

N. J. CONRAD.

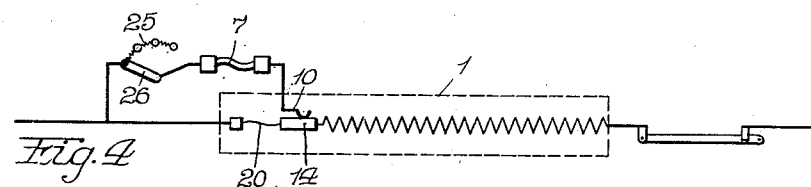
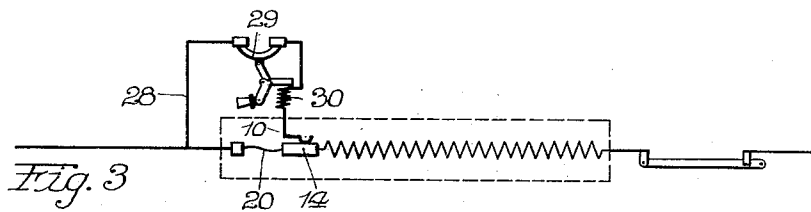
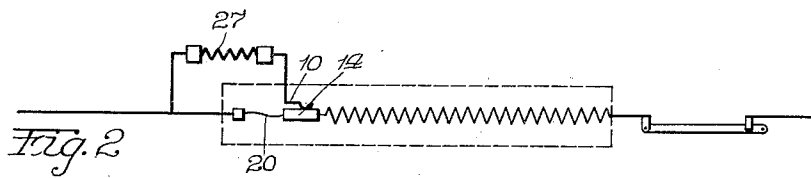
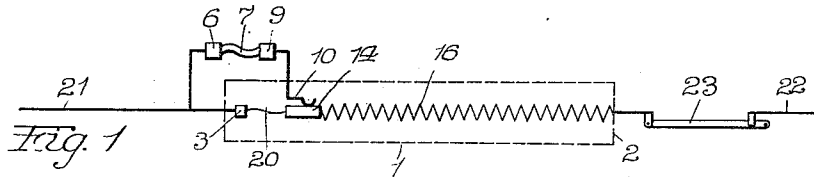
METHOD OF AND MEANS FOR SWITCHING CURRENT FLOW AT HIGH POTENTIAL.

APPLICATION FILED FEB. 26, 1917.

1,294,621.

Patented Feb. 18, 1919.

5 SHEETS—SHEET 1.



Inventor
Nicholas J. Conrad
By Brown, Hanson & Bottcher
Attorneys.

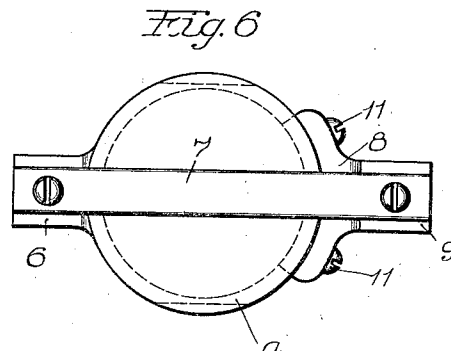
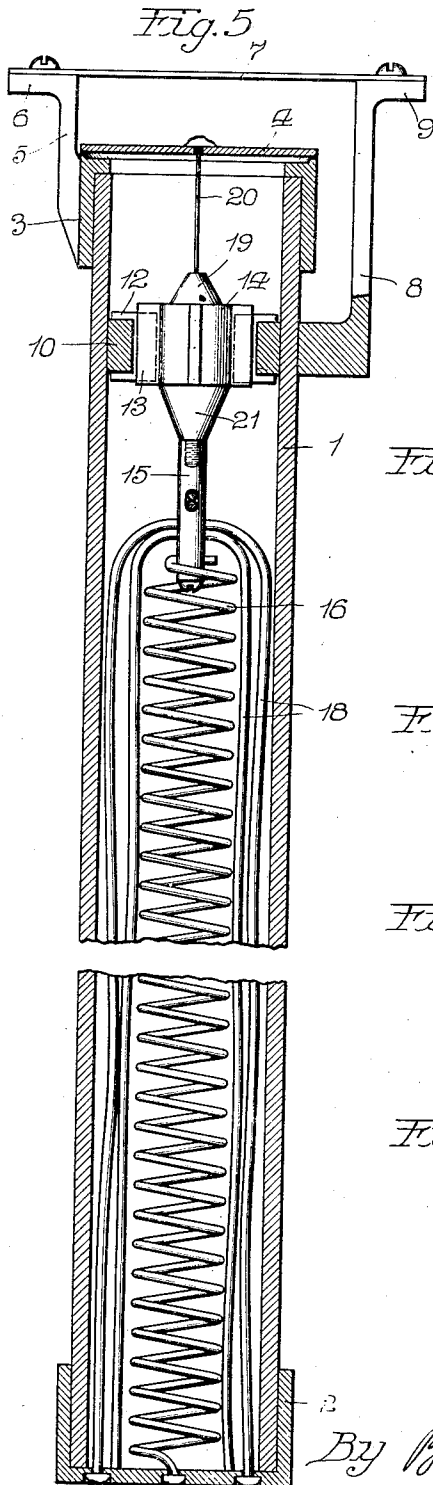


Fig. 7

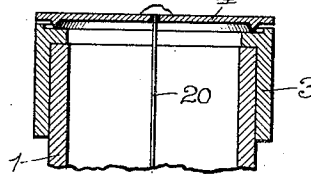


Fig. 8



Fig. 9

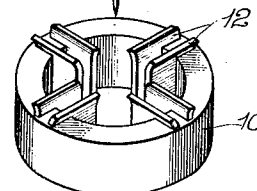
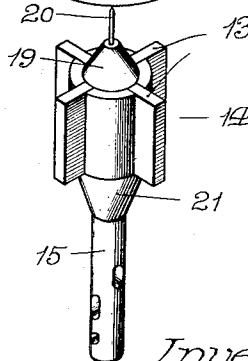


Fig. 10



Inventor
Nicholas J. Conrad
By Brown, Hanson & Bretcher
Attorneys.

