L. C. NICHOLSON.

ELECTRIC SWITCHING APPARATUS.

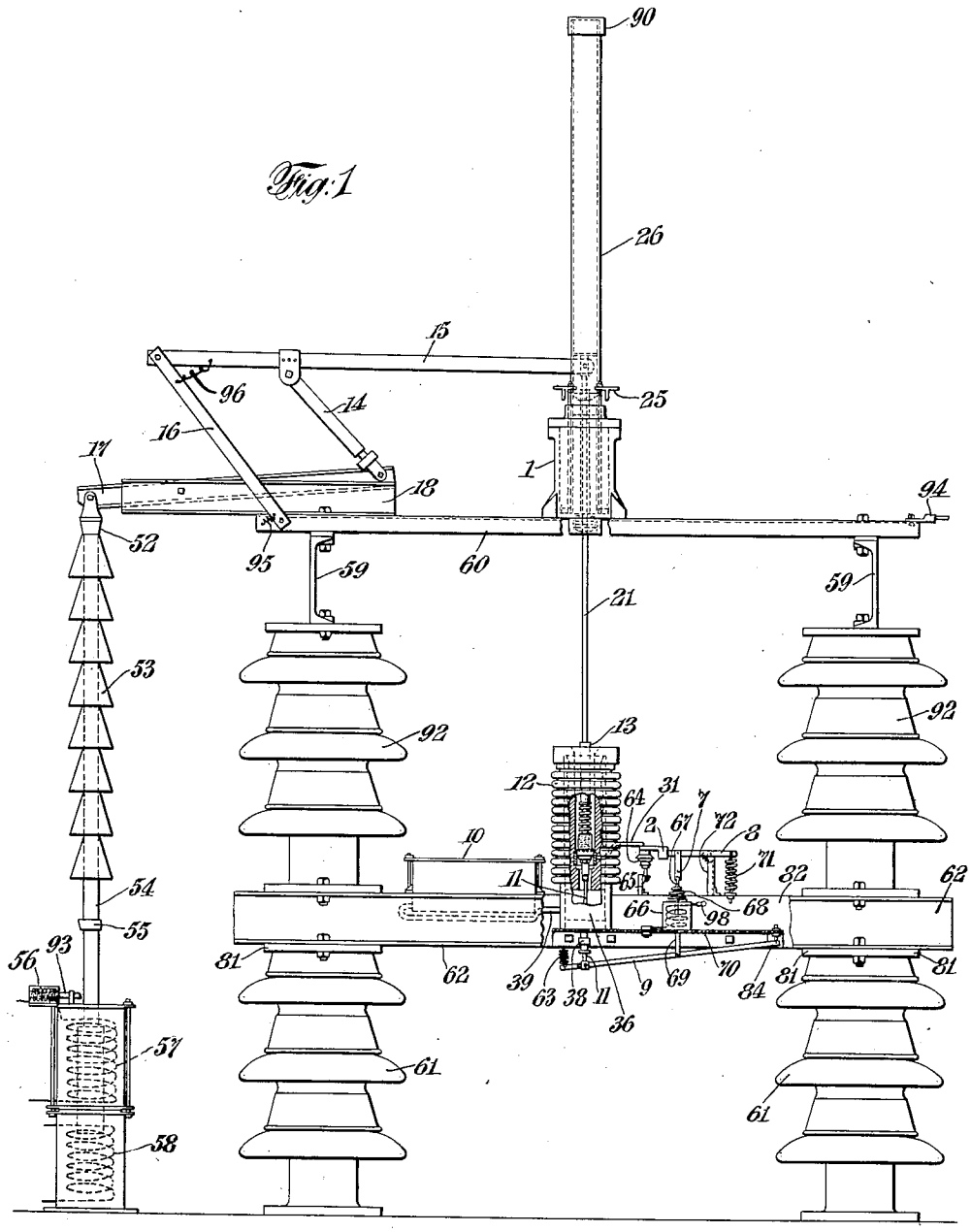
APPLICATION FILED DEC. 20, 1917.

1,402,310.

Patented Jan. 3, 1922.

