Oct. 23, 1951 C. STULZ 2,572,406

HIGH-VOLTAGE OIL CIRCUIT BREAKER

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Fig. 1

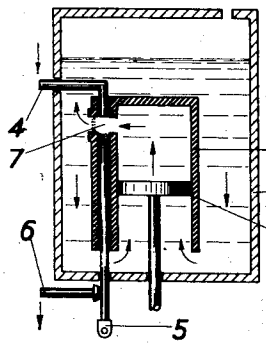


Fig. 2

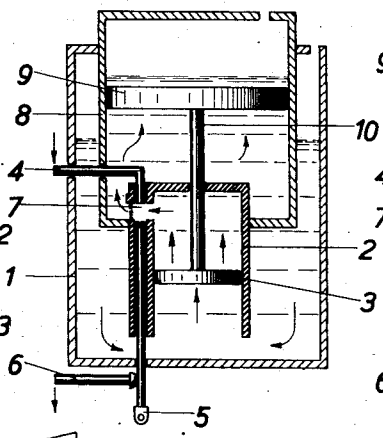


Fig. 3

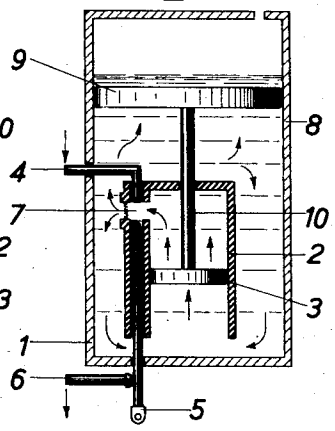


Fig. 4

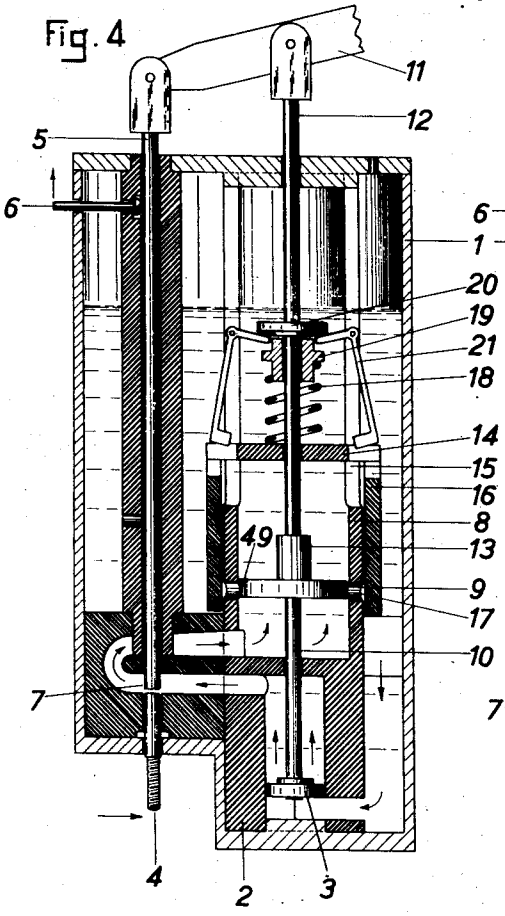
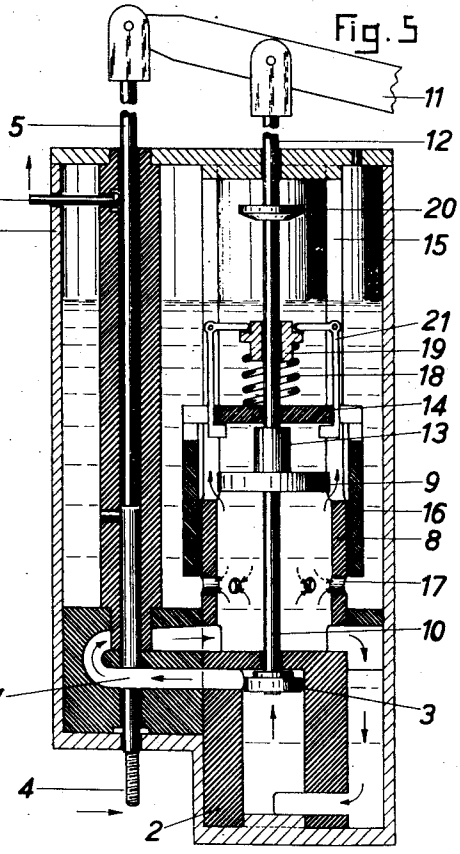