N. J. CONRAD.
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 5 SHEETS—SHEET 3.

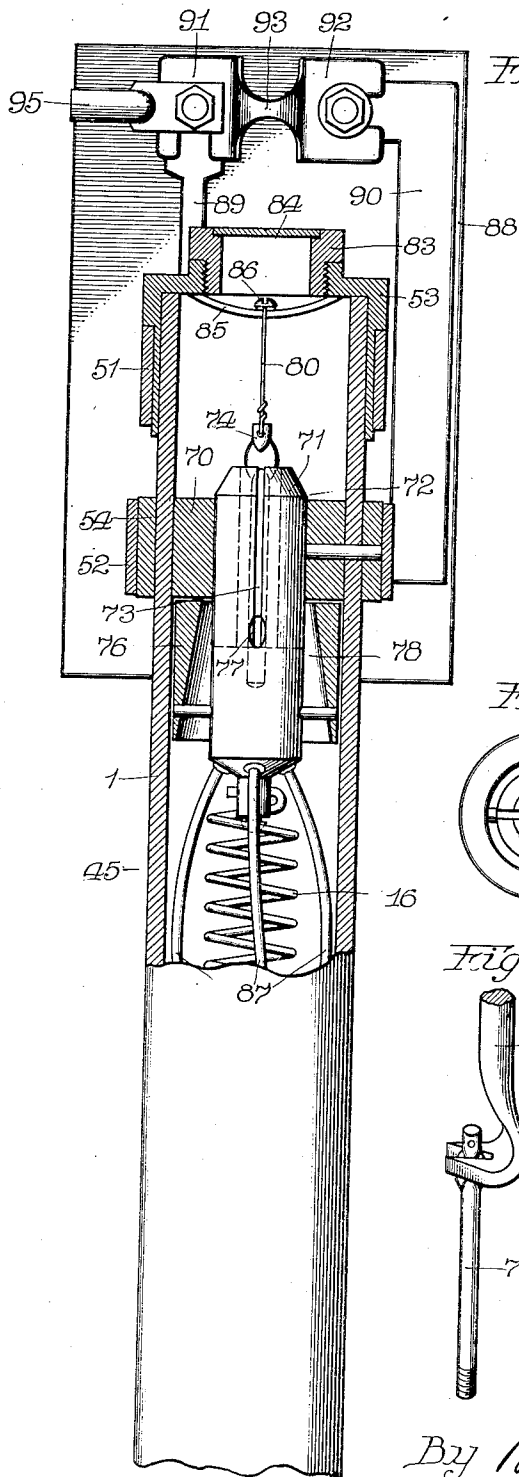


Fig. 11

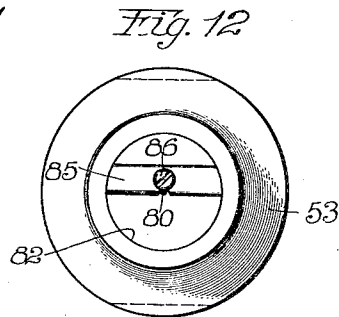


Fig. 12

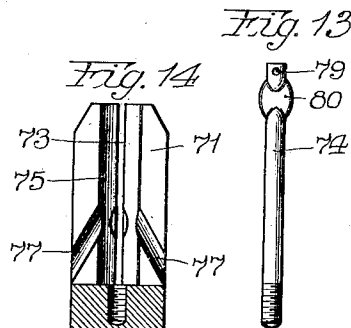


Fig. 13

Fig. 14

Fig. 15

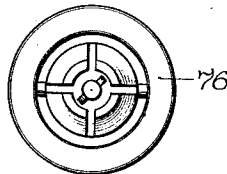


Fig. 17

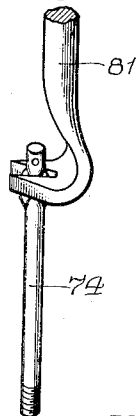
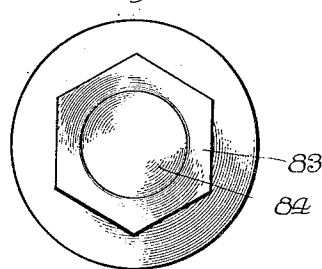
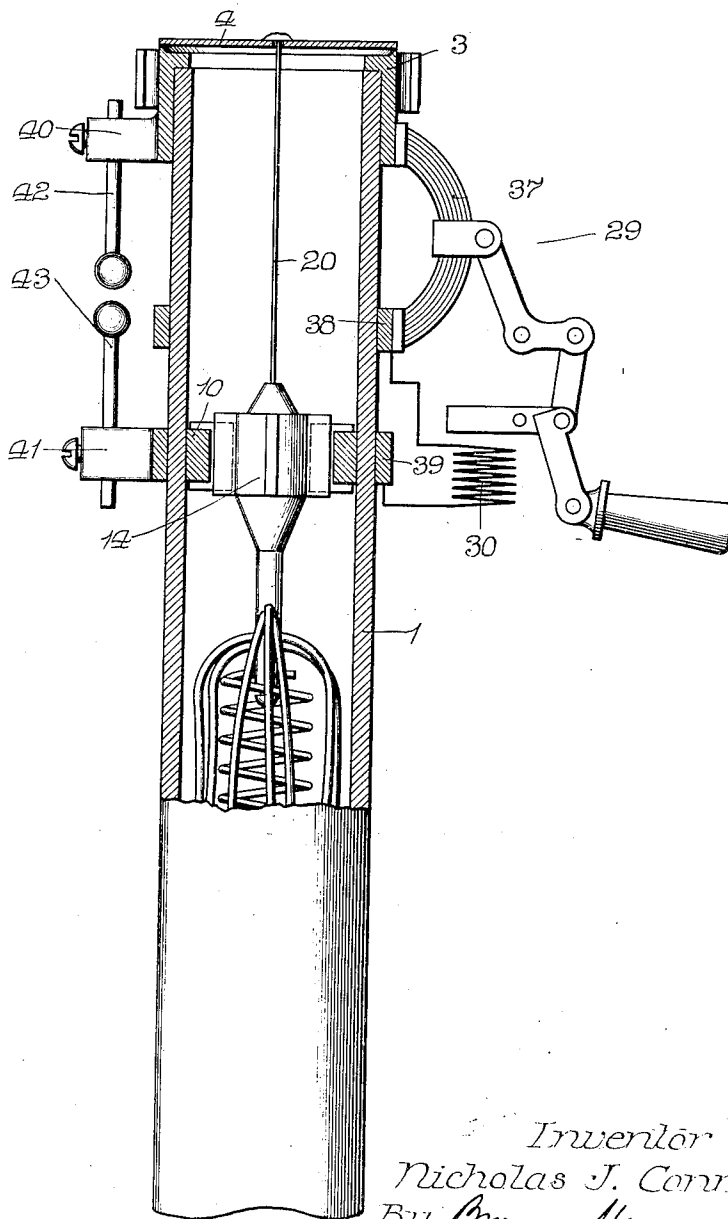


Fig. 16



Inventor
 Nicholas J. Conrad
 By Brown, Hanson & Bottcher
 Attorneys.

