

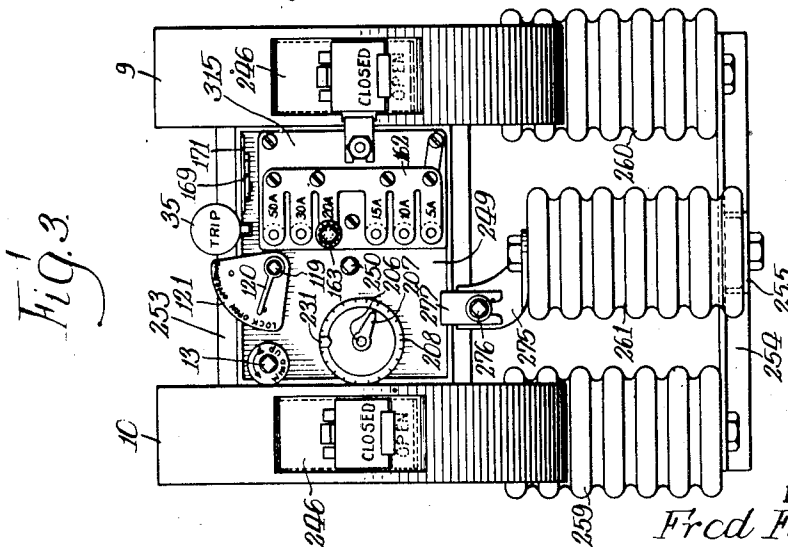
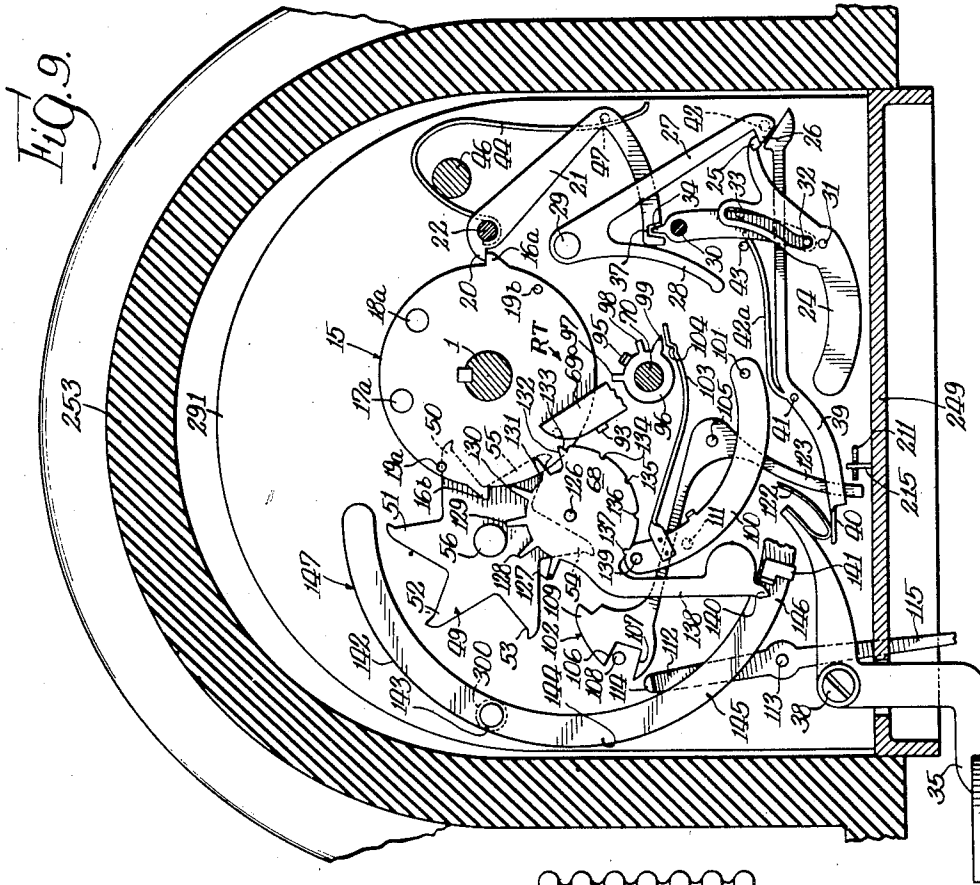
May 2, 1950

F. FARRELL
CIRCUIT BREAKER

2,506,546

Filed Nov. 20, 1943

9 Sheets-Sheet 2



INVENTOR.
Fred Farrell.
BY
Grown Jackson Bortner & Penner
Attys.

May 2, 1950

F. FARRELL
CIRCUIT BREAKER

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9 Sheets-Sheet 3

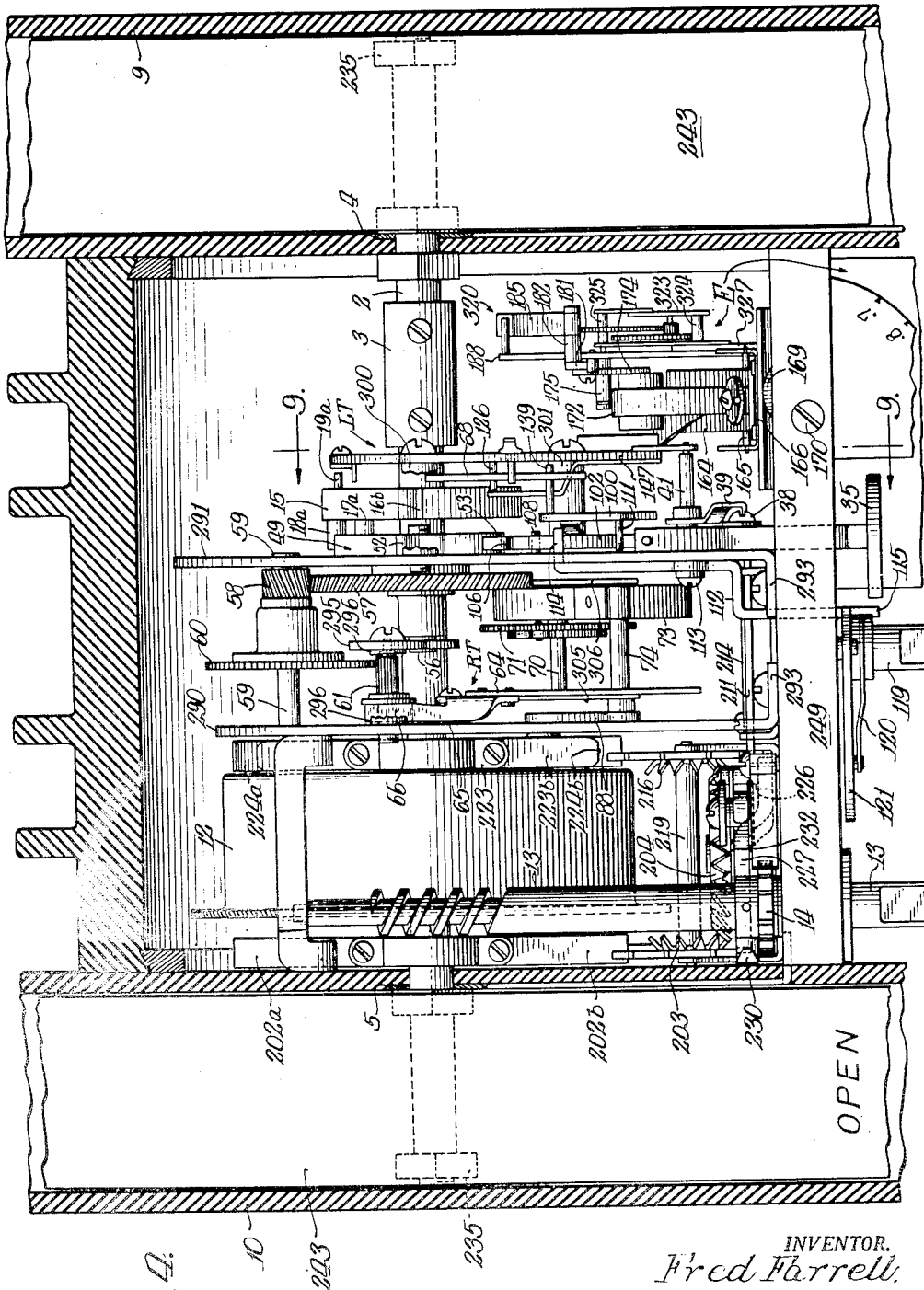


Fig. 4.

