

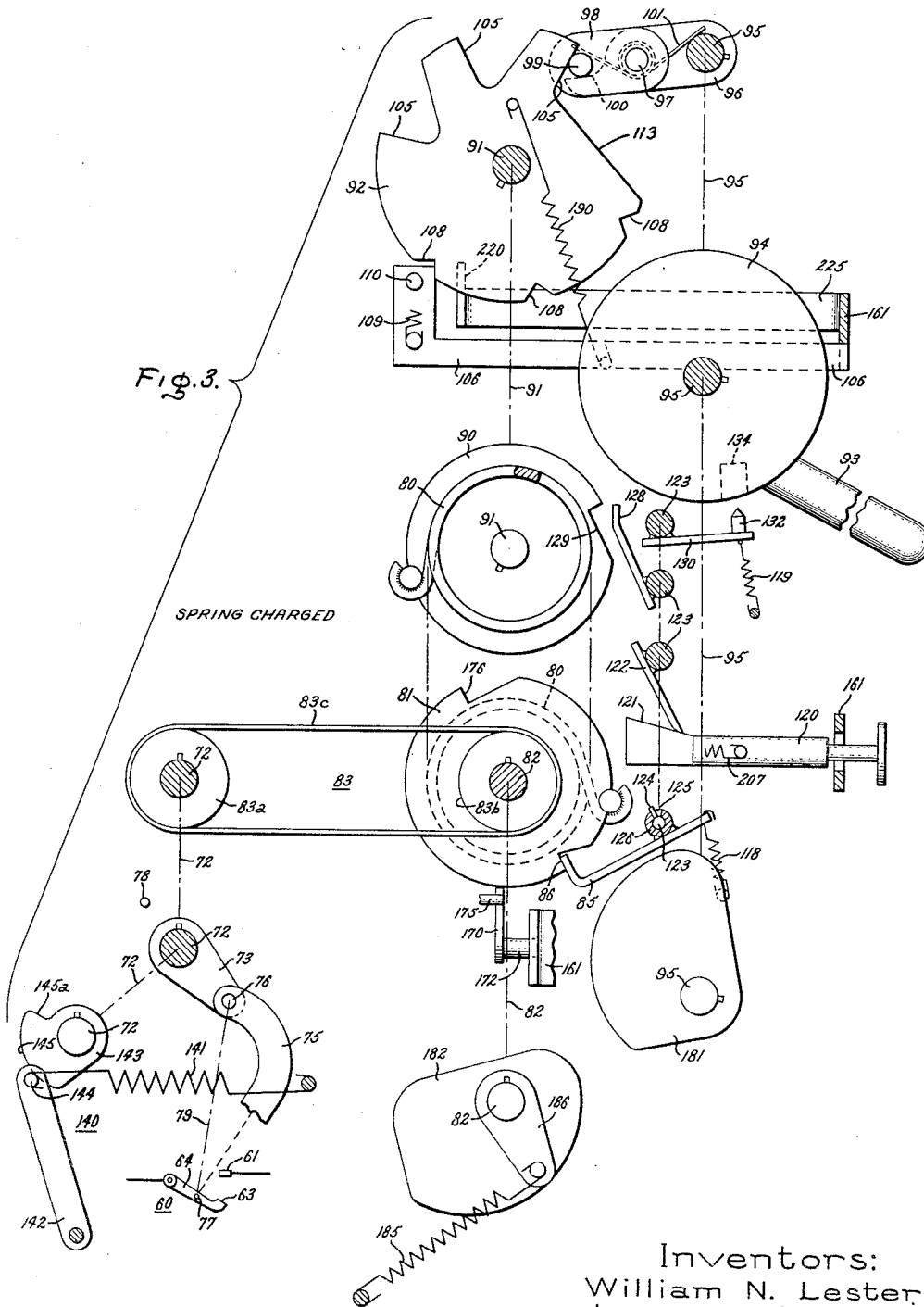
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ELECTRIC SWITCHGEAR

2,914,635

Filed Aug. 11, 1958

5 Sheets-Sheet 3



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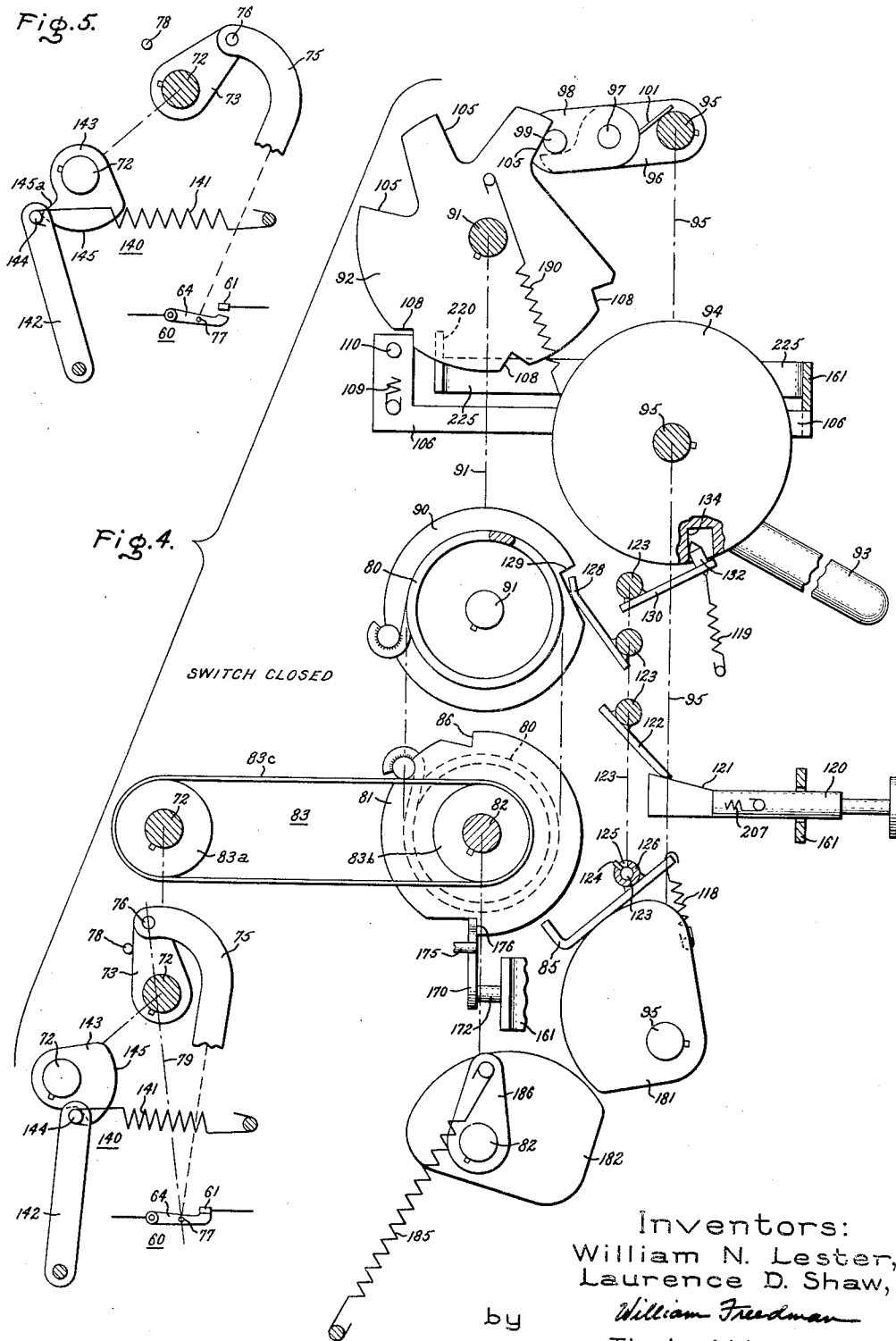
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ELECTRIC SWITCHGEAR

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Application August 11, 1958, Serial No. 754,400

26 Claims. (Cl. 200—114)

This invention relates to electric switchgear and, more particularly, to that type of switchgear which comprises the combination of an electric fuse and switch connected in series circuit relationship.

In one embodiment of the present invention, an electric switch is provided which is capable of closing against currents greatly in excess of the currents which it is capable of interrupting upon opening. A fuse connected in series with the switch is relied upon for interrupting those currents which the switch is incapable of interrupting. It is important in such an arrangement that only the fuse, and not the switch, be utilized for attempted interruption of currents in excess of the switch interrupting capacity. Reliance on the switch for interrupting such currents can be hazardous both to operating personnel and to the associated equipment.

Thus, an object of the present invention is to provide a switch-fuse combination which is so constructed that only the fuse and not the switch will be relied upon for interrupting substantially all currents in excess of the switch interrupting capacity.