3 SHEETS—SHEET 1.

Fig. 1



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Fig. 3

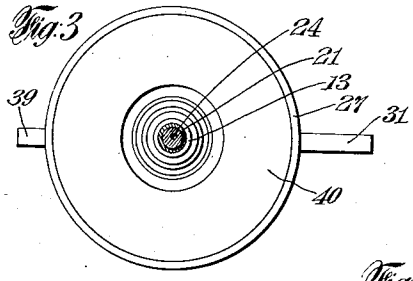


Fig. 4

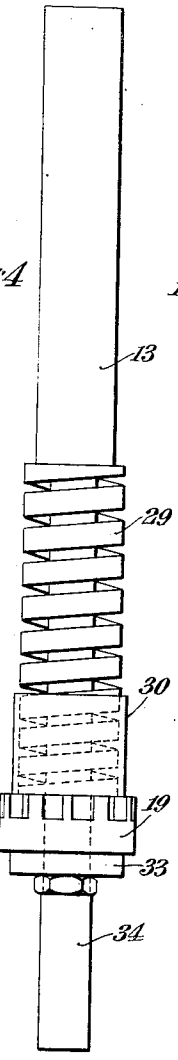


Fig. 5

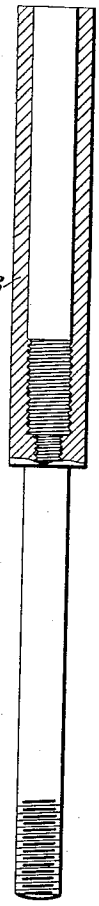


Fig. 6

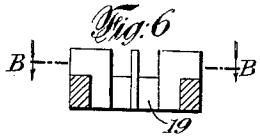


Fig. 7

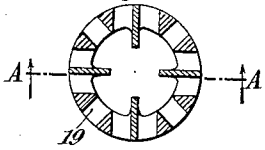


Fig. 8



Fig. 2

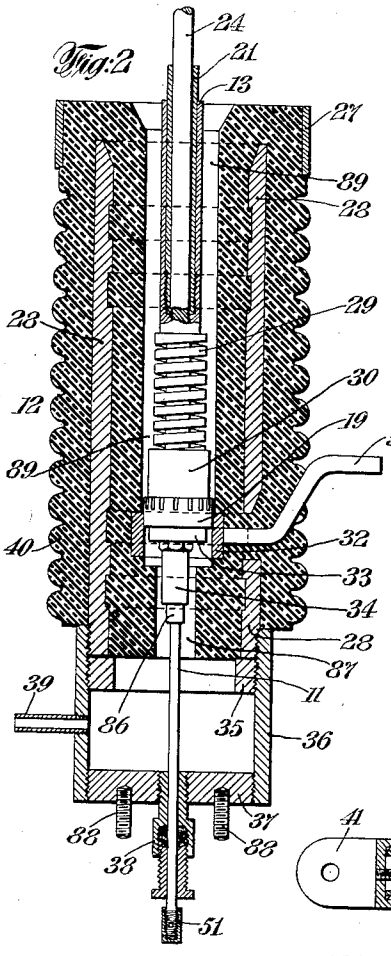


Fig. 9

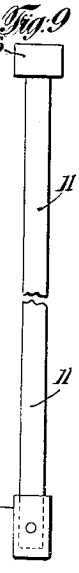


Fig. 10

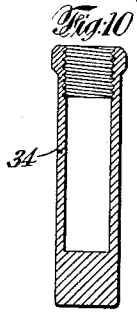


Fig. 11

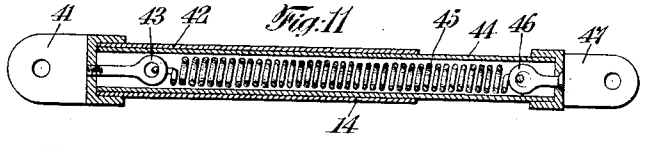


Fig. 12

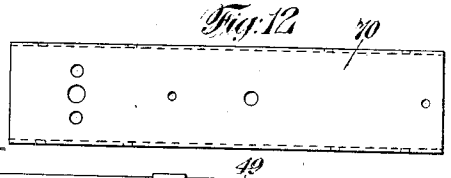


Fig. 13

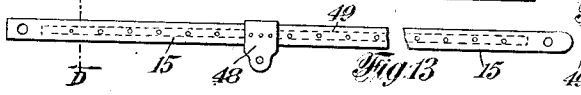


Fig. 14



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3 SHEETS—SHEET 3.