Fig. 5



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Fig. 6

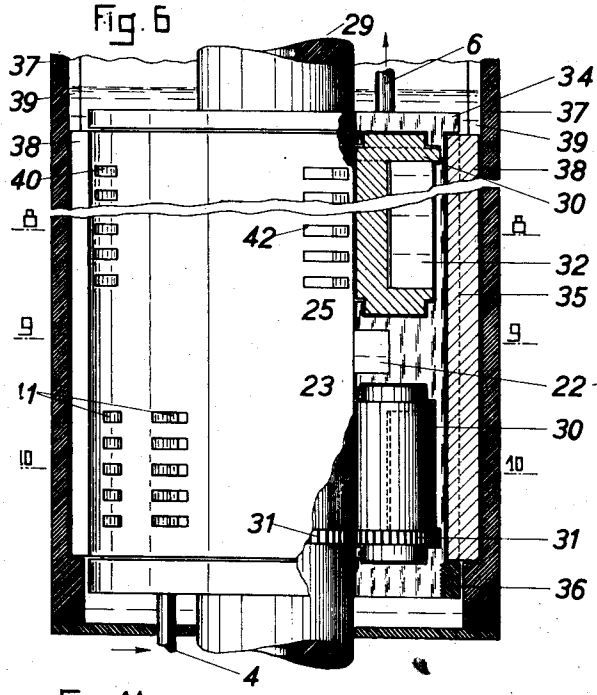


Fig. 7

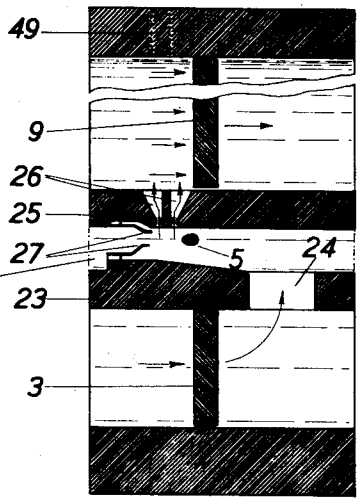


Fig. 11

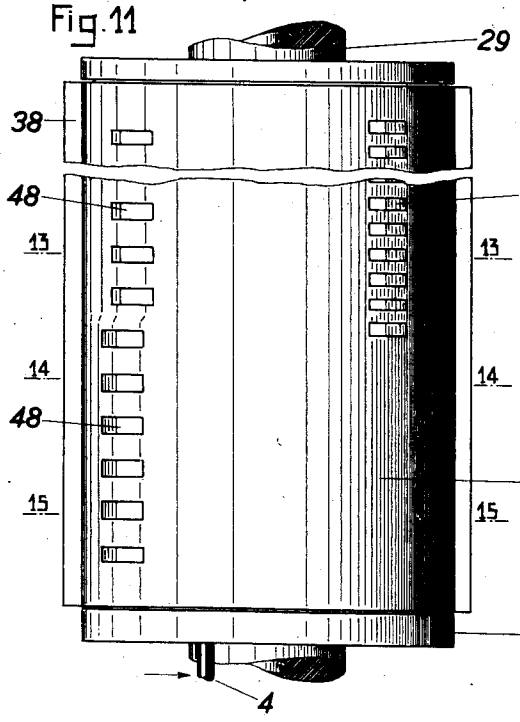
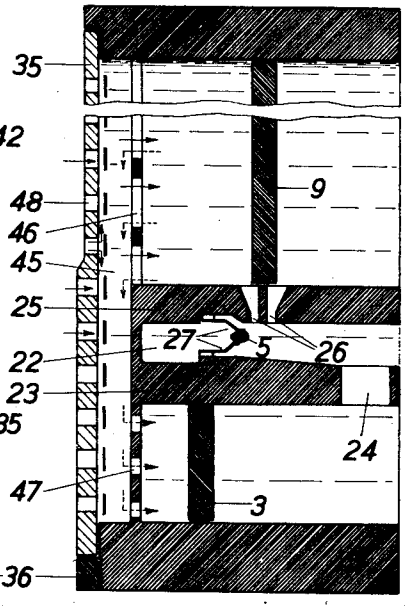


