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T. E. CURTIS
ENCAPSULATED SWITCH ASSEMBLY FOR UNDERGROUND
ELECTRIC DISTRIBUTION SERVICE

3,471,669

Filed Jan. 16, 1968

2 Sheets-Sheet 1

Fig. 2.

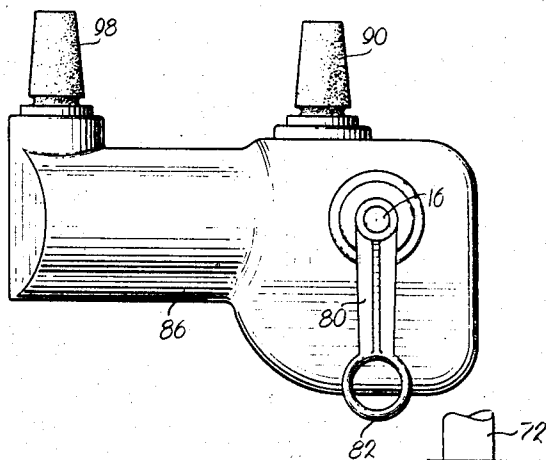
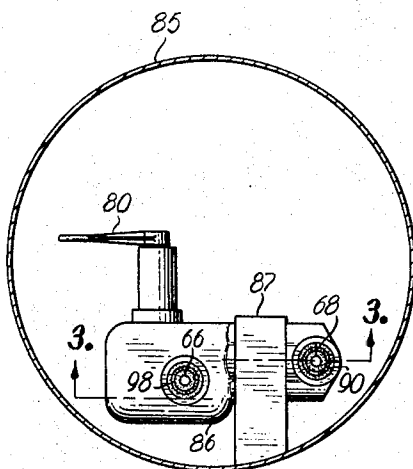


Fig. 1.

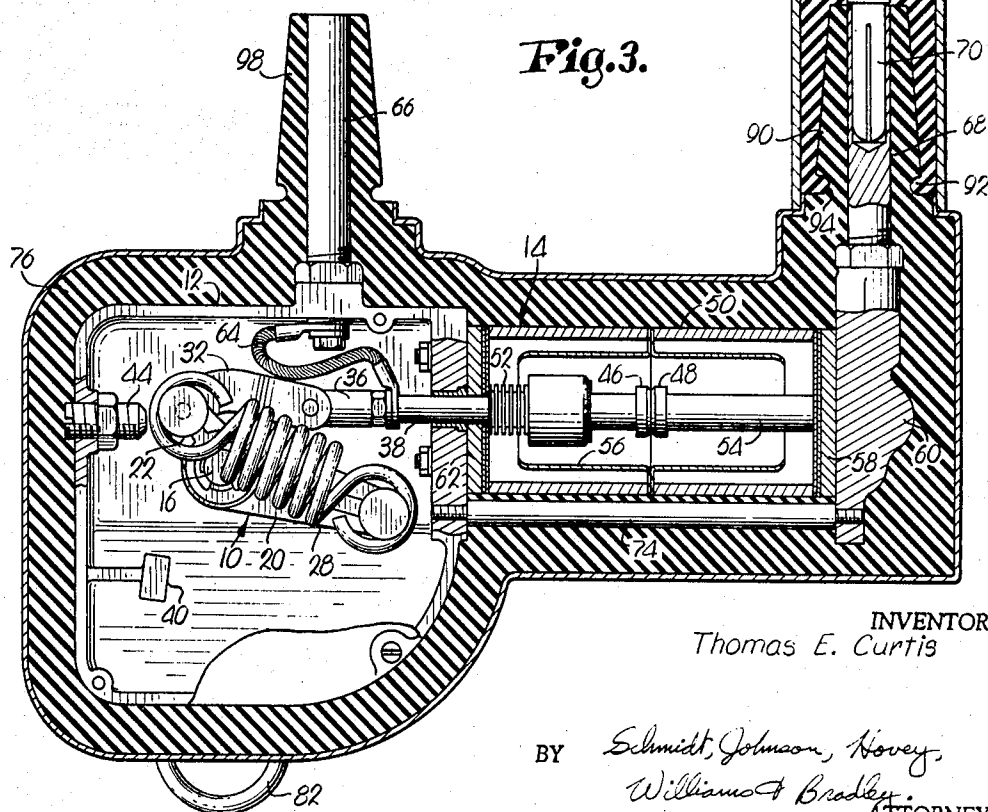


Fig. 3.