The present invention is also concerned with providing a simple and sturdy operating mechanism which is capable of successfully closing the switch even against short circuit currents. To this end, the mechanism employs a chargeable closing spring that can be charged by the operation of a suitable handle and that can thereafter be released to impart the required closing power to the switch.

In connection with a mechanism of this nature, it is another object of the invention to construct the mechanism in such a manner that the same handle can be utilized for opening the switch as is relied upon for charging the closing spring. By attaining this object, it is possible to eliminate the need for a separate opening-control system, thus helping to simplify and reduce the cost of the operating mechanism.

Another object is to construct the switch-operating mechanism in such a manner that switch-opening can take place without appreciable opposition from the switch-closing spring and yet without requiring the linkage between the switch and the closing spring to be of a complicated, collapsible nature.

Another object is to provide a relatively simple interlock which assures, among other things, that the fuse and not the switch will be relied upon for interrupting currents in excess of the switch interrupting capacity, that the closing spring is fully charged before switch-closing is initiated, and that the spring-charging handle is in a proper position to initiate opening when switch-opening might be required.

In one of its aspects, the invention is particularly concerned with an arrangement in which the fuse, the switch and the switch-operating mechanism are constructed as a portable assembly that can be shifted into and out of a connected position in an enclosure. In connection with such an assembly, it is an additional

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object of the present invention to provide interlock structure capable not only of operating in the manner set forth in the immediately preceding paragraph but capable also of precluding the assembly from being withdrawn while its closing spring is charged and capable also of precluding the assembly from being moved into and out of its fully-connected position while the switch is closed.

In carrying out our invention in one form, we provide an electric switch and fuse connected in series-circuit relationship. The switch is capable of interrupting currents up to a predetermined value, and the fuse is automatically operable to interrupt currents in excess of this value, which the switch is incapable of interrupting. The fuse requires a predetermined interval of time to effect interruption of currents slightly exceeding said predetermined value once said value has been exceeded. Switch-closing means is provided for closing the switch even against currents greatly in excess of said predetermined value, and manually-controlled switch-opening means is provided for opening the switch. Switch-protective means is provided for disabling the switch-opening means after completion of a switch-closing operation for a period of time exceeding said predetermined interval of time, thus assuring operation of the fuse in the event that the switch is closed against a sustained current in excess of said predetermined value.

In accordance with one aspect of our invention, we provide, for closing the switch, a chargeable closing spring that can be charged by the operation of a suitable handle and that can thereafter be released to impart the required closing power to the switch. Spring-charging is effected by repetitively oscillating this handle, whereas switch-opening is effected by operation of the handle in one direction. The forces for effecting switch-opening are transmitted to the switch through a mechanism that is in a disabled condition during the spring-charging operation but is rendered operable by a switch-closing operation. When this mechanism is operable, it is capable of transmitting forces from the handle to the switch to enable the handle to effect switch-opening.

In accordance with still another aspect of our invention, the spring is first charged by driving one of its ends into a charged position where it is held, after which the other end of the spring is released to effect switch-closing. A simple linkage provided between the switch and the closing spring causes subsequent switch-opening to drive said other end of spring in a direction opposite to its direction of movement during switch-closing. Interlock means is provided for rendering such reverse movement ineffective to charge the closing spring. The interlock means operates in this manner by requiring that said one end of the spring be released as a prerequisite to initiating a switch-opening operation.

For a better understanding of these and other features of our invention, reference may be had to the following description taken in conjunction with the accompanying drawing wherein:

Fig. 1 is a side elevational view, partly in section, showing switchgear apparatus comprising a switch-fuse combination embodying our invention.

Fig. 2 is a perspective view of mechanism for operating the switch utilized in the assembly of Fig. 1. The operating mechanism embodies a chargeable closing spring which is shown prior to its being charged. The switch is shown in an open position.

Fig. 2a is a perspective view showing a portion of the mechanism of Fig. 2 in combination with additional structure that has been omitted from Fig. 2 for the sake of clarity.

Fig. 3 is a diagrammatic view of the mechanism of

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Figs. 2 and 2a with the parts shown in the position they occupy after the spring has been charged but before the spring has been released to close the switch.

Fig. 4 is a diagrammatic view similar to that of Fig. 3, but showing the various parts after the spring has been released to close the switch.

Fig. 5 is a diagrammatic view of a portion of the operating mechanism at a particular instant during the switch-closing operation.

Fig. 6 is a diagrammatic view of the operating mechanism showing the parts in a position through which they pass during an early portion of a switch-opening operation.

Fig. 7 is an enlarged sectional view of a portion of the mechanism of Figs. 2-6.

General description of the removable switchgear assembly

Referring now to Fig. 1, the switchgear apparatus shown therein comprises a stationary enclosure 10 and a removable, or draw-out, switchgear unit in the form of a fuse-switch assembly 11. The removable assembly 11 comprises a truck 12 mounted on suitable wheels 13, which allow the removable assembly 11 to be rolled horizontally into and out of its fully-connected position shown in Fig. 1. In the fully-connected position of Fig. 1, a set of plug type disconnect contacts 15 carried by the movable assembly 11 is fully inserted into a set of socket-type stationary disconnect contacts 16 suitably supported on the enclosure 10. Mating pairs of contacts 15 and 16 form the terminals for a power circuit extending through the assembly 11 and controlled thereby, as will soon be explained. The contacts 15 and 16 can be of any suitable conventional form, but in the drawing, each stationary contact 16 is shown formed as a longitudinally split tube encircled by a pair of garter springs 17. Each of the movable plug contacts 15 is shown formed with an enlarged head that is adapted to be forceably slid to the left into one of the tubes 16. To provide the desired contact pressures when the disconnect contacts 15 and 16 are in their fully-engaged position, the garter spring 17 must be relatively strong, and, as a result, considerable force is required in order to force the movable contacts 15 to the left from a position of initial-contact-engagement to the illustrated position of full engagement. Likewise, considerable force is required in order to withdraw the assembly 11 and its contacts 15 to the right from their position shown in Fig. 1.

To aid in driving the switchgear assembly 11 together with its movable disconnect contacts 15 into and out of the fully-connected position of Fig. 1, a racking mechanism 20 is provided. This racking mechanism can be of any suitable form but is preferably of the type disclosed and claimed in application S.N. 705,657, Eichelberger et al., assigned to the assignee of the present invention. The disclosed racking mechanism 20 comprises an internally threaded nut 21, which is mounted on the enclosure 10 by means of a tube 22 fixed to the enclosure and an anchoring pin 23. The racking mechanism 20 further includes a jack screw 26 which is carried by the movable switchgear assembly 11 and is rotatably mounted thereon. The jack screw 26 extends in a direction generally parallel to the path of movement of the switchgear unit 11, and at its left hand end, has external threads 27 which are adapted to mesh with the internal threads of the nut 21. When these threads are in mesh, rotation of jack screw 26 causes the threads to shift the jack screw longitudinally, and this longitudinal movement is utilized to rack the switchgear assembly 11 into and out of its fully-connected position. Rotation of the jack screw 26 is effected by means of a suitable wrench or the like (not shown) applied to the right hand end of the jack screw. The wrench can be inserted through an opening in a protected panel 38 suitably secured to

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the right hand side of the movable assembly 11, assuming that an interlock bar shown at 161 is properly positioned. The manner in which the position of this interlock bar 161 is controlled will be explained in detail hereinafter.

For utilizing longitudinal movement of the jack screw 26 to produce the required racking action, coupling means comprising a U-shaped bracket 30 fixed to the movable assembly 11 is provided. Each arm 31 of the bracket 30 has an opening therein which loosely receives an unthreaded portion of the jack screw 26. Between the arms 31 and encircling the jack screw is a sleeve 32, which is freely rotatable with respect to the arms 31. The sleeve 32 has a slot 35 formed therein and extending longitudinally of the jack screw. A projecting pin 34 fixed to the jack screw 26 is received within the slot 35 so as to couple the jack screw and the sleeve together.

In inserting the switchgear assembly 11, the assembly 11 is pushed to the left into a position of initial engagement of the contacts 15, 16. When this position of initial contact engagement has been reached, the jack screw can be threaded into the nut 21, thereby moving the pin 34 on the jack screw into engagement with the forward wall of the slot 35. Thereafter, as the jack screw moves longitudinally to the left in response to rotation thereof, the pin 34 acts through the sleeve 32 and the brackets 31 to drive the movable switchgear assembly 11 to the left. This is continued until the switchgear assembly 11 together with its contacts 15 have reached their fully-connected position, depicted in Fig. 1.

