Sept. 6, 1966 F. KESSELRING 3,271,548

CONTACT CONSTRUCTIONS FOR CIRCUIT INTERRUPTERS

Filed Sept. 16, 1964

3 Sheets-Sheet 1

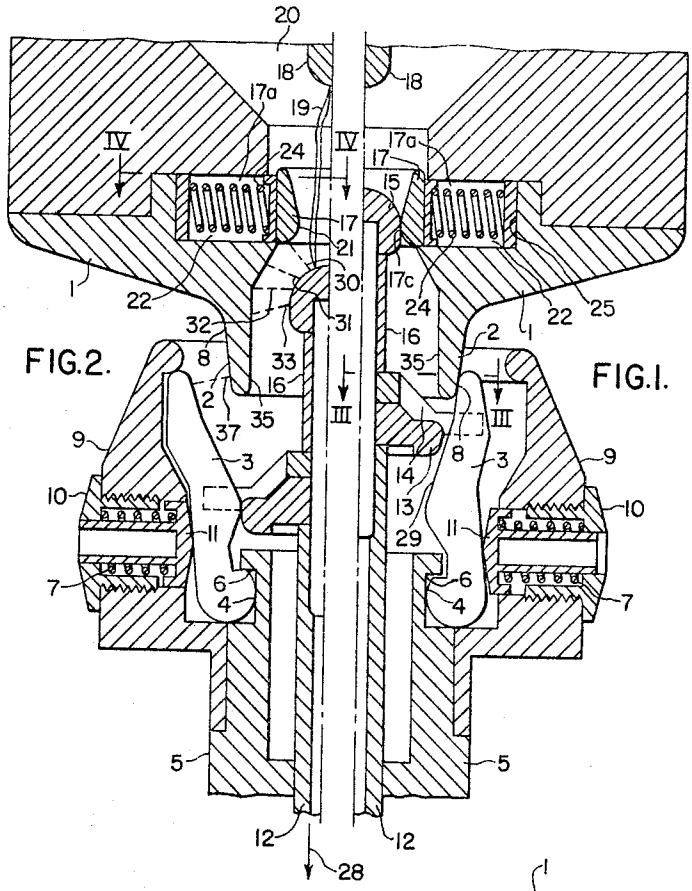


FIG.2.

FIG.1.

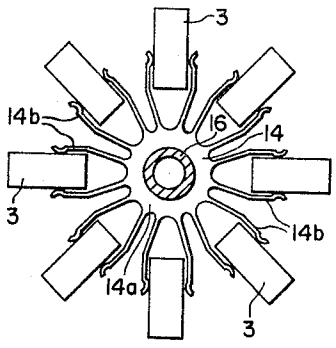


FIG.3.

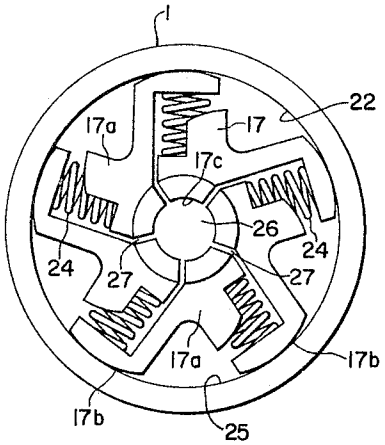


FIG.4.