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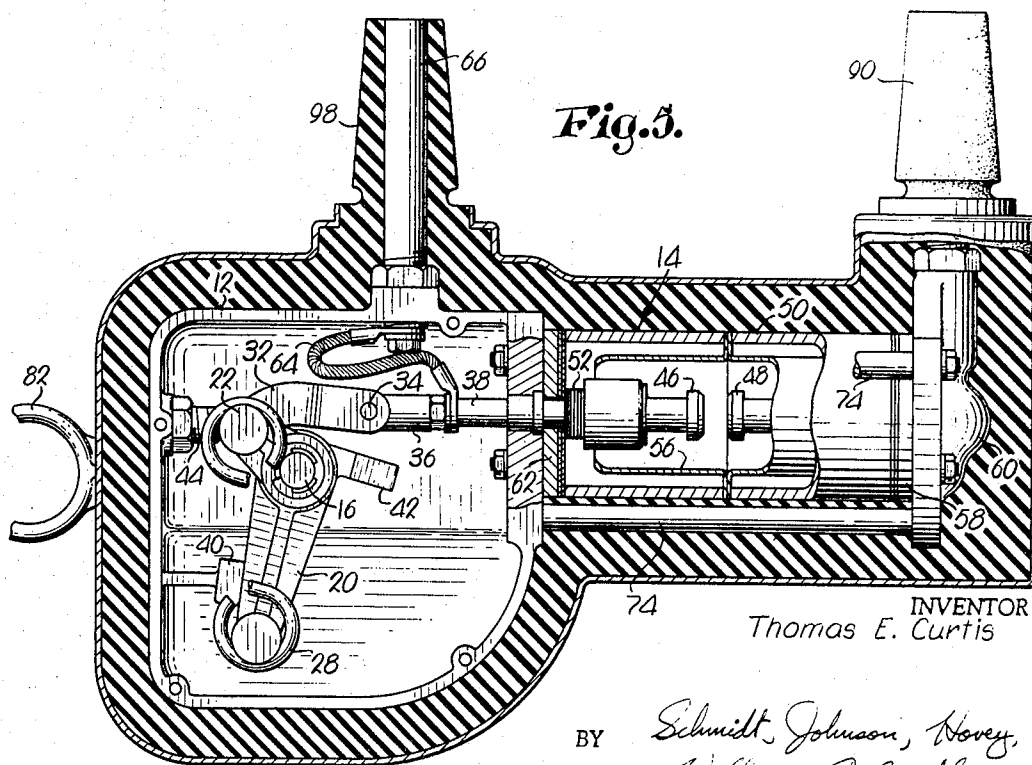
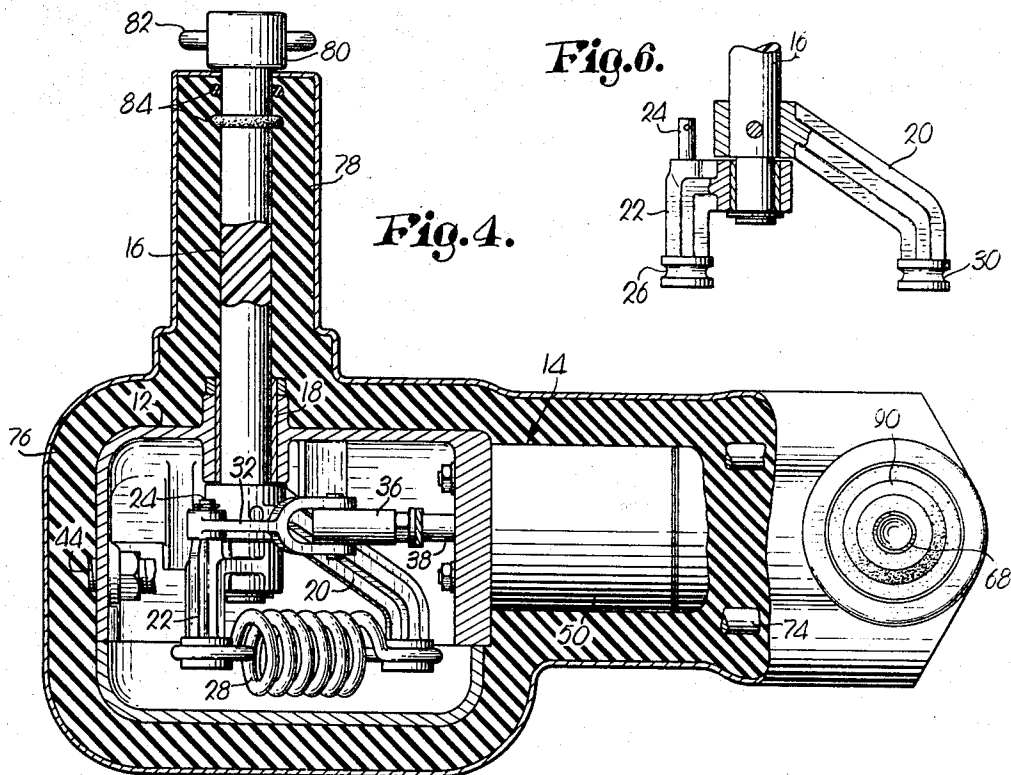
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1