The specific manner in which the fuse and the switch of Fig. 1 are supported on the truck is not a part of our invention and is disclosed in greater detail and claimed in application S.N. 754,469 Eichelberger et al., filed August 11, 1958, and assigned to the assignee of the present invention. It is believed, however, that the following brief description of these components will facilitate an understanding of the present invention. Referring now to Fig. 1, it will be noted that the movable fuse-switch assembly 11 comprises a horizontally-extending base plate 40 supported on the truck 12 by means of suitable vertically-extending channels 41. This base plate 40 constitutes a support for all of the major operating components of the movable switch-fuse assembly. In this regard, the jack screw supporting channel 30 is suitably secured to the base plate 40. The disconnect contacts 15 are supported on the base plate 40 by means of pin type insulators 43 and 44 mounted on the base plate at vertically-opposite sides thereof. Horizontally spaced from the insulators 43 and 44 and also supported on the base plate 40 is a vertically-extending through bushing 48 having a conductive stud 49 extending vertically there-through. Mounted atop the conductive stud 49 is a fuse clip structure 50. Mounted atop the insulator 43 is another fuse clip structure 52 connected to the upper disconnect contact 15.

Electrically bridging the fuse clips 50 and 52 is an elongated electric fuse 54. Mounted at the lower side of the base plate 40 is a load break switch 60. This switch includes stationary contact structure 61 suitably mounted at the lower end of the conductive stud 49 and conductive pivot structure 62 mounted at the lower end of the insulator 44. The conductive pivot structure 62 is electrically connected to the lower disconnect contact 15. Pivotaly mounted on the pivot structure 62 is a conductive circuit-controlling blade 64 which, at its outer end, carries movable contact structure, shown in simplified form at 63, for cooperating with the stationary contact structure 61. When the blade 64 is moved toward its dotted-line position, the contacts 61, 63 are separated to open switch. When the blade 64 is in the generally horizontal position shown in Fig. 1, the contacts 61, 63 are engaged, the switch is therefore closed and the blade

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64 conducts currents between the stud 49 and the pivot 62. Thus, it will be seen that when the switch is closed, the fuse and the switch are connected in series between the disconnect contacts 15.

Opening of the switch is effected by driving the blade from its solid-line horizontal position into the dotted line position shown. Assuming the circuit through the assembly to be energized, this opening movement of the blade 64 establishes a circuit-interrupting arc between the contacts 63 and the contacts 61. For extinguishing the arc to interrupt the circuit, a suitable arc chute 67 supported from the lower end of the through insulator 48 is provided. The arc is suitably driven into this chute where it is rapidly cooled and elongated and thereby extinguished, all in a well known manner. The details of this arc chute form no part of the present invention, and the arc chute can, for example, be constructed as described in greater detail in U.S. Patent No. 2,417,683, Harlow, assigned to the assignee of the present invention.

The switch-operating mechanism

For driving the blade 64 between its open and closed positions, a switch-operating mechanism 70 is provided. This operating mechanism 70 is shown partially in block form in Fig. 1 but is shown in greater detail in Figs. 2-6. Referring now to Fig. 2, the pivoted switch blade 64 is shown in diagrammatic form in the lower left hand corner of the figure. The movable contact 63 is shown carried by the switch blade 64 so that it can contact the stationary contact 61 in circuit-closing engagement when the blade 64 is driven counterclockwise from its open position shown into a horizontal position.

For transmitting switch-closing forces to the blade 64, a rotatable switch operating shaft 72 is provided. This operating shaft 72 has a crank 73 coupled thereto for rotation therewith. Connected between the crank 73 and the blade 64 is a connecting link 75 which is connected by pivots 76 and 77 at its respective opposite ends to the crank 73 and the blade 64. When the operating shaft 72 is rotated in a counterclockwise direction from its position of Fig. 2, the crank 73 acting through the link 75 lifts the blade 64 and thus closes the switch. The switch is depicted in its fully-closed position in Fig. 4, where it can be seen that counterclockwise motion of the crank 73 has been terminated by a suitable stop 78 engaging the crank 73. This stop 78 is so located that in the position of Fig. 4, the crank 73 is overcenter with respect to the connecting link 75, and, thus, the switch blade 64 is, in effect, locked in its closed position. With regard to this overcenter relationship, note that a reference line 79 connecting the pivots 76 and 77 remains to the right of the shaft 72 during initial switch-closing, as will be evident from Fig. 3. However, when the closed position of Fig. 4 is approached, the reference line 79 is shifted to the left of the operating shaft 72, where it remains so long as the switch is fully-closed. It will be apparent that magnetic forces tending to drive the switch blade 64 out of its closed position simply urge the crank 73 in the direction of the stop 78 and are, therefore, ineffective to force the switch open.

Switch-closing operation

The forces for driving the switch through its above-described closing stroke are derived from a chargeable helical spring 80. As shown in Fig. 2, the output end of the spring 80 is coupled to a rotatable output member 81, which is keyed to a rotatable output shaft 82. This output shaft 82 is coupled to the switch-operating shaft 72 by suitable means such as the conventional chain and sprocket drive shown at 83. This chain and sprocket drive 83 comprises suitable sprockets 83a and 83b respectively keyed to the operating shaft 72 and the output shaft 82 and interconnected by a suitable chain 83c extending over the peripheries of the sprockets.

The output member 81 is normally held in its position

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of Figs. 2 and 3 by means of a suitable latch 85 engaging a shoulder 86 formed on the periphery of the output member 81. When the latch 85 is released, i.e., driven counterclockwise out of its position of Figs. 2 and 3, the output member 81 becomes free to rotate in a counterclockwise direction. Assuming that the helical spring 80 is then fully charged, it will respond to releasing of the latch 85 by driving the output member 81 together with the output shaft 82 rapidly counterclockwise. This counterclockwise motion is transmitted through the chain drive 83 to the operating shaft 72 and acts to drive the operating shaft 72 counterclockwise to produce the above-described switch-closing.

Charging of the switch-closing spring

For charging the helical spring 80 so as to prepare it for a switch-closing operation, a rotatable charging member 90 is provided. This charging member 90 is coupled to the rear end of the spring 80 and is movable in a counterclockwise direction from its position of Fig. 2 to effect spring-charging. To aid in driving spring charging member 90 counterclockwise, a rotatable ratchet wheel 92 is coupled to the charging member for rotation therewith. Preferably, this coupling between the members 90 and 92 comprises a rotatable shaft 91 upon which both members 90 and 92 are mounted and to which both members are keyed. When the ratchet wheel 92 is driven counterclockwise, it drives the charging member 90 counterclockwise and thus charges the helical spring 80, assuming that the front end of the helical spring is then restrained by the latch 85.

For rotating the ratchet wheel 92 counterclockwise so as to effect the above described charging of the spring 80, an oscillatable, manually-operable handle 93 is provided. This handle 93 is received within a suitable opening provided in the periphery of a rotatable hub 94. The hub 94 is keyed to a rotatable shaft 95, which, in turn, is keyed to a charging crank 96. The charging crank 96 carries a laterally projecting pivot pin 97 upon which a charging pawl 98 is pivotally mounted. The charging pawl 98 carries a ratchet driving pin 99 at its outer end. As shown in Fig. 2, the ratchet driving pin 99 normally rests against a driving projection 100 at the outer end of the crank 96. A suitable torsion spring 101 normally maintains the driving pin in this position of Fig. 2.

When an attendant pumps the handle 93 in a clockwise direction, he swings the charging crank 96 clockwise about the axis of shaft 95 and thus moves the ratchet driving pin 99 into a first one of the notches 105 provided in the periphery of the ratchet wheel 92. Referring to Fig. 2, when the ratchet driving pin 99 has engaged the top wall of the groove 105, this clockwise motion of the handle 93 is transmitted through the pin 99 to the ratchet wheel 92 and thus acts to drive the ratchet wheel counterclockwise. After a predetermined amount of such counterclockwise motion of the ratchet wheel, a holding pawl 106 comes into operation. More specifically, holding pawl 106, at this time, falls into a notch 108 formed in the periphery of ratchet wheel 92 and thus prevents the ratchet wheel from backtracking from the position to which it has been advanced by the first stroke of the handle 93. This holding pawl 106 is upwardly biased toward the periphery of the ratchet wheel 92 by a suitable tension spring 109 and has its upper travel limited by a suitable stop 110 working in a groove 111 formed on a stationary part, all as shown in Fig. 2. The holding pawl was brushed aside by the ratchet wheel 92 when the pawl had first engaged the wall 113 thereof, but when the notch 108 was moved into registry with the front corner of the holding pawl 106, the spring 109 drove the pawl upwardly into holding engagement with the notch 108.

After the holding pawl 106 has engaged the first notch 108, the attendant can, of course, return the handle 93 to its position of Fig. 2 without allowing the ratchet wheel 92 to backtrack to its initial position. The yield-

able connection provided between the driving pawl 98 and the charging crank 96 allows the handle 93 to be returned in a counterclockwise direction to its position of Fig. 2 without significant interference from the ratchet wheel 92.