Fig. 12



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Fig. 8

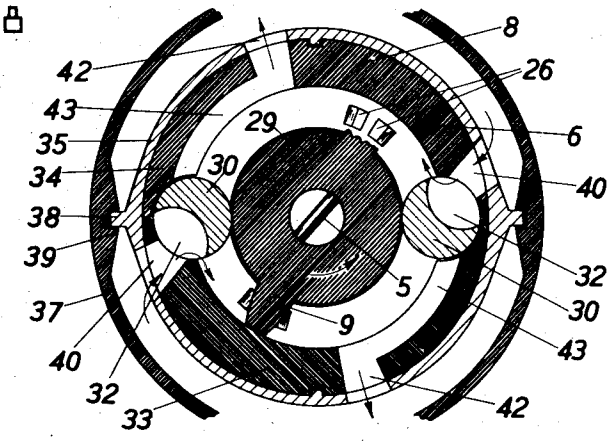


Fig. 9

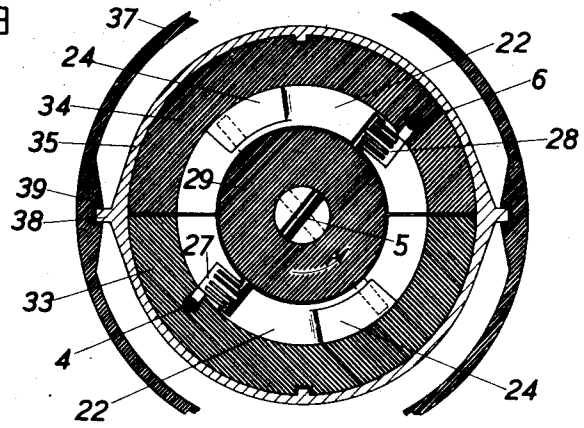
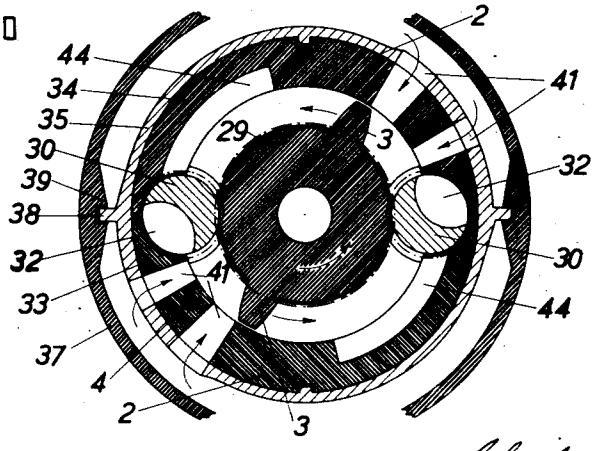


