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F. KESSELRING ET AL
CIRCUIT BREAKERS
Filed July 18, 1938

Serial No.
219,932
3 Sheets-Sheet 1

Fig. 1

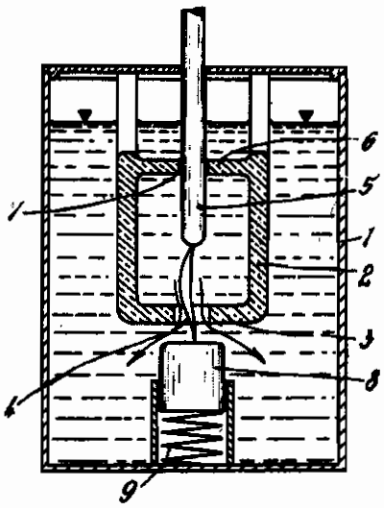


Fig. 2

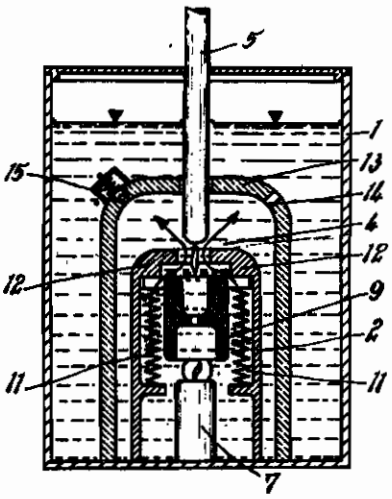


Fig. 3

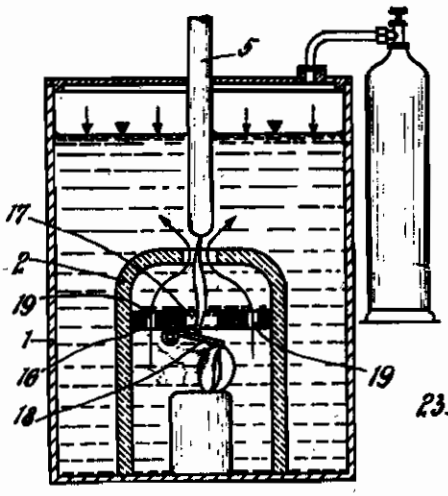
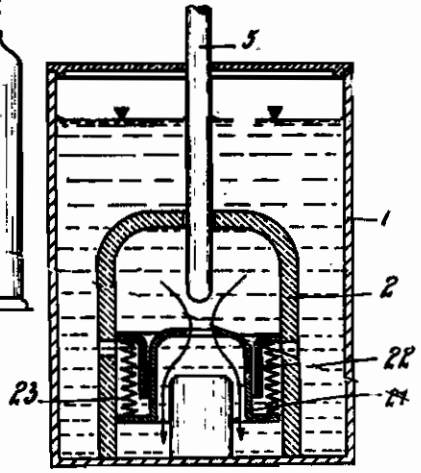


Fig. 4



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By Knight Bros
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Fig. 5