Fig. 18



Inventor
Nicholas J. Conrad
By Brown, Hanson & Betteke,
Attorneys.

N. J. CONRAD.

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1,294,621.

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5 SHEETS—SHEET 5.

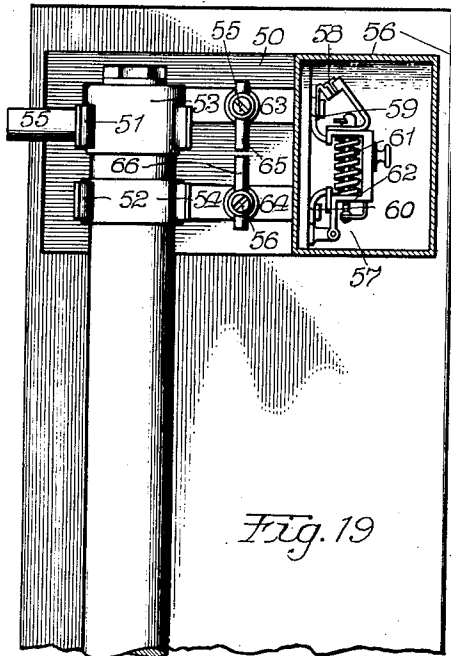


Fig. 19

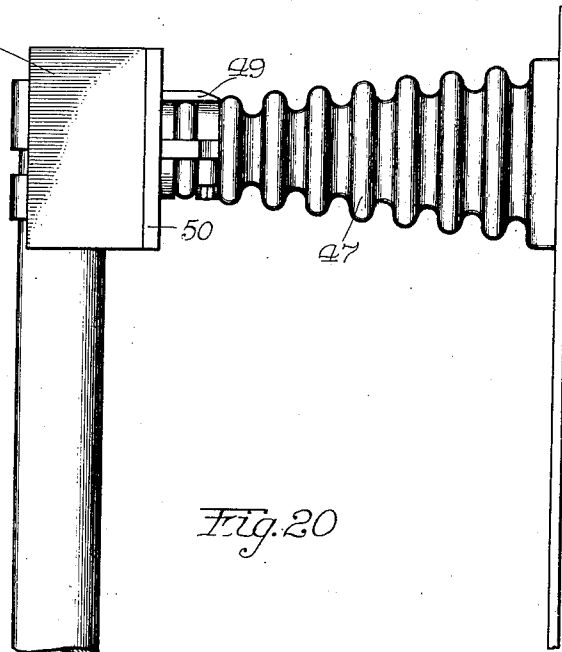
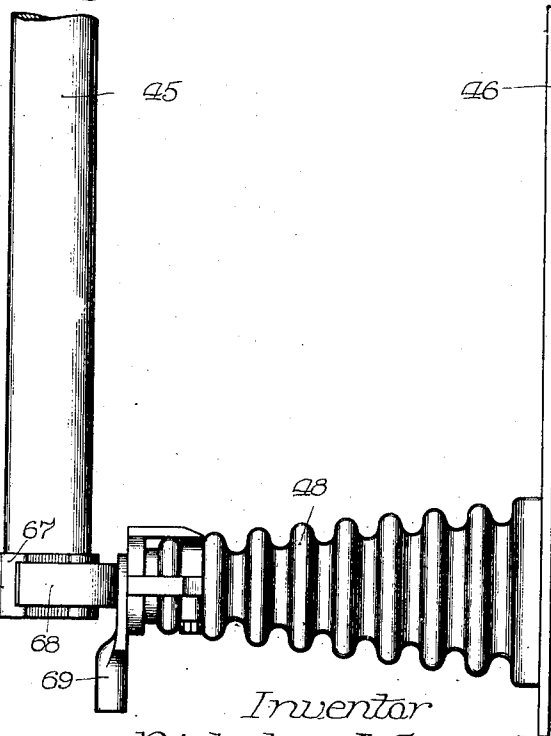
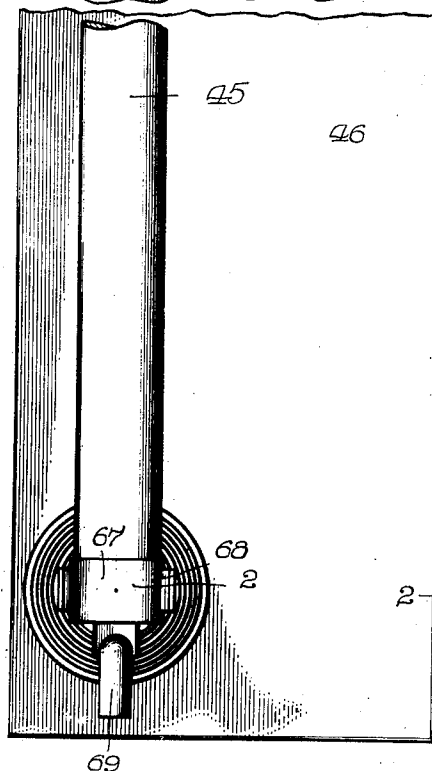


Fig. 20



Inventor
Nicholas J. Conrad
By Brown, Hanson & Motteher
Attorneys

UNITED STATES PATENT OFFICE.

NICHOLAS J. CONRAD, OF CHICAGO, ILLINOIS, ASSIGNOR TO SCHWEITZER & CONRAD, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

METHOD OF AND MEANS FOR SWITCHING CURRENT-FLOW AT HIGH POTENTIAL.

1,294,621.

Specification of Letters Patent.

Patented Feb. 18, 1919.

Application filed February 26, 1917. Serial No. 151,068.

To all whom it may concern:

Be it known that I, NICHOLAS J. CONRAD, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Methods of and Means for Switching Current-Flow at High Potential, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to a novel method of and means for switching current flow at high potential.

One of the most difficult problems in high tension electrical transmission work is the interruption of current flow particularly in connection with securing relief under short circuit conditions. Switching of normal current flow under high voltage is difficult enough but the difficulties under short circuit conditions are enormously increased. The apparatus which I have chosen to illustrate my invention is designed to operate upon voltages of the order of 100,000 to 150,000 volts which at the present state of the art represent the highest commercial transmission voltages and which present the greatest difficulty to which switching apparatus is now subjected. The invention it is to be understood is applicable to all voltages low or high.