WITNESSES

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CONTACT CONSTRUCTIONS FOR CIRCUIT INTERRUPTERS

Filed Sept. 16, 1964

3 Sheets-Sheet 2

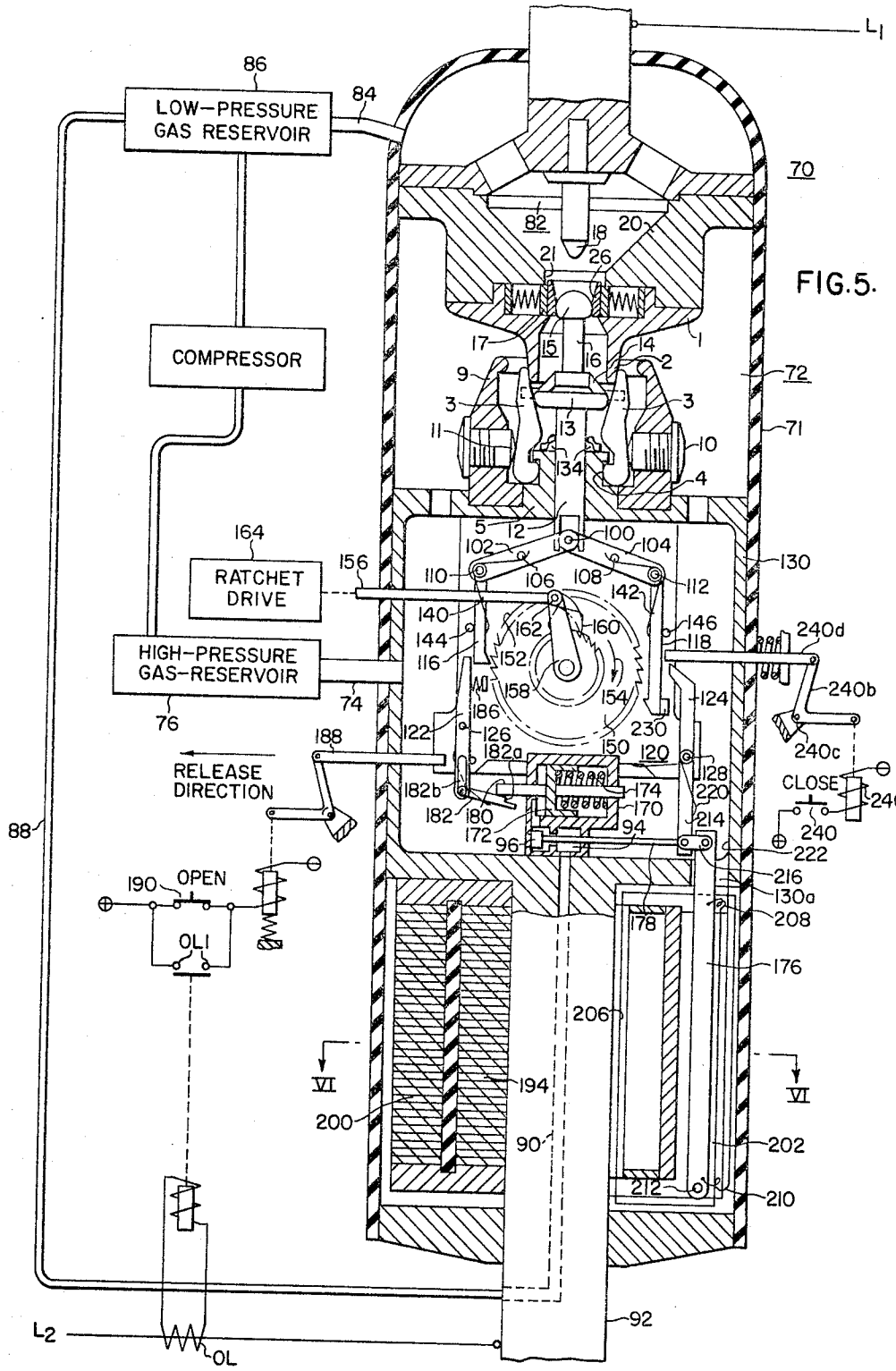


FIG.5.

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CONTACT CONSTRUCTIONS FOR CIRCUIT INTERRUPTERS

Filed Sept. 16, 1964

3 Sheets-Sheet 3

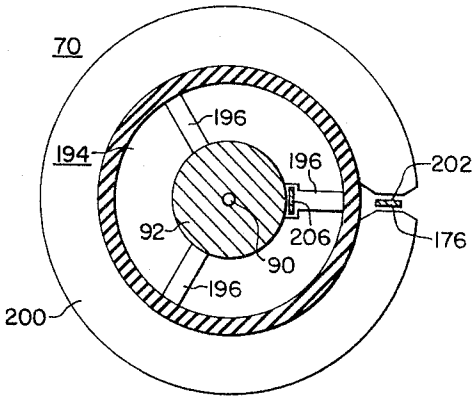
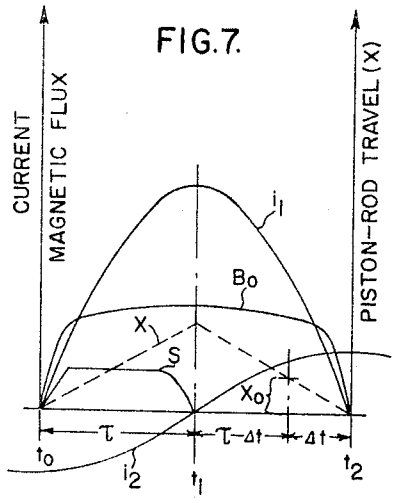


FIG.6.