2

3,471,669 ENCAPSULATED SWITCH ASSEMBLY FOR UNDERGROUND ELECTRIC DISTRIBUTION SERVICE

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12 Claims

ABSTRACT OF THE DISCLOSURE

A vacuum interrupter unit is affixed to a housing which contains a toggle assembly for opening and closing the contacts of the interrupter unit. The composite assembly and line connectors therefor are encapsulated by a waterproof, elastic jacket of high dielectric strength but having an electrically conductive outer surface to distribute the electrical stress. The toggle assembly employs an operating shaft of insulating material which extends through the encapsulation and has a crank at its outer end adapted for operation from a remote location by a lineman's hook stick. Moisture seals are provided at the shaft and the connectors to provide a switch assembly suitable for underground installation and operable when immersed in soil contaminated water.

Until recently the majority of the switching apparatus for underground residential distribution systems has been mounted aboveground in cabinets into which the connecting cables are brought from underground. Often these same cabinets contain the distribution transformers and necessary protective fuses of the system. However, with the present emphasis on further improving the appearance of residential areas by the complete burial of all electric distribution facilities, the need has arisen for switching equipment which may be located underground in a vault type installation.

Such a switch for use in underground electric distribution or transmission must be capable of interrupting the load currents and any cable charging currents to be anticipated on the circuit, and must be capable of making any transformer inrush currents or interrupting any transformer magnetizing currents that may be anticipated. Additionally, the switch must withstand closure against the highest anticipated short circuit current and still remain operative, must withstand the dielectric stresses induced by the operating voltage and the impulse voltages to which it may be subjected even when completely submerged in soil-contaminated water, and must be designed such that, when mounted in an underground vault, the switch can be safely operated by one man with an insulated hook stick.

It is, therefore, the primary object of this invention to provide switching apparatus for underground electric service which meets the criteria set forth above.

More particularly, it is an important object of the instant invention to provide switching apparatus as aforesaid which is completely encapsulated to adapt the same for underground installation even in the presence of contaminated water.

As a corollary to the last mentioned object, it is an important aim of the invention to provide an encapsulation for the switching apparatus which has high dielectric strength, is elastic in nature to provide the necessary moisture seals and preclude fracture thereof by expansion and contraction of the components therewithin or by a physical blow, and is capable of distributing the electrical stress to preclude buildup of stresses which would

exceed the safe dielectric value of the encapsulation.

Furthermore, with respect to switching applications in general whether above or below ground involving the use of apparatus which may or may not be encapsulated depending on the requirements of the installation, it is an important object of this invention to provide an improved toggle-type operating mechanism for single or multiple load interrupter units which is capable of effecting rapid contact separation and yet normally holds the interrupter contacts closed under sufficient force to reduce the tendency of the contacts to jump apart under a fault condition.