Thereafter, clockwise motion of the handle 93 is repeated with the ratchet-driving pin 99 this time engaging the next groove 105 on the ratchet wheel 92. This advances the ratchet wheel 92 through another counterclockwise charging increment, after which the holding pawl 106 engages the next notch 108 on the ratchet wheel, so as to hold the ratchet wheel in its newly-advanced position. The handle 93 is then returned to its initial position, after which it is once again driven through a clockwise spring-charging stroke. At the end of this clockwise charging stroke, the handle 93 is left in its end or lower position, for reasons which will soon be explained. The spring is then fully charged and prepared to drive the switch closed upon release of the latch 85 at its opposite end.

Releasing the closure-initiating latch

For releasing the latch 85, a reciprocable closure-initiating member 120 is provided. This closure-initiating member 120 has a wedge shaped cam surface 121 formed thereon cooperating with a paddle 122 secured to a rotatable latch-releasing shaft 123. The latch-releasing shaft 123 is coupled to the latch 85 by means of a pin 124 projecting through a slot 125 in a cylindrical hub 126 of the latch 85. When the closure-initiating member 120 is pulled to the right from its position of Fig. 3, it acts through cam surface 121 to rotate the latch-releasing shaft 123 counterclockwise. This causes the pin 125 to drive the latch 85 counterclockwise to effect release of the output member 81 in the manner previously-described. This allows the closing spring 80 rapidly to discharge and effect switch-closing, all as previously-described. Suitable reset springs 118 and 119 are provided for urging the latch 85 and the latch-releasing shaft 123 back to their respective positions of Fig. 3. As will be apparent from Fig. 6, the latch 85 can reset into its latched position of engagement with the shoulder 86 only after the output member 81 has been returned to its position of Fig. 2 responsive to switch opening.

Assuring that sufficient closing power is available

To insure that the spring 80 has been fully-charged before a closing operation is initiated, an interference arm 128 is secured to the latch-releasing shaft 123. The outer periphery of the spring charging member 90 prevents this arm from being moved in a counterclockwise direction from its position of Fig. 2 until a groove, or recess, 129 formed thereon registers with the outer end of the interference arm 128. Only when the spring 80 is fully charged does the groove 129 register with the outer end of arm 128, and, as a result, only when the spring is fully-charged, is the latch releasing shaft 123 capable of being operated to release the closure-initiating latch 85. By assuring that the closing spring 80 is fully charged before closure is initiated, assurance is had that sufficient closing power will be available to successfully close the switch even against short circuit forces.

Assuring proper positioning of the spring charging handle

Another prerequisite to initiating a closing operation is that the handle 93 be in its lower position, shown in Fig. 3. Unless the handle is in its lower position, a second interference member 130, also secured to the latch-releasing shaft 123, will block motion of the latch-releasing shaft in a counterclockwise closure-initiating direction from its position of Fig. 3. In this regard, the interference arm 130 is provided with a projecting pin 132 that will abut against the outer periphery of the hub 94 to block counterclockwise motion of the interference arm

130 and the latch-releasing shaft 123 while the handle is out of its lower position. Only when the handle is in its lower position does a recess 134 in the periphery of the hub 94 align with pin 132, and only when this latter condition exists can the latch-releasing shaft 123 be rotated counterclockwise from its position of Fig. 3 to initiate the switch-closing operation. The reason for requiring that the handle be in its lower position during this interval will soon be explained.

Booster arrangement for assisting in closing

To assist the spring 80 in driving the switch blade 64 into closed position, a booster arrangement 140 coupled to the operating shaft 72 is provided. This booster arrangement 140 comprises a tension spring 141 coupled to the upper end of a crank 142, which is pivotally mounted at its lower end. A cam 143 fixed to the switch operating shaft 72 acts through a pin 144 to hold the spring 141 charged during the first portion of the switch-closing operation, but toward the end of the switch-closing operation, the spring 141 is permitted to discharge and supply switch-closing forces through the generally radially-extending surface 145a of the cam 143. In this latter regard, when the cam 143 moves through the position of Fig. 5 near the end of a closing stroke, the cam surface 145 no longer holds the crank 142 in its position of Fig. 3. The spring 141 then becomes free to drive the crank in a clockwise direction, and this action, as will be evident from Fig. 5, provides added force for closing the switch. This added force is needed in order to drive the switch closed against high magnetic opposing forces encountered when closing during a heavy overload or fault condition. It will, of course, be apparent to those skilled in the art that this booster arrangement 140 can be omitted if the spring 80 is of such a size that it is capable of alone closing the switch 60.

Introduction of interlock mechanism

Before describing a switch-opening operation, reference will be had to the interlock mechanism 160 shown best in Fig. 2. This interlock mechanism comprises a slidable interlock bar 161 which can be laterally shifted by means of a handle 162. In this regard, the handle 162 and a crank 164 are fixed to a pivotally-mounted shaft 163, which has its axis stationarily located relative to the switchgear assembly 11. The crank 164 has a fork at its upper end which receives a pin 165 secured to the interlock bar 161. When the handle is pivoted in a counterclockwise direction from its position of Fig. 2, it shifts the interlock bar 161 to the left, and correspondingly when the handle is returned to its position of Fig. 2, it shifts the interlock bar to the right back to its position of Fig. 2.

There are three distinct spaced-apart positions into which the interlock bar 161, and hence the handle 162, must be shifted before certain preselected operations can be performed with the switch assembly. More specifically, it is necessary to position the interlock bar in its "close and charge" position as a prerequisite to charging the spring 80 and as a prerequisite to releasing the spring 80 to close the switch. It is necessary to position the interlock bar 161 in its "open" position as a prerequisite to opening this switch, and it is necessary to position the interlock bar 161 in its "rack" position as a prerequisite to racking the switch assembly out of or into its fully-inserted position of Fig. 1.

It was assumed during the above-described charging and closing operations, that the interlock bar was disposed in its position of Fig. 2, i.e., its "close and charge" position, thus allowing these particular operations to be carried out without interference from the interlock mechanism.

Preparing for a switch-opening operation

It will now be assumed that it is desired to open the switch, and that to this end the interlock handle 162

is moved from its "close and charge" position to its "open" position, which is a prerequisite to opening. This handle motion will shift the interlock bar 161 to the left from its position of Fig. 2. Such leftward shifting of the interlock bar 161 will perform two distinct operations. It will release the holding pawl 106 at the rear end of the spring 80 and will also release an interlock latch 170 cooperating with the output member 81 at the front or output end of the spring 80. Release of the pawl 106 is effected by means of a cam 171 formed on the interlock bar 161. This cam 171 drives the holding pawl 106 downwardly out of engagement with the ratchet wheel 92 in response to this movement of the handle and interlock bar 161 into their respective open positions. With regard to release of the interlock latch 170 at the output end of the spring 80, it is to be noted from Fig. 2 that this latch 170 is pivoted on a shaft 172 carried by the interlock bar 161 and is biased in a counterclockwise direction about the shaft 172 by means of a suitable tension spring 173. When the interlock bar 161 is shifted to the left from its position of Fig. 2, it carries the latch 170 to the left, and thus causes the latch 170 to engage a stationary pin 175 which forces the latch in a clockwise direction away from the periphery of the output member 81. As will be apparent from Fig. 4, when the switch is closed, this interlock latch 170 is in engagement with a shoulder 176 formed on the output member 81. This engagement precludes a switch-opening operation, but when the interlock bar 161 is shifted to the left to its open position the latch 170 is moved out of engagement with the shoulder 176 by means of the pin 175. The output member 81 is then in a condition to be rotated in a clockwise direction, as occurs during a switch-opening operation.

Switch-opening operation

Assuming that the interlock bar 161 is in its "open" position (which means that the latch 170 and the holding pawl 106 have been released, as above described), the next step in the opening operation is to pivot the handle 93 in a counterclockwise direction from its position of Fig. 4 through its position of Fig. 6. It is this counterclockwise motion of the handle 93 which is utilized for opening the switch. In this regard, a first cam 181 is fixed to the same shaft 95 as the handle 93, and a second cam 182 is fixed to the output shaft 82 of the closing spring 80. Referring to Fig. 4, initial counterclockwise motion of the handle 93 drives the first cam 181 counterclockwise into engagement with the second cam 182, and when this occurs, further counterclockwise motion of the handle 93 causes the first cam 181 to drive the other cam 182 in a clockwise direction. This motion of the second cam 182 is transmitted to the switch operating shaft 72 through the chain drive 83 and the output shaft 82, and acts to rotate the switch-operating shaft 72 in a clockwise or switch-opening direction.