INVENTOR.
Fred Farrell.

BY

Max Jacobson & Co., Inc. Designers
Attys.

May 2, 1950

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9 Sheets-Sheet 4

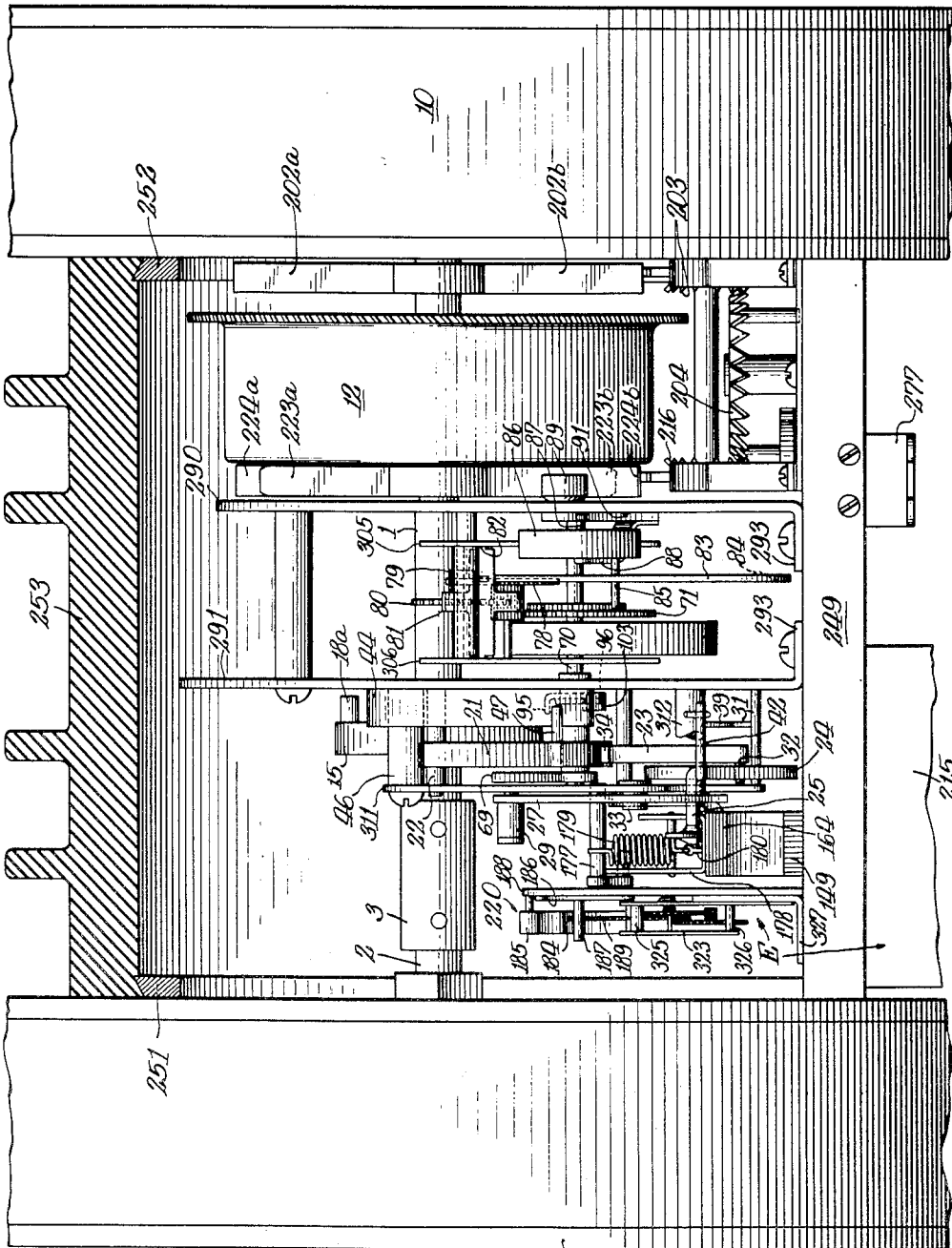


Fig. 5.

INVENTOR.
Fred Farrell,
BY
Brown & Bortnick, Denver
Attys.

May 2, 1950

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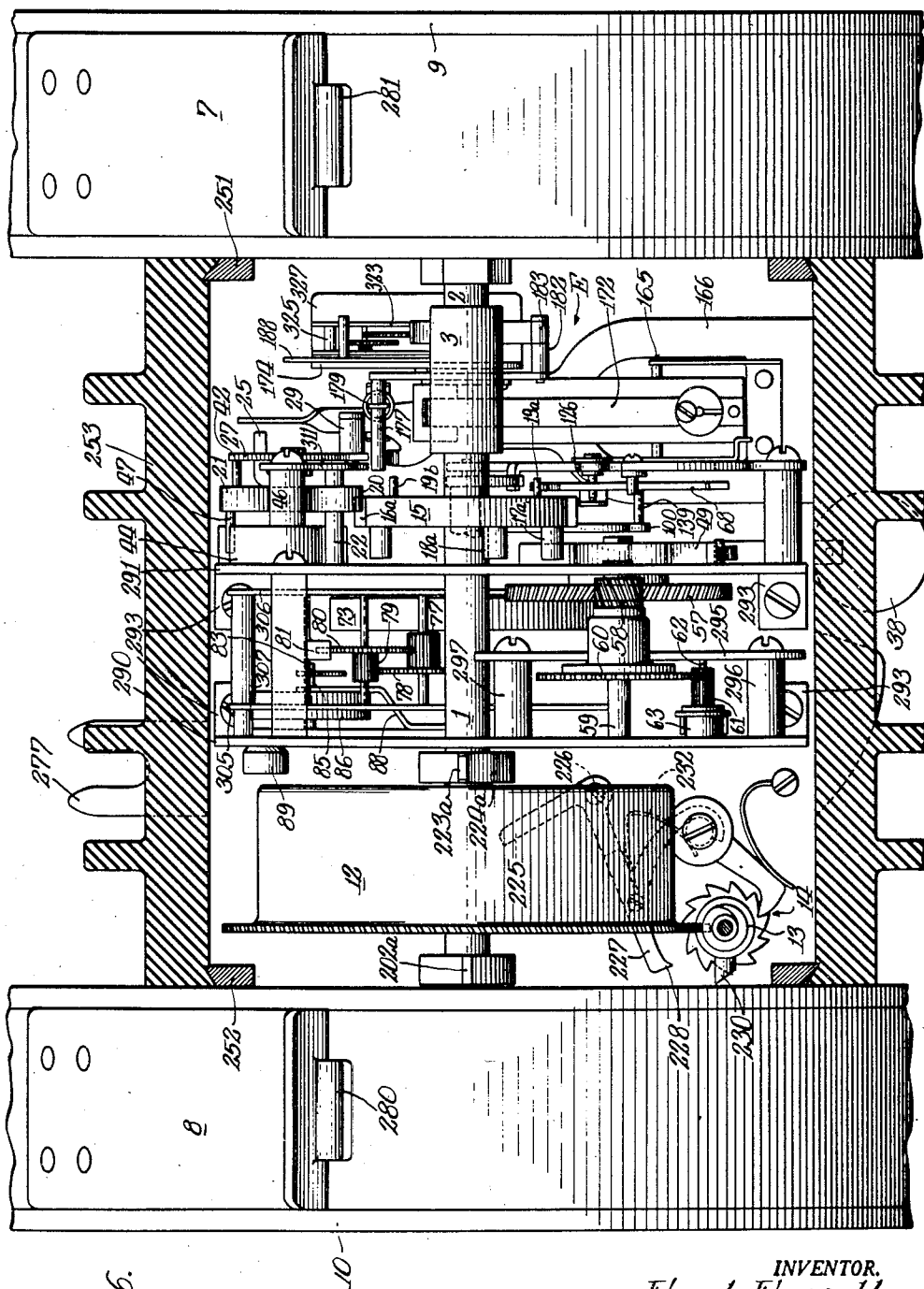


Fig. 6.