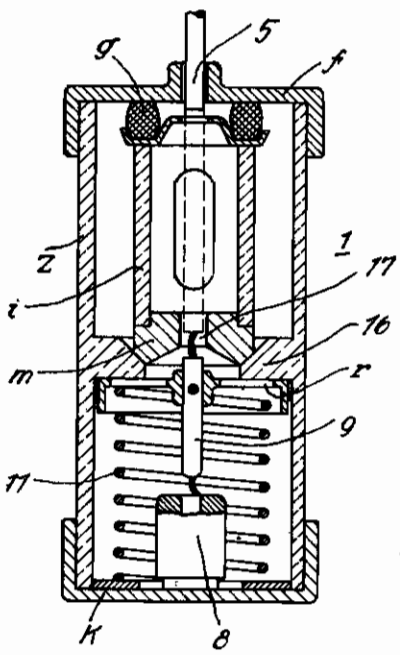

Fig. 8

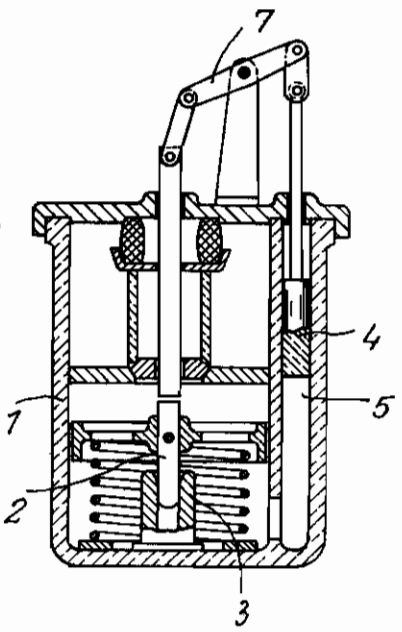

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Fig. 7

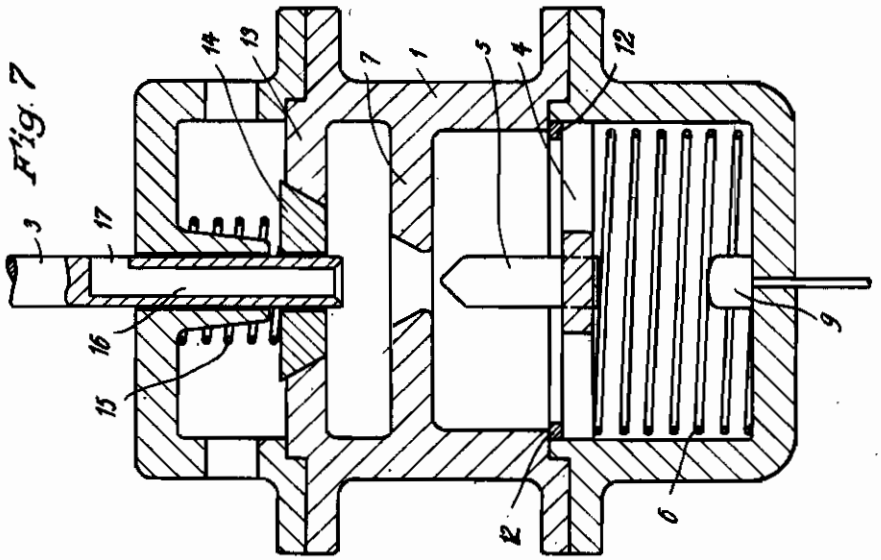
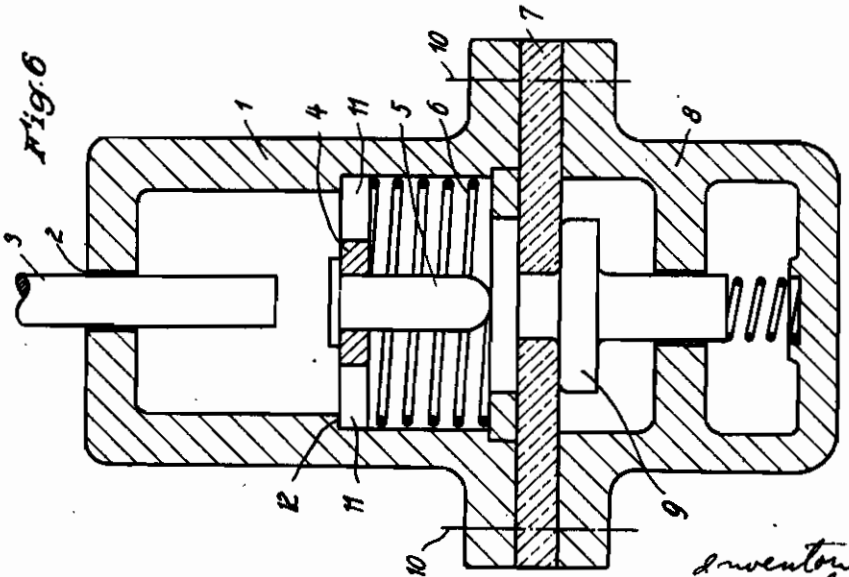


