between said contacts cause a rapid flow of air through said plates to assist in quickly extinguishing the arc, and a plurality of thicknesses of fine wire mesh for cooling the hot gases incident to the formation of the arc and for mechanically arresting hot particles of metal carried by said gases.

20. An arc extinguishing device for a circuit breaker provided with a fixed contact and a movable contact operable into and out of engagement with one face of said fixed contact, comprising a curved plate formed of magnetizable material, said plate being positioned adjacent to said contacts wth a preponderance of its material located in spaced relation with said face and extending on the opposite side thereof, and a second curved plate of magnetizable material positioned adjacent to said contacts and in spaced relation with said first plate, a conductor for said stationary contact extending in parallel relation with said face for a short distance and thence upwardly at right angles to said face to form a single turn blowout coil when an arc is drawn between said contacts, the flux from said blowout coil causing said arc to move into engagement with said plates while the preponderance of said material below said face causes said arc to move over the surface of said plates.

21. An arc-extinguishing device for a circuit breaker provided with a fixed contact and a movable contact operable into and out of engagement with said stationary contact, a conductor connected to said stationary contact and extending therefrom in a direction substantially parallel with the path of said movable contact to form in conjunction with the arc drawn between said contacts a single turn blowout coil, and a magnetizable plate the major portion of which is arranged in spaced relation with said contacts, and one end of which extends within the single turn of said blowout coil.

22. A circuit breaker comprising a fixed contact and a movable contact, operating means for operating said movable contact into and out of engagement with said stationary contact, walls forming a substantially air-tight housing for said contacts and said operating means, means mounting said stationary contact in one corner of said

housing, an opening being provided in the end wall adjacent said fixed contact, a pair of insulating supports, the adjacent end portions of which are arranged to nest within said opening adjacent the inner side walls of said casing, a curved magnetizable plate mounted on said insulating supports the upper portion of said plate being located in spaced relation with said stationary contact said plate being curved so that the opposite end of the plate is located substantially below said stationary contact, a second curved plate formed of magnetizable material having an upwardly extending flange at one end thereof, means pivotally mounting said plate between said insulating supports in a position so that said supports can be moved into said opening when the end of said plate opposite said flange is tilted upwardly, said flange being arranged to form a protecting surface for the upper wall of said casing when the end of said plate is rotated downwardly, and means for interlocking said end of said plate with said supports for maintaining it in fixed position, walls forming a passageway extending from said opening along said end wall and said adjacent bottom wall, said passageway being divided into substantially equal parts by said plates so that the arc drawn between said contacts is divided between said stationary contact and said movable contact into three parts when said movable contact is operated to said open circuit position the heat of said arc causing a gas pressure within said housing which produces a rapid flow of air between said plates to assist in extinguishing said arc.

23. An arc extinguishing device for a circuit breaker provided with a fixed contact and a movable contact operable into and out of engagement with one face of said stationary contact, a plate formed of magnetizable material said plate being positioned in the arc path, the major portion of said plate extending below said face of said fixed contact, a conductor connected to said stationary contact and extending upwardly from said face of said contact at substantially right angles thereto whereby said conductor and the arc drawn between said contacts form a single turn blowout coil causing said arc to move into engagement with said plate, the reaction between the magnetic field surrounding said arc and the major portion of the plate extending below the face of the contact causing said arc to move downwardly over the surface of said plate.

24. In combination, a housing, a circuit breaker mounted therein and provided with a pair of contacts one of which is movable relatively to the other between open and closed circuit positions, operating means for said one of said contacts including an operating handle movable between open and closed circuit positions, said handle being provided with a pair of ledges located respectively on opposite sides of said handle, a cover for said housing provided with an opening to permit a portion of said handle to extend therethrough, said cover being provided with recesses arranged on opposite sides of said opening to receive said ledges, and connecting means between said operating handle and said operating means for permitting movement of said handle so that said ledges can be pressed against said recesses so as to seal said housing substantially air-tight.

25. The combination in a circuit breaker, a housing formed of insulating material and provided with an opening, a ledge formed integrally with said housing and located adjacent said opening, a cover for said housing provided with a flange forming in conjunction with said ledge a substantially air-tight seal for said housing, a supporting strap for said housing, locking members secured at one end to said strap and means securing the opposite ends of said locking members to said housing, said strap overlapping said cover to hold it securely in place.

26. A circuit breaker provided with a stationary contact and a movable contact operable into and out of engagement with said stationary contact, a continuous magnetizable member in spaced relation with said contacts having a portion extending along the path of movement of said movable contact so that the lines of force surrounding the arc drawn between said contacts are concentrated in said member to move said arc outwardly against said member and then along the surface of said member, a substantially air-tight housing for said circuit breaker provided with walls forming a passageway extending from said housing adjacent said contacts, said walls surrounding said magnetizable member so that the rise in gas pressure created in said housing by the flow of a predetermined abnormal current in said circuit breaker causes a quick movement of air over said magnetizable member and through said arc to assist in quickly extinguishing the arc.

27. A circuit breaker including a fixed contact and a movable contact, means mounting said movable contact for operation into and out of engagement with said stationary contact, walls forming a substantially air-tight housing for said contacts and said operating means, said housing being provided with an opening in the wall adjacent said stationary contact, a pair of insulating supports mounted adjacent said contacts, a pair of magnetizable plates mounted by said supports in spaced relation with each other, one of said plates having an end positioned slightly above said stationary contact, the remaining portion of said plate being curved so that the opposite end of said plate is located in spaced relation with said fixed contact and substantially below the same, and walls forming in conjunction with said housing a passageway surrounding said plate extending from said opening downwardly along the lower wall of said housing so that the gas pressure due to the heat created by the flow of a predetermined abnormal current in the circuit breaker causes a rapid flow of air through the plates to assist in quickly extinguishing the arc.

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