Fig. 15

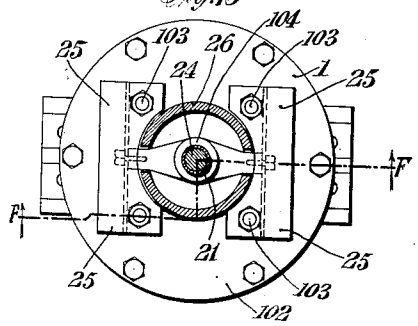


Fig. 20

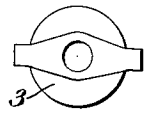


Fig. 19

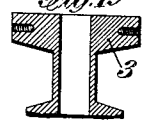


Fig. 23

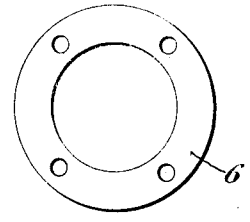


Fig. 24

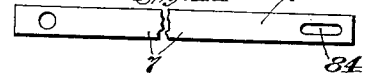


Fig. 16

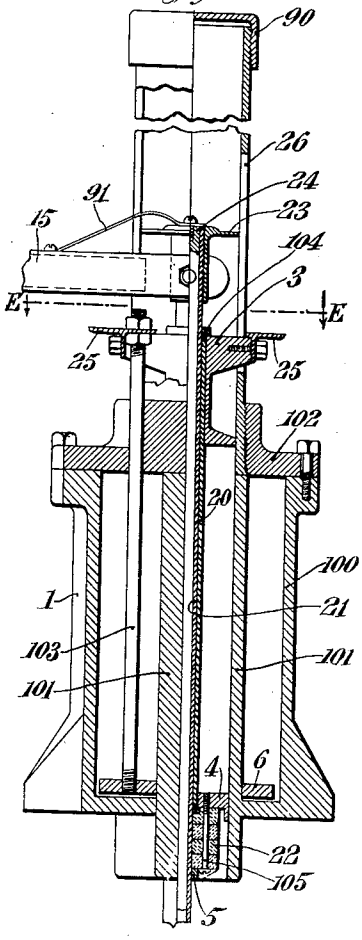


Fig. 18

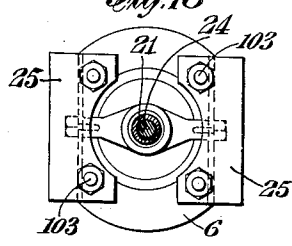


Fig. 25



Fig. 26

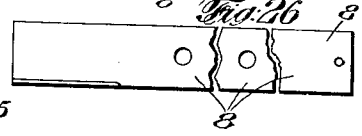


Fig. 27

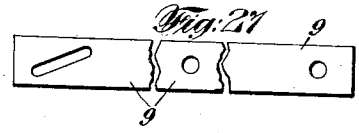


Fig. 17

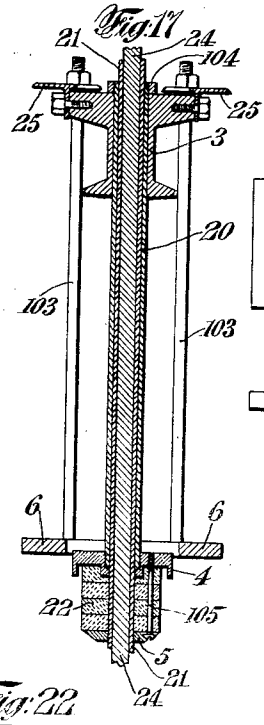


Fig. 28

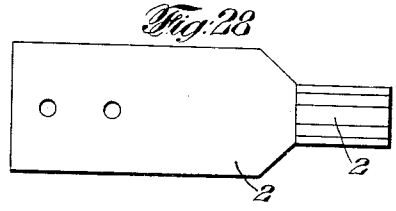


Fig. 29

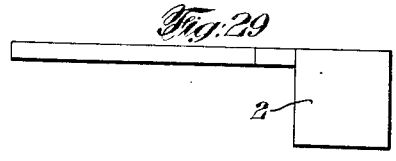


Fig. 30

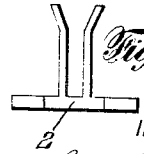


Fig. 21

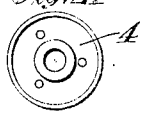
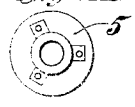


Fig. 22



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UNITED STATES PATENT OFFICE.

LLOYD C. NICHOLSON, OF BUFFALO, NEW YORK.

ELECTRIC SWITCHING APPARTAUS.

1,402,310. Specification of Letters Patent. Patented Jan. 3, 1922.

Application filed December 20, 1917. Serial No. 208,060.

To all whom it may concern:

Be it known that I, LLOYD C. NICHOLSON, a citizen of the United States, and a resident of Buffalo, in the county of Erie and State of New York, have invented certain new and useful Improvements in Electric Switching Apparatus, of which the following is a specification.

My invention relates to improvements in electric switching apparatus and is particularly adapted to the opening of alternating current high tension circuits, such as those on which a voltage of 10,000 volts or over exists, although it may be used to advantage on lower voltage circuits carrying heavy currents. One object of the invention is to provide a switch which is extremely quick in action. When used to its fullest extent, my invention will provide for the operation of the circuit breaker when a short circuit occurs on the line in less than 1/25 second, so that the short circuit may be eliminated without disturbing the operation of rotating synchronous machinery on the connected system. Furthermore, according to my invention, the use of oil in which the circuit breaks, with the consequent production of explosive vapors which frequently explode within the oil switch tanks with disastrous results, is avoided. When used to its fullest extent, the operation is so rapid that an arc as such may be said not to exist between the contacts, between which the circuit is broken, so that burning of the contacts is practically eliminated. Further objects, features and advantages will more clearly appear from the detailed description given below, taken in connection with the accompanying drawings which form a part of this specification.

In the drawings, Fig. 1 is a vertical view of an apparatus embodying my invention in one form, certain parts being broken away to more clearly illustrate other parts. Fig. 2 is a vertical section of the "gun" containing the switch contacts which are adapted to break the circuit. Fig. 3 is a top plan view of parts shown in Fig. 2. Fig. 4 is a vertical view of the upper contact member and piston shown in Fig. 2. Fig. 5 is a vertical detail of the part carrying the piston and contact of Fig. 4. Fig. 6 is a vertical section of the outer piston member shown in Figs. 2 and 4, taken on the line A—A of Fig. 7. Fig. 7 is a horizontal section, taken on the lines B—B and C—C of Figs. 6 and 8 respectively. Fig. 8 is an elevation of the outer piston member shown in Figs. 6 and 7. Fig. 9 is a detail vertical view of the lower switch contact member shown in Fig. 2. Fig. 10 is a vertical section of the upper switch contact member shown in Figs. 2 and 4. Fig. 11 is a vertical section of one of the links shown in Fig. 1. Fig. 12 is a plan of the channel iron shown in Fig. 1 supporting the overload solenoid. Fig. 13 is a side view detail of the lever of the top lever member of Fig. 1. Fig. 14 is cross section, taken on the line D—D of Fig. 13. Fig. 15 is a top view of the dash pot or damping device taken on the line E—E of Fig. 16. Fig. 16 is a vertical section of the same taken on the line F—F of Fig. 15. Fig. 17 is a vertical section of the air piston, oil ring and attached parts shown in Fig. 16. Fig. 18 is a top plan view of parts shown in Fig. 17. Fig. 19 is a vertical section of the cross head shown in Figs. 16 and 17. Fig. 20 is a plan view of the same. Fig. 21 is a bottom plan view of the air piston shown in Figs. 16 and 17. Fig. 22 is a bottom plan view of the bottom disc shown in Figs. 16 and 17. Fig. 23 is a plan view of the oil ring shown in Figs. 16 and 17. Fig. 24 is a side view of link connected with the overload solenoid of Fig. 1. Figs. 25 and 26 are a plan and side view respectively of the movable switch blade pivoted to the link of Fig. 24. Fig. 27 is a detail side view of the lever operating the lower contact member shown in Fig. 9. Figs. 28, 29 and 30 are a bottom plan view, a side view and an end view respectively of the stationary switch member of Fig. 1, which switch member cooperates with the switch blade of Figs. 25 and 26.