Additionally, it is an important object of this invention to provide switching apparatus for underground electric service employing a toggle mechanism as aforesaid which is remotely operable from a location outside of the vault that houses the apparatus.

Still another important object of the invention is to provide a toggle mechanism as aforesaid having a toggle spring which applies maximum force to the interrupter contacts when holding the latter closed against one another in order to thereby reduce the above mentioned tendency of the contacts to jump apart.

Yet another important object is to provide a toggle mechanism as aforesaid in which the driving parts thereof for closing the interrupter contacts are freely movable in a direction to close the contacts and are restricted in such movement only by the ultimate engagement of the contacts so that a good electrical connection is assured regardless of any contact erosion that may be present.

In the drawings:

FIG. 1 is a top plan view of the encapsulated switch assembly showing the same mounted in an underground vault, the operating arm thereof being shown in the open position;

FIG. 2 is an enlarged, side elevational view of the encapsulated switch assembly of FIG. 1, the operating arm being shown in the closed position;

FIG. 3 is an enlarged, vertical sectional view taken along line 3—3 of FIG. 1 showing the interrupter contacts closed and illustrating one of the male cable connectors;

FIG. 4 is a plan view of the structure shown in FIG. 3 with the top of the toggle mechanism housing and a portion of the encapsulation being broken away to reveal the interior construction;

FIG. 5 is a view similar to FIG. 3 but showing the interrupter contacts open and the components of the toggle mechanism correspondingly shifted; and

FIG. 6 is a plan detail view of the two cranks of the toggle mechanism and the inner end of the operating shaft.

A toggle mechanism 10 is mounted within a box-like metal housing 12 to which a vacuum interrupter unit 14 is affixed. The mechanism 10 includes a rotatable operating member or shaft 16 of insulating material extending from housing 12 and having its inner end portion journaled in the wall of housing 12 by a bearing 18. A crank 20 is rigidly secured to the inner end of shaft 16 within housing 12 and a second crank 22 is rotatably mounted on the inner end of shaft 16 as is particularly clear in FIG. 6. The crank 22 is shorter in effective length than the crank 20 and is of generally T-shaped configuration, the stem of the T being the radial leg portion of the crank 22. The top of the T terminates in a pivot pin 24 at one end thereof, the opposite end being grooved at 26 to receive one end of a toggle spring 28. The opposite end of spring 28 is received within a similar groove 30 in the outer end of the longer crank 20.

An elongated link 32 has one end thereof slipped over pin 24 to form a pivotal connection with the shorter crank 22, the opposite end of link 32 being bifurcated

and pivotally connected by a pin 34 to extension member 36 connected to and aligned with the longitudinal axis of an elongated, reciprocable operating element or rod 38 extending into housing 12 from interrupter unit 14. A pair of spaced stops 40 and 42 are integrally formed with housing 12 and define the limits of swinging movement of the longer crank 20. An adjustable, threaded stud 44 provides a stop for limiting movement of the shorter crank 22 during breaking of the circuit through interrupter unit 14.

The operating rod 38 is electrically conductive and terminates within unit 14 in a contact 46 which is movable toward and away from a stationary contact 48. Unit 14 has a cylindrical, ceramic envelope 50 which is evacuated, a sealing bellows 52 being employed with rod 38 to permit reciprocal movement thereof without destroying the vacuum condition within envelope 50. The stationary contact 48 is formed at the end of an electrically conductive shank 54, the latter and rod 38 being longitudinally aligned and coaxially disposed with respect to envelope 50. A copper gas shield 56 of cylindrical, open-ended configuration is supported in the space between contacts 46, 48 and envelope 50 and is utilized to condense volatile metal that may escape from the contacts during load break operation of unit 14.