Fig. 6



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ALIEN PROPERTY CUSTODIAN

CIRCUIT BREAKER

Fritz Kesselring, Berlin - Frohnau, Friedrich Gieffers, Berlin-Charlottenburg, Werner Kaufmann, Berlin-Siemensstadt, Germany; vested in the Alien Property Custodian

Application filed July 18, 1938

The present invention relates to improvements in high-capacity circuit breakers operating with an extinguishing fluid and ensuring the interruption of the circuit with the smallest possible number of means. According to the invention a fluid flowing in parallel relation to the axis of the arc is employed for extinguishing the same. The fluid is suddenly caused to flow by the use of a control device which may be operated in response to the distance or still better to the pressure and is so guided that it encloses the arc and the gas envelope surrounding under circumstances the arc. A conducting and in general a non-inflammable liquid is employed to advantage as an extinguishing liquid. Alcohols having slight amounts of water, particularly multivalent alcohols, such as glycol, glycerin, erythrite, mannite and the like have proved particularly effective as extinguishing liquids. Particularly favorable conditions are obtained, for instance, in an extinguishing liquid consisting of 80 to 60% glycol mixed with 20 or 40% water. Besides the abovementioned very favorable extinguishing properties this liquid has the further advantage that the solidifying point lies at about −60 to −80° and that the dissolving power as compared to water is very slight so that the conductivity is not practically varied. Furthermore, the viscosity is far less dependent upon the temperatures than is, for instance, the case with oil.

In the accompanying drawings are shown some embodiments of the invention in diagrammatic form.

In Fig. 1, 1 denotes a liquid container in which is placed a chamber 2 which at the botom 3 is provided with an aperture 4 for the passage of the contact rod 5. The chamber 2 is provided with a partition wall 6 through a hole 7 of which the contact rod 5 passes without the slightest clearance. An inverted cup-like counter-contact 8 cooperates with the contact rod. The counter-contact may be either firmly arranged below the aperture 4 at a suitable distance or it may be pressed according to another form of the invention by a spring 9 against the opening 4 so that it practically closes the aperture temporarily and permits the flow of the liquid therethrough only when the pressure produced by the arc has exceeded a certain value.

By the pressure of the gas bubbles produced by the arc the liquid flows out of the lower chamber aperture, in which case the gas may be deviated by guiding members so that the arc is restricted by a liquid or gas sleeve and is thereby extinguished.

Another form of the invention is shown in Fig. 2. The chamber consisting of insulating material is in this case provided with an opening at the upper part thereof and contains besides the stationary counter-contact 7 an intermediate contact 9 which is guided within the chamber, a sufficient intermediate space for the circulation of the liquid being left free at the sides. The intermediate contact which may, under circumstances, be, furthermore, under the influence of springs 11 is at first entrained through friction by the contact rod 5 so that an auxiliary arc is ignited between the contact 8 and the intermediate contact 9, which arc supports the circulation of the liquid. As soon as the intermediate contact has attained a limit determined by the stops 12 the contact rod is separated therefrom, in which case the main arc is ignited in the neighborhood of the chamber aperture and is constricted by a liquid or gas sleeve owing to the liquid circulation caused by the auxiliary arc and is thereby extinguished. Under circumstances a discharge chamber may be formed adjacent to the switch chamber by an additional wall 13 through which the contact rod passes without the slightest clearance, which discharge chamber communicates with the outer liquid chamber either through small holes 14 or valves 15 or both, thus causing an increase in pressure so that the switching operation is effected under super-atmospheric pressure and therefore under particularly favorable conditions.

A further form of the invention is shown in Fig. 3. In this case a switch chamber 2 having also at the upper part thereof an opening is employed within a liquid container 1. The switch chamber is subdivided by a stationary partition wall 16 having in the central portion thereof an opening 17 for the passage of the contact rod 5, which aperture may be closed by a metal flap 18. Furthermore, lateral holes 19 are provided. During the switching operation an arc which remains between the metal flap and the stationary contact and leads from the metal flap to the contact rod is at first struck between the two contacts. Owing to the pressure produced at the lower portion of the arc and which cannot be reduced as a result of the aperture being closed by the flap, the liquid is forced through the lateral holes 19 and flows out through the switch chamber opening so that a flow of liquid or gas constricting the arc is produced by means of which the arc is extinguished.