Referring to the drawings and particularly to Fig. 1, supported upon insulators 61 are, by means of cross plates 81, two channel irons 62 and 82, arranged on edge, and the channel 62 being shown broken away to more clearly illustrate parts between the channel irons. Extending between the channels 62 and 82 and secured thereto, is a channel iron 70, which carries a solenoid 66 adapted when energized by

an overload current to pull down a core on the end of rod 67, the upper end of which rod is connected to link 7. The upper end of the link 7 is connected to the switch blade 8, which is pivoted to the post 72 carried on the channels 62 and 82. A spring 71 normally acts to throw the switch blade 8 between the jaws of switch member 2 carried upon insulator 64 supported by member 65. The link 7 is pivoted to member 67 by a slot 84 (Fig. 24) and pin connection and a spring 68 holds the core and member 67 in its upper position in the slot 84. This provision is made so that ordinary vibrations of the solenoid core due to ordinary load currents passing through solenoid 66 will not affect the switch 8, 2.

Extending into the solenoid 66 is a non-magnetic rod 69 with its lower end pivoted to a lever 9. The lever 9 is pivoted at 84 to the framework. Pivoted to the other end of the lever 9 is a rod 11 having a cap 51 on its lower end (Fig. 9) for making the pivotal connection. On the upper end of the rod 11 is a head 86 acting as a switch contact member to contact with switch contact member 34 in the chamber 87 of the "gun" 12 (see also Fig. 2). A spring 63 normally holds up the lever 9 to keep the contact 86 normally in contact with the contact member 34.

The body 40 of the "gun" 12 is formed of insulating material such as bakelite reinforced by a steel ring 27 at the top and a steel cylinder 28 in the body portion. The body of the gun should have high electrical insulating qualities and be waterproof and strong mechanically, parts 27 and 28 being arranged so that they reinforce the same laterally with metal from top to bottom. 32 represents a copper contact ring molded into the body portion 40 and provided with a conducting terminal 31 brought out through a hole in the reinforcing cylinder 28 and connected electrically to the switch member 2. The upper part of the body 40 is molded to provide a cylindrical cavity 89 in which a piston member 19 is adapted to operate. The piston 19 and conducting ring 32 are slightly tapered so as to form good electrical connection therebetween by a wedging action when they are forced together. Situated within the cylinder 89 is a piston rod or member 13 (see also Figs. 4 and 5) with its lower end extending through the piston 19 and a nut washer 33 is screwed on to the lower end of the piston rod 13 to support the piston 19, the piston 19 being hollow, as shown in Figs. 6 and 7, so that it is capable of sliding on the rod 13. Screwed onto the lower end of rod 13 below the disc nut 33 is the contact member 34 which is adapted to contact with switch contact member 86 and also serve as a lock nut for disc nut 33. The disc nut 33 is adapted to normally close the lower opening through the piston 19. On top of the piston 19, and provided with a central bottom hole through which the member 13 passes, is a cup 30 containing the lower end of a strong spring 29 tending to force the piston 19 firmly against the disc nut 33. On the lower end of the gun 12 and screwed to the reinforcing cylinder 28 is a water chamber 36, from which water is supplied to the small water chamber 87. A nut locking ring 35 prevents the chamber 36 from working loose and a disc 37 is screw-threaded into the bottom of the chamber 36 to form the bottom thereof, and carries a stuffing box 38 through which the rod 11 slides, the stuffing box 38 preventing leakage of water from the chamber 36 around the rod 11. Screws 88 are provided to secure the gun to the channel iron 70. The chamber 36 is connected to a water reservoir 10 by a pipe 39, the reservoir 10 being carried by the channel irons 62 and 82.