The accepted manner of switching current under normal conditions is to employ a switch having its contacts working under oil. Such switches are generally constructed with an overload tripping coil serially related to the line so that in the event of excessive current flow as under short-circuit conditions the contact of the switch may be opened automatically. These switches as at present constructed are intended for repeated operation but it has been found that they are subject to very rapid deterioration and consequently are required to be inspected and repaired at very frequent intervals. The mechanical construction is clumsy, a very considerable amount of space is required and the expense of such switches is excessive both for initial cost and for upkeep.

I have devised a novel method of switching high-pressure current both for normal switching operations and for abnormal or

short-circuit conditions of operation. According to my invention oil switches as such are dispensed with and switch units or switch links capable of only one switching operation are inserted in the current. That is to say I supplant the prior permanent switch which is intended for repeated operation by a replaceable switch which is capable of only one operation and which must then be renewed. This is a great simplification of existing methods and provides much sought relief from present difficulties. For these individual switching units or links I employ as a basis the arc extinguishing apparatus developed by myself and Edmund O. Schweitzer as will be apparent from the patents granted to us singly or jointly and applications now pending.

Each link or unit is a complete self-contained circuit-breaking device capable of one single operation having a self-supporting casing or body bearing external terminals which are easily attached to and detached from the line terminals and containing all the mechanism required for positively executing one successful circuit-breaking operation. Each unit after performing its switching operation is removed for renewal while another unit in proper condition is inserted in the circuit.

The chief object of my invention is to provide an improved method of and means for switching current flow at high potential.

In carrying out the main invention above outlined I have made a number of important improvements in apparatus and methods of operation some of which are outlined in the following objects.

It is a further object of my invention to provide an improved method of interrupting current flow at high tension. Another object is to provide an improved form of automatic thermally controlled circuit-breaker. A further aim is to provide an improved form of circuit-breaker mounting.

Other objects will be apparent from the following detailed specification.

Figure 1 represents in diagrammatic form one form of my invention which is described in detail later;

Fig. 2 is a diagram of a modification embodying my invention and showing a shunt

automatically operating upon resistance interposed by the temperature coefficient of a part of the shunt;

Fig. 3 is a diagram of a further modification employing the electro-magnetic effect of the current for increasing the resistance of the shunt;

Fig. 4 is a diagram of the invention showing both manual and automatic means for increasing the resistance of the shunt;

Fig. 5 is a longitudinal section of an embodiment of my invention;

Fig. 6 is a top plan view of the same;

Fig. 7 is a fragmentary sectional view showing the removable vent member;

Figs. 8, 9 and 10 are isometric views of the vent, the annular contact and the movable contact members respectively;

Fig. 11 is a partly sectional and partly elevational view of the modified form of my invention mounted upon a suitable board;

Fig. 12 is a top plan view of the switching unit with the vent cap removed;

Fig. 13 is a detail elevational view of the removable tip;

Fig. 14 is a sectional view of the movable contact member;

Fig. 15 is a top plan view of the movable contact member with the liquid director connected to the same;

Fig. 16 is a top plan view of the switching unit;

Fig. 17 illustrates the manner in which the removable tip shown in Fig. 13 may be manipulated;

Fig. 18 is a sectional view partly diagrammatic illustrating the manner in which a magnetic overload circuit breaker may be mounted upon the side of the switching unit;

Fig. 19 is a front view partly in section;

Fig. 20 is a side view of a switching unit mounted upon a suitable insulated mounting.

For carrying out my invention I employ as the starting point of development of my invention the fusible circuit breaker of the type shown in Patent No. 1008496, November 14th, 1911, granted to E. O. Schweitzer and myself.

I have found that where this type of fuse is employed for very high voltages and to carry several hundred amperes a very large fuse must be employed and the energy liberated by blowing of such a fuse under short circuit conditions is so great as to be highly undesirable within the container.

I have, therefore, as a first and important conception placed the main current carrying fuse outside of the container and have placed a complete circuit breaking switch within the container. This switch is normally held in the closed position by a wire of small diameter but of great tensile strength which in itself forms a fuse in parallel with the main current carrying fuse. In other words, the

main fuse forms a low resistance shunt about the auxiliary fuse. As a consequence the current carried by the small wire which forms the auxiliary fuse is comparatively insignificant and the heat generated by fusion of the same is not so great but that it can readily be sustained in the interior of the vessel.

As a further important conception in improving that type of fuse I have provided means which permits manual control of the shunt about the auxiliary fuse for the purpose of causing the auxiliary fuse to blow and open the switch, thus making the device capable of use either for automatic overload switching or for manually controlled switching under normal current.

In order to apprise those skilled in the art how to practice my invention I shall now describe the details of a particular embodiment in which my invention appears. In Fig. 1 I have shown the diagrammatic arrangement and in Figs. 5 to 10 the structural details of an automatic switching device depending for its automatic operation upon the thermal effect of the current.

The main body of the switching unit shown in Fig. 5 consists of a tube or sleeve 1 of insulating material. This sleeve may be made of glass although on account of structural difficulties I have found that fiber impregnated with bakelite is preferable. A cap 2 is secured to the lower end of the sleeve and closes off the lower end and forms an external circuit terminal for the switching unit. A cap 3 surrounds the upper end of the sleeve 1 and forms an external circuit terminal as will be described later. The cap 3 is provided with a removable vent member 4 which may be blown off by the interior pressure within the sleeve 1 when the switch operates. The cap member 3 is provided with a projecting bracket 5 forming at its upper end 6 a terminal for securing conductively one end of the main fuse member 7. Another bracket member 8 is mounted upon the side of the sleeve 1 having its upper end 9 projecting upward to substantially the level of the upper end 6 of the bracket 5 and forming a terminal for the other end of the main fuse 7.

Within the sleeve 1 and adjacent the upper end thereof I have mounted a conducting ring 10 in electrical conductive relation with the bracket 8 by means of the screws 11 which connect these parts together. The ring 10 within the sleeve 1 is provided with four sets of stationary switch contact blades 12 which are preferably formed of flat spring metal to provide yielding contact surface with the fins or vanes 13 of the movable terminal member 14. The movable terminal 14 is provided with a detachable stem member 15 which is connected mechanically to a coil tension spring 16, the other end of

which spring is fastened to the bottom 17 of the cap member 2. A plurality of flexible conducting cables 18 are connected between the stem 15 and the bottom of the cap 2 in such manner as to offer a path of low resistance in shunt of the spring 16. These conducting cables prevent damage to the spring 16 and at the same time provide a path of low resistance and thereby prevent heating in the casing 1. The movable member 14 is provided at its upper end with a reduced portion 19 to which is connected a fuse 20 fastened at its upper end to the vent member 4. The fuse 20 is preferably a wire of high resistance and of great tensile strength. The function of the wire 20 is to support the movable terminal 14 in conducting relation with the stationary terminal 10 during normal condition of the switching unit.