Fig. 10



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Fig. 13

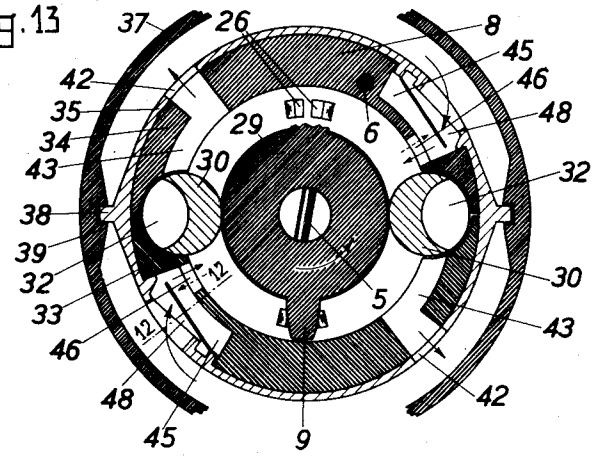


Fig. 14

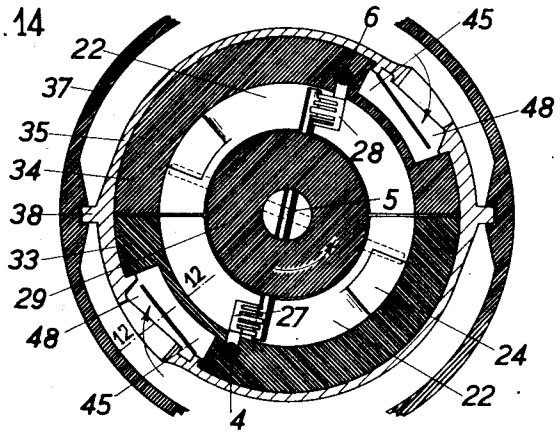
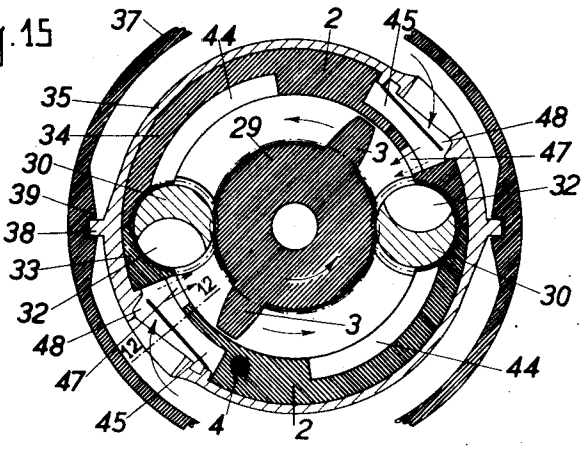


Fig. 15



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2,572,406

HIGH-VOLTAGE OIL CIRCUIT BREAKER

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Application September 2, 1948, Serial No. 47,386

4 Claims. (Cl. 200—150)

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The present invention relates to an arc extinguishing device.

The main purpose of the invention consists in providing an arc extinguishing device for high-voltage circuit breakers wherein the gases and vapors generated thereby are collected and used to operate an oil pump which forces oil in the path of the arc generated when the current is interrupted, for the purpose of preventing arcing.

This and other objects of the invention will be made readily apparent by reference to the following specification and to the accompanying drawings wherein:

Figure 1 illustrates a schematic sectional embodiment of a conventional circuit arc-extinguishing device;

Figure 2 represents, in section, an improvement of the device shown in Figure 1;

Figure 3 is a sectional representation of a further modification of the invention;

Figure 4, is a sectional elevation of an additional modification of the invention;

Figure 5 is similar to Figure 4, but shows the pistons in a different position;

Figure 6 is an elevation, partly in section and with parts broken away, representing an embodiment of the interrupting chamber;

Figure 7 is a vertical section taken along a plane intersecting the pistons medially and extending from one end of the rotating valve gear to the other end of the adjacent valve gear;

Figures 8, 9 and 10 are sections on line 8—8; 9—9 and 10—10, respectively, of Figure 6;

Figure 11 is a vertical elevation of the interrupting chamber;

Figure 12 is a vertical section on line 12—12 of Figures 13 to 15;

Figure 13 is a section on line 13—13 of Figure 11;

Figure 14 is a section on line 14—14 of Figure 11; and

Figure 15 is a section on line 15—15 of Figure 11.