FIG.7.



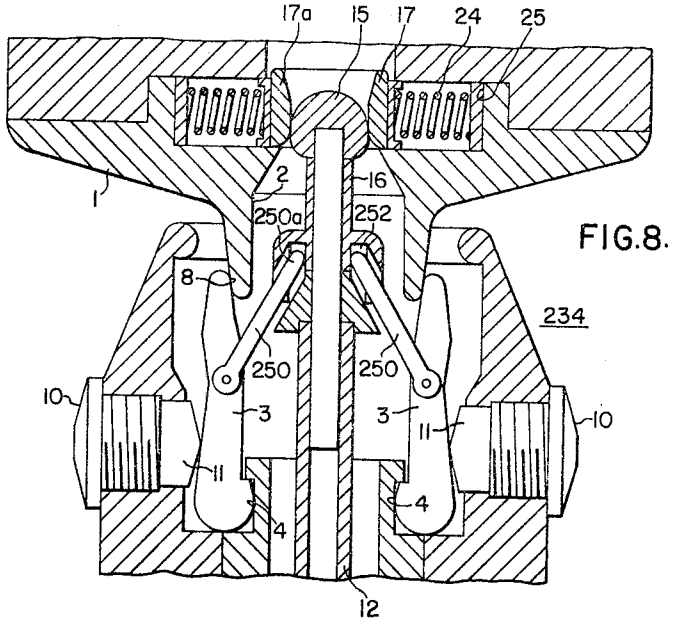


FIG.8.

United States Patent Office

3,271,548

Patented Sept. 6, 1966

3,271,548

CONTACT CONSTRUCTIONS FOR CIRCUIT INTERRUPTERS

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Claims priority, application Germany, Oct. 11, 1963, S 87,834
8 Claims. (Cl. 200—148)

This invention relates generally to contact constructions for circuit interrupters and, more particularly, to improved contact constructions in which there are provided both main contacts and arcing contacts for maintaining good contacting surfaces between the main contacts in the closed-circuit position of the interrupter.

A general object of the present invention is to provide an improved contact arrangement in which the contact surfaces between the main contacts are maintained free from arc erosion, and arcing contacts are provided to assume the arc erosion, or pitting during the opening operation of the interrupter.

Another object of the present invention is to provide an improved contact arrangement for a compressed-gas type of circuit interrupter in which provision is made for preventing the restriking of the arc, due to "clogging" effects or back-pressure conditions in the orifice, from deleteriously effecting the main contact surfaces.

Still a further object of the present invention is the provision of an improved contact construction particularly suitable for use in a fluid-blast synchronous type circuit interrupter.

Yet a further object of the present invention is the provision of an improved contact construction involving main and arcing contacts, in which the inertia of rotation of the movable main contacts is reduced during the opening and closing operations thereof.

An ancillary object of the present invention is the provision of an improved contact construction for a fluid-blast circuit interrupter of the nozzle type, in which the relatively stationary arcing contacts are disposed at the most constricted portion of the nozzle for highly-effective gas-blast action.

In U.S. patent application, filed May 21, 1964, Serial No. 369,208 by Fritz Kesselring entitled, "Electric Circuit Breaker," and assigned to the assignee of the instant application, there is illustrated and described a novel type of fluid-blast synchronous circuit interrupter, in which the energy of a rotating mass is utilized to effect very fast opening and closing operations of the circuit interrupter. It is yet a further object of the present invention to provide an improved fluid-blast contact construction for the type of synchronous circuit interrupter disclosed in the aforesaid patent application, rendering the same adaptable for the carrying of high current values with a minimum of arc erosion on the movable main contact surfaces.