Screwthreaded into the top of the piston rod 13 is a steel pipe 21 containing an aluminum conducting rod 24, which is also screwthreaded into member 13. The pipe 21 and rod 24 extend up through a dash pot or damping device 1 (see Figs. 15, 16, 17 and 18) and into a pipe 26 screwthreaded into the top of the damping device 1 and provided with a top cap 90. At their upper ends the pipe 21 and rod 24 are pivoted to a lever 15 and electrically connected thereto by a flexible connection 91. The lever 15 is made of two steel members 49 with an aluminum member 50 all riveted together, to obtain lightness and strength, as well as sufficient current carrying capacity. (See Figs. 13 and 14). The dash pot or damping device 1 is carried by a channel iron 60 supported by spacing members 59 on insulators 92 which insulate it and the parts carried thereby both from the ground and from the channels 62 and 82 and parts carried thereby. The lever 15 is fulcrumed on the upper end of two links 16 having their lower end pivoted to the channel 60. Pivoted between channel irons 18 secured to the channel 60 is a lever 17 adapted to be operated by the lever 15 through the link 14 connecting the two. A wooden rod 54 having a head 52 pivoted to the lever 17 is protected from the weather by metal skirts 53 and carries on its lower end a magnetic core adapted to be pulled up by a solenoid 57 and down by a solenoid 58. When pulled down, a catch 55 engages under a latch 93 which holds it down. When the solenoid 57 is energized to pull it up, a solenoid 56 is simultaneously energized to pull back the latch 93 and release the catch 55.

The operation of the parts so far described is as follows:

The line current flows through the ap-

paratus as follows: from the terminal 94 on channel iron 60, through channel iron 60, flexible connection 95, link 16, flexible connection 96, link 15, flexible connection 91, rod 21, piston rod 13, parts 33 and 19 carried thereby, copper contact ring 32, terminal 31, air switch members 2 and 8, flexible connection to support 72, support 72, channels 62, 82 and 70, then through solenoid 66 and out to the line through terminal 98. There is also a parallel path for the current from the piston rod 13 to the channel iron 70, this path being through the switch contact member 34, switch contact member 86, rod 11, levers 9 to channel 70, so that the air switch 2, 8 is in shunt relation to the switch contacts 34 and 86.

When an undesirable overload occurs on the line, as, for example, a short circuit due to an insulator failure or an arc on the line, the increase in current in solenoid 66 causes it to pull down its core and open the air switch 2, 8. This causes all the current to flow through the shunt path through switch contact members 34 and 86. As the core of solenoid 66 further descends, it strikes rod 69, causing lever 9 to move downwardly, carrying with it rod 11, so that the contact head 86 on rod 11 is separated from the switch contact member 34. The water in the chamber 87 immediately acts as a conductor between said switch contact members and the current flowing through the water causes it to be rapidly vaporized to steam and the pressure of the steam causes the piston 19 and associated parts operating in the cylinder 89 of the gun, to be shot out of the gun with great force, thus rapidly and widely separating the switch contact members 34 and 86 and completely breaking the line circuit. Any arc tending to form between the switch contact members 34 and 86 is extinguished or prevented from forming, due to the high pressure of the steam, which forms an exceptionally good agent for this purpose. Furthermore, the fact that the contacts are separated with great speed and in the presence of water, or in a semiconducting medium tends to prevent the formation of an arc. So great is the pressure quickly generated that the piston and associated parts in the cylinder are shot entirely out of the gun carrying upwardly with them the pipe 21 and rod 24, which guide the upward movement of the parts by operating in pipe 26. The upward movement of pipe 21 and rod 24 causes the operation of lever 15, the end of which extends through a slot in pipe 26 and is pivotally attached to the upper end of pipe 21 and rod 24. This upward movement of lever 15 causes the operation of lever 17 through the link connection 14, so that the rod 54 is forced downwardly, until catch 55 engages under latch 93. Immediately, the line circuit is thus broken, the solenoid 66 becomes deenergized, so that rod 11 is moved back up under the action of spring 63 and the air switch 2, 8 is also promptly closed under the action of spring 71. The apparatus operates so rapidly that the circuit is opened and the overload or short circuit switched off the line before the rotating synchronous machinery on parallel connected systems will get out of step or lose its load. So far, experience indicates that the apparatus will operate on small currents more satisfactorily with a relatively small column of water in chamber 87, rather than a large column. By energizing the solenoids 56 and 57, the catch 55 is released and the parts returned to their normal positions first described. The solenoids 56 and 57 may be energized by manual control or automatically, as upon the closing of air switch 2, 8. If desired, latch 93 and catch 55 may be omitted and the switch thus allowed to close immediately after opening. The rebound of the parts is sufficient to cause the switch to be closed in a very short space of time. When it is desired to open the line circuit independently of the solenoid 66, the solenoid 58 is energized by any suitable means, manually controlled or automatically controlled, so that rod 54 is pulled downwardly and, through the lever and link connections, pipe 21 and rod 24 pulled upwardly so as to separate the contact 34 from contact 86 and the contact piston 19 from the copper contact ring 32, so as to completely open the line circuit. It may be again closed by energizing solenoids 56 and 57 as above described.

The link 14 is formed of two pieces of pipe 42 and 44, one telescoping the other and provided with heads 41 and 47 respectively. A tension spring 45 is stretched between and connected to the heads by eye bolts 43 and 46 respectively. The purpose of this construction is to permit of the light lever 15 moving upwardly without having to move the other heavier links, levers, etc., as fast as if the link 14 were solid. That is, the parts 17 and 54, by reason of the spring extensibility of link 14, are not required to travel at the high rate of speed of the lever 15, but move along more slowly in their movement under the action of spring 45.