The shank 54 is supported by a conductive end plate or cap 58 to which a terminal member 60 is bolted. The opposite end of unit 14 is closed by a conductive plate or cap 62 which is bolted to the wall of housing 12. The operating rod 38, being integral with the movable contact 46, presents the other terminal of unit 14, a flexible shunt lead 64 being connected to rod 38 and housing 12 to provide a low resistance connection between housing 12 and rod 38 and yet permit reciprocal movement of the latter. Three strain rods 74 of insulating material extend from housing 12 adjacent cap 62 to the terminal member 60 to add structural strength to the assembly.

A female connector 66 is formed from solid rod stock and has its inner end threaded to permit mounting of connector 66 directly to the top of housing 12. The threaded end of connector 66 projecting into housing 12 also provides a convenient means of physically and electrically connecting lead 64 to housing 12, as is clear in FIGS. 3 and 5.

A second female connector 68 is similar in construction to connector 66 and is shown in longitudinal section in FIG. 3, the lower end of connector 68 being received in a tapped opening (not shown) in terminal member 60 to both mechanically and electrically join connector 68 with terminal 60. A mating male connector 70 for female connector 68 is also illustrated in FIG. 3 and is electrically and mechanically joined to the end of an insulated cable 72.

The housing 12, unit 14, and connectors 66 and 68 are encapsulated by a waterproof, elastic jacket 76 of molded plastic material. The encapsulating material has a high dielectric strength and preferably comprises a suitable synthetic resin substance such as one of the elastomers, silicon rubber, or epoxy rubber. A degree of elasticity is important to provide moisture seals at the connectors 66 and 68 and the operating shaft 16; additionally, utilization of an elastic material reduces the danger of fracture thereof by expansion and contraction of the metallic components of the assembly or by a physical blow.

It should be noted that the insulating shaft 16 projects laterally from housing 12 and is encased in a laterally projecting portion 78 of the encapsulation integral with the main jacket portion 76 thereof, the outer end of shaft 16 projecting from the termination of encapsulation portion 78 and being provided with an operating arm 80 formed with a ring 82 at its outer end. A pair of O-rings 84 surround shaft 16 adjacent the end of the projecting encapsulation portion 78 and, prior to molding, shaft 16 is coated with a parting agent. Thus, the shaft 16 is freely

rotatable within the encapsulation but the ingress of moisture thereinto is precluded.

Referring to FIG. 1, the encapsulated switch assembly is shown in an underground installation disposed within a vault 85 and attached to a suitable mounting means 87 extending inwardly from the sidewall of vault 85. The assembly is oriented with the connectors 66 and 68 projecting upwardly and with the axis of the operating shaft 16 of crank arm 80 horizontally disposed.

A continuous covering 86 extends over the outer surface of both the main body portion 76 and the laterally projecting portion 78 of the encapsulating jacket and is electrically conductive in nature for the purpose of containing electric fields within the jacket and controlling the electrical stresses within the insulating material. The covering 86 may be in the form of a conductive coating such as a layer of the same substance as the main encapsulation with suitable conductive material added thereto. Alternatively, a metallic netting or a complete metal sheathing may be utilized to provide the continuous conductive covering 86. It may be appreciated that electric fields will be produced within the switch assembly under load conditions; therefore, control of the distribution of electrical stress is important in order to assure that the stresses do not exceed the safe dielectric value of the encapsulation.

Referring to FIG. 3, it may be seen that the male connector 70 there illustrated in association with female connectors 68 is enveloped by an insulating shroud 88 of cylindrical configuration which complementally receives the frusto-conical sheath 90 formed around the female connector 68 by the encapsulating jacket. The shroud 88 may be of the same material as the encapsulation and is provided with a radially inwardly extending, annular lip 92 at its outer end which is received within a corresponding annular recess 94 in the base of sheath 90. A suitable conductive covering 96 extends over the outer surface of shroud 88 and is in contact with the conductive covering 86 of the encapsulating jacket to form a continuous, electrically conductive outer surface over the connectors 68 and 70 when lip 92 is snapped in place within recess 94. An identical male connector (not shown) is provided on the end of a second connecting cable and mates with the female connector 66 as the shroud thereof complementally receives the frusto-conical sheath 98 surrounding female connector 66.