In accordance with one particular aspect of the present invention, there is provided a nozzle-type stationary contact structure including a constricted orifice opening, adjacent to which is provided circumferentially-disposed arcing contact segments, biased radially inwardly. A main contacting portion depends from the aforesaid stationary nozzle contact, and the exterior outer sides thereof cooperate with a plurality of pivotally-mounted main contact fingers. A movable arcing contact member has a cam portion movable therewith for cam actuating the main movable contact fingers into the open-circuit position prior to the separation of the arcing contact from the segmental stationary arcing contact segments. As a result, pivotal camming action is exerted upon the main contact fingers, and any restriking of the arc between the arcing contacts is prevented from occurring at a location, which would have a deleterious effect upon the contact surfaces of the main contact fingers.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIGURE 1 is a fragmentary vertical sectional view taken through the improved contact structure of the present invention, the contacts being illustrated in the closed-circuit position;

FIGURE 2 is a view similar to that of FIG. 1, but illustrating the disposition of the several contact components during the opening operation;

FIG. 3 is a sectional view taken substantially along the line III—III of FIG. 1;

FIG. 4 is a detailed sectional view taken substantially along the line IV—IV of FIG. 1;

FG. 5 illustrates an application of the contact structure of FIGS. 1–4 inclusive, as applied to a fluid-blast synchronous-type of circuit interrupter, the disposition of the parts being indicated in a condition corresponding to energization of the tripping coil, and releasing action of the trip rod having taken place, the contacts however having not as yet separated;

FIG. 6 is a sectional view taken substantially along the line VI—VI of FIG. 5;

FIG. 7 illustrates diagrammatically the main current, control current, and flux conditions for effecting synchronous control; and

FIG. 8 illustrates a modified-type of contact structure of the present invention, which may be substituted for that illustrated in FIGS. 1–4.

The present invention is particularly concerned with a novel contact arrangement particularly adaptable for synchronous-type circuit interrupters, but not limited thereto, being provided with main and arcing contacts and particularly suitable for an axial flow of a compressed-gas arc-extinguishing medium. Preferably, although this is not a necessary limitation, the stationary arcing contact segments form the narrow cross-section of a quenching nozzle, which is opened up during the opening operation. In addition, the movable contacts preferably make contacting engagement with the outer sides of the arc-quenching nozzle, so that any possible arc erosion, or burning action, may occur only on the inner sides of the quenching nozzle, so that the outer surfaces thereof, which are used for making contact, remain undamaged.

In order to completely avoid arc erosion of the main contacts, there has previously been suggested the concept of using main and arcing contacts in such manner that during the opening operation, first the main contacts are opened, and then the current is transferred to the arcing contacts, following which interruption occurs only at the arcing contacts. In some constructions of the prior art, the arc is initiated between the stationary and movable arcing contacts, and then it is blown from the latter to a stationary arcing electrode, after which the arc is extinguished at the next passage of the current through zero. However, in the case of non-synchronous interruption of a large current, it may frequently occur that a back pressure, or "clogging" condition, occurs in the fluid nozzle due to the heating of the interrupting gases, whereby under some conditions, the hot arcing gases can be driven rearwardly, even against the flow of the quenching medium, so that the arc in such case is restruck between the movable main contacts, and the latter are consequently destroyed. To prevent such "clogging" action, or the production of high-back pressure conditions, there have been proposed the use of a larger nozzle diameter, higher gas pressures, and the use of suitable arc-quenching gases which provide a minimum amount of interrupting effort.

In a synchronous-type circuit breaker with high-speed reclosing, in the case of an unsuccessful synchronous interruption, the conditions are fundamentally different. Of course, the arc again occurs at the arcing contacts, and it may be blown against a stationary arcing electrode, so that during a normal synchronous interruption no back-pressure conditions take place. But if, as an exception, for example, due to too small contact separation distance at the moment of the passage of the current through zero value, the arc is not extinguished, then the movable contact piece of the movable contact structure is immediately reversed, and is returned into the closed-circuit position, such action occurring at the latest even when the movable contact structure has reached its fully-open circuit position. But if, during such action, the current increases to a relatively high value, experience has shown that the arc, when the current increases, has the tendency to jump from the stationary arcing electrode to the stationary contact surfaces of the main contact, which results in a large amount of arc erosion occurring at the main contact surfaces, which is undesirable.

The back-pressure, which may possibly occur, is in itself harmless, but after a reclosing operation, the hot gases should be blown away from the interrupting gap. However, this process must be completed before the next, or second synchronous interruption can be started shortly before the next current passage through zero, for only then are the most favorable conditions for arc extinction during a synchronous interruption present.