With particular reference to Figure 1, it shows a typical embodiment of the arc-controlling device, in which a casing 1 is filled with oil and contains an oil pump comprising a cylinder 2 and a piston 3. The current flows from the fixed contact 4 through the moving contact 5 to the fixed contact 6. The compression space of the pump communicates with the casing 1 by means of the port 7. During the breaking operation, the piston driven by an externally applied pressure of a spring, is forcing oil through the

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arc path and through the discharge port 7. At the succeeding current zero, the gases and vapours generated by the arc are wiped away by the oil flow and replaced by an oil wall. During the zero current pause, the thickness i. e. the dielectric strength of this oil wall must have increased at a rate sufficient to withstand the re-striking voltage, otherwise the arc is re-established. This is equivalent to saying that the circuit is broken, when the velocity of the oil flow will exceed a minimum value determined by the parameters of the circuit. In order to attain the necessary velocity of oil flow, considerable spring pressure is required. Besides, the effect of the back-pressure of the arc, increasing as it does with arc energy, is to oppose the movement of the oil piston. Tests made in this connection, have shown that for a given spring pressure and for increasing values of current to be broken, the piston is moving more and more slowly till it is stopped. Thus, a more or less large part of the pressure of the spring will be neutralized by the back-pressure and only the remaining part of pressure energy will be changed into kinetic energy of the oil flow.

In order to remove the above stated inconveniences, the present invention provides a closed room or expansion chamber, collecting the hot gases and vapours generated by the arc and utilizing the expansive forces of the same to drive an expansion piston mechanically connected to the piston of the oil pump.

Fig. 2 may schematically illustrate an arc-controlling device according to my invention. Fig. 2 differs from Fig. 1 only by adding an expansion cylinder 8 with its piston 9 mechanically connected to the piston 3 by a connecting rod 10. The arc established upon separation of the contacts 4 and 5, instantaneously builds up a pressure in the expansion chamber as well as in the compression space of the oil pump. The diameter of the expansion piston 9 being greater than that of the oil piston 3, the overwhelming force of the expansion piston begins to drive the oil piston upwards. Let S and s be the areas of the expansion piston and oil piston respectively, then, it may be written $S=ns$, wherein n is greater than one. Let p be the overpressure in the expansion chamber, which is the force exerted by the gases on the expansion piston, and also, on the oil piston, will be given by

$$F=pS=pns$$

and the pressure in the compression space of the oil pump instantaneously rises to $P=F/s=np$.

The velocity of the oil flow through the port 7, being a function of the pressure difference between the two chambers, will, thus, be determined by the equation $P-p=(n-1)p$. As seen, the prejudicial back-pressure has turned into a useful pressure $(n-1)p$. Substituting, for instance, in a numerical example 3 for n and 4 for p, the useful pressure difference will, then, be $P-p=(3-1)4=8$ kg./cm. 2.

A still better result may be attained by an expansion chamber completely enclosing the oil-pump as schematically shown in Fig. 3. During the breaking operation, oil will flow from the upper side of the oil piston 3 to the underside of the expansion piston 9, and oil will flow, in a circular movement, from the upper side of the oil piston to the underside of the same. The gas overpressure p, set up in the expansion room by the arc, will exert on the underside of the expansion piston 9 a force $F=pS=pns$ and on the under-side of the oil piston 3 a force $f=ps$. Both forces have the same direction and will drive the oil piston with a resulting force

$$F+f=pns+ps=(n+1)ps$$

The pressure in the compression space of the pump will instantaneously rise up to

$$P=(n+1)ps/s=(n+1)p$$

and the useful pressure difference will be $P-p=np$. Referring to the above stated numerical example, the useful pressure difference will now be $P-p=3\times4=12$ kg./cm.2.

Doubling, for instance, the area of the expansion piston $(n=6)$, the additional volume of the expansion space formed by the displacement of the piston, will also be doubled for a piston stroke of the same length. Too, assuming the quantity of the gaseous products of the arc to be unvaried, the pressure in the expansion space will only rise to $\frac{1}{2}p=2$ kg./cm.2 and the useful pressure difference will now be $P-p=6\times2=12$ kg./cm.2. As seen, the pressure differential is only depending upon the quantity of gases generated, in accordance with the principle of conservation of energy. However, the pressure in the compression space of the oil pump $P=np+p$ decreases with the pressure p in the expansion space. On the other hand, the energy of the arc is proportional to the pressure P. The decreased pressure P consequently will result in a decreased volume of generated gases and, in a decreased pressure p in the expansion room, which may be compensated by an adequately increased magnitude of the current to be broken. Therefore, switchgear for larger short-circuit currents will preferably be designed with larger expansion piston in order not to exceed a given pressure. With heavy currents, pressure can also be held within a given limit by other devices well known in the art such as pressure valves and special release vents, as will be illustrated hereinafter in the examples of execution.