The casing 1 is filled with an arc extinguishing liquid preferably carbon tetrachloride or the liquids described in the copending application of Schweitzer & Conrad Serial No. 120625, filed September 18, 1916, namely, poly chloro-derivatives of hydrocarbon compounds.

A flared or conical liquid director 21 is mounted upon the stem of the movable switch member 14 and serves to throw the liquid outward upon the fins or vanes 13 and about the tip 19 in such manner as to cause a violent agitation of the liquid and to cause it to extinguish the arc which may be drawn between the stationary terminals 12 and the movable terminal 14.

In Fig. 1 I have shown the diagram of connections. The outgoing line wire is connected to the terminal 3 and the incoming line 22 is connected through the disconnecting switch 23 to the lower terminal 2. The auxiliary fuse 20 which is contained within the casing 1 and which normally holds the main switch 10, 14 in closed position is shunted by the main fuse 7 which is external to the casing 1.

The operation of the switching unit is as follows: When excessive current flows through the lines 21, 22, and through the switching unit, the fuse member 7 will be subjected to such a degree of heat as will melt the metal comprising the same thereby greatly increasing the resistance of the shunt around the fuse 20. Normally this shunt amounts almost to a total short circuit and the high resistance of the auxiliary fuse 20 prevents any material current flows through the same. When the resistance of the shunt is increased by fusing of the member 7 the potential drop across the wire 20 will be increased and a flow of current through this wire sufficient to fuse the same will occur. It is to be noted in this connection that there is no intention of relying upon the fuse 7 for breaking the flow of current as this function is performed by the switch 10, 14 which is in

series with both fuses 7 and 20. This switch operates as soon as the wire 20 releases the same and promptly opens the circuit stopping the flow of current. After the current flow has been stopped the disconnecting switch 23 is opened and the switching link is removed from the line terminals and another switching unit in the proper set condition is put in its place. The disconnecting switch 23 is then closed.

As manual control of the switching unit is desirable manual means may be provided for increasing the resistance of the shunt path thereby causing operation of the switch. Such manual means may consist of a switch, rheostat or any other means for increasing the resistance of the shunt path.

In Fig. 4 I have shown a rheostat 25 having a movable switch member 26 in the shunt circuit, this movable member being operable to increase the resistance of the shunt by including more of the resistance of the rheostat and thereby causing operation of the switch 10, 14.

The automatic operation need not be dependent upon the heating effect caused by actual fusion but may depend upon the rise in resistance caused by the temperature coefficient. In Fig. 2 I have illustrated the shunt as including a wire 27 having a large positive temperature coefficient, such for instance as copper or iron or certain alloys thereof. Excessive current flow through the wire 27 raises the temperature of the same and consequently raises the resistance to such a degree that the auxiliary fuse or releasing device 20 causes the switch to open to break the current through both paths.

The fuse 20 will operate whenever the current flow is sufficient. The low resistance shunt need not have a different coefficient of resistance to be completely operative but a sharper definition and greater assurance of proper operation is secured by keeping the current flow out of the wire 20 until the moment it is to be fused.

It is also to be understood that the increase in magnetic action may be relied upon for increasing the resistance of the shunt. I have shown in Figs. 18, 19 and 20 means dependent upon the electromagnetic force exerted by the increased flow of current, for increasing the resistance of the shunt. In Fig. 3 I have illustrated diagrammatically the manner in which this may be accomplished. The current carrying switch includes a mechanical switch 29 which is of the overload release type having an overload coil 30 serially related to the current flowing in the shunt 28. Upon the occurrence of excessive current flow the switch 29 will be opened not for the purpose of breaking the flow of current in the line but for the purpose of increasing the resistance of the shunt thereby causing a greater poten-

tial drop across the terminals of the switch controlling fuse 20. This increased drop of potential across the switch controlling fuse 20 causes increased flow of current and brings about the operation of the main switch 10, 14.

In Fig. 18 I have illustrated a structure in which instead of employing a fusible element in the shunt path about the auxiliary fuse 20, I have shown a magnetically controlled overload switch 29 mounted upon the side of the casing 1 having a movable switch member 37 normally closing the connection between the upper external terminal 3 and an auxiliary terminal 38 which is mounted upon the side wall of the container 1 and which is connected through the overload trip coil 30 to a terminal ring 39 that is electrically connected to the stationary member 10 of the main switch. I have provided bracket members 40 and 41 which are connected to the terminal members 3 and 39 respectively, and which bear electrodes 42 and 43 so spaced that when the switch 29 is opened by excessive current, the current will tend to cross the gap at the electrodes 42, 43 rather than arc at the switch 29 thus preventing damage to the switch. Opening of the switch 29 increases the resistance of the shunt path to such an extent that a large increase of current flows through the switch operating member 20 and causes opening of the main switch 10, 14.

In Figs. 19 and 20 I have shown a switching unit or link 45 connected to a suitable mounting for high voltage installations. A base or support 46, has mounted thereupon a pair of suitable insulators 47 and 48 for the upper and lower ends respectively of the switching unit. The upper insulator 47 supports, by means of a clamp member 49, a board or plate 50 of insulating material carrying two sets of terminals 51 and 52 that are connected to suitable external terminals 53 and 54 of the switching unit 45. The terminals 51 and 52 are in the form of spring clips which engage suitably flattened parts on the sides of the terminals 53 and 54 on the switching unit 45. The upper terminal 51 is connected to the line at 55. The insulating board 50 supports a casing 56 which contains a circuit breaker 57. This circuit breaker is of a type well known having carbon break contact 58 and laminated spring contacts 59 and 60 and a tripping coil 61 with an adjustable trip 62. The tripping coil is connected between the stationary contacts 59 and 60 and upon the occurrence of excessive current trips out the release 62 and opens the switch. I have provided a manual trip not shown for operating the release 62 to control manually the opening of the circuit.