Switch-opening is aided by means of an overcenter tension spring 185 coupled to a crank 186 which is fixed to the output shaft 82. At the beginning of the opening operation, the spring 185 is to the left of the axis of shaft 82, as shown in Fig. 4, but when the parts have been moved through the position of Fig. 6, the spring 185 has been carried to the right of the axis of shaft 82 and is thus free to rapidly contract. This contraction of the spring 185 drives the output shaft 82 in a clockwise direction and is transmitted to the switch-operating shaft 72 through the chain drive 83. The switch contacts 63 and 61 are so constructed that they remain in engagement until the spring 185 takes over and, accordingly, it is the spring which primarily controls the speed of motion of the switch blade 64 during the actual circuit interruption. When the spring 185 takes over, it drives the cam 182 ahead of the cam 181 and through a region wherein the cam 181 is incapable of engaging the cam 182. This

enables contact-opening to take place at the desired preselected speed irrespective of the speed at which the operator moves the handle 93.

At the end of a switch-opening operation, the output member 81 will have been returned clockwise to its position of Fig. 2 after having passed through the intermediate position of Fig. 6. When the output member 81 has been so moved clockwise into the position of Fig. 2, the latch 85 is restored to its latching position behind the shoulder 86 by the reset spring 118. The outer periphery of the output member 81 blocked latch-resetting until this point, but before this point the lost-motion connection at 124, 125 allowed the interference member 130 to be reset by its spring 119 without interference from the blocked latch 85.

From the above description of a switch-opening operation it will be apparent that the same handle 93 that is used for charging the closing spring is also utilized for producing switch-opening. While charging of the spring 80 is accomplished by oscillating or pumping the handle 93, opening of the switch is accomplished simply by unidirectional motion of the handle from its extreme lower position of Fig. 4 to its normal position of Fig. 2. Spring-charging operations have no effect on the position of the switch blade 64 due to the fact that, during spring charging, the cam 182 is positioned out of the path of movement of the other cam 181 in what might be termed a "disabled position." For example, referring to Fig. 2, the driving cam 181 can be oscillated by the shaft 95 without ever engaging the driven cam 182, so long as the driven cam remains in its disabled position of Fig. 2. A switch-closing operation, however, shifts the driven cam 182 from its disabled position into the position of Fig. 4. When the driven cam 182 is in this position of Fig. 4, the driving cam 181 can engage the driven cam when the driving cam 181 is moved counterclockwise by the handle 93. It is this engagement which is utilized for transmitting switch-opening power from the handle 93 to the output shaft 82 during switch-opening operation, as has been described in greater detail hereinabove. By constructing the mechanism in such a manner that the same handle can be used for switch-opening as for spring-charging, the need for a separate opening-control system has been eliminated, and this has most advantageously helped simplify and reduce the cost of the switch-operating mechanism.

It has already been pointed out under the heading "Assuring proper positioning of the spring-charging handle" that the handle 93 must be left in its lower position of Fig. 3 before a switch-closing operation can be initiated. Otherwise, as was pointed out, the interference members 130, 132 will block initiation of a switch-closing operation. Because the handle 93 will be in its lower position of Fig. 3 when the switch has been closed, it will be apparent that the handle is invariably properly positioned to initiate an opening operation at the particular time when the opening might be needed. Furthermore, the fact that the handle must be positioned in its lowermost position of Fig. 3 when switch-closing is initiated is also relied upon to assure that switch-closing will not impart abrupt motion to the handle 93. In this regard, when the handle 93 is positioned in its lowermost position of Fig. 3, the cam 182 can move from its position of Fig. 3 to its position of Fig. 4 responsive to switch-closing without engaging the cam 181 and, thus, without imparting motion to the handle 93. On the other hand, if the handle had been in some intermediate position when switch closing was initiated, the cam 182 would have struck the cam 181 a sharp blow and driven the handle 93 abruptly clockwise. Such abrupt motion could be a hazard to the safety of the attendant, and the desirability of eliminating such hazard is readily apparent.

The closing spring during a switch-opening operation.

It will be noted that switch-opening drives the rotatable output member 81 in an opposite direction from the direction that it was driven by the spring 80 during a switch-closing operation. If the rear end of the spring 80 were allowed to remain latched by the holding pawl 106 during this interval, it would be apparent that switch-opening would tend to charge the closing spring 80. This could unduly interfere with the desired switch-opening speeds and could unduly increase the forces required for switch-opening. This problem is avoided in the disclosed arrangement by releasing the holding pawl 106 prior to initiation of a switch-opening operation. This release of the holding pawl 106 was effected by movement of the interlock bar 161 into its "open" position, as has been previously pointed out. Since movement of the interlock bar 161 into its "open" position was a prerequisite to initiating a switch-opening operation, it will be apparent that this release of the holding pawl 106 will always have taken place prior to a switch-opening operation.

Since the holding pawl 106 is released prior to initiation of a switch-opening operation, it will be apparent that the closing spring 80 will offer no significant opposition to switch-opening. Switch opening will simply rotate the output member 81, the spring 80 and the spring-charging members 90 and 92 all as a unit, thus avoiding any significant charging of the spring 80. By having all of these parts rotate as a unit during switch-opening, we are able to use a simple non-collapsible linkage (83) between the switch 60 and the closing spring 80 inasmuch as it is unnecessary to free this linkage from the closing spring during a switch-opening operation.

It is to be understood that the closing spring 80 is preferably of such a construction that after it has been released to effect one switch-closing operation, no significant amount of energy remains stored therein. The presence of the booster arrangement 140 makes it possible to design the spring 80 so that no energy remains stored therein since it is the booster arrangement 140 rather than the closing spring 80 that supplies the closing energy during the final portion of the switch-closing stroke. Since no energy remains in the spring 80 after completion of a closing operation, then it follows that when the holding pawl 106 is released prior to initiation of a switch-opening operation, the closing spring 80 exerts no substantial force tending to rotate the ratchet wheel 92 in a clockwise direction. There is a reset spring 190 provided to aid in returning the ratchet wheel 92 clockwise to its initial position of Fig. 2, and to aid thereafter in holding the ratchet wheel in its position of Fig. 2, but this spring is incapable of returning the ratchet wheel without the assistance of the switch-operating handle 93 during the previously-described switch-opening operation. In this latter regard, after the holding pawl 106 has been released, the charging pawl 98 remains in this position of Fig. 4. For the ratchet wheel to move clockwise under the influence of reset spring 190, it would have to force charging crank 96 in a counterclockwise direction about the axis of its shaft 95. This would be prevented by the engagement of the cams 181 and 182 inasmuch as cam 181 is coupled to the shaft 95. Only when the handle 93 is lifted to effect switch-opening would the restraint of the charging pawl 98 be removed to allow the ratchet wheel to be returned to its initial position of Fig. 2. Thus, it will be apparent that movement of the interlock bar 161 into its "open" position releases the holding pawl 106 but does not cause the ratchet wheel 92 to be reset from its position of Fig. 4. A switch-opening operation is a prerequisite to reset of the ratchet wheel 92 to its position of Fig. 2. This feature of the mechanism is relied upon in connection with an additional interlock feature which will soon be pointed out.

The interrelationship of the switch and the fuse

In the disclosed switch-fuse combination, the operating mechanism 70 is capable of closing the switch 60 against currents greatly in excess of those which the switch is capable of interrupting upon opening. Currents which the switch is incapable of interrupting are interrupted by the fuse 54 connected in series with this switch. From a safety viewpoint, it is most important that only the fuse and not the switch be utilized for attempted interruption of currents in excess of the switch interrupting capacity.

The only occasion upon which this requirement presents a real problem is immediately after the switch is closed. If the attendant realizes that he has closed the switch upon a faulted or overloaded line, he might attempt to open the switch before the fuse has had a chance to operate. To preclude such attempted switch-openings, we have provided means including a timing device 200 which blocks switch-opening operations for a period of time at least equal to the time required for the fuse to interrupt currents slightly in excess of the interrupting capacity of the switch. Since higher currents are interrupted by the fuse in a shorter time, this time delay is sufficiently long to assure that switch-opening will not take place during such higher currents, as well as during slight overloads.

Referring to the detailed cross-sectional view of Fig. 7, the timing device 200 is preferably of the dashpot-type and comprises a liquid-filled stationary cylinder 201 and a movable piston 202 coupled to the closure initiating member 120. The liquid within the dashpot offers no significant resistance to movement of the closure-initiating member 120 to the right, i.e., in a latch-releasing direction, but retards return movement of the closure-initiating member 120 to its normal position of Figs. 2, 3 and 7. With regard to movement of the closure-initiating member 120 to the right, a check valve 204 provided in the piston allows liquid to flow freely from the right hand to the left hand side of the piston 202, thus preventing retardation of the piston by the liquid. When the piston is returned to the left to its initial position, no flow can take place through the check valve 204, and the piston speed is governed primarily by the rate at which liquid can be forced through a small metering passage 205 provided in the piston 202. This metering passage is so dimensioned that the time required for the closure-initiating member 120 to return to its initial position under the influence of a suitable resetting spring 207 is at least equal to the time required for the fuse 54 to interrupt currents slightly in excess of the interrupting capacity of the switch. In one typical switch-fuse combination, this time is about 30 seconds.