The pressure difference $P-p$ is proportional to the pressure p, the latter is in turn proportional to the magnitude of the current to be interrupted. Consequently, the described arc-control devices are self-regulating just as the well-known device using an auxiliary pressure generating arc, but compared to the latter, they offer a series of advantages. Thus, they do not require an auxiliary arc and the delay occurring, because the auxiliary arc which has first to be drawn, is omitted. Then, the auxiliary arc is only efficient when lengthening; drawn out, it will be

protected against the contact with oil by an insulating gas mantle, thus reducing oil quantity to be evaporated. On the contrary, in the herein described devices, the arc is standing in an oil flow of high velocity, a great volume of oil will, per unit time, come into a close contact with the hot centre of the arc and be decomposed to vapours and gases. Increasing volume of gas, however, is identical with increasing piston pressure and increasing velocity of oil flow. Thus, oil flow is accelerating itself to definitive arc extinction. Moreover, the volume of the generated gases is also proportional to the length of arc and to the pressure in the arc path resulting in a further acceleration of oil flow from the separation of the contacts to the end of arcing time.

Summing up, the described devices will draw off the arc a great deal more caloric units and transform them into mechanical arc-extinguishing energy resulting in an adequately increased breaking capacity, in a reduced arcing time and in a smaller critical current range.

Fig. 4 shows the elevation in section of an example of execution in circuit according to the scheme of Fig. 2 and Fig. 5 shows the same but cut out of circuit and according to the scheme of Fig. 3.

The lever 11 acts on the moving contact 5 and on the piston 3 of the oil pump by means of the connecting rods 12 and 10. A spring not shown driving the lever 11, will also have to furnish the energy necessary to break currents within the critical ampere range. The pressure set up by the arc, established upon the simultaneous motion of the moving contact 5 and the piston 3, will lift up the expansion piston 9 and, thus, accelerate the velocity of the piston 3. The current being interrupted, the expansion piston 9 will continue to rise and, by means of the stop 13, will lift up the crossbar 14 sliding in the guide slots 15 of the cut open expansion cylinder 8. The crossbar 14 is fastened to the cylindrical valve 16 sliding on the expansion cylinder 8. The outlets 17 and the slots 15 (Fig. 5) will be uncovered and will permit escape of the gases. The lower end of a cylindrical helical spring 18 presses upon the cross-bar 14 and the upper end of the same acts on the sliding ring 19. In switching-on position (Fig. 4), the sliding ring is held by the stop 20 fastened to the connecting rod 12, in switching-off position (Fig. 5), the sliding ring acts on the locking levers 21 to hold the cross-bar 14 in its upper position. In switching on, the expansion piston 9 will force oil being under the piston area through the outlets 17 (see arrows in dotted lines in Fig. 5). Just before reaching the switching-on position, the stop 20 will push down the sliding ring 19 and simultaneously open the locking levers 21 (Fig. 4), whereupon the spring 18 will shift the cylindrical valve into its end position.

After each operation, the switch gear is put back in circuit, after the gases will have evacuated the expansion space. This requires a period of time too great to permit a high-speed reclosing. This difficulty can be avoided by designing the arc-extinction device with rotating pistons and rotating contacts, whereby, after the interruption of the current, the expansion piston will automatically wipe away the gases from its back-side and suck in from the expansion chamber fresh oil before reaching the switching-on position. Such embodiments are illustrated in Figures 6 to 15.