The casing 56 within which the circuit breaker 57 is mounted is filled with carbon

tetrachlorid or with a liquid of the type disclosed in the above mentioned application of Schweitzer & Conrad. The use of this liquid has a two-fold function. First it improves the electrical operation in preventing overheating and fusion of the contact parts and in quickly extinguishing the arc but this is not the main reason for its employment. I have found that submerging the circuit breaker in a bath of those liquids improves the mechanical operation of the same by preventing the condensation of moisture upon the parts, by preventing gumming of the movable parts as would occur by employment of lubricating oil, particularly at low temperatures, by keeping out dirt, insects and the like, and by preventing the parts from oxidizing and keeping the same in good mechanical condition.

The stationary terminals 59 and 60 of the switch 57 are connected by suitable conductors 63 and 64 to the spring terminals 51 and 52 respectively. A pair of spark gap terminals 55 and 56 are connected to the conductors 63 and 64 in such relation that opening of the switch 57 will cause the current to pass between the electrodes 65 and 66 across intervening gap, if the voltage is sufficiently high, and the gap will in that case protect the switch 57. The lower terminal 67 of the switching unit 45 is connected by means of a spring switch or terminal 68 to the line terminal 69 mounted on the outer end of the insulator 48.

The details of the switching unit 45 are shown in Figs. 11 to 17, inclusive. A suitable insulating sleeve 1 carries at its upper end the cap member 53 which forms an external terminal that is connected to the spring clip or contact 51. Below the cap 53 a ring 54 is mounted on the sleeve 1, this ring being connected to the spring clips or terminals 52. The ring 54 is connected to an interior ring 70 which has a smooth central bore adapted to receive the spring plug 71 that forms the movable terminal of the main circuit breaking switch 72. The movable terminal 71 comprises a hollow cylindrical member slotted as shown at 73 to provide a yielding contact within the annular terminal 70. A removable pin 74 is attached as by means of screw threads to the plug member 71 lying in the bore 75 of the member 71. This bore is substantially larger than the size of the pin 74 so as to permit free movement of the slotted arms of the member 71. The movable member 71 bears a liquid director 76 which surrounds this member and directs the flow of arc extinguishing liquid with which the casing 1 is filled around the outside of this movable member in order to extinguish the arc which may be drawn. A plurality of diagonal passageways 77 communicate with the bore 75 and the space 78 formed between the

liquid director and the member 71 so that liquid is forced through the passageways 77 into the bore 75 and completely enveloping the pin 74. The pin 74 is provided at its upper end with a suitable terminal portion 79 to which is connected the high resistance high tensile strength wire 80 which supports the movable terminal 71 against the tension of the spring 16. The pin 74 is also provided with a flattened portion 80' which permits it to be engaged by a suitable tool 81, shown in Fig. 17, for the purpose of substituting a new pin with a wire 80 properly attached, when the switching unit is to be renewed.

The cap member 53 has an opening 82 in the top thereof, this opening being normally closed by a vent plug 83 which has soldered at its upper end a removable vent member 84 that is adapted to be blown off when the pressure in the switching unit becomes excessive. A bridge member 85 on the cap member 53 below the opening 82 is adapted to support the upper end of the wire 80 as by means of the screw 86. The vent plug 83 is provided with suitable engaging surfaces for applying a wrench or the like.

The spring 16 is shunted by means of suitable flexible conductors 87 which are of suitable current carrying capacity.

The spring terminals 51 and 52 are mounted upon a suitable board 88 which is similar to the board 50 and is mounted in a similar manner and the spring terminals are connected by means of the conductors 89 and 90 to the terminals 91 and 92 of a fusible member 93. The terminal 91 of the fusible member 93 is connected to a line terminal 95. The fusible member is mounted directly in line with the opening in the vent member 83 so that any liquid which may be ejected from the switching unit 45 will tend to strike the fusible member 93 and prevent arcing at the same.

It can now be seen that I have provided a novel method of and means for accomplishing the switching of current in a high voltage system. I do not intend to be limited solely to the use of my invention in connection with high voltages but have described the same in connection with the highest known voltages as illustrating the capacity of devices constructed in accordance with my invention to cope with the most difficult situation.

Heretofore in the art fuses of the type shown in prior Patent #1008496 above referred to have been provided for breaking overload current or short circuit current in circuits of various voltages but attention is called to the fact that the fusible member in that case is designed to carry full load current and that the circuit is broken at the fusible member. In accordance with my present invention the circuit is not broken

at the fuses, or at least need not be so broken because of the provision of the main switch which is in series with both paths which is designed to break the flow of current even under the most adverse condition. The switching unit of my invention is in reality a switch of very large capacity but of small size adapted to be inserted into the circuit and to be opened by excessive current flow under overload or short circuit conditions, or to be opened by a manual act when it is desired to break the flow of current for any other reason.

As the circuit breaking switch is completely inclosed and connected only electrically with the outside parts, visual observation of the switch is not possible. However, the condition of the shunt path reveals the condition of the switch. If the main current carrying fuse as 7 in Fig. 5 or 93 in Fig. 11 is blown then the main switch is open. Similarly if the switch 29 in Fig. 18 or 57 in Fig. 19 is open it will be known that the main switch is open. This indicating feature is distinctly valuable particularly when the casing is made of opaque material.

The particular advantage of the above described distribution of current in the shunt path and the release path is that current flow through the release path is almost zero at all times except during the instant when the release is actuated. This means that the release element will not be subject to objectionable heating. Such operation is particularly valuable in the inclosed structure above described as there is negligible current flow, the heating negligible in the interior of the casing. No damage is therefore caused by accumulation of heat.

I do not intend to be limited to the precise details shown or described as the invention may obviously be embodied in other forms.

What I claim is:

1. In combination a switch, a fuse normally holding the switch in closed position, and a shunt of low resistance about said fuse.

2. In combination a switch, a fuse of relatively high resistance normally holding the switch closed, and a shunt of low resistance about said fuse normally preventing operation of said fuse.

3. In combination a switch, means for opening said switch, a fuse of small current capacity mechanically controlling said means, and a shunt of low resistance about said fuse.

4. In combination a switch, means for opening said switch, a fuse of small current carrying capacity controlling said means, and a shunt of low resistance electrically connected about said fuse, said shunt having means for changing the relative resistance of said shunt and said fuse.

5. In combination a switch, means for opening said switch, a fuse of small current carrying capacity controlling said means, a shunt of low resistance electrically connected about said fuse and a fuse of large current carrying capacity in said shunt.

6. In combination, a switch, means for opening said switch, a fuse of small current carrying capacity controlling said means, and a shunt of low resistance electrically connected about said fuse, said shunt having automatic means for increasing the resistance of the shunt.