More particularly, the present invention is particularly concerned with contact arrangements, particularly adaptable for synchronous-type circuit interrupters with high-speed reclosing, having main and arcing contacts, and preferably provided with an axial flow of arc-extinguishing medium. The invention is particularly distinguished by that the stationary contact pieces of the arcing-contact system form a narrow, or restricted cross-section of the quenching nozzle, which nozzle preferably widens toward the tubular stationary contact piece of the main contact in the direction of the opening movement of the circuit interrupter, so that the movable main contact fingers of the main contact structure surrounds the tubular stationary contact piece of the main contact. As a result, in the closed-circuit position, contact is established between the movable contact fingers and the stationary tubular contact piece formed at the outer surface of the latter.

With particular attention being directed to FIG. 1 of the drawings, it will be noted that the reference numeral **1** designates the stationary contact support plate having a tubular contacting depending portion **2** associated therewith. The reference numeral **3** indicates main contact fingers arranged in a circle around the stationary contact member **2**, being pivoted at the point **4** on the stationary current stud **5**, and being secured against axial movement by a groove **6** formed on the contact stud **5**. As shown, contact pressure is produced by compression springs **7** so that contact pressure is exerted at the points **4**, and also at the points of contact **8**. During the interruption of large-amperage currents, in addition to the forces exerted by the compression springs **7**, there additionally appear electrodynamic-type forces, which increase the contact pressure.

The reference numeral **9** indicates a stationary contact housing in which the compression springs **7** and adjustment screws **10** are preferably located. The housing **9** and the screws **10** can be made of metal, or, if desired, of insulating material. The reference numeral **11** indicates guides by means of which the forces of the compression springs **7** are transmitted to the main contact fingers **3**. Attached to the main movable arcing contact **15** is a disc-like, or camming slide piece **13** fixedly attached to the operating rod **12**. Above it is arranged a star-shaped sliding contact **14**, the construction of which is shown in more detail in FIG. 3 of the drawings. As shown, it transfers the current from the main contact fingers **3** to the movable arcing contact **15**, which is connected with the sliding contact **14** by means of a connecting tube **16** made of a good conducting material. The reference numeral **17** indicates the stationary arcing contacts, comprising a plurality of circumferentially-disposed arcing contact segments **17***a*, the construction of which is more apparent from a study of FIG. 4 of the drawings.

Preferably, a stationary arcing electrode **18** is provided, to which the arc **19** may terminate on the outlet side **20** of the nozzle **21** during the opening operation. During an opening operation, the arc **19** is established, as shown in FIG. 2. The stationary arcing contact pieces **17***a* of the stationary arcing contact assembly **17** are preferably arranged within a recess **22** provided in the contact support plate **1**.

With reference to FIG. 3, it will be noted that the sliding contact **14** comprises a central ring **14***a*, in which are mounted flexible sheet metal contacts **14***b*, the outer ends of which bear in sliding contacting engagement with the main pivotal contact fingers **3**.

With reference to FIG. 4, it will be noted that the Z-shaped arcing contact segments **17***a* have their outer ends **17***b* pressed by compression springs **24** against the inner surface **25** of the retaining groove of the cylindrical recess **22** in the contact support plate **1**. The inside ends, **17***c* or inner surfaces of the contact segments **17***a*, are preferably made of a suitable arc-resisting material, such as a molybdenum-silver alloy, for example, Preferably, they form collectively the narrowest or most constricted cross-section **26** of the quenching nozzle **21**. In the closed-circuit position, as illustrated in FIG. 1, it will be noted that there exists gaps **27** between the individual stationary arcing contacts **17***a* through which the hot ionized gases may escape, which is particularly desirable in the case of high-speed reclosing.