This form of the invention shows a further possibility of operating the circuit breaker under super-atmospheric pressure by connecting a pressure bottle 20—which, for instance, may be filled up with carbonic acid, nitrogen or the like—to the sealed switch chamber, by means of which bottle a great pressure influencing in addition the pressure conditions within the chamber is exerted on the liquid level.

A form of the invention with a differential piston is shown in Fig. 4. Within the switch chamber 2 is arranged the differential piston 21 which

is located in a stuffing box 22 in such a manner that its smaller piston surface lies at the upper part and its larger piston surface at the lower part thereof. When interrupting the circuit an increased pressure is brought about by the arc causing an upward movement of the piston against the force of the springs 23 owing to the difference between the piston surfaces, by which upward movement the extinguishing liquid flows from the space formed in the upper part of the chamber and practically closed by the contact rod into the lower space through the piston by means of a central piston aperture 23, thereby constricting and extinguishing the arc drawn through this aperture.

The invention is not limited to the forms shown; instead of a differential piston a pressure may also be produced by a system of levers or in another manner. For instance, an explosive substance may be brought to ignition, thus imparting to the liquid the necessary circulation. It is also possible to drive the movement of the piston directly from the contact rod it being essential that a rapid flow of liquid through the switch chamber aperture through which the arc is drawn be caused as a result of the movement of the piston.

The liquid level is chosen preferably very high as will be seen from the drawings.

The novel circuit breaker prevents with certainty any fire risk and ensures an extinction of the arc within very small distances between the contacts. In this manner it is possible to design a switch employing the liquid according to the invention smaller than has hitherto been possible, thus ensuring a considerable saving in raw materials and a reduction of the cost of manufacture.

This arrangement may be still improved in the manner that the circuit breaker is designed in the form of a liquid container which is subdivided by a partition wall into an upper discharge chamber and a lower pressure chamber. In this case the intermediate contact is moved at the upper end of the pressure chamber against the force of a spring in such a manner that it may follow all movements caused by the contact rod.

In this case it is particularly advantageous to arrange in the upper space an inner chamber interrupted by lateral escape orifices and into which flows the liquid.

According to the invention this inner chamber together with the opening—forming the guide nozzle for the liquid circulation—may be elastically supported in such a manner that it is movable with respect to the partition wall and when moved opens lateral escape orifices which form a by-pass for the nozzle and the inner chamber.

Such an embodiment of the invention is shown in Fig. 5. 1 denotes the liquid container which consists substantially of a metallic cover *f* and an insulating cylinder *z*. The lower end of the insulating cylinder is closed by a metal cap *k* carrying the stationary counter-contact 8 designed in the form of an inverted cup. The movable intermediate contact 9 designed as a contact rod is guided in the lower portion of the cylinder by a frame *r* and is supported by a spring 11. The highest position of the intermediate contact is determined by the fact that the plate *r* comes into engagement with the intermediate wall 16 which subdivides the container into an upper space (discharge space) and a lower space (pressure space). The intermediate wall has the form of a conical valve seat. On this seat rests a mouth piece *m* shaped in a similar manner having in the central portion thereof an aperture 17 for the passage of the contact rod 5, the opening 17 serving as a guide nozzle for the flow of liquid. This mouth piece is in turn associated with another cylinder *i* of insulating material enclosing an inner chamber which in turn communicates with the upper part of the container through lateral holes. Between the cover *f* and the upper end of the cylinder *i* is arranged a rubber ring *g*.