INVENTOR.
Fred Farrell.
BY
Maurice S. Sotter, Attorney

Attys.

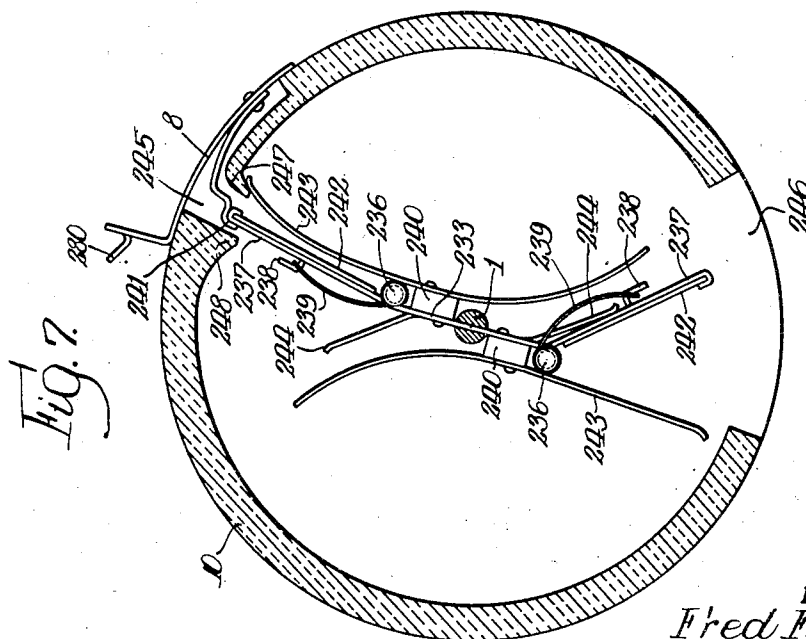
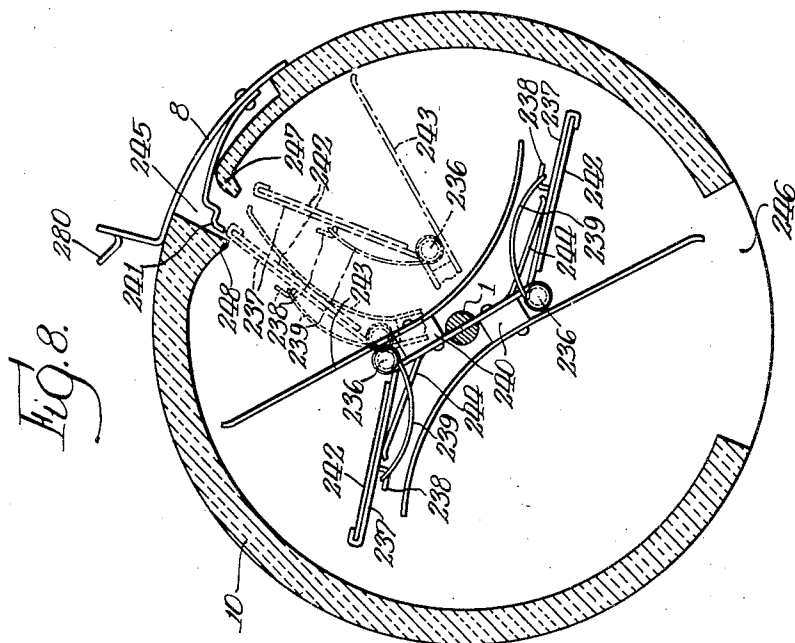
May 2, 1950

F. FARRELL
CIRCUIT BREAKER

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9 Sheets-Sheet 6



INVENTOR.
Fred Farrell.
BY
Morgan Jackson Bottcher. Treas.
Atty's

May 2, 1950

F. FARRELL
CIRCUIT BREAKER

2,506,546

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9 Sheets-Sheet 7

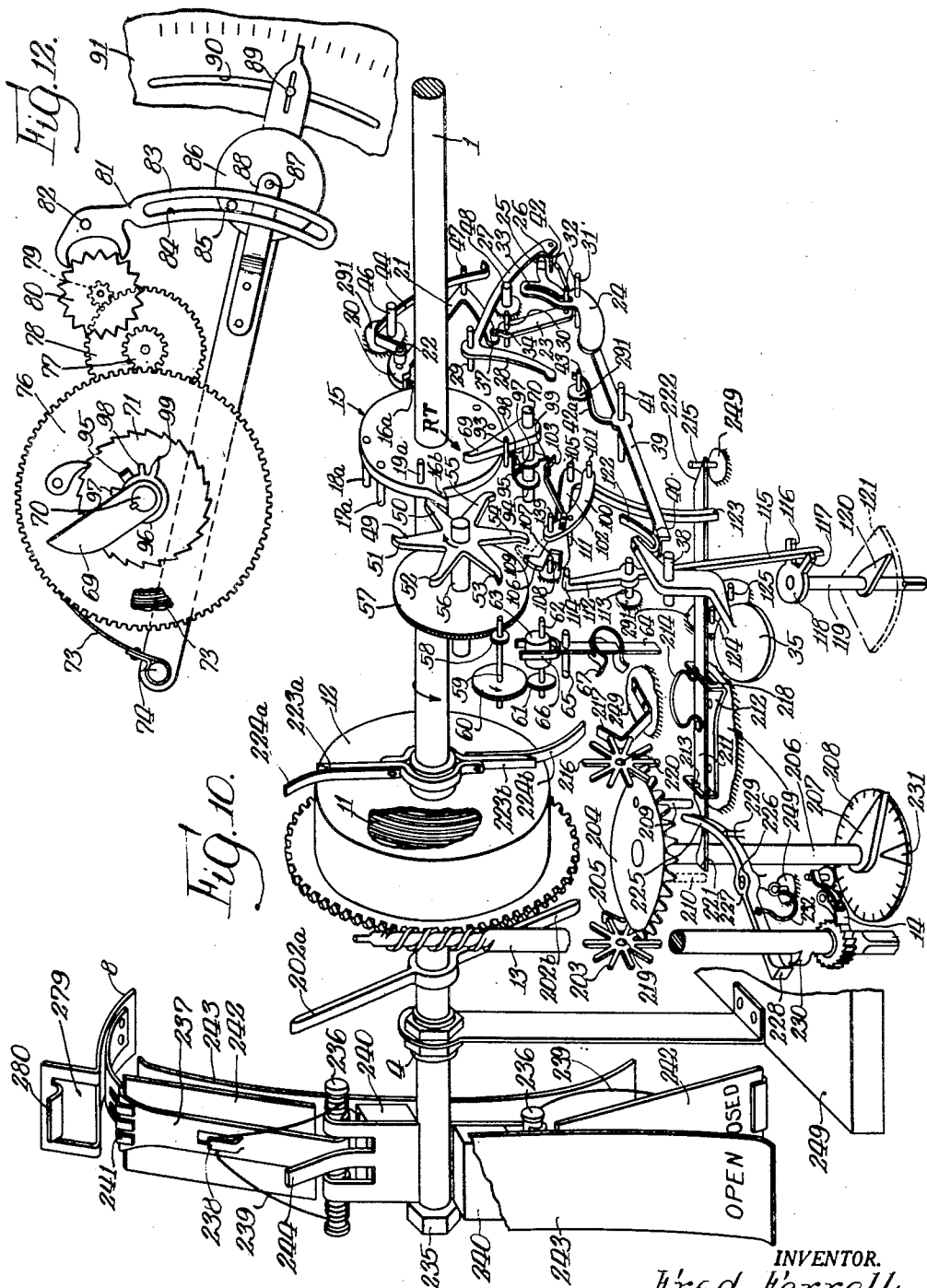


Fig. 10.

Fig. 12.

INVENTOR.
Fred Farrell.

BY

Proctor, Rosen & Bortner, Attys.