The manner in which the timing device 200 acts to block a switch-opening operation after switch-closing can be best described by referring to Fig. 2. When the interlock bar 161 is in its position of Fig. 2, it will be apparent that the enlarged portion of a keyhole shaped opening 210 formed in the interlock bar 161 aligns with the cylindrical closure-initiating device 120. As a result, the interlock bar 161 when in the position of Fig. 2 will allow the closure-initiating device 120 to be pulled to the right. Assume that the main spring has been fully charged as shown in Fig. 3, and that the closure-initiating member 120 is then pulled to the right from its position of Figs. 2 and 3. This will effect switch-closing and will also position the enlarged cylindrical portion of closure-initiating member 120 in the enlarged portion of the keyhole slot 210. So long as the enlarged portion of closure-initiating member 120 is so positioned, the closure-initiating member 120 will act to block movement of the interlock bar 161 to the left, due to the fact that the width of the restricted portion of the keyhole slot 210 is less than the diameter of the enlarged cylindrical portion of the closure-initiating member 120. Thus, during this interval an operator seeking to turn the handle

162 to the "open" position would find motion of the handle to be blocked. Only after the resetting spring 207 had returned the closure-initiating member 120 approximately to its initial position, would the interlock bar 161 be allowed to move to the left. Since movement of the interlock bar to the left into its "open" position is a necessary prerequisite to a switch-opening operation, as has been previously described, it will be apparent that switch-opening will be precluded after switch-closing for at least the period required for the closure-initiating member 120 to be moved toward its initial position out of blocking engagement with the interlock bar 161. Since this period is sufficiently long to allow the fuse to operate even for currents slightly in excess of the switch interrupting capacity, it will be apparent that switch-opening is blocked for a sufficiently long interval after switch-closing to assure fuse operation for such excess currents.

If it be assumed that the interlock bar 161 has been shifted to its "open" position upon expiration of the required time interval after closing and that a switch-opening operation has then been initiated by appropriate operation of the handle 93, then it should be apparent that another closing operation cannot be initiated until the interlock bar 161 is returned to its "close and charge" position. It is only after the interlock bar 161 has been so returned that the closing spring 80 can again be charged and the closure-initiating member 120 can again be pulled to the right from its position of Fig. 3 to initiate switch-closure. It should also be apparent that to initiate another switch-opening operation, the interlock bar 161 would have to be again shifted to its "open" position, and this would necessitate waiting for the required time interval after closing before such shifting could be effected.

Interlock features relative to rack-out of the removable switchgear assembly

When the switchgear assembly 11 is being racked out of or into its fully connected position of Fig. 1, it is important that the switch then be in open position, so as to avoid establishing possibly damaging arcs between the disconnect contacts 15 and 16. It is also important that the closing spring 80 be discharged before the switchgear assembly 11 is withdrawn from its enclosure 10, so as to avoid the possibility of possibly-hazardous accidental discharge of the spring 80 during maintenance or repair. We prefer also that the spring 80 be discharged whenever the switch is near its connected position so as to insure against establishment of a power circuit through the switch as a result of possible accidental spring-discharge and resultant switch-closing.

With a view toward satisfying these requirements, the interlock bar 161 is so constructed that it blocks access to the racking jack screw 26 whenever the switch is closed and whenever the closing spring 80 is charged. This can be best understood by referring to Fig. 2, where the jack screw is shown schematically at 26 and the interlock bar 161 is shown with an opening 215 through which the jack screw operating tool must be inserted in order to apply the tool to the jackscrew. When the interlock bar 161 is in its "close and charge" position, shown in Fig. 2, the opening 215 is out of alignment with the jack screw 26, and it is therefore not possible to apply the tool to the jackscrew. When the interlock bar is in its "open" position, the opening 215 is still out of alignment with the jackscrew 26, and it is therefore still not possible to apply the tool to the jackscrew. It is only when the interlock bar 161 has been shifted into its "rack" position (indicated in Fig. 2 by the position of handle 162) that the opening 215 aligns with the jackscrew 26 and allows the jackscrew operating tool to be applied thereto.

Necessary prerequisites for shifting the interlock bar 161 into its "rack" position are that the spring 80 be

discharged and that the switch 60 be open. Thus, it will be apparent that only when the spring 80 is discharged and the switch 60 is open can the switchgear assembly be racked into and out of its fully-connected position.

With regard to these necessary prerequisites to shifting of the interlock bar 161 into its "rack" position, assume first that the switch 60 is still open but that the spring 80 is charged (as depicted in Fig. 3) when the attendant shifts the interlock bar 161 from its "close and charge" position of Fig. 2 to its "open" position. In response to such shifting, the cam surface 171 on the interlock bar 161 will release the holding pawl 106 and will thus cause the spring 80 to discharge at its rear end, resetting the ratchet wheel 92 from its position of Fig. 3 to its position of Fig. 2. The switch then being open and the spring 80 then being discharged, the interlock bar 161 can be further shifted to the left into its "rack" position so as to allow for racking the switchgear assembly out of its fully-connected position of Fig. 1. It will be apparent that releasing the holding pawl 106 in this manner makes it possible to discharge the spring without the necessity of closing the switch.

Instead of assuming that the switch is open when the above-described shifting of the interlock bar 161 from its "close and charge" position to its "open" position is effected, assume that the switch is closed. The cam surface 171 on the interlock bar 161 will once again release the holding pawl 106 in response to movement of the interlock bar 161 leftward into its "open" position but this will not cause the switch 60 to open or will not cause the ratchet wheel to reset. With regard to the failure of the ratchet wheel to reset under these conditions, it will be recalled that tripping of the holding pawl 106 when the closing spring 80 is discharged causes no resetting movement of the ratchet wheel 92 because substantially no energy remains in the closing spring 80 and because the charging crank, then being in its position of Fig. 3, will preclude clockwise resetting motion of the ratchet wheel under the influence of light resetting spring 190. As a result, the interlock bar 161 cannot be moved past its "open" position toward the "rack" position so long as the switch is closed because the ratchet wheel 92 blocks movement of the interlock bar 161 so long as the ratchet wheel 92 is out of its reset position. This blocking relationship is illustrated in Fig. 4 where the ratchet wheel is shown abutting a shoulder 220 formed on a projecting arm 225 integral with the interlock bar 161. Only when the ratchet wheel 92 has been returned to its reset position of Fig. 2 or Fig. 2a, is it possible to move the shoulder 220 of the interlock bar 161 to the left past the ratchet wheel 92. This is the case because it is only when the ratchet wheel has been reset that the shoulder 220 aligns with the large cutout 222 in the ratchet wheel. This condition of alignment is best shown in Fig. 2a. Such alignment is required in order to permit movement of the interlock bar 161 to the left past the "open" position. Since the ratchet wheel resets only in response to switch-opening, it will therefore be apparent that the interlock bar 161 cannot be shifted into its "rack" position until the switch is open. Since such shifting is a prerequisite to racking-out of the switch, it will be apparent that only when the switch is open can the switchgear assembly be racked-out.

It will be noted from Figs. 2 and 2a that the interlock bar 161 cooperates with an interference angle member 226 carried by the internal sidewall of the enclosure 10. The presence of this interference member 226 makes it necessary that the interlock member 161 be in its "rack" position before the switchgear assembly can be moved out of its fully-connected position or through any travel near its fully-connected position. Only when the interlock bar 161 is moved into its "rack" position does the interlock bar 161 clear the interference member 226, and only when this clearance is established, is it possible to move the switchgear assembly out of its fully-connected

position or through travel in the immediate vicinity of the fully-connected position. During a racking-in operation, if the switchgear assembly is only partially racked into its fully-connected position, the interference member 226 will block shifting of the interlock bar 161 to the right into either its "open" or "close and charge" positions, and, thus, will prevent charging of the spring and switch-closing operation while the switchgear assembly is so positioned. Only when the switchgear assembly has been moved into its fully-connected position (or has been withdrawn to a point wherein the disconnect contacts 15 and 16 are safely spaced from an electrical clearance viewpoint) does the interference member 226 allow the interlock bar 161 to be shifted into its "open" or its "close and charge" positions.

While we have described our switch and switch-operating mechanism in connection with a switch-fuse assembly, it is to be understood that certain aspects of the invention are equally applicable to other forms of switchgear, for example, switchgear containing a switch only and no power fuses.

While we have shown and described a particular embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects and we, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. Switchgear apparatus comprising an electric switch which is capable of interrupting currents only up to a predetermined value, an electric fuse connected in series with said switch and being automatically operable to interrupt currents in excess of said predetermined value which said switch is incapable of interrupting, said fuse requiring a predetermined interval of time to effect interruption of currents slightly exceeding said predetermined value once said predetermined value is exceeded, means for closing said switch even against currents greatly in excess of said predetermined value, manually-controlled means for opening said switch, said switch-protective means for disabling said manually-controlled switch-opening means after completion of a switch-closing operation for a period of time exceeding said predetermined interval, whereby to assure operation of said fuse in the event that said switch is closed against a sustained current in excess of said predetermined value.