7. In combination, a switch, means for opening said switch, a fuse of small current carrying capacity controlling said means and a shunt of low resistance electrically connected about said fuse, said shunt comprising means for increasing the resistance of the shunt and thereby increasing the current flow through the fuse.

8. In combination, a switch, means for opening said switch, current operated means of relatively high resistance controlling said switch opening means, an inclosing casing for said switch, said opening means and said controlling means, and a shunt of low resistance and relatively large current capacity external to said casing connected about said fuse.

9. In combination, a switch, means for opening said switch, current operated means of relatively high resistance controlling said switch opening means, an inclosing casing for said switch, said opening means and said controlling means, a body of arc extinguishing liquid in said casing and a shunt of low resistance and relatively great current carrying capacity external to said casing and connected about said fuse, said shunt comprising a fusible member.

10. In combination, a switch, a spring for operating the switch, a fuse of high tensile strength holding said switch closed, a casing inclosing the switch, the spring and the fuse, and an external shunt about said fuse.

11. In combination, a switch comprising stationary and movable terminals, a spring connected to the movable terminal, a fuse of high tensile strength holding said movable terminals in engagement with the stationary terminals, a casing inclosing the switch, the spring and the fuse, said stationary terminals being mounted on the inside of said casing and an external shunt about said fuse.

12. In combination a switch, a spring for opening the switch, a fuse of high tensile strength holding said switch in closed position, a casing inclosing said switch and said spring, a shunt exterior to the casing, said shunt being connected about said fuse, and an arc extinguishing liquid in said casing.

13. In combination a switch having a mov-

able element a spring for operating the movable element of said switch, a fuse of high tensile strength holding said switch in closed position, a casing inclosing the switch and the spring, a body of liquid in the casing and means for projecting said liquid upon the arc drawn by the movable element of said switch.

14. In combination, a casing comprising a tubular sleeve of insulating material, a terminal member encircling the upper end of said sleeve, a terminal member encircling the lower end of the sleeve closing off the same to form a liquid tight container, a switch in said container, said switch comprising a stationary member secured to the wall of said casing and a movable member normally in contact with said stationary member, means in said casing for separating said switch members, a fuse in said casing holding said switch members normally in contact, and an external fuse of low resistance shunting first said fuse.

15. In combination, a tubular member of insulation, a metallic cap closing off the lower end of said tubular member, a metallic cap closing off the upper end of said tubular member, a stationary switch contact in said tubular member secured to the walls thereof, a movable switch member adapted to engage said stationary switch member, a fuse member of small capacity connected between the upper cap and said movable contact member, means for separating said switch contact, a terminal member mounted upon the outside of the tubular member and a shunt of low resistance connecting said terminal member and said upper cap member.

16. In combination, a tubular sleeve of insulation, a terminal cap closing off the bottom of said sleeve, a terminal cap closing off the top of said sleeve, said upper terminal cap having an axial opening and having a vent plug for closing said opening, a supporting member connected to the terminal cap below said axial opening, a switch in said tubular sleeve, said switch comprising a relatively stationary member and a relatively movable member and a wire of small diameter and of relatively high tensile strength connected between the movable switch member and the supporting member.

17. In combination, a tubular sleeve of insulation, a switch mounted in said sleeve adjacent the upper end thereof, said switch comprising a relatively stationary and a relatively movable member, a terminal cap closing off the top of the sleeve, said cap having a supporting member, and a wire of relatively high resistance and high tensile strength connecting the movable switch member with said supporting member.

18. In combination, a tubular sleeve of insulation, a metallic cap closing one end of the sleeve and forming an external terminal,

a stationary switch member comprising an annular contact mounted adjacent the one end of the sleeve, a movable switch member comprising a yielding plug for engaging said annular contact, and a fuse member of small current carrying capacity connecting the movable switch member with the metallic cap and holding said switch in closed position.

19. In combination, a tubular sleeve of insulation, an annular stationary switch member mounted near one end of said sleeve, a relatively movable plug member adapted to engage said stationary annular member, a spring for moving said movable member, a liquid director surrounding said movable member, a metallic external terminal at said one end of the sleeve and a fuse of small current carrying capacity connected between the movable switch member and said terminal.

20. In a device of the class described, a sleeve of insulation, a cap member adapted to close the end of said sleeve, said cap having an axial hole, a supporting member across said axial hole, a stationary switch member mounted on the interior of the sleeve independently of the cap, a vent plug removably secured in said axial hole, said vent plug having a relatively large passage adapted to be opened by excessive pressure and having a disk covering said opening and a movable switch element contained in said sleeve.

21. In combination, a tubular sleeve of insulation, a metallic cap member closing off the top of the sleeve, a switch in said sleeve, said switch comprising a stationary member mounted on the side walls of the sleeve, and a movable member adapted to contact with said stationary member said movable member having a separable tip and a fusible member connecting said tip to said metallic cap member.

22. In combination, a sleeve of insulation, a metallic cap for said sleeve, a switch in said sleeve, said switch comprising an annular stationary contact, and a movable contact, said movable contact comprising a plurality of yielding spring fingers, and a removable pin mounted centrally of said fingers, and a fusible member connecting said pin to the metallic cap.

23. In combination, a sleeve of insulation, a metallic cap for said sleeve, an annular stationary switch contact mounted in said sleeve adjacent the end thereof, a movable contact member for engaging said stationary contact, said movable member comprising a cylinder of conducting material having a hollow bore for a part of its length and having slots cut substantially radially to provide a plurality of spring fingers, and a removable tip mounted independently of said spring fingers on the contact member.

24. In combination, a sleeve of insulation, a metallic cap for said sleeve, an annular stationary switch contact mounted in said sleeve adjacent the end thereof, a movable contact member for engaging said stationary contact, said movable member comprising a cylinder of conducting material having a hollow bore for a part of its length and having slots cut substantially radially to provide a plurality of spring fingers, and a removable tip mounted independently of said spring fingers on the contact member, said movable member having passageways for an arc extinguishing liquid through the side walls thereof and a liquid director secured to said movable member.

25. In combination, a switch having a movable element, a current controlled member of relatively low resistance in series with said switch, a shunt of high resistance about said member and connected to the movable element of the switch.

26. In combination, a switch having a pair of contacts, including a movable contact, a control element for said switch, said control element being connected electrically to the movable contact of said switch and normally restraining the switch from opening, and a shunt of low resistance about said control element.

27. In combination, a switch comprising a movable and a stationary contact, a marginal current operated control element for said switch having two terminals and having one terminal connected to said movable contact and a shunt of low resistance connected between the other terminal of the control element and the stationary switch contact.