In use, the connectors 66 and 68 provide a means of electrically coupling the contacts 46 and 48 of interrupter unit 14 in series with a current carrying line, the circuit therethrough extending along shunt lead 64, along the operating rod 38 and through the contacts 46 and 48 to the terminal 60. The contacts 46 and 48 are shown closed in FIG. 3 and open in FIG. 5, separation thereof being effected by rotation of arm 80 through an angle of 90° to, in turn, rotate shaft 16 in a clockwise direction as viewed in FIGS. 3 and 5.

Noting FIG. 3, it may be seen that the toggle spring 28 is in tension between the outer ends of the two cranks 20 and 22 and biases the same toward each other. In rotating the longer crank 20 in a clockwise direction to the position thereof shown in FIG. 5, the crank 20 is shifted from a position abutting stop 42 to a position in engagement with stop 40. During such travel crank 20 moves over center to cause spring 28 to reverse the effective direction of the force applied thereby to crank 22; this, in turn, drives crank 22 in a counterclockwise direction about shaft 16 to effect a rapid separation of the contacts 46 and 48. It should be understood that the operating speed of the force applied thereby to crank 22; this, in turn, drives crank 22 in a counterclockwise direction about shaft 16 to effect a rapid separation of the contacts 46 and 48. It should be understood that the operating speed of crank 20, the contact 46 remaining in engagement with the stationary contact 48 until such time that crank 20 moves over center or past its toggle position.

The stud 44 serves as an adjustable stop to set the spacing of contacts 46 and 48 in order to prevent over-

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stressing of the bellows 52. However, when it is desired to reclose the contacts 46 and 48, movement of the shorter crank 22 in a clockwise direction is unrestricted and is limited only by the ultimate re-engagement of the contacts 46 and 48. Thus, if contact erosion should occur, it is assured that the toggle spring 28 will forcibly hold contact 46 in engagement with contact 48.

Furthermore, with reference to FIG. 3, it may be seen that the toggle spring 28 and the shorter crank 22 are positioned such that the moment arm about the axis of shaft 16 is at a maximum for the operating cycle when the contacts 46 and 48 are fully closed. Therefore, maximum force is transmitted to operating rod 38 by link 32 and extension 36 when the spring 28 is holding the movable contact 46 against the stationary contact 48. This reduces the tendency of the contacts to jump apart if a fault should occur upon closure thereof or at any time when the contacts are closed.

Movement of operating arm 80 between the positions thereof illustrated corresponding to the open and closed positions of the interrupter contacts may be readily accomplished by one man utilizing a lineman's hook stick inserted through the ring 82 at the outer end of arm 80. Thus, the apparatus may be readily operated in its installed position within the vault 85 from a remote location at ground level or above. Furthermore, the male and female connectors 70 and 68 and the identical male counterpart and the female connector 66 may be readily coupled and uncoupled at ground level by one man utilizing an insulated tool as a safety precaution. Full seating of the telescoping male and female connectors is assured by the snap action of the annular lip 92 and the corresponding recess 94 which also, in cooperation with the mating surfaces of the sheath 90 and the shroud 88, provide an effective moisture seal.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A switch assembly for underground electric service comprising:

a housing;

an interrupter unit affixed to said housing and having a pair of contacts, one of the latter being movable between an open position spaced from the other contact and a closed position in engagement with said other contact, and an operating element coupled with the movable contact for shifting the latter between said positions and extending into said housing;

a remotely operable toggle mechanism disposed in said housing and including a rotatable operating member, a first crank rigid with said member, a second crank rotatable about the axis of rotation of said member and coupled with said element, and yieldable means interconnecting said cranks and biasing the latter toward each other to normally forcibly hold the movable contact against said other contact and to rotate said second crank in a direction to shift the movable contact to its open position under the bias of said yieldable means as said first crank is rotated over center, whereby the contacts rapidly separate;

a waterproof, elastic jacket of high dielectric strength encapsulating said housing and said unit, said member extending from said housing through said jacket and being provided with means spaced from said housing adapted for actuation from a remote location to rotate the member and thereby operate said mechanism; and

connector means electrically coupled with said contacts for connecting the latter to a current-carrying line.

2. The invention of claim 1, there being means rotatably mounting said second crank for free movement in the opposite direction restricted only by the engagement of said contacts, whereby to assure that a good electrical connection is established by the contacts regardless of erosion thereof.