As to the water level in chamber 87, for proper operation of the circuit breaker, in the particular apparatus shown, which is designed for 60,000 volt circuits, there is a feasible variation of perhaps 2 inches. Since the amount of water consumed in the chamber 87 is slight, this chamber is promptly refilled to the proper level, from the reservoir 10 through pipe 39 and chamber 36, it requiring a large number of operations to reduce the level in reservoir 10 to a point where it will not supply water to an operating level in chamber 87. The level of the

water in chamber 87 should not be much below the bottom of contact member 34 nor much above the top of piston 19.

On account of the speed attained by the moving parts, the dash-pot or damping device 1 has been provided. (See Figs. 1, 15–23). It consists of a combined air and oil dash pot arranged so that the air dash pot is used to set the moving parts of the oil dash pot into operation. A cylindrical casting 100 (Fig. 16) is provided with an integral inner coaxial cylinder 101, both being covered by a cap 102 secured thereto and onto which the guide pipe 26 is screw-threaded. Operating in the outer oil dash cylinder 100 is a piston ring 6, carried by vertical rods 103, which are secured at the top ends thereof to cross members 25, which, in turn, are secured to the piston head 3. The head 3 is provided with lateral projections working in the guide slots in the pipe 26. Adapted to slide through the head 3 is pipe 20 having a nut 104 screwthreaded on its upper end to prevent the pipe 20 falling through the head 3. On the lower end of the pipe 20 is an air piston 4 operating in the air dash cylinder 101. The pipe 21, with its contained rod 24, is adapted to slide freely through the pipe 20. Surrounding the pipe 21 (Figs. 16, 17, 22) is a disc 5 and surrounding the pipe 21 between the disc 5 and air piston 4 are rubber discs 22, these parts being held together by screws 105.

When the piston rod 13 is shot upward, as above explained, the top thereof strikes disc 5 and the rubber discs 22 provide a cushioning effect before the air piston 4 is set into full movement. As the air piston 4 is moved upwardly by the impact, it tends to compress the air in the air cylinder 101 between the air piston 4 and head 3, thus further cushioning and damping the movement of the moving parts. The compression of the air in cylinder 101, however, soon causes the piston head 3 to move upwardly, drawing with it, by means of rods 103, the oil piston ring 6 working in oil dash cylinder 100, so that the movement of the moving parts is further cushioned and damped by this oil dash pot arrangement. The oil piston ring 6 fits the cylinder 100 loosely at the bottom and tightly at the top, so that the clearance between the ring 6 and the oil cylinder 100 decreases as the ring ascends. This result is obtained by making the bore of the cylinder 100 slightly cone-shaped. The object is to give more escape for the oil around the ring 6 at the beginning of the stroke on account of its necessarily higher speed. By providing the cushions 22, the pipe 20 is prevented from buckling when the impact is received from piston rod 13. Upon resetting the switch, the head 23 forces the pipe 20 and head 3 downwardly, so as to return the piston 4 and piston ring 6 to their starting position. The piston head 3 is elongated vertically, so that it reaches down into the upper part of the air cylinder formed in the lower part of pipe 26, to a distance of about 4 inches below the bottom of the slots in pipe 26. This ensures that the comparatively heavy members of the oil dash pot, consisting principally of parts 3, 25, 103 and 6, are put into motion through a distance of at least four inches under air pressure, until the lower end of piston head 3 passes the lower end of the slots in pipe 26, when the air pressure in the air dash cylinder is released through these slots and piston 4 rises until it engages head 3, whereupon the total damping effect is derived from the oil dash pot.

By providing the air switch 2, 8, the apparatus is capable of carrying heavier load currents, since normally the most of the load current passes through the switch 2, 8, instead of through the contacts 34 and 86. The invention in its broader aspects would, however, still be employed if the switch 2, 8 were omitted, as the apparatus without it is capable of a certain load current, which is limited by the size of the contacts 34 and 86.

By arranging the piston 19 to be spring pressed against its seat 33 of smaller diameter, a spring controlled safety valve is provided, so that in the case of opening a circuit carrying very large current, the excessive sudden steam pressure will cause the piston 19 to be raised from the nutwasher or seat 33 against the action of spring 29, and thus permit steam to escape up through the piston 19 and around the cup 30 to the external atmosphere, and so relieve the excessive pressure which might injure the parts before the moving parts could be set sufficiently in motion to relieve the pressure. The cup 30 serves to keep the heated vapors from affecting the temper of the spring 29.

Instead of water, any other suitable vaporizing liquid which will produce sufficient vapor and pressure under working conditions, may be used. But water is preferred, although alcohol, glycerine, etc., may be added thereto in cold weather to prevent the liquid from freezing, especially where the apparatus is located out in the open.

The drawings illustrate a single pole breaker, but to provide a multiple breaker, as, for several phases, it is only necessary to duplicate the arrangement for each line conductor, and connect the solenoids 56, 57 and 58 respectively of the different poles, in circuit to be energized simultaneously.