When closed the intermediate contact 9 is pressed into the counter-contact 8 by means of the contact rod 5 so that the current path is closed. When interrupting the circuit the contact rod 5 is moved in the upward direction, the intermediate contact 9 following the rod under the influence of the spring 11 so that an auxiliary arc is ignited between the lower end of the intermediate contact and the stationary contact. By means of the auxiliary arc the extinguishing liquid surrounding the same is partly evaporated, thereby causing a great pressure resulting in an axial flow of liquid through the escape orifices. As soon as the intermediate contact has reached its uppermost position the main arc is drawn between the intermediate contact and the contact rod through the same escape orifice so that this arc is restricted by a concentric flow of liquid and is thereby extinguished under the most favorable conditions. If in the case of relatively high currents the pressure in the pressure chamber should assume an extremely high value the inner chamber is raised by the pressure exerted on the mouth piece *m*, thus uncovering an escape orifice between the intermediate plate 18 and the mouth piece *m*, through which orifice occurs a certain relief of pressure. Owing to the pressure-responsive control of the orifices this additional orifice is kept so small that at all events a sufficient flow of liquid takes place through the orifice 17, thus ensuring the extinction of the arc.

In this form of the invention a very simple construction is obtained, since the necessary insulation between the upper and the lower part of the circuit breaker is offered by the insulating cylinder *z*. In this case it is possible to move the contact rod 5 to a further extent so as to attain an additional gap if desired. Under circumstances an additional gap may also be arranged at another point in series with the above-mentioned contacts at which the circuit is broken, whereby the arc is extinguished. The metal parts are connected to advantage to the insulating parts by turning out in both parts corresponding grooves which are filled up with a solidifying body of a metal having a low fusing point or with pressed material.

The invention is not limited to the embodiment shown. Under circumstances a valve for the equalization of the pressure which connects the pressure chamber at a suitable point with the discharge chamber lying thereabove may, for instance, be employed instead of the resilient arrangement of intermediate plates and of an inner cylinder movable with respect to each other. The intermediate contact may also be designed in the form of an inverted cup, the counter-contact having then the form of a contact rod. The inverted cup then encloses at the upper end as well as at the lower end thereof a contact rod. In this manner particular current supply leads to the single segments of the contact in the form of an inverted cup are not necessary, which implies a further advantage. The upper and lower

half of the contact may, if desired, be so closed with respect to each other as to be liquid-tight.

This improvement presents under circumstances considerable advantages even when using insulating extinguishing liquids or the like.

Instead of providing an inner chamber above the intermediate wall it is also possible to close the upper part of the pressure chamber by a cover which is resiliently supported. Such a arrangement may also be employed besides the inner chamber. The resilient support of the cover as well as of the inner chamber need not only be effected by a rubber ring but by any other resilient means, for instance, also by springs. The resilient members are arranged to advantage in such a manner that they lie outside the range of the hot gases and therefore are not impaired by repeated switching operations. It is particularly advantageous to design the upper contact as a pressure contact and the lower contact in the form of an inverted cup, in which case a greater contact pressure may be ensured on the upper contact by the spring (11). The spring itself may be insulated with respect to the lower fixed contact and under circumstances with respect to the intermediate contact. It may be particularly convenient to arrange the additional escape orifices (valve ring) as near as possible to the nozzle in order that the flow of liquid or vapor upon the operation of the valve is deviated or disturbed as little as possible.

According to the invention a further considerable improvement may be obtained in high-capacity circuit breakers of the above-indicated character by limiting the separation of the main contacts to the most favorable distance of extinction, which may be easily determined for any type of circuit breakers. In this case it is possible to separate the auxiliary contacts which ignite auxiliary arcs lying in series with the main arc to such an extent that a sufficient gap free of surface leakage path, if desired, is created.

By such an arrangement the performance of the arc and therefore the ionization of the main arc is kept very small as compared to the arrangements hitherto known so that the current may be interrupted with certainty.

A switch chamber may be allotted to advantage to each of the two arc paths the pressure produced on the auxiliary arc setting into motion an extinguishing medium which is guided in a nozzle-like device to the main switching gap.

In the case of such a nozzle-like design the movement of at least one of the two electrodes which are allotted to the main switching gap is controlled in such a manner that the latter is spaced a distance from the nozzle during the interruption at which the blow-out effect of the nozzle is most efficacious.

With such an arrangement it is under circumstances possible to continue the movement of the other electrode even beyond the so-called optimum distance between the contacts without impairing the blow-out effect.