As shown in Figs. 6 and 7, the interrupting

chamber of insulating material consists of three superimposed compartments, namely the oil pump chamber with its piston 3, the contact room 22 and the expansion cylinder room with its piston 9. A partition 23 with passage 24 therethrough separates the oil pump from the contact room. A partition 25 with the double-ports 26 separates the contact room from the expansion chamber. The contact-fingers 27 are fixed at the inside of the two partitions. The current flows from the fixed contact 4 with the contact-fingers 27 through the moving contact 5 (Fig. 9) to the fixed contact 6 with its fingers 28. The switch pin is fixed to a solid or hollow shaft of insulating material 29 showing, moreover, two pairs of diametrically opposed tooth-shaped elevations forming the pistons of the oil pump 3 and the expansion pistons 9 respectively (Figs. 7, 8 and 10). Rotating cylindrical valve gears of an aluminum alloy 30 (Figs. 6, 8 and 10) driven by the shaft 29 by means of the spur gears 31, divide both the cylinder room of the oil pump 2 and the expansion room of the cylinder 8 into two halves, Fig. 10 shows in dot and dash lines the addendum circles of the spur wheels, the peripheries of the shaft 29 and of the valve gears, at the same time, representing the pitch circles. The diameter of the valve gears is exactly half the diameter of the shaft. The valve gears and the shaft fitting closely, have to divide into two tightly closed halves both the pump room and the expansion room during the arcing period. The valve gears may also be used automatically to regulate the supply of oil of the expansion chambers. The valve gears show hollows 32 (Figs. 6, 8, 10) so determined as to permit the passage of the pistons from one half of the cylinder room to the other. The passage being effectuated, when the switch pin is moving from switching-off to switching-on position, the pistons must not fit closely in the hollows. The head areas of the pistons, however, are fitting closely in the cylinder sleeve of insulating material. The latter is separated into two halves 33 and 34, split along a vertical diametrical plane (Figs. 6, 8, 9, 10). The interrupting chamber, being assembled, will be inserted into a pressure cylinder 35 of an aluminium alloy and held in position by an internally screw-threaded ring of insulating material 36 (Fig. 6). Then, the interrupting chamber will be inserted into a supporting cylinder of insulating material 37, the bars 38 of the pressure cylinder sliding in the slots 39 of the supporting cylinder. As shown, the interrupting chamber consists of two separated oil pumps and expansion chambers with a common contact room, thus forming a double-break circuit-breaking device combined in one container.

Having thus described the structure of the rotating arc-extinction device embodying my invention, the operation is as follows:

When starting from switching-on position by means of an externally applied pressure, the expansion piston 9 (Fig. 8) will suck in oil flowing from the space, situated between the interrupting chamber and the supporting cylinder, through the inlet passage 40 and the hollow 32 of the valve gear 30 into the expansion room, too, oil will be sucked in through the first of the double ports 26, the pump piston 3 simultaneously sucking in oil through the inlet passages 41 (Fig. 10). When contacts break away, the valve gear will close tightly the expansion room and the piston will entirely cover the second of the double-ports, the pump piston simultaneously forcing oil through the first port. During the arcing time, the generated gases and vapours will constantly accelerate the speed of the shaft to final interruption of the current, the second port, too, having eventually to come into action. After the circuit is broken, the shaft will continue its rotation and the expansion piston will open the outlet 42 and let escape the gases. Continuing to move, the expansion piston will enter a space closed by the valve gear 30, and displace the fresh oil from the front-side of the piston through the hollow 43 to the back-side, thereby sweeping away the resting gases. The rotation will be stopped, when the switching-off position is reached. At the instant, when gases begin to escape, the pump piston 3 (Fig. 10) will open the hollow 44, in order to permit escape of the oil of the compression room and to avoid an unnecessary braking resistance. In case of immediate switching on, after one operation of the device, the above described process of operation will continue, until the pistons enter the hollows 32 of the valve gears 30. After having passed said hollows, the expansion piston will suck in oil through the inlet passage 40 and the hollow 32 and the pump piston will run light, until having nearly reached the switching-on position.