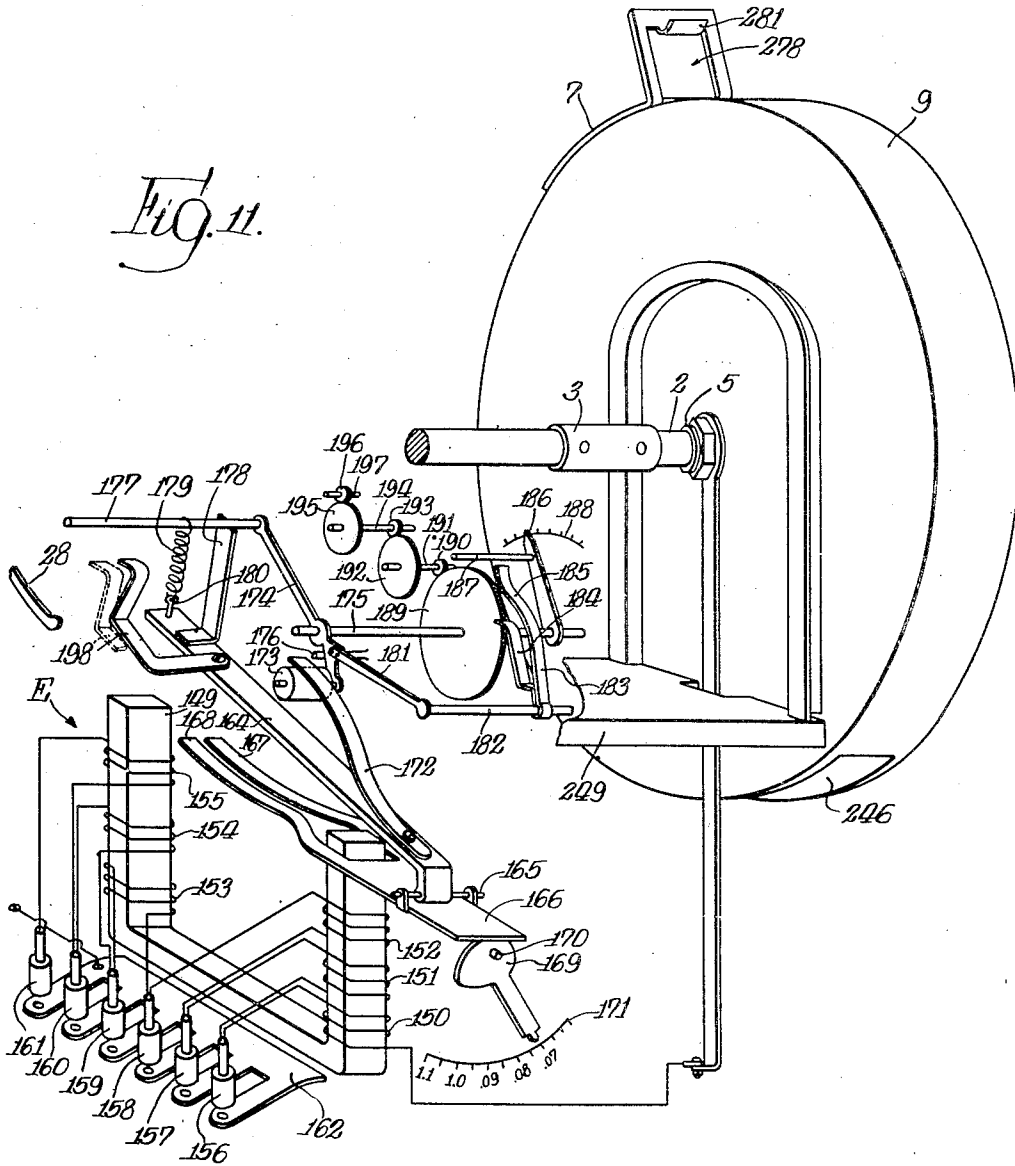
May 2, 1950

F. FARRELL
CIRCUIT BREAKER

2,506,546

Filed Nov. 20, 1943

9 Sheets-Sheet 8



INVENTOR.
Fred Farrell,
BY
Amory Jackson Bostick, Attorney
Attys.

UNITED STATES PATENT OFFICE

2,506,546

CIRCUIT BREAKER

Fred Farrell, Cedar Rapids, Iowa, assignor to
Electrical Engineers Equipment Company, Mel-
rose Park, Ill., a corporation of Illinois

Application November 20, 1943, Serial No. 511,019

17 Claims. (Cl. 200—89)

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The present invention relates to a circuit breaker and more particularly to a circuit breaker of the automatic opening and reclosing type.

There has been a long felt need in the art for an electric switch possessing the following advantages: (1) A switch which may be removed from the line without interruption of the service for purposes of adjustment and inspection, and which may be reinserted in the line without subjecting the operator to danger by close proximity of the line; (2) a switch of the automatic reclosing type having means providing for adjustment over a range of a predetermined number of successive opening and closing operations of the switch before lock-out of the switch in open position; and (3) a switch which is adapted to be automatically tripped by electro-magnetic means having an adjustable time delaying action means providing a time delay before the electro-magnetic means is effective to trip the switch, but in which an instantaneous tripping action may be superimposed upon the time delay means to trip the switch instantaneously i. e. independently of time delay, when the line current reaches a predetermined magnitude in excess of the current at which the switch was set to trip. So far as I am aware none of the switches of this character of the prior art possess the above noted advantages. It is an object of my invention to provide an automatic reclosing switch of sufficiently light weight to be handled manually and which may be constructed at small cost and yet reliably obtain the above noted advantages.

A switch of the above type should be readily and safely removable from service or be replaced in service without deenergizing the line and without subjecting the operator to the hazard of too close proximity to a dangerous electric circuit, so that the switch contacts and associated controlling mechanism requiring repair or adjustment, due to wear on the various parts and stresses occasioned by service may be readily attended to by a repairman. It is a further object of my invention to provide an automatic reclosing switch comprising a mounting means having suitably associated insulators comprising the stationary part or section of the switch for incorporation in the line, and a removable housing section comprising the switch contacts and associated controlling mechanism in which the size and weight of the removable housing section are sufficiently small to be within the physical scope of an operator or repairman to man-

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ually remove or replace by the use of an insulated hook stick or pole.

Another object of my invention is to provide an automatic reclosing switch in which the number of reclosing operations before lockout may be adjusted over a predetermined range for a predetermined number of successive operations before locking out.

A further object of my invention is to provide an automatic reclosing circuit breaker having mechanical tripping means responsive to the action of an electromagnetic means provided with an adjustable time delay means which can be adjusted to respond only after a predetermined time has elapsed after line current reaches a predetermined magnitude, and which also provides an adjustable means to allow an instantaneous tripping action, independent of time delay, when the line current reaches a predetermined magnitude in excess of the current at which the tripping mechanism was adjusted.

In order to attain the aforesaid objects, I propose to provide a stationary mounting means which consists primarily of a base member or frame for insertion in line at the desired place of service, and which has suitably assembled thereto suitable supports of insulating material, such as the common form of porcelain insulators. The insulators preferably are mounted on the base or frame at a sufficient distance apart to form a gap in the line for safe operation at the voltage on which the switch is to operate. An electrical contact member is mounted on the outer end of each of these insulating supports and are used to form electrical contacts with and to mechanically support, the removable housing section containing the operating mechanism of the circuit breaker. Suitable connections are provided on the electrical contact members of the stationary mounting means for attaching the line wires thereto. Preferably, a pair of conducting links are pivotally mounted one each on the contact members in such a manner that the links may be manually moved into or out of engagement with each other by use of an insulated hook stick or pole to close or open the gap between the insulators which is spanned by the removable housing section of the automatic circuit breaker. A third insulator is fixed to the base of the stationary mounting means and the outer end of it is provided with a threaded stud to engage a projection on the removable housing section to hold the removable section in rigid assembly with the stationary mounting means. The end of this threaded

stud is formed to be engaged by an insulated hook stick or pole so that the stud may be tightened manually while the electric circuit is energized.