The contact arrangement functions as follows: The operating rod **12** is moved downwardly by a force acting in the direction of the arrow **28**. After a travel of approximately 2 millimeters, the disc-shaped cam actuator **13** comes into contact with the opposite slanted surfaces **29** of the main contact fingers **3**, whereafter these main contact fingers **3** are forced radially outwardly about their contact pivot points **4**, until the open-circuit positions is reached, illustrated in FIG. 2 of the drawings. Shortly after separation of the main contact fingers **3** from their contact points **8** on the tubular main contact portion **2**, there follows a separation between the movable arcing contact **15** and the stationary arcing contacts **17***a* of the arcing contact assembly **17**. The arc **19** (FIG. 2) is initiated, and is very quickly blown toward the stationary arcing electrode **18**. At the synchronized opening and successfully synchronized interruption, the arc **19** is extinguished in this position without endangering the main contacts **2**, **3** in any way. However, in the case of an unsuccessful synchronous interruption, the arc **19** burns generally at first between the tip of the retractable arcing contact **15** and the arcing electrode **18**, as indicated by the arc location **19**, but if "clogging" action occurs, or back-pressure conditions arise, due to a relatively high current being interrupted, then the arc **19** can move back into one of the positions **30**, **31**, **32** or **33** indicated by the dotted lines in FIG. 2. If the inside surface **35** of the tubular arcing contact **2** were also the contact surface of the main contact, as is generally the case with conventional contact constructions, then a considerable arc-erosion action would occur at the main contacts **2**, **3**, which would result in an increase of contact resistance in the closed-circuit position of the interrupter. But according to the present invention, the contact points, or surfaces **8** are located on the external surfaces of the tubular main contact member **2**, and, therefore, as confirmed by experiments, no arc can restrike at the location **37** (FIG. 2) even during a persistent back-pressure condition, because it finds much more favorable conditions at the locations **30**–**33**. The arcs **30**–**33** now extinguish as soon as the movable arcing contact **15** again enters into contact with the station-

ary arcing contact **17**. As a result, it is seen that the hot gases, which have accumulated inside of the main arcing ring contact **2**, can escape through the gaps **27** between the contact pieces **17***a* of the stationary arcing contact assembly **17** in several milliseconds, so that the contact system is again ready for the next following synchronous interruption, and is cleared of all hot and ionized gases.

During the closing operation, first contact is established between the movable arcing contact **15** and the stationary arcing contact **17**. Because here a sliding contact is essentially involved, practically no chattering of the contacts is encountered. Shortly before reaching the final closed-circuit position, the main contact fingers **3** strike the contact points **8**. As a result, under some circumstances, a slight contact chattering can occur, but it is harmless because the circuit is already closed through the main arcing contacts **15**, **17**. It can be seen from an inspection of FIG. 1, that in the closed-circuit position, no additional forces are needed to produce a sufficiently low contact resistance, whereby the operating mechanism is simplified.

FIG. 5 illustrates an application of the improved contact construction of FIGS. 1–4 to a fluid-blast synchronous-type circuit interrupter, generally designated by the reference numeral **70**. As shown, the synchronous-type circuit interrupter **70** includes a casing **71** enclosing a high-pressure region **72**, which is maintained at high pressure by a conduit **74** supplied from a high-pressure gas reservoir chamber **76**, preferably filled with sulfurhexafluoride (SF_6) gas at a high pressure, say of 250 p.s.i.g.

On the downstream side of the nozzle exhaust **21** there is provided a relatively low-pressure region **82** communicating by a conduit **84** with a relatively low-pressure gas reservoir **86**. The low-pressure gas reservoir **86** also communicates by way of a conduit **88** to a passageway **90** extending through the lower terminal stud **92** into a region **94** to one side of a two-way valve **96**, the operation of which will become more apparent hereinafter.

To effect opening and closing operations of the separable contact structure, there is provided a connection **100** linking the operating rod **12** to a pair of double-ended levers **102**, **104** pivotally mounted, respectively, on stationary pivots **106**, **108**. The ends of the levers **102**, **104** are pivotally connected, as at **110**, **112**, to ratchet levers **116**, **118** of a synchronous-control device, generally designated by the reference numeral **120**.

The synchronous control device **120** includes a pair of pivotally-mounted actuating levers **122**, **124** pivotally mounted, respectively on stationary pivots **126**, **128**.

As shown in FIG. 5, the movable contact **15** is directly connected with a metal cylinder **130** through a plurality of 132 contact fingers **134**. The ratchet levers **116**, **118** are pressed by springs **140** and **142** against pins **144** and **146** respectively. A rotating mass **150** is provided at its circumference with a toothed rim **152**. The mass **150** is rotated in the direction of the arrow **154** by movement of an insulating rod **156** through a ratchet drive mechanism **158**, **160**, **162**. The insulating rod **156** can be driven, for example, by a compressed gas mechanism **164** arranged at ground potential.