My apparatus is far quicker in action than the conventional oil circuit breaker. The particular apparatus illustrated in the drawings will open a 60,000 volt circuit carrying

currents up to 8000 amperes or more, in from 1/50 to 2/50 seconds. The use of oil is obviated with the consequent absence of explosive oil vapors which frequently explode within the oil switch tanks with disastrous results. Since the operation of the switch is so rapid, no substantial arc exists between the contacts 34 and 86 which are in water or steam, and the burning of the contacts is substantially eliminated. If sodium chloride or calcium chloride or other suitable chemical be added to the water to make it more conducting, the rod 11 with its contact 86 may be omitted in some cases, particularly if operating on low voltages. The rod 11 might also be omitted if the switch 2, 8 be operated in a small oil chamber. For certain purposes, the circuit breaker would be useful without either the rod 11, or switch 2, 8 or solenoid 66; for example, if the switch was connected in series with an air gap and used as a lightning arrester between a transmission conductor and ground. In this case channel 62 would be grounded and the operating lever 15, etc., would be omitted, leaving rod 21 simply to rise up by operation of the steam and to fall down into place by gravity.

Many other changes and modifications may be made without departing from the spirit and scope of the invention in its broader aspects, and the invention may be embodied in apparatus of widely different forms. Hence, the invention is not limited to the details shown and described, and it is intended to cover all forms coming within the language of the appended claims. What I claim and desire to secure by Letters Patent, is:

1. An apparatus of the class described having in combination two solid switch contacts normally contacting with one another, means for separating said contacts responsive to certain electrical fluctuations, means whereby the separation of said contacts causes current to flow through a vaporizable liquid to vaporize the liquid and means whereby the pressure exerted by such vapors causes a rapid further separation of said contacts to insulate the same from one another by air insulation.

2. An apparatus of the class described having in combination two solid switch contacts and means whereby one of said contacts is moved away from the other to open a circuit responsive to certain electrical fluctuations by the pressure exerted by vapor produced by current flowing through a conducting vaporizable liquid.

3. An apparatus of the class described having in combination two solid switch contacts normally contacting with one another, means causing a vaporizable liquid to surround said contacts at the point of contact, means for separating said contacts to permit current to flow therebetween through the liquid and means whereby the pressure of the vapor from the liquid produced by the current flowing therethrough causes further separation of said contacts and one of the contacts to move out of contact with said liquid.

4. An electrical switch having two solid switch contacts, means for causing a vaporizable liquid to surround the contacts of the switch at the point of contact, the liquid being adapted to vaporize upon current flowing therethrough between the switch contacts, whereby the vapor aids in extinguishing any arc between said contacts, and means whereby the pressure exerted by said vapor causes a further separation of said contacts to a point where one of them is out of contact with said liquid.

5. An electrical switch having two solid switch contacts, means for causing a vaporizable liquid to surround the contacts of the switch at the point of contact, the liquid being adapted to vaporize upon current flowing therethrough between the switch contacts, whereby the liquid or vapor aids in extinguishing any arc between said contacts, and means for bringing said contacts together in contact with one another with the point of contact beneath said liquid.

6. An apparatus of the class described having in combination, a chamber containing water, two solid switch contacts in said chamber, adapted to have their terminals beneath the surface of said water, means whereby a current is caused to flow between said contacts and through the water to vaporize the water and open the circuit between said contacts and remove one of the switch contacts from contact with the water.

7. An apparatus of the class described having in combination, a chamber containing water, two solid switch contacts in said chamber, adapted to have their terminals beneath the surface of said water, means whereby a current is caused to flow between said contacts and through the water to vaporize the water and open the circuit between said contacts, one of said contacts having a piston cooperating therewith and adapted to be operated by the pressure of the steam produced by the vaporization of the water, to move said contact away from the other and out of contact with the water.

8. An apparatus of the class described having in combination, a chamber containing water, two solid switch contacts normally contacting with one another in said chamber, adapted to have their terminals beneath the surface of said water, means whereby a current is caused to flow between said contacts and through the water to vaporize the water and open the circuit between said contacts, and a switch in shunt relation to said contacts.

9. An apparatus of the class described having in combination two solid switch contact members normally in contact with one another, means whereby a current may be caused to flow from one contact to the other through a conducting vaporizable liquid after the contacts have been separated from one another, and said liquid be vaporized by said current, said last mentioned means embracing a switch in shunt relation to said contact members, and means for causing said switch to open and said contact members to separate to cause a current to flow through said liquid to vaporize the same and open the circuit between said contact members.

10. An apparatus of the class described having in combination two solid switch contact members, means whereby a current may be caused to flow from one contact to the other through a vaporizable liquid, and said liquid be vaporized by said current, and means whereby one of said members is moved away from the other and out of contact with the liquid, responsive to the vaporization of said liquid by the current passing therethrough.

11. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members adapted to electrically contact with one another, an electric circuit, a cylinder connected with said container, a piston in said cylinder and adapted to be moved by the pressure of the vapors produced by current flowing through said liquid and responsive to current variations in said circuit, and means whereby movement of the piston operates one of said switch members.

12. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members, a cylinder connected with said container, a piston in said cylinder and adapted to be moved by the pressure of the vapors produced by current flowing through said liquid, and means whereby movement of the piston operates one of said switch members, said piston being provided with means to permit the escape of vapors therethrough upon the pressure of the vapors exceeding a predetermined value.