The removable housing section containing the operating mechanism preferably consists of a housing assembly comprising two arcing chambers, one at either end of the assembly, each of which contains a fixed contact and a movable current carrying switch arm in order to provide a double break in the electric circuit when the switch is opened, and, with the housing section between these two arcing chambers containing the mechanical power supply means for a plurality of switch operations, and associated mechanical and electrical apparatus and means for automatically controlling the opening and closing of the switch contacts. In the preferred form of the invention the energy for actuating the switch to open and closed positions is obtained by means of an energy storing means in the form of a wound spring for driving a shaft assembly carrying the current carrying switch arms. The removable housing section is also provided with a suitable fitting adapted to be engaged by the end of an insulated hook stick or pole for manual removal or replacement of the removable housing section into and out of assembly with the stationary mounting means. Suitable trip levers and spring winding elements and the like are also carried by the removable housing section and are adapted to be engaged with an insulated hook stick or pole for manual operation of the various switch functions.

The principal function of a switch of the character to which my present invention is directed is for automatically opening the electric circuit when faults occur on the line, and to thereby terminate the flow of fault current by deenergizing the section of line on which the fault has occurred, and then to reclose, after a predetermined time to re-establish service. It sometimes may be necessary to open the circuit a plurality of times to eliminate the flow of fault current, and if the fault current continues after a predetermined number of switch openings and closings, within a predetermined time, it must then be assumed that the fault is of such a nature as to render the line inoperable and the switch should then become locked in open position until the necessary line repair has been made to remove the fault.

Such a switch should also function so that if the fault on the line should clear during successive opening and closing operations of the switch within the predetermined time, and with a fewer number of operations than at which the switch was set to lockout, and remain closed for a predetermined length of time, the switch should automatically re-set to perform through another complete operating cycle.

From the above it will be observed that it is therefore necessary that a switch having these operating characteristics be provided with adjustable means for controlling the time allowed between opening and reclosing, adjustable means for controlling the time the switch must remain closed to eliminate lock-out after a predetermined number of successive operations, and an adjustable means for predetermining the number of successive opening and closing operations allowable before locking out in open position. I propose to provide a reclosing timing mechanism for controlling the time required between tripping open and reclosing of the switch, which in general comprises a pronged wheel drivingly connected

to a train of speed increasing gears of which the last or end gear is provided with a cam or eccentric having engagement with a pendulum arm, whereby each revolution of the cam imparts an oscillatory movement to the pendulum arm. The pronged wheel is arranged in relation to the shaft assembly carrying the current carrying arms for controlling rotation thereof. The oscillating speed of the pendulum arm is controlled by a weight adjustable thereon to increase or decrease the speed at which the cam is allowed to revolve under its driving force. The speed of rotation of the pronged wheel is governed by the train of gears and pendulum arm, and the pronged wheel in turn governs rotation of the shaft assembly of the switch to provide for controlling of the time required between opening and closing of the switch.

It is common for the current in the lines of an electric distribution system to continually fluctuate to some degree, and sometimes momentary surges of a heavy current occur due to disturbances on the system by the action of a heavy machinery load or the like. When a switch having no time delay means is used in such a system it is necessary to provide a trip mechanism which will prevent tripping of the switch during these momentary periods of heavy current flow. However, the disadvantage of using a switch with no time delay before tripping is that dangerous overloads may occur for a considerable time which are not quite large enough to operate the tripping mechanism, and the distribution system is therefore subject to this overload without release. In switches of the prior art having a time delay mechanism, the tripping mechanism is usually set to operate at a slightly larger current load than the normal load requirements of the circuit. An adjustment is provided for the time delay mechanism to prevent the switch from tripping for a sufficient length of time to allow momentary heavy surges to recede to normal without allowing the switch to trip. However, when extremely heavy or destructive fault currents occur on the system, it is of great advantage to have the switch trip open immediately without delaying the action of the switch by the time delay feature. It is a further feature of my invention to provide a construction comprising means whereby an adjustable time delaying action may be imposed upon the tripping mechanism and an additional action may be superimposed upon the time delay to allow instantaneous tripping of the switch independently of the time delay, when line current reaches a predetermined magnitude in excess of the current at which the switch was set to open. The tripping mechanism of my invention generally comprises a U-shaped electromagnet having a plurality of coils wound thereon through which the line current passes, and a movable magnet bar which is urged to move the tripping member for the switch into tripping position by magnetic attraction of the U-magnet, when line current reaches a predetermined magnitude. The time delay means comprises a train of gears which must be rotated through a predetermined angular extent by motion of the magnet bar before the tripping member is allowed to reach tripping position, the amount of power being delivered by motion of the magnet bar determining the rate at which the train of gears is forced to rotate. The means whereby instantaneous tripping action is allowed to take place, independent of the time delay feature, but only after line current has reached a predetermined magnitude in excess of that for

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which the mechanism was set to trip, consists of a tripping arm attached directly to the magnet bar and movable therewith, and which may be adjusted into, or out of position, to trip the switch by direct motion of the magnet bar.

Further objects, advantages and features of my invention will appear from the detail description.

Now, in order to acquaint those skilled in the art with the manner of constructing and operating an automatic circuit breaker in accordance with my invention, I shall describe in conjunction with the accompanying drawings a preferred embodiment of the same.

Figure 1 is a side elevational view of a circuit breaker constructed in accordance with my invention;

Figure 2 is a plan view of the circuit breaker of Figure 1;

Figure 3 is a bottom view of the circuit breaker shown in Figures 1 and 2;

Figure 4 is a front elevational view of the operating mechanism of the automatic circuit breaker of Figure 1 with the removable housing therefor in section;

Figure 5 is a rear elevational view of the operating mechanism contained within the removable housing of the circuit breaker of my invention and showing a portion of the housing in section;

Figure 6 is a plan view of the operating mechanism contained within the removable housing with a part of the housing being shown in section;

Figure 7 is a detail vertical sectional view taken on line 7—7 of Figure 2 looking in the direction indicated by the arrows and showing the switch in closed position;

Figure 8 is a view corresponding to Figure 7 but showing the switch in its open position;

Figure 9 is a detail vertical sectional view taken substantially on the line 9—9 of Figure 4 looking in the direction indicated by the arrow;

Figure 10 is an isometric view of the left hand portion of the mechanism contained within the removable housing as viewed from the front with the parts being suitably spaced for clarity of illustration and corresponding to the left hand portion of the front elevational view of Figure 4;

Figure 11 is an isometric view of the operating mechanism of the right hand portion of the mechanism contained with the removable housing as viewed from the front, and corresponding to the right hand portion of the front elevational view of Figure 4;

Figure 12 is a detail side elevational view of the lock-out timer mechanism associated with certain of the mechanism shown in Figure 10, the latter not being included in the figure last referred to; and

Figure 13 is a schematic diagram of a hypothetical distribution circuit in which a plurality of circuit breakers of the instant invention have been incorporated.

The switch shown in the drawings is designed for operation on circuits up to 50 amperes at 7500 volts, and the parts as shown on Figures 10 and 11 are drawn on a scale of slightly less than half the size of an automatic circuit breaker constructed as shown in the drawings which was found to operate satisfactorily in the range above noted. The drawings of Figures 4, 5 and 6 are full scale drawings of the switch constructed. A description of the salient elements of the invention will be more readily understood from

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Figures 9, 10, 11, and 12 to which reference may now be had. In this connection reference may also be had to Figures 4, 5 and 6 which are full size front, rear and plan views, respectively, of the switch shown in the figures first referred to. Figures 4, 5, and 6 will be described in greater detail hereinafter. It is believed that a ready understanding of the operation of the circuit breaker of my invention may be obtained from Figures 9, 10, 11 and 12, and hence a description of the elements therein shown and the manner in which they operate will facilitate a better understanding of the other drawings. For convenience of examination, Figure 11 may be arranged at the right hand end of Figure 10.