28. In combination, a switch comprising a movable and a stationary contact, a marginal current operated control element for said switch, having one terminal connected to said movable contact, a shunt of low resistance connected between the other terminal of the control element and the stationary switch contact, and means for automatically increasing the resistance of said shunt upon excessive current flow through the switch.

29. In combination, a switch having a movable and a stationary contact, terminals for said contacts, means tending at all times to move the movable contact toward the open position, arc extinguishing means for the switch, brought into action by movement of the movable contact, fusible means for mechanically holding the contacts in engagement, said means being connected electrically between the line and one of the contacts and a second fusible means connected between the terminal for the stationary contact and the line.

30. In combination, a switch comprising a

movable contact and a cooperating contact, a terminal, a fusible link governing the movement of the movable contact, said link being connected between said terminal and one of the switch contacts, and a fusible link of greater current carrying capacity connected in shunt about said first fusible link.

31. In combination, a switch comprising a movable contact and a cooperating contact, a terminal, a fusible link controlling the movement of the movable contact, said link being connected between said terminal and one of said switch contacts, and a fusible link of greater current carrying capacity connected between the terminal and the cooperating switch contact in shunt of said first fusible link.

32. In combination, a switch comprising a movable contact and a cooperating contact, a terminal, a fusible link governing the movement of the movable contact, said link being connected between said terminal and one of the switch contacts, and a shunt containing a device for automatically increasing the resistance of the shunt upon excessive current flow connected between the terminal and the cooperating switch contact.

33. In combination, a switch comprising movable and stationary contacts, a terminal, a control element for the switch, connected between the terminal and the movable contact, and a shunt for the control element connected across the terminal and the stationary contact, said shunt comprising a conductor adapted to increase the resistance of the shunt when the switch is to be operated.

34. In combination, a switch comprising movable and stationary contacts, a terminal, a control element for the switch, connected between the terminal and the movable contact, and a shunt for the control element connected across the terminal and the stationary contact, said shunt having means for automatically increasing the resistance of the shunt upon excessive current flow to cause the release element to operate.

35. In combination, a terminal, a switch comprising a movable contact and a cooperating contact, said movable contact being biased to open position, an element governing the movement of said movable contact and being electrically connected between said movable contact and said terminal and a member of relatively low resistance connected between said terminal and the cooperating contact of the switch.

36. In combination a switch adapted to be connected in series in a line, said switch having a movable contact, a controlling element mechanically restraining the movable element against movement, said controlling element comprising a fusible conductor of relatively high resistance, serially related to the

line, and a shunt of low resistance about the controlling element.

37. In combination, a switch having a movable contact, a controlling element mechanically restraining the movable contact from movement, said controlling element comprising a fusible conductor of relatively high resistance serially related to the line, a shunt of low resistance about the controlling element and means forming a part of the shunt for increasing the resistance of the shunt.

38. In combination, a tubular casing of insulation forming a cylinder, a first main terminal at one end of the casing, a second main terminal at the other end of the casing, a piston member guided in said tubular casing, a movable switch contact carried by said piston, a stationary switch contact in the casing, a spring for moving said piston and said movable contact, said cylinder containing an arc extinguishing fluid and means for projecting the fluid into the space between the stationary and the movable contacts.

39. In combination, a tubular casing of insulation, a first main terminal at one end of the casing, a second main terminal at the other end of the casing, a piston member guided in said tubular casing, a movable switch contact carried by said piston, a stationary contact in the casing, a spring for moving said piston and said movable contact, said casing being adapted to contain a body of fluid for extinguishing the arc, and means carried by the piston for projecting the fluid into the space where the arc is formed.

40. In combination a tubular casing of insulation, a stationary switch contact in said casing, a piston member in said casing, a movable switch contact carried by said piston and adapted to cooperate with the stationary contact, a spring for moving said piston and movable contact away from the stationary contact and fusible means normally holding said switch contact together.

41. In combination, a tubular casing of insulation, a switch terminal secured at one end of the casing, a stationary switch contact in said casing, a piston member guided in said tubular casing, said piston member bearing a movable switch contact adapted to cooperate with said stationary switch contact, spring means for moving said piston and said movable contact away from the stationary contact, said casing being adapted to contain a body of fluid for extinguishing the arc, said movable switch contact having a hollow bore for the discharge of fluid into the path of the arc.

42. In combination, a tubular casing of insulation, a stationary contact in said casing, a piston in said casing, a tubular switch contact carried by said piston, spring means

for moving the piston and the tubular contact away from the stationary contact and current controlled means for holding the tubular contact normally in engagement with the stationary contact.

43. The method of controlling a switch, which consists in holding the switch closed with a fusible element serially related to the switch, then shunting a part of the current about said fusible element, then increasing resistance of the shunt to throw sufficient current through the fusible element to fuse the same.

44. In combination, a switch, means tending normally to open the switch, and a fusible mechanically restraining element for said switch, said element being connected electrically in series with the switch.

45. In combination, a switch, means tending to open the switch, a current controlled mechanically restraining element for said switch, said element being connected electrically in series with the switch, and a shunt of low resistance about said element, said shunt comprising means for automatically increasing the resistance of the shunt upon excessive current flow.

46. In combination, a switch and a current controlled governing element for governing the opening of the switch, said element being connected electrically in series with the switch, a casing inclosing the switch and said elements, a body of fluid in the casing and means for automatically projecting said fluid upon the arc when said switch is opened.

47. In combination, a switch, a current controlled governing element for mechani-

cally governing the opening of the switch, said element being connected electrically in series with the switch, and means connected in parallel with the element for controlling the flow of current through said element, said means comprising a device for automatically increasing the resistance of the shunt upon excessive current flow.

48. The method of controlling a switch which consists in holding the switch closed with a fusible element serially related to the switch, then shunting a part of the current about said fusible element, then increasing resistance of the shunt to throw sufficient current to the fusible element, then fusing said fusible element to release the switch.

49. In combination, a switch adapted to be connected in series in a line, means controlling the opening of said switch, a fuse of relatively small current carrying capacity governing the operation of said controlling means, a shunt of low resistance about said fuse, said shunt and said fuse being connected in parallel with each other and in series with the line, the portion of the parallel circuit including the fuse being of relatively much higher resistance than that of the shunt and said shunt comprising means for increasing the ratio of the resistance of the shunt with respect to the resistance of that portion of the parallel circuit including the fuse.

In witness whereof I hereunto subscribe my name this 23rd day of February, A. D., 1917.

NICHOLAS J. CONRAD.