13. An apparatus of the class described having in combination a container containing a vaporizable liquid, two solid switch members adapted to contact with one another and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause operation of one of said switch members responsive to certain electrical fluctuations.

14. An apparatus of the class described having in combination a container containing a vaporizable liquid, two solid contact switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause operation of one of said switch members, and said vapors will aid in extinguishing any arc between said switch members and insulate the switch members from one another against high potentials.

15. An apparatus of the class described having in combination a container containing a conducting vaporizable liquid, two switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause one of said switch members to move away from the other and means for damping such movement.

16. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause one of said switch members to move away from the other and means for damping such movement, said last mentioned means comprising an oil dash pot with its operating member connected to the moving switch member through an air dash pot device.

17. An apparatus of the class described having in combination a container containing a conducting vaporizable liquid, two solid switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause one of said switch members to move away from the other, and means for locking said moved switch member in its removed position.

18. An apparatus of the class described having in combination a container containing a conducting vaporizable liquid, two switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause one of said switch members to move away from the other, and electrically controlled means for returning said moved switch member to normal position.

19. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members and means whereby, upon current flowing through said liquid and vaporizing the same, the pressure exerted by the vapors will cause one of said switch members to move away from the other, and means for locking said moved switch member in its removed position, and electrically controlled means for releasing said removed switch member and returning the same to normal position.

20. An apparatus of the class described

having in combination a container with water therein, two solid switch members normally contacting with one another, means whereby a current may be caused to flow through the water to vaporize the water responsive to certain electrical fluctuations, and means whereby the pressure of the steam so produced causes the operation of one of said switch members.

21. An apparatus of the class described having in combination a container containing a conducting vaporizable liquid, two switch members, a cylinder connected with said container, a piston in said cylinder and adapted to be moved by the pressure of the vapors produced by current flowing through said liquid responsive to certain electrical fluctuations, means whereby movement of the piston operates one of said switch members to move it out of contact with said vapors.

22. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members, a cylinder connected with said container, a piston in said cylinder and adapted to be moved by the pressure of the vapor produced by current flowing through said liquid, and means whereby movement of the piston operates one of said switch members, and means for damping the movement of said piston, said means comprising a combined oil and air dash device.

23. An apparatus of the class described having in combination a container containing a vaporizable liquid, two switch members, an electric circuit, a cylinder connected with said container, a piston in said cylinder and adapted to be moved by the pressure of the vapors produced by current flowing through said liquid and responsive to current variations in said circuit, means whereby movement of the piston operates one of said switch members, means whereby the vapors may escape by the piston after the piston has moved along the cylinder, and means for damping the movement of said piston.

24. In an apparatus of the class described, the combination of two cooperating switch contact members, a piston connected to operate one of said members, a cylinder in which said piston operates, electroresponsive means for controlling the movement of the other contact member, a switch in shunt relation to said contact members and also controlled by said electroresponsive means, and means for holding a volatile liquid about said first mentioned contact members at the point where they are adapted to contact with one another.

25. In an apparatus of the class described, the combination of two switch members, a framework carrying the same, means insulating said framework from the ground, a piston operatively connected with one of said switch members, means whereby a current is adapted to flow from one switch member to the other and volatilize a liquid to operate said piston and open the circuit between said contact members, means for guiding the movement of said piston, means insulating said guiding means from the ground and from said framework, and means for returning said piston to its normal position.

26. In an apparatus of the class described, the combination of a cylinder constructed of insulative material, a conducting piston operating in said cylinder, a volatile liquid chamber, a solid switch member in said cylinder and carried by said piston, a second solid switch member in said cylinder and adapted to make electrical contact with the first switch member, and means for moving said second switch member.

27. In an apparatus of the class described, the combination of a cylinder constructed of insulative material, a conducting piston operating in said cylinder, a volatile liquid chamber, a switch member in said cylinder and carried by said piston, a second switch member in said cylinder and adapted to cooperate with the first switch member, and conducting means extending through the cylinder and adapted to make electrical connection with the piston, and a switch having one terminal connected to said conducting means and operatively related to said first mentioned switch members.

28. In an apparatus of the class described, the combination of a volatile liquid chamber, two solid switch members having their terminals within said chamber, means whereby the pressure of vapors of the volatile liquid in said chamber is adapted to cause the operation of one of said switch members and move it out of contact with the volatile liquid and a volatile liquid reservoir connected to said liquid chamber.

29. In an apparatus of the class described, the combination of two switch members, a framework carrying the same, means insulating said framework from the ground, a piston operatively connected with one of said switch members, means whereby a current is adapted to flow from one switch member to the other and volatilize a liquid to operate said piston and open the circuit between said contact members, means for guiding the movement of said piston, means insulating said guiding means from the ground and from said first mentioned framework, and means for returning said piston to its normal position, said returning means embracing a solenoid and cooperating core insulated from said first mentioned framework and from said guiding means.

30. In an arrangement of the class de-

scribed the combination of two solid metal switch contacts and means whereby when one is moved a circuit through said contacts is opened by the pressure exerted by vapor produced by current flowing through a vaporizable liquid.

Signed at Buffalo, in the county of Erie and State of New York, this 17th day of December, A. D. 1917.

LLOYD C. NICHOLSON.

Witnesses:
ALEX C. STARK,
F. VAUGHAN.