The removable housing section of the switch comprises a shaft assembly formed by two horizontally extending shafts 1 and 2 of electrical conducting material which are coupled rigidly together with their adjacent ends spaced from each other by a coupling 3 of insulating material. Two current carrying arms 237 of the switch, described in detail hereinafter, are fixed one to each of the outer ends of this shaft assembly and are enclosed within suitable arcing chambers 9 and 10 formed of insulating material. Current carrying sleeves 4 and 5 to which are connected suitable current carrying members are assembled one at each end of the shafts 1 and 2, respectively, opposite their coupled ends and provide a mechanical bearing support for the shaft assembly. The sleeves 4 and 5 for the shafts 1 and 2 have suitable electrical connection with an electromagnet means to be described in detail hereinafter to provide an electric circuit therethrough, together with the base 249 of the switch shunting the insulating coupling 3.

Opening and closing of the switch is accomplished by revolving the shaft assembly formed by the parts 1 and 2 and the insulating coupling 3. Fixed electrical contacts 7 and 8 are carried by the insulating arcing chambers 9 and 10, respectively, so that as the shaft assembly is rotated the current carrying arms 237 are brought into and out of contact with the fixed contacts 7 and 8. The means provided for holding the shaft in either opened or closed position will be described in detail hereinafter.

Rotation of the shaft assembly is accomplished by energy adapted to be stored in a coil spring 11 one end of which is fixed to the shaft 1 and the other end of which is fixed to a spring barrel 12 disposed coaxially of the shaft assembly. Energy sufficient to provide a plurality of switch operations is stored in the spring 11 by rotation of the spring barrel 12 to wind the spring by means of worm shaft 13 arranged for rotation about a vertical axis and positioned so that the worm thereof engages the teeth in the periphery of one side edge of the barrel 12. The spring 11 is retained in wound condition by a ratchet 14 engaging a toothed wheel fixed to shaft 13.

The shaft assembly comprising the shafts 1 and 2, and the insulating sleeve 3 is held in stationary position against the rotational urge of the coil spring 11, when the contact current carrying arms are in contact position with the fixed contacts 7 and 8, by means of a controlling member 15 rigidly fixed or keyed to the shaft 1 of the shaft assembly for rotation therewith. The current carrying arms 237 which are fixed to each end of the shaft assembly are of dual construction, that is, duplicate arms are extended at right

angles to the shaft, 180° apart at each end of the shaft assembly so that the current carrying arms at each end of the shaft assembly are brought into electrical contact with the fixed contacts 7 and 8 during each 180° revolution of the shaft assembly. For this reason the controlling member 15 should preferably be of dual construction, namely, each 180° of revolution of the controlling member must consist of duplicate design features. In the subsequent description of these various dual features of the controlling member 15 I have identified them with the suffixes *a* and *b*, that is all elements thereof numbered with suffix *a* perform the same function for 180° revolution of the controlling member 15 as like elements having the same number but identified with the suffix *b* performed during the other 180° revolution of the controlling member 15.

When the shaft assembly 1, 2 and 3 is revolved to a position where the current carrying arms 237 are in electrical contact with the fixed contacts 7 and 8, the projection 16a on the periphery of the controlling member 15 strikes a projection 20 of a lever arm 21 of a latch mechanism controlling opening and closing of the switch. The lever arm 21 is mounted for pivotal movement about a fixed pivot 22 and when its projection 20 is in engagement with the projection 16a of the controlling member 15 it is prevented from turning by the levers 23 and 24 of the latch mechanism which are assembled in suitable relation with respect to each other to reduce torsional stress. These several levers are held against the turning force of spring 11 exerted through the controlling member 15 by the engagement of a projection 26 at one end of a toggle release latch 27 for a toggle formed by levers 23 and 24 and which latch 27 is adapted to be engaged under projection 25 of the lever 24.

In the 50 ampere-7500 volt switch constructed in accordance with the present disclosure the coil spring 11 was of a strength exerting a force of approximately 15 inch-pounds with the switch held in closed position. Therefore the series of lever arms 21, 23 and 24 are assembled in the manner shown to proportionately reduce the torsional stress at the projection 25 of lever 24, when the same is engaged with the projection 26 of the toggle release latch 27, to a magnitude sufficiently small to make possible the disengagement of the toggle release latch 27 by a comparatively small electromagnetic means E. This reduction of torsional stress on projection 20 of the lever arm 21 to the projection 25 of lever arm 24 determines the magnitude of the magnetic thrust which must be built into the tripping mechanism of the electromagnetic means E for tripping the switch.

In the embodiment of the invention shown on the drawings, the magnet coils of the electromagnetic means E for tripping the switch are in series with the line current and these coils must be of sufficient cross sectional area to carry 50 amperes continuously without undue heating, and must also withstand fault current up to 1000 amperes for a period of two seconds without fusing. For economical utilization in its field of service, such a switch should also be adjustable to be able to trip open on line current fault as low as 3½ amperes. Therefore, by the torsional stress reduction from lever arm 21 to lever arm 24 it is possible to release latch 27 by an electromagnetic means having comparatively large conductor size and proportionally small number of turns, but which has sufficient magnetic urge to

overcome the small frictional engagement of the projection 26 with the projection 25. The use of magnet coils having a small number of turns is important in reducing manufacturing cost, weight and space in the switch assembly. It is also important in reducing reactional electrical stresses on the coils during heavy fault current on the line which would be occasioned on coils having a much larger number of turns.

It will be observed from the structure thus far described that the switch may be tripped open either by action of the electromagnetic means or by manual actuation of a trip lever 35. When being tripped by the electromagnetic means E the magnetic thrust of the rod 177 of the tripping mechanism is brought to bear against the toggle release latch 27 upon the arm 28 thereof. The toggle release latch 27 is pivoted about a fixed pivot at 29 and rests by gravity against the fixed stop peg 48, and the stress of the rod 177 disengages the projection 26 of the toggle release latch 27 from projection 25 of lever 24, allowing levers 21, 23 and 24 to respond to the torsional stress being exerted on projection 20 of lever 21 by projection 16a of the controlling member 15, thereby allowing the controlling member 15, together with the associated shaft assembly and current carrying arms to revolve under urge of the spring 11. The current carrying arms are thus rotated out of electrical contact with the fixed contacts 7 and 8 and the circuit is opened.

The action of lever arms 21, 23 and 24 is as follows, as viewed in the isometric illustration on the drawing shown in Figure 10: When the projection 26 of toggle release latch 27 is forced out of engagement with projection 25 of lever 24 by action of the electromagnetic means E, lever 21 is allowed to revolve clockwise about its fixed pivot 22. The lever 21 is provided with a notch 37 in which the prong 34 at one end of the lever 23 is in engagement. This engagement of the levers 21 and 23 forces the latter to rotate about its fixed pivot 30 in a counterclockwise direction upon clockwise rotation of lever 21, and a peg 32 fixed in the end of lever 23 opposite the prong 34 engages in a slot 33 of lever 24 forcing the latter to revolve clockwise about its fixed pivot 31. When the peg 32 has reached the end of slot 33 adjacent the projection 25, lever 23 has revolved a sufficient distance to permit the prong 34 thereof to pass out of engagement with the notch 37 of the lever 21, and lever 21 is then free to rotate about its pivot 22 permitting projection 16a of the controlling member 15 to escape from engagement with the projection 20 of the lever 21.

The switch may also be tripped open by manual thrust on the trip lever 35, which is pivotally mounted at 38 intermediate its ends. The end of the lever opposite the handle thereof carries a leaf spring 122 which rests against a lever 39 at the end 40 thereof. The lever 39 is pivoted about a fixed pivot 41 disposed intermediate its ends and transmits the thrust imparted by tripping of the lever 35 against a peg 42 carried by the toggle release latch lever 27 at the end thereof in which the projection 26 is formed to force the latter lever out of engagement with lever 24. The subsequent action and motion of lever 21, 23 and 24 is then the same as if tripped by the rod 177 of the electromagnetic means E engaging the arm 28 of the latch release lever 27 previously described. In order to hold the lever 39 in a normally inoperative position, and to have it respond only to manual thrust on the trip lever 35, a leaf spring 42a is fixed at pivot 41 with its

opposite free end disposed at one end to the lever 39 under a fixed stationary peg 43. The tripping force on lever 35 must be sufficient to overcome the force of spring 42a before lever 39 can be moved to trip position. The spring action of the leaf spring 42a being exerted at the fixed pivotal mounting 39 at the pivot 41 is transmitted to the trip lever at the end 40 thereof and holds the trip lever 35 normally in inoperative position against the stationary peg 125, which is positioned to engage the lever 35 below its pivotal mounting 38.