The synchronizing device **120** includes a cylinder **170**, a piston **172**, a spring **174**, and the two-way valve **96**, which is coupled with a movable conductor **176** by means of a rod **178**. At the return stroke of the piston **172** a piston rod **180** becomes positively connected with a curved lever **182** in a manner explained hereinafter, whereby the actuating lever **122** rotates in a clockwise direction about its pivot point against a spring **186**. A release rod **188** may be operated by hand **190** or from an overcurrent protective OL, as shown.

The movable conductor **176** is connected in the secondary circuit of an air-gap current transformer **194** with air gaps **196**. The transformer **194** is energized by current i_1 flowing through the terminal bolt **92**. The reference character **200** designates a magnet system which is also energized by the current i_1 and in the air gap **202** of which moves the conductor **176**. A secondary winding **206** of the current transformer **194** is connected, by means of flexible conductors **208** and **210** with the conductor **176** which is movable about its pivotal support **212**. The upper end of the conductor **176** is connected with a lever **214** by means of a link **216**. The conductor **176** and the lever **214** are kept in the position shown by a spring **220**.

The synchronized breaker shown in FIGS. 5 and 6 functions as follows: When the current i_1 is increasing (see FIG. 7), the current transformer **194** produces in the conductor **176** a current i_2 which is shifted by approximately 90° with reference to i_1 and which produces together with induction or field strength B_0 in the air gap of the magnet system **200** a force F according to the formula

$$F = lB_0 i_2$$

where l is the effective length of the conductor **176**. From t_0 to t_1 (see FIG. 7) this force is negative, and moves the conductor **176** instantaneously to the right against the stop **222** formed by the wall of the cylinder **130** through the bottom **130***a* of which the conductor **176** extends. In FIG. 7 this movement of the conductor **176** is shown by the line s. At the time t_1, the force F reaches the zero value; but already before this, the conductor **176** has moved back again into the position shown under the effect of the spring **220** and remains there during the time t_1 to t_2, because then it is pushed against the stop by the force F.

By means of the rod **178** the movement of the conductor **176** opens the valve **96** on the side of the space which is under high pressure. The compressed gas enters behind the piston **172** which then moves to the right against the spring **174** in proportion to the increasing pressure. When the maximum of the current is reached, the valve **96** is closed on the high-pressure space by the conductor **176**, and it is opened on the low pressure side **94**. This results in movement of the piston **172** under the force of the spring **174** to the left. The travel of the piston rod **180** solidly connected with piston **172**, is shown in FIG. 7 by x. When the distance x_0 is exceeded, the curved lever **182** turns in the counterclockwise direction and, therefore, becomes positively connected at the stop **182***a* with the piston rod **180** on the return travel of the latter. The lever **122** is rotated clockwise by the lever **182** and thus engages the lever with the toothed rim **152** of the rotating mass **150**. The movable contact **15** is brought into the open position at a great speed by the kinetic energy of the mass **150** through the lever **102**.

It can be seen from FIG. 7 that the travel x of the piston rod **180** is the longer, the longer is the time τ. If the travel x_0, which corresponds to the lowest value of τ at which a release just still takes place, is not reached, then the lever **182** remains in the position shown. As can be seen from FIG. 7, at longer half-waves the release takes place always at the same interval Δt from the current zero.

However, the described opening procedure can take place only when the release rod **188** is in the "release position" as shown. If it is moved to the right until it is in contact with the perpendicular part **182***a* of the curved lever **182**, then also in the case of an overcurrent, releasing is not possible because the curved lever **182** cannot then rotate. Otherwise, the synchronized operation always takes place in orderly manner by the release rod **188** when the release is unblocked. The release is independent of the time instant when the release rod **188** is moved to the left.

In the case of a multipole breaker there occurs a possibility that due to some circumstances the extinguishing does not take place in the intended current zero or

that the so-called re-strike occures. Then the breaker must be brought instantly into the closed position, whereby a provision must be made to the effect that the synchronized opening can take place again at the next current zero. With the arrangement shown in FIG. 5 this happens in the following manner: When the current i_1 again increases, the conductor **176** moves, as previously explained, to the right and thus the lever **124** is rotated in a counterclockwise direction. In the open position of the contact member **15**, a lug **230** on the lever **118** is located opposite the upper end of the lever **124** so that when the latter is rotated, the lever **118** engages with the toothed rim **152**, and the breaker is brought again into the closed position, in which it is held by the frictional engagement of the contact fingers **14***b*. Such friction also holds the breaker in the open position.