2. Switchgear apparatus comprising an electric switch which is capable of interrupting currents only up to a predetermined value, an electric fuse connected in series with said switch and being automatically operable to interrupt currents in excess of said predetermined value which said switch is incapable of interrupting, said fuse requiring a predetermined interval of time to effect interruption of currents slightly exceeding said predetermined value once said predetermined value is exceeded, means for closing said switch even against currents greatly in excess of said predetermined value, manually-controlled means for opening said switch comprising a component that is manually-actuable to initiate a switch-opening operation, interference means for blocking switch-opening operation of said manually-actuable component, means responsive to initiating of switch-closing action for maintaining said interference means in blocking relationship relative to said manually-actuable component for a period of time after switch-closing exceeding said predetermined interval, whereby to assure operation of said fuse in the event that said switch is closed against a sustained current in excess of said predetermined value.

3. Switchgear apparatus comprising a movable switch member, a chargeable helical spring coupled to said switch member and releasable at one end to drive said switch member toward closed position, a rotatable member coupled to the other end of said spring and rotatable to

charge said spring, a pivotally-mounted handle, means including a unidirectional drive connection between said handle and said spring-charging member for progressively rotating said spring-charging member to charge said spring in response to repetitive oscillations of said handle, said unidirectional drive connection causing rotation of said spring-charging member in response to motion of said handle in one direction but allowing said charging member to remain stationary during motion of said handle in an opposite direction, means operable after said spring is charged to a predetermined energy level for releasing said spring at said one end to effect closing of said switch member, switch-opening means connected between said handle and said switch member but inoperable to transmit forces from said handle to said switch member during spring-charging oscillations of said handle, means responsive to switch-closing release of said spring for rendering said switch-opening means operable to effect switch-opening in response to motion of said handle in said opposite direction.

4. Switchgear apparatus comprising a movable switch member, a chargeable helical spring coupled to said switch member and releasable at one end to drive said switch member toward closed position, a rotatable member coupled to the other end of said spring and rotatable to charge said spring, a pivotally-mounted handle arranged for oscillation between a normal and a displaced position, means including a unidirectional drive connection between said handle and said spring-charging member for progressively rotating said spring charging member in a spring-charging direction in response to repetitive oscillations of said handle, said unidirectional drive connection causing rotation of said spring-charging member in a spring-charging direction in response to movement of said handle from said normal to said displaced position but allowing said charging member to remain stationary during motion of said handle from said displaced to said normal position, means operable after said spring is charged to a predetermined energy level for releasing said spring at said one end to effect closing of said switch member, switch-opening means connected between said handle and said switch member but inoperable to transmit forces from said handle to said switch member during spring-charging oscillations of said handle, means responsive to switch-closing release of said spring for rendering said switch-opening means operable to effect switch-opening in response to motion of said handle from said displaced toward said normal position, and means requiring said handle to be positioned generally in said displaced position as a prerequisite to switch-closing release of said spring, whereby said handle is in a position to initiate switch-opening after a switch-closing operation.

5. Switchgear apparatus comprising a movable switch member, a chargeable spring coupled to said switch member and releasable at one end to drive said switch member toward closed position, a spring member coupled to the other end of said spring and movable in a predetermined direction to charge said spring, a pivotally-mounted handle, means including a unidirectional drive connection between said handle and said spring charging member for notching said spring charging member in a spring-charging direction in response to repetitive oscillations of said handle, said unidirectional drive connection causing motion of said spring-charging member in said predetermined direction in response to motion of said handle in one direction but allowing said spring-charging member to remain stationary during motion of said handle in an opposite direction, means operable after a predetermined amount of spring charging for releasing said spring to effect closing of said switch member, switch-opening means comprising first and second power transmitting members, means coupling said first power-transmitting member to said handle and oscillating said first power-transmitting member in response to spring-charging oscillations of said handle, means coupling said sec-

and power-transmitting member to said spring at said other end thereof and acting to position said second power-transmitting member in a disabled position out of power-transmitting engagement with said first power-transmitting member during spring-charging oscillations of said handle, said second power-transmitting member being shifted by switch-closing release of said spring into a position enabling said second power-transmitting member to be engaged by said first power-transmitting member, motion of said handle in said opposite direction after said shifting of said second power-transmitting member acting to cause said first power-transmitting member to drive said second power-transmitting member toward its disabled position, and means controlled by motion of said second power-transmitting member toward its disabled position for driving said switch member toward open position.

6. The apparatus of claim 5 in combination with means requiring said handle to be positioned near the end point of its motion in said one direction as a prerequisite to initiation of switch-closing release of said spring, whereby said handle is in a position to initiate switch-opening after a switch-closing operation.

7. The apparatus of claim 5 in which positioning said handle near the end point of its motion in one direction locates said first power-transmitting member in a position free from engagement with said second power-transmitting member during shifting thereof in response to switch-closing release of said spring, motion of said handle in said opposite direction establishing engagement between said power-transmitting members and acting to drive said power-transmitting members in a direction to open said switch member.

8. The apparatus of claim 7 in combination with means requiring said handle to be positioned near the end point of its motion in said one direction as a prerequisite to initiation of switch-closing release of said spring, whereby to assure that said first power-transmitting member will not interfere with said second power-transmitting member during closing of said switch member.

9. Switchgear apparatus comprising a movable switch member, a chargeable switch-closing spring, means at one end of said spring for holding said spring charged and operable to release said one end to allow said spring to discharge, means interconnecting said one end of the spring and said switch member for driving said switch member toward closed position in response to release of said spring at said one end, a spring-charging member coupled to the other end of said spring and movable into a predetermined position to charge said spring, restraining means at said other end of the spring for holding said spring-charging member in a predetermined position while said spring is being released at said one end, release of said spring acting to drive said one end of the spring in a predetermined direction, means for moving said switch member from a closed position toward an open position and for driving said one end of the spring during switch-opening in a direction opposite to said predetermined direction, and means for releasing said restraining means at said other end of the spring prior to completion of a substantial portion of a switch-opening operation so as to allow switch-opening to take place without appreciably recharging said spring.

10. Switchgear apparatus comprising a movable switch member, a chargeable switch-closing spring, means at one end of said spring for holding said spring charged and operable to release said one end to allow said spring to discharge, means interconnecting said one end of the spring and said switch member for driving said switch member toward closed position in response to release of said spring at said one end, a spring-charging member coupled to the other end of said spring and movable into a predetermined position to charge said spring, restraining means at said other end of the spring for holding said spring-charging member in a predetermined posi-

tion while said spring is being released at said one end, release of said spring acting to drive said one end of the spring in a predetermined direction, means for moving said switch member from a closed position toward an open position and for driving said one end of the spring during switch-opening in a direction opposite to said predetermined direction, means for releasing said restraining means so as to cause said one end of the spring, said spring, and said spring-charging member to be driven as a unit in said opposite direction by a switch-opening operation, and means requiring release of said restraining means as a prerequisite to initiation of a switch-opening operation.

11. Switchgear apparatus comprising an enclosure, a switchgear unit movable into and out of a connected position within said enclosure, said switchgear unit comprising a movable switch member, a chargeable switch-closing spring, means at one end of said spring for holding said spring charged and operable to release said one end to allow said spring to discharge, means interconnecting said one end of the spring and said switch member for driving said switch member toward closed position in response to release of said spring at said one end, a spring-charging member coupled to the other end of said spring and movable from an initial position into another position to charge said spring, restraining means at said other end of the spring for holding said spring-charging member in said other position while said spring is being released at said one end and while said switch member is being closed, release of said spring acting to drive said one end of the spring in a predetermined direction, means for moving said switch member from a closed position toward an open position and for driving said one end of the spring during switch-opening in a direction opposite to said predetermined direction, means for releasing said restraining means prior to completion of a switch-opening operation so as to cause said spring-charging member to be returned to approximately its initial position by forces transmitted through said spring during a switch-opening operation, interference means sensitive to the position of said spring-charging member for blocking movement of said switchgear unit out of its connected position until said charging member has been returned to approximately its initial position and thereafter allowing movement of said switchgear unit out of its connected position.

12. The apparatus of claim 11 in combination with means precluding return of said spring-charging member to its initial position while said switch is closed.

13. The apparatus of claim 11 in combination with means requiring that a predetermined amount of energy be stored in said spring as a prerequisite to initiation of a switch-closing operation, a single switch-closing operation extracting from said spring substantially said predetermined amount of energy so that substantially no energy is stored in said spring upon the completion of said switch-closing operation, thereby preventing said spring after a switch-closing operation from returning said spring-charging member to said initial position upon release of said restraining means, thus necessitating a switch-opening operation to effect said return.