After the switch has been tripped into open position it is necessary to reset levers 21, 23 and 24 together with the toggle release latch 27, such that the projection 20 of lever 21 will engage projection 16b of controlling member 15 without yielding when the switch comes into the next closed position. This is accomplished by means of a retrieving spring 44, one end of which is assembled on peg 22 and which is flexed between a fixed peg 46 and a peg 47 carried by the lever 21. When the switch is tripped, and lever 21 is caused to turn clockwise by the torsional stress of the spring 11 acting through the controlling member 15, the spring 44 is flexed by motion of the peg 47 traveling with the lever 21. When the controlling member 15 has revolved far enough to be disengaged from lever 21, the lever 21 is then revolved in a counterclockwise direction by the spring 44. When the projection formed by the notch 37 at the lower end of lever 21 comes into engagement with prong 34 of lever 23, the lever 23 is caused to rotate in a clockwise direction, and the peg 32 which travels in the slot 33 of lever 24 causes the latter to revolve counterclockwise to position projection 25 of the latter lever over projection 26 of the toggle release latch lever 27. As described above, the toggle release latch lever 27 is pivoted about a fixed pivot 29, and rests by gravity against a stationary peg 48 and consequently responds by gravity to cause the projection 25 to be engaged by the projection 26. The levers just described are now in a position to receive and withstand the force of the shock of engagement of projection 16b of the controlling member 15 with the projection 20 of lever 21 as the switch reaches the next closed position.

In the embodiment of the invention disclosed the retrieving spring 44 is designed to reset levers 21, 23 and 24 to latched position in approximately $\frac{1}{16}$ second, and the time element interposed for this design between tripping and reclosing is adjustable, by means to be hereinafter described, through a predetermined range of 1 to 3 seconds. This relative time required between latching of levers 21, 23 and 24 and reclosing of the switch assures latching of the levers before the switch reaches the next closed position. When the switch trips into open position, the line current is interrupted, and the rod 177 of magnetic tripping mechanism E moves away from arm 28 of the toggle release latch 27 freeing levers 21, 23 and 24 to respond to the action of the retrieving spring 44, as described.

When the shaft assembly has been caused to rotate either by action of the hereinafter described electromagnet means E acting upon the arm 28 of the lever 27, or by manually tripping of the trip lever 35, the shaft assembly carries the current carrying arms 237 out of electrical contact with the stationary contacts 7 and 8. The breaking of contact between arms 237 and the stationary contacts 7 and 8 is rapid as the spring

11 is allowed to exert its full energy without retardation. This rapid action occurs through 45° revolution of the shaft assembly, whereupon the shaft assembly comes into engagement with adjustable mechanical reclosing timing means RT for slowing down the speed of revolution of the shaft assembly and thereby inserting an adjustable time delaying action to the succeeding 90° of revolution of the shaft assembly. When the shaft assembly escapes out of engagement with the reclosing timing means RT it is free to revolve unretarded through the next succeeding 45° of revolution providing for quick closing of the contacts between the current carrying arms 237 with the stationary contacts 7 and 8. In the description of the switch thus far in this closed position the projection 16b of the controlling member 15 comes into mechanical engagement with the projection 20 of lever 21 thereby holding the switch in the next closed position until tripped by the electromagnet means E or by manual actuation of trip lever 35 above described. The controlling member 15 has fixed thereon adjacent its periphery four pegs 17a, 17b, 18a and 18b extending from the face of the controlling member toward the coil spring housing 12 and in parallel alignment with the shaft assembly 1, 2 and 3. The pegs 17a and 18a perform the same function through one operating cycle of the switch, that is, through 180° revolution of the shaft assembly, as the pegs 17b and 18b perform during the next succeeding operating cycle of 180° shaft revolution. Therefore the peg 17a is fixed in controlling member 15 diametrically opposite the peg 17b, or 180° apart, peg 18b is diametrically opposite peg 18a, or 180° apart.

The reclosing timing mechanism RT comprises a pronged wheel 49 having projecting prongs 50, 51, 52, 53, 54 and 55 which are all of the same substantially triangular shape and spaced equally around the circumference of the wheel 49. The prong wheel 49 is rigidly fixed to a horizontally extending shaft 56 to which also a gear wheel 57 is rigidly fixed. The shaft 56 is free to rotate in suitable bearings supported in wall or partition members to be described in greater detail hereinafter. The gear wheel 57 is in meshing engagement with a smaller gear wheel 58 fixed to a horizontally extending shaft 59. The opposite end of shaft 59 has fixed thereto a larger gear wheel 60. The gear wheel 60 is in meshed engagement with a small gear wheel 61 carried on a horizontally extending shaft 62 to which is also fixed a cam or eccentric 63. The shafts 59 and 62 are suitably supported for rotation about horizontal axes in a manner to be hereinafter described. A pendulum arm 64 is pivoted upon a horizontal shaft 65 and has a fork 66 at its upper end which is in engagement with the cam or eccentric 63 in a manner so that revolution of the cam 63 will impart oscillating movement to the pendulum arm 64. A weight 67 is attached to and adjustable lengthwise on the pendulum arm 64 to the side of the pivot 65 opposite the forked end 66. The weight provides for adjustment to either increase or decrease the speed at which the cam 63 can rotate.

When the switch is in closed position, the pronged wheel 49 is stationary with one of its prongs 50 through 55 so located that upon tripping of the switch into open position the controlling member 15 is allowed to rotate freely through 45°. In the position of the parts shown in the drawing, the peg 17a will engage the prong 50 when the latch mechanism is tripped. Upon

tripping the energy of the spring 11 is exerted through peg 17a in a gear-like motion to the pronged wheel 49 and thence through the train of gears 57 through 62 to the cam 63. The pendulum arm 64 responds with oscillating motion to the force of spring 11. Before peg 17a has revolved far enough to become disengaged from prong 50, the peg 18a has mechanically engaged with the next succeeding prong 51 and continues a gear-like transmission of motion to the pronged wheel 49 which was originally imparted by peg 17a. When the controlling member 15 has rotated 90° from the point at which the peg 17a came into engagement with the prong 50, the peg 18a escapes out of mechanical engagement with prong 51 allowing the shaft assembly to rotate freely through the next succeeding 45° into closed position of the switch, at which point the projection 16b of controlling member 15 comes into engagement with the prong 20 of lever 21 holding the switch in closed position until again tripped by the electromagnet means E or by manual tripping of the trip lever 35, as previously described. During this 90° rotation of the controlling member 15, that is from the time the peg 17a engages prong 50 to the time that peg 18a is disengaged from prong 51, the speed of revolution of controlling member 15 and its associated shaft assembly is under control of the pendulum 64, and when peg 18a is disengaged from prong 51 there is no further motion of the pronged wheel 49 with its associated train of gears until the switch is again tripped out of closed position. Prong 52 in the position of the parts shown in the drawings then rests in a position to be engaged by peg 17b for the next operation of the switch.

Referring now to Figures 9, 10 and 12, there is shown a lock-out time mechanism LT the function of which is to lock-out the switch in open position under certain circumstances. The mechanism LT is operative to lock out the switch in open position if after a predetermined number of successive opening and closing operations a fault should reoccur within a predetermined time after the last reclosure. The member of the times the switch is allowed to trip open without remaining closed for this predetermined time, without locking out, is adjustable through a plurality of switch operations and is controlled by the recycling disc 68 shown in detail in Figure 9. For clarity of illustration, the view of the recycling disc 68, that part of the structure shown in Figure 9 has been omitted from the isometric illustration of Figure 10. In order to facilitate an understanding of the lock-out timer mechanism LT, I will explain the action of the lock-out timer as it would operate if no recycling disc such as the disc 68 was used, and thereafter will explain the manner in which the recycling disc 68 functions in the lock-out timer mechanism to provide for adjusting the number of switch operations before conditioning that mechanism to provide for lock-out of the switch in open position if a fault reoccurs within a predetermined time, which time is also adjustable.