A particularly favorable form for a circuit breaker according to the invention may be obtained by providing one or both of the switch chambers allotted to the two arc paths with pressure-responsive resilient elements so that in the case of excessive interrupting capacities the chamber is not destroyed.

In this case the closure of the lower chamber may be effected by the contact itself substantially in the manner that the latter closes the opening as a pressure contact. Under circumstances it may, however, also be advantageous to design the chamber in the form of a so-called resilient chamber. In this case it is possible to cause an extinction of the arc with relatively low currents with the aid of pressure-responsive escape orifices provided for both chambers owing to the relief of pressure occurring upon the uncovering of these orifices in the sense of the so-called expansion circuit breaker. This represents a valuable improvement insofar as with a relatively low current the flow of the extinguishing medium caused by the auxiliary arc is under circumstances not sufficiently strong to ensure the extinction of the arc. In this manner the further advantage is obtained in that during the extinction a static pressure is maintained, whereby comparatively high voltages may be controlled or a smaller extinguishing distance may be chosen for a given voltage.

Fig. 6 shows such an embodiment. 1 denotes an insulating casing which is constricted in the upper part in the form of a switching chamber the central portion of which being provided with an opening 2 for the passage of the movable contact rod 3. Within the switch chamber is arranged an intermediate wall 4 carrying a movable intermediate contact 5. The intermediate wall 4 is pressed in the upward direction by a spring 6. The casing 1 is associated with a chamber-like casing 8 in which is placed the stationary contact 9 through an insulating plate 7 with a passage for the intermediate contact 5. The parts 1, 7 and 8 may be secured either rigidly to one another by fastening means 10; however, by the use of resilient means the single parts may be caused to separate from one another in response to pressure in the form of an elastic chamber of an expansion circuit breaker. In the intermediate plate 4 are provided lateral apertures 11 which ensure a passage of the extinguishing medium. The movement of the intermediate plate in the upward direction is limited by stops 12 to an amount for which the most favorable extinguishing distance exists between the contact 5 and the counter-contact 9.

When switching-in the circuit breaker, the contact rod 3 strikes the upper end of the intermediate contact 5 in the form of a pressure contact and entrains the intermediate contact and presses it into the contact 9 designed substantially in the form of an inverted cup.

When interrupting the circuit the movable contact rod 3 moves in the upward direction. In this case the contact 5 follows under the action of the spring 6 so that the contacts 5 and 9 are separated from each other, thus striking the main arc across the same. However, at the same time at least at the moment at which the stop 12 is reached also the contacts 3 and 5 are separated across which is ignited the auxiliary arc. In this manner the extinguishing liquid introduced in to the switch chamber closed by the counter contact 9 (for instance, by the resilient member) evaporates, thereby producing a pressure. Under the influence of this pressure the contact 9 moves in the downward direction and uncovers the opening of the plates 7 so that by the pressure of the auxiliary arc the extinguishing liquid begins to flow surrounding completely and restricting the main arc ignited between the contacts 5 and 9. By this flow of the extinguishing medium an extinction of the arc is ensured, since the best extinguishing conditions are attained by the favorable distance between the contacts 5 and 9 and since as above mentioned

the quenching conditions are under circumstances furthermore favorably influenced by a static super-atmospheric pressure. The contact rod 3 moves in the meantime out of the chamber 7 so that a switching gap free of surface leakage path and having a length depending upon the operating voltage and the conductivity of the extinguishing medium is obtained.

Another form of the invention is shown in Fig. 7. In this figure 1 denotes a chamber-like casing within which an intermediate plate 4 is moved in the upward direction by a pressure spring 6. The intermediate plate is provided with an intermediate contact 5 which comes into engagement with a stationary contact 9; the latter is arranged in the lower part of the casing 1. Above the intermediate contact 5 is arranged a partition wall 7 integral with the casing 1, the wall 7 having in the central portion thereof a nozzle-like aperture for the passage of the movable contact rod 3. In this case the position of the plate is so chosen that in the uppermost position of the intermediate contact 5 determined by the stops 12 such a distance exists between the nozzle and the intermediate contact as to give the nozzle the most favorable blow-out effect.