To close the breaker, the closing button **240** may be manually pressed to energize solenoid **240***a* and rotate bell-crank **240***b* in a counterclockwise direction about stationary pivot **240***c*. This will force a closing rod **240***d* to engage the ratchet lever **118** and so close the contacts **15, 17.**

FIG. 8 illustrates a modified-type of contact construction **234** wherein an umbrella-type operating arrangement is utilized. The levers **250** engage with their upper ends **250***a* in a seat **252** and when in the closed position they are seated with a clearance so that there is guaranteed a positive contact between the contact finger **3** and the tubular contact piece **2** of the main contact.

An important advantage of this contact arrangement, especially in the case of a synchronized circuit breaker, consists of that, that the relatively large mass of the contact fingers **3**, due to current-carrying capacity during the course of travel enters into the picture as effective mass of only approximately 5 to 8%, because of the rotating motion in conjunction with the wedging action.

It can be seen that the contact system according to this invention combines the following advantages: small effective mass, no danger to the contact surface of the main contacts from the arc especially in case of "back-pressure," retractable contact is practically without chatter, additional dynamic pressure being present on the contact fingers of the main contact, no contact force acting in the direction of opening, simple construction and easy replacement of the retractable contact which is subject to erosion.

Although there has been illustrated and described specific contact arrangements, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

I claim as my invention:

1. Separable contact structure for a circuit interrupter including means defining a conducting nozzle portion having an outlet portion and a tubular depending main contact portion on the upstream side thereof, a plurality of circumferentially-disposed pivotally-mounted contact fingers making main contacting engagement with the external portion of said depending contact portion, a movable arcing contact having a cam actuator for engaging the main contact fingers and effecting opening operation thereof, means providing a relatively stationary arcing contact structure within said nozzle portion, means separating the movable arcing contact from the stationary arcing contact following separation of the main contact fingers from the external sides of the depending main contact portion, whereby restriking of the extinguished arc will take place at a location remote from the main contacting area.

2. The combination according to claim **1**, wherein fluid-blast means are provided for directing a blast of radially inwardly-directed fluid past the main ring-shaped contact portion and through the nozzle portion to the outlet side thereof.

3. The combination according to claim **1**, wherein a stationary arcing electrode is disposed on the outlet side of the nozzle portion.

4. In combination, a relatively stationary conducting nozzle portion having a relatively stationary arcing contact adjacent the restricted portion thereof, a depending ring-shaped main contacting portion, a plurality of pivotally-mounted main contact fingers making contacting engagement with the external sides of said main ring-shaped contacting portion, a movable arcing contact having a cam actuator for camming the main contact fingers into an opening operation, means effecting separation between the movable arcing contact and the stationary arcing contact following previous separation between the main pivotally-mounted contact fingers and the external sides of the tubular main contact portion, whereby restriking of the established arc will occur at a place remote from the main contact area.

5. The combination according to claim **4**, wherein a star-shaped movable sliding contact is affixed to the movable arcing contact and makes sliding contacting engagement with the plurality of main pivotally-mounted contact fingers.

6. A synchronous-type fluid-blast circuit interrupter including relatively stationary nozzle means defining a stationary arcing contact adjacent the restricted portion of the nozzle, a plurality of pivotally-mounted main contact fingers, a movable arcing contact separable from the stationary arcing contact to establish an arc, said nozzle portion having a depending main ring-shaped contact portion, the ends of the pivotally-mounted main contact fingers making contacting engagement with the external sides of the ring-shaped main contact, and cam actuator means movable with the movable arcing contact for camming the pivotally-mounted main contact fingers to their open position.

7. The combination according to claim **6**, wherein a stationary arcing electrode is disposed on the downstream side of the nozzle outlet.

8. In combination, a relatively stationary segmental-type arcing contact structure having a depending ring-shaped main contact portion, a plurality of circumferentially-disposed main contact fingers, means pivotally mounted said main contact fingers so that the ends thereof contact the external sides of the ring-shaped main contact portion, a movable arcing contact having a cam actuator for actuating the movable main contact fingers to the open position, and a movable generally star-shaped sliding contact movable with the movable arcing contact and making sliding engagement with the sides of the several main contact fingers.

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