Figs. 11–15 show an example of construction with rotating pistons and contacts according to the scheme of Fig. 3. The pump cylinder 2 is in direct communication with the expansion cylinder 8, by means of a connecting channel 45 and the passages 46 and 47 (Figs. 12–15). Superimposed flapper valves 48 are placed in the exterior cylinder-sleeve of the channel, being closed according to the overpressure or opened according to the vacuum generated in the channel. The sucking in period begins after the passage of the expansion piston through the hollow 32 of the valve gear 30 (Fig. 13) and ends only, when contacts will be separated, whereas the pump piston 3 will run light in the same period, until having reached the switching-on position. Upon separation of the contacts, the pressure, set up by the arc, will propagate in the expansion room, in the channel and in the pump room situated behind the pump piston, whereby the flapper valves are closed, and oil will flow from the expansion room to the pump room, as shown in Figs. 12, 13 and 15 by arrows in dotted lines. The process of operation will be the same as described in the preceding example.

In order to hold pressure set up by heavy short-circuit currents, within given limits, besides pressure valves, release vents 49 may also be designed, as shown in dotted lines in Figs. 4 and 7, the number and dimensions of the same being adapted to the currents to be broken.

The above described examples of construction with rotating contacts and pistons offer still other advantages. Thus, the direction of rotation, being the same in switching-on and switching-off operation, the described devices lend themselves to an easy solution of the problem of ultra-rapid reclosure after each operation. Furthermore, multi-break circuit-breakers can easily be realized by providing several interrupting chambers installed on the same shaft and connected in series, the shaft having a vertical or a horizontal position. Furthermore, the electrodynamic forces, due to short-circuit currents, have the tendency to aid rotation as well in switching-off as in switching-on operation. Finally, the reaction forces, due to the pressure set up in the expansion rooms and in the com-

pression rooms of the oil pumps, are acting on the rotating valve gears and, thus, form two torsional moments of the same value, but in opposite direction resulting, therefore, in a smooth switching-off operation.

While I have shown my invention in its preferred forms, it will be obvious to those skilled in the art that it is susceptible of many modifications and changes in detail without departing from the spirit thereof. Thus, for instance, in case of relatively small short-circuit currents, it may, sometimes, be advantageous to omit the expansion chamber and to use only the rotating switch pin and the rotating pistons of the oil pump driven by an adequately reinforced externally applied pressure, in order to realize an easy solution of the problem of a high-speed reclosure after clearing a fault. I desire, therefore, that only such limitations shall be placed upon my invention, as are specifically set forth in the appended claims.

I claim as my invention:

1. An arc extinguishing device comprising a casing containing an insulating fluid, a cylinder in said casing, upper and lower differential pistons in said cylinder, a common piston rod connecting said pistons, said cylinder having passages placing opposite sides of said pistons in communication with said casing, valve means operated by said piston rod for controlling said passages and including a sleeve valve slidable about said cylinder, and cooperating electrical contacts in one of said passages, one of said contacts being movable with said piston rod to cause a gasifying spark generating gases and resulting in movement of said pistons in one direction and flow of the insulating fluid in the path of said spark.

2. An arc extinguishing device as set forth in claim 1, a lock controlled by said pistons for maintaining said valve means in a position to open some of said passages to permit exit of the gases generated by the spark, said lock including a cross bar slidably supported by the piston rod and connected to said sleeve valve, a sliding ring on the piston rod, locking arms between said cross bar and sliding ring, and a spring between said cross bar and sliding ring.

3. An arc extinguishing device comprising a cylindrical casing containing an insulating fluid, a cylinder in said casing, a rotary element in said cylinder having piston elements integral therewith, said cylinder having passages placing said piston elements in communication with said casing, rotary valves controlling said passages, gearing means between said piston elements and said valves, cooperating electrical contacts, one movable to cause a gasifying spark generating gases and resulting in rotation of said piston elements and flow of the insulating fluid in the path of said spark.

4. An arc extinguishing device as set forth in claim 3, a second casing enclosing said first named casing, said second casing having passages through its walls and flap valves controlling said last named passages.

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