The casing is closed by an intermediate wall 13 arranged above the wall 7 so as to form a chamber, in which wall 13 a ring rests on a conical valve-like seat which is pressed into the closed position by a spring 15. In this manner the casing forms an elastic chamber which upon exceeding a given pressure is opened by the upward movement of the valve ring 14.

When breaking the circuit the contact 5 follows the contact rod 3 under the action of the spring 6 till it reaches the stops 12; i. e. till the contact is in the most favorable extinguishing position with respect to the nozzle, in which case the auxiliary arc is struck between the contacts 5 and 9. Upon the further movement of the contact rod 3 the latter separates from the intermediate contact 5 and draws the main arc through the nozzle through which at the same time the fluid flows under the effect of the already ignited auxiliary arc, thus extinguishing the arc. If with small current intensities an extinction of the arc does not occur in this manner a sudden relief of pressure is initiated by the lifting of the valve ring 14 or by the removal of the rod 3 out of the upper chamber aperture so that an interruption of the arc occurs as is the case with expansion circuit breakers.

In this arrangement a hollow contact rod is employed to advantage which when its point passes through the nozzle plate 7 establishes a connection with the atmosphere through its bore 16 and the opening 17, thereby facilitating the escape of the gases. Under circumstances it is possible to establish a contact between the contacts 5 and 9 in the form of pressure contacts, thus ensuring through the elastic pressure, for instance, caused by springs, a pressure between the contacts as well as the closure of the lower chamber aperture. Not only a conducting liquid but also either oil or a non-inflammable insulating liquid may under circumstances be also employed as an arc extinguishing liquid.

In the case of the circuit breaker types so far described the extinguishing liquid is intensely heated by the arc and evaporated at least partially, thereby causing a considerable increase in pressure. In this case the increase in pressure is at least partially dependent upon the corresponding current to be interrupted. This increase in pressure also acts on the contacts moving away from each other—depending upon the direction of motion—either in the sense of an acceleration or also under circumstances of a retardation. Consequently, the speed of switch action which is brought about by outer mechanical means, gears, slackening of springs or the like will differ considerable depending upon the intensity of current at which the interruption occurs. However, this has great drawbacks, since in case of an additional acceleration at high intensities of current the speed of motion becomes much greater, thereby also increasing materially the distance between the contacts up to the moment of the interruption of current. In this manner also the power of the arc is considerably increased so that the extinguishing conditions are impaired to a great extent. If the pressure acts in the sense of a retardation of the contact motion, the pressure may become so great that the necessary minimum distance between the contacts is attained very late, thus also complicating or preventing the interruption.

According to a further improvement this drawback may be removed by the fact that a second constructional element of approximately the same surface is arranged in the switch chamber close to the movable contact rod, which element is so coupled to the contact rod as to move in opposite direction. Thus the influence of pressure on the motion of the contact rod is completely eliminated. In this case a further advantage is obtained in that any decrease in volume within the switch chamber is avoided by the contact movement which, particularly in the case of a comparatively small switch chamber and when carrying out switching operations at a low current intensity is of advantage, insofar as the pressure developed by the formation of the arc is utilized to the full extent.

The above-described form of the invention is shown in Fig. 8. 1 is the switch chamber of a circuit breaker in which a contact rod 2 cooperates with a counter-contact 3. 4 denotes a plunger, for instance, of insulating material which is guided in a bore 5 communicating with the switch chamber. The contact rod and the plunger are so coupled with each other through a system of levers 7 as to move in opposite direction.

In this improvement it is not so important in which manner the movement of the parts in opposite direction is brought about. Also gear racks, gear wheels and similar transmission members may under circumstances be employed. It is also possible to give the contact rod and the compensating member a different cross-section and to compensate the difference in cross-section by a corresponding transmission of the movement (lever arm).

Also in the case of other circuit breaker types, such as pressure gas circuit breakers, oil circuit breakers in which the pressure caused by the arc may act on the movable circuit breaker part in the sense of an acceleration or retardation considerable advantages may be obtained according to the invention.

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