3. The invention of claim 2, said yieldable means being disposed to apply maximum force to said element when holding the movable contact against said other contact, whereby to reduce the tendency of the contacts to jump apart under a fault condition.

4. The invention of claim 2, there being a pair of spaced stops in said housing engageable by said first crank and defining the limits of its path of travel.

5. The invention of claim 4,

said second crank being rotatably mounted on said member,

said mechanism including a link pivotally connected with said element and pivotally joined to said second crank at a point radially spaced from said axis of the member.

6. The invention of claim 1,

said unit being of the vacuum interrupter type and including an evacuated envelope secured to said housing and having said contacts disposed therewithin, said element being elongated, longitudinally reciprocable, and having an inner end within said envelope presenting said movable contact,

said yieldable means comprising a toggle spring in tension between said cranks and connected to said first crank at a point in greater spaced relationship to said axis of the member than the point of connection of the spring to said second crank,

said mechanism further including a drive connection between said second crank and the outer end of said element for imparting rectilinear motion to the latter as said second crank is rotated in said direction or the opposite direction by said spring.

7. A switch assembly for underground electric service comprising:

an electrically conductive housing;

an interrupter unit affixed to said housing and having a pair of terminals, a movable contact for establishing or breaking an electrical circuit between said terminals, and an operating element coupled with said contact for shifting the latter between positions respectively opening and closing said circuit,

said element extending into said housing and presenting one of said terminals of the unit;

means electrically interconnecting said element and said housing;

a remotely operable actuating mechanism disposed in said housing and coupled with said element for shifting the latter to, in turn, open and close said circuit;

a first connector mounted on said housing and electrically connected to the latter;

a second connector mounted on said unit and electrically connected to the other of said terminals thereof;

a waterproof, elastic jacket of high dielectric strength encapsulating said housing, said unit, and said connectors,

said mechanism including a shiftable operating member of insulating material extending from said housing through said jacket, said member being provided with means spaced from said housing adapted for actuation from a remote location to shift the member and thereby operate said mechanism; and

a moisture seal between said member and the surrounding jacket.

8. The invention of claim 7, said jacket having an outer surface provided with electrically conductive means extending thereover to present a continuous outer covering for containing electric fields within the jacket and controlling electrical stress therewithin.

9. The invention of claim 7,

said first and second connectors projecting outwardly from said housing and said unit respectively,

said jacket being configured to define a sheath extending over each connector respectively,

there being a mating connector for each of said first and second connectors respectively provided with a

waterproof, elastic, insulating shroud complementary to and cooperable with the corresponding sheath to form a moisture seal at each pair of connectors when the latter are mated.

10. A switch assembly comprising:

a load interrupter having a pair of contacts, one of the latter being movable between an open position spaced from the other contact and a closed position in engagement with said other contact, and an operating element coupled with the movable contact for shifting the latter between said positions;

a toggle mechanism including a rotatable operating member, a first crank rigid with said member, a second crank rotatable about the axis of rotation of said member and coupled with said element, and yieldable means interconnecting said cranks and biasing the latter toward each other to normally forcibly hold the movable contact against said other contact and to rotate said second crank in a direction to shift the movable contact to its open position under the bias of said yieldable means as said first crank is rotated over center, whereby the contacts rapidly separate, said member being provided with means adapted for actuation to rotate the member and thereby operate said mechanism; and

connector means electrically coupled with said contacts for connecting the latter to a current-carrying line.

11. The invention of claim 10,

there being means rotatably mounting said second crank for free movement in the opposite direction restricted only by the engagement of said contacts, whereby to

assure that a good electrical connection is established by the contacts regardless of erosion thereof, said yieldable means being disposed to apply maximum force to said element when holding the movable contact against said other contact, whereby to reduce the tendency of the contacts to jump apart under a fault condition.

12. The invention of claim 11,

said second crank being rotatably mounted on said member,

said mechanism including a link pivotally connected with said element and pivotally joined to said second crank at a point radially spaced from said axis of the member.

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U.S. Cl. X.R.

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