14. The apparatus of claim 13 in combination with a booster arrangement automatically operable near the end of a switch-closing operation to supply added closing power to said switch member.

15. Switchgear apparatus comprising an enclosure, a switchgear unit movable into and out of a fully-connected position within said enclosure, racking means connected to said switchgear unit for driving said unit into and out of said fully-connected position, said switchgear unit comprising a switch including a movable switch member, switch-closing means comprising a chargeable switch-closing spring, closure-initiating means at one end of said spring for holding said spring charged and operable under predetermined conditions to release said one end to

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allow said spring to discharge in a switch-closing direction, means interconnecting said one end of said spring and said switch member for driving said switch member into closed position in response to release of said spring at said one end, a spring-charging member coupled to the other end of said spring and movable through predetermined positions to charge said spring, restraining means at said other end of the spring normally operable to hold said spring-charging member in positions wherein said spring is charged, switch-opening means for opening said switch and for driving said one end of the spring during switch-opening in a direction opposite to said switch-closing direction, interlock means comprising interlock-controlling structure having three spaced-apart positions; said interlock means operating when said controlling structure is in a first one of said positions to allow operation of said racking means, to block operation of said closure-initiating means, and to disable said restraining means; said interlock means acting when said controlling structure is in a second one of said positions to block operation of said racking means, to allow said restraining means to be operable so that said spring can be charged, and to allow operation of said closure-initiating means so that said spring can be discharged to close said switch; said interlock means acting to prevent switch-opening operation of said switch-opening means whenever said interlock-controlling structure is displaced from a third one of said positions and responsive to movement of said interlock-controlling structure into said third position to render said switch-opening means operable to effect switch-opening, said interlock means blocking operation of said racking means when said controlling structure is in said third position.

16. The switchgear apparatus of claim 15 in combination with means sensitive to the position of said switchgear unit for blocking movement of said interlock-controlling structure out of said first position whenever said switchgear unit is displaced from but is near its fully-connected position.

17. The apparatus of claim 15 in which said interlock means operates when said interlock-controlling structure is in said third position to disable said restraining means so that switch-opening can take place without appreciably charging said spring.

18. The apparatus of claim 15 in which said switch is capable of interrupting currents only up to a predetermined value, an electric fuse connected in series with said switch and being automatically operable to interrupt currents in excess of said predetermined value which said switch is incapable of interrupting, said fuse requiring a predetermined interval of time to effect interruption of currents slightly exceeding said predetermined value once said predetermined value has been exceeded, said switch-closing means being capable of closing said switch even against currents greatly exceeding said predetermined value, and means including a timer for blocking movement of said interlock-controlling structure from said second to said third position after operation of said closure-initiating means for a period of time exceeding said predetermined interval.

19. Switchgear apparatus comprising an enclosure, a switchgear unit movable into and out of a fully-connected position within said enclosure, racking means connected to said switchgear unit for driving said unit into and out of said fully-connected position, said switchgear unit comprising a switch including a movable switch member, switch-closing means comprising a chargeable switch-closing spring, closure-initiating means at one end of said spring for holding said spring charged and operable under predetermined conditions to release said one end to allow said spring to discharge in a switch-closing direction, means interconnecting said one end of said spring and said switch member for driving said switch member into closed position in response to release of said spring at said one end, a spring-charging member coupled to the

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other end of said spring and movable through predetermined positions to charge said spring, restraining means at said other end of the spring normally operable to hold said spring-charging member in positions wherein said spring is charged, interlock means comprising interlock-controlling structure having at least two spaced-apart positions; said interlock means operating when said controlling structure is in a first one of said positions to allow operation of said racking means, to block operation of said closure-initiating means, and to disable said restraining means; said interlock means acting when said controlling structure is in a second one of said positions to block operation of said racking means, to allow said restraining means to be operable so that said spring can be charged, and to allow operation of said closure-initiating means so that said spring can be discharged to close said switch; movement of said interlock-controlling structure from said second to said first position causing said spring, if then charged, to discharge at said other end upon disablement of said restraining means.

20. The apparatus of claim 19 in combination with means sensitive to the position of said switchgear unit for blocking movement of said interlock-controlling structure into said second position whenever said switchgear unit is displaced from but is near its fully-connected position.

21. The apparatus of claim 19 in combination with switch-opening means for opening said switch and in which said interlock-controlling structure has a third position spaced from said other two positions; said interlock means acting to prevent switch-opening operation of said switch-opening means whenever said interlock-controlling structure is displaced from said third position and responsive to movement of said interlock-controlling structure into said third position to render said switch-opening means operable to effect switch-opening, said interlock means blocking operation of said racking means when said controlling structure is in said third position.

22. The apparatus of claim 21 in which said third position is located between said first and second positions and in which movement of said interlock-controlling structure from said second to said third position disables said restraining means and causes said spring, if then charged, to discharge at said other end.

23. Switchgear apparatus comprising an electric switch which is capable of interrupting currents only up to a predetermined value, an electric fuse connected in series with said switch and being automatically operable to interrupt currents in excess of said predetermined value which said switch is incapable of interrupting, said fuse requiring a predetermined interval of time to effect interruption of currents slightly exceeding said predetermined value once said predetermined value has been exceeded, means for closing said switch even against currents greatly in excess of said predetermined value, manually-controlled means for opening said switch, interlock means comprising interlock-controlling structure having first and second spaced-apart positions, said interlock means operating when said controlling structure is in said first position to preclude a switch-closing operation but to allow operation of said manually-controlled switch-opening means to effect switch-opening; said interlock means acting to prevent operation of said switch-opening means whenever said interlock-controlling structure is displaced from said first position, said interlock means allowing operation of said closure-initiating means to effect switch-closing when said interlock-controlling structure is in said second position, and means including a timer for blocking movement of said interlock-controlling structure from said second to said first position for a period of time after operation of said closure-initiating means exceeding said predetermined interval.

24. Switchgear apparatus comprising a movable switch member, a chargeable helical spring, a rotatable output member coupled to said spring at one end thereof, latch

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means for restraining said output member to hold said spring charged and operable to release said output member to allow said spring to discharge, means interconnecting said output member and said switch member for driving said switch member toward closed position in response to discharge of said spring, a rotatable spring-charging member collinear with said output member and movable into a predetermined angular position to charge said spring sufficiently to enable said spring to close the switch member against overload currents, a latch-releasing shaft coupled to said latch means and extending along the length of said helical spring between said latch means and said spring-charging member, an arm coupled to said latch-releasing shaft and abutting against a peripheral portion of said spring-charging member to block latch-releasing motion of said shaft so long as said spring-charging member is displaced from said predetermined position, and a recess in the peripheral portion of said spring-charging member for rendering said arm incapable of blocking latch-releasing motion of said shaft when said recess registers with said arm, said recess being located to register with said arm when said spring-charging member has moved into said predetermined position.

25. Switchgear apparatus comprising an enclosure, a removable switchgear unit movable into and out of a fully-connected position within said enclosure, means for driving said unit into and out of said fully-connected position, said switchgear unit comprising a switch including a movable switch member, switch-closing means comprising a chargeable switch-closing spring, closure-initiating means at one end of said spring for holding said spring charged and operable under predetermined conditions to release said one end to allow said spring to discharge in a switch-closing direction, means interconnecting said one end of said spring and said switch member for driving said switch member into closed position in response to release of said spring at said one end, a spring-charging member coupled to the other end of said spring and movable through predetermined positions to charge said spring, restraining means at said other end of the spring normally operable to hold said spring-charging member in positions wherein said spring

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is charged, interlock means comprising interlock-controlling structure having at least two spaced-apart positions; said interlock means operating when said controlling structure is in a first one of said positions to allow said switchgear unit to be withdrawn from said enclosure and to disable said restraining means; said interlock means acting when said controlling structure is in a second one of said positions to prevent withdrawal of said switchgear unit from said enclosure, to allow said restraining means to be operable so that said spring can be charged, and to allow operation of said closure-initiating means so that said spring can be discharged to close said switch; movement of said interlock-controlling structure from said second to said first position causing said spring, if then charged, to discharge at said other end upon disablement of said restraining means.

26. In combination: a relatively stationary enclosure; a removable switchgear unit comprising a switch and a stored-energy closing device which is dischargeable to close said switch, said removable switchgear unit being disposed for reciprocating movement into and out of said enclosure; means for imparting said reciprocating movement to the removable unit; and interlock means comprising movable interlock-controlling structure normally disposed to block movement of said removable unit completely out of said enclosure, manually-operable actuating means for moving said interlock-controlling structure in a manner to unblock said removable switchgear unit, and means associated with said closing device and controlled by said actuating means for discharging said closing device upon operation of said actuating means.

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