When the switch has tripped into open position and the controlling member 15 is rotating with its associated shaft assembly 1, 2 and 3 under control of the reclosing timer RT, the peg 19a, in the position shown in the drawings, which is fixed in the controlling member 15 and extends horizontally in a direction opposite the pegs 17a, 17b, 18a and 18b, comes into mechanical engagement with a lever arm 69 fixed to a horizontally

rotatable extending shaft 70. The shaft 70 is adapted to be rotated in a clockwise direction as the controlling member 15 rotates under the urge of the spring 11. A coil spring 73 (see Figure 9) is fixed at one end by stationary pin 74 and the other end of the spring 73 is fixed to the shaft 70 so that the spring 73 is adapted to be flexed or energized by clockwise rotation of the shaft 70. When the peg 19a and controlling member 15 have rotated a sufficient distance to escape out of mechanical engagement with lever arm 69, there is no further clockwise rotation of shaft 70 and the energy thus stored in the spring 73 is effective to rotate the shaft 70 in a counterclockwise direction. A ratchet wheel 71 is fixed to the shaft 70 and is held in engagement against counterclockwise rotation with a gear 76 of a train of gears. The gear 76 is rotated in a counterclockwise direction by the energy thus expended by spring 73, and this energy is transmitted from gear 76 to the subsequent train of gears 77, 78 and 79 to the escapement wheel 80.

An escapement fork 81 is pivoted about a fixed pivot pin 82, and has a forked end for engagement with the escapement wheel 80 and below its pivotal mounting it is formed to extend into a pendulum arm portion 83. A balance wheel 86 is free to rotate about a pivot 87 carried by an arm 88 so located that a peg 85 fixed in the balance wheel 86 is engaged in a slot 84 of the pendulum arm portion 83.

The rotation of the escapement wheel 80 transmits an oscillating motion to the pendulum arm 83, and this oscillating motion is transmitted to the balance wheel 86 which acts as a pendulum weight to control the speed at which pendulum arm 83 is allowed to oscillate. The arm 88 which supports the balance wheel 86 is pivoted about the fixed pivot 74, and the angular position of the arm 88 is adjustable on a quadrant scale 91 by means of a screw 89 fitting in a slot 90 of the quadrant 91 so that the length of stroke of pendulum arm 83 may be adjusted, and thereby control the time required for the energy of spring 73 to rotate the shaft 70 counterclockwise to its normal position in which the lever arm 69 engages against a stationary stop peg 93 shown in Figures 9 and 10. The lever arm 69 is then in position to be mechanically engaged by peg 19b carried by controlling member 15 diametrically opposite the peg 19a at the next operation of the switch. It will be seen that the motion of the shaft 70 consists of approximately 90 degree rotation clockwise under urge of the peg 19a carried by controlling member 15, while the controlling member 15 is under control of the reclosing timing mechanism RT previously described, and then a counterclockwise rotation of the same angular extent under control of the lock-out timer mechanism LT.

Referring now to Figures 9, 10 and 12, it will be seen that the shaft 70 has fixed thereto a collar 94 for rotation therewith, the collar having an arm 95 projecting axially of the shaft. A second collar 96 is loosely mounted on the shaft 70 in a position so that the arm 95 of the collar 94 is disposed between the prongs 97 and 98 of a fork formed in the collar 96. The prongs 97 and 98 are spaced a sufficient angular distance apart as to allow the arm 95 of the collar 94 to rotate approximately 90° of its angular rotation before transmitting a rotating motion to the loosely mounted collar 96. As the shaft 70 is rotated clockwise under urge of the peg 19a against lever 69, the arm 95 of collar 94 comes into engagement

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with projection 98 of the collar 96, and the point end 99 of the collar opposite its projections 97 and 98, is forced against the diagonally extending free end of a resilient leaf spring member 103. The resilient member 103 is rigidly fixed at its opposite end to a lever arm 100 which is pivoted at one end about a fixed pivot pin 101 and rests by gravity in the position shown in Figure 10. When the pointed end 99 of collar 96 is rotated against the diagonally extending end of the spring member 103, a clockwise rotating motion is transmitted to the spring 103 and the lever 100 about its pivot 101. The pointed end 99 of the collar 96 is forced into a notch 104 at the diagonally extending free end of the spring member 103 when the shaft 70 has rotated to its extreme clockwise position under the influence of the peg 10a. A peg 111 is fixed in lever arm 100 at its end opposite the pivot pin 101 in a position to be directly below a lever locking dog 102. The locking dog lever 102 is pivoted about a fixed pivot pin 105 and rests by gravity with its notched end 106 resting on a stationary peg 108. In this position the locking projection 109 of lever 102 will not be in position to engage any of the prongs 50 through 55 of the pronged wheel 49, when the prong wheel 49 is being revolved by pegs 17a and 13a, or 17b and 13b of controlling member 15 when the switch is operating from open position to closed position under control of the reclosing timer mechanism RT.

When the pointed end 99 of collar 96 is being forced into the notch 104 of the resilient spring member 103, by the clockwise rotation of shaft 70, and a clockwise rotational movement is thereby being transmitted to lever arm 100, the peg 111 in lever arm 100 describes an arc in a general upward direction thereby lifting the adjacent end of locking dog lever 102 until the prong 107 of locking dog lever 102 comes into mechanical contact with a stationary peg 108. This peg prevents any further upward or clockwise motion of locking dog lever 102. In the assembly the locking dog lever 102 is placed in the same plane as the pronged wheel 49, so that when locking dog lever 102 has been moved to its extreme clockwise position and is stopped by the prong 107 engaging against the rigid or stationary peg 108, the locking nose 109 of locking dog lever 102 is then in the position shown in dotted lines on Figure 10 in which position it will mechanically engage any one of the prongs 50 through 55 of the prong wheel 49.

If the switch should be tripped open while locking nose 109 is in the dotted line position, the controlling member 15 with its associated shaft assembly 1, 2 and 3, and current carrying arms 237 would rotate freely through 45° to open the circuit, and the peg 17a of controlling member 15 would then engage prong 50 of the pronged wheel 49 and thereby transmit a clockwise rotational movement to the member 49, the speed of this movement being under control of the reclosing timing mechanism RT, and the prong 54 of pronged wheel 59 would then be brought into mechanical engagement with locking nose 109 thereby preventing any further rotation of controlling member 15 and its associated shaft assembly. The switch would then be held or locked in open position.

In the embodiment of the invention shown, the allowable rotation of controlling member 15 and its associated shaft assembly 1, 2 and 3, when tripping open with the locking dog lever 102 in the locking position indicated in dotted lines

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is 60°, 45° being free motion and the additional 15° taking place after the reclosing timer RT has been set in motion and the pronged wheel 49 is rotated a sufficient angular distance to engage prong 54 with the locking nose 109 in the position indicated in dotted lines. This allowable rotation of controlling member 15 and associated shaft assembly is a design feature and may be increased or decreased without limiting the scope of my present invention.

It will further be observed that resilient spring member 103 must be of sufficient rigidity to transmit the necessary lifting force against gravity to the lever arm 100 and lock-out dog lever 102 without flexing, and yet of a character so that it may flex and have energy stored therein by urge of the pointed end 99 of the collar member 96 if rotary motion of the lever 100 and locking dog lever 102 is prevented.

It will therefore be seen that when the locking nose 109 of the locking dog lever 102 is in its dotted line position it will be in position to lock the switch in open position if the switch should trip open. The locking dog lever will be held in this position as long as the pointed end 99 of the collar 96 is in engagement with the notch 104 of the resilient leaf spring member 103.

The locking dog lever 102 cannot drop to its inoperative position until the pointed end 99 of the loosely mounted collar 96 has been forced out of engagement with the notch 104 of the resilient leaf spring member 103 by counterclockwise rotation of the shaft 70. The counterclockwise rotational speed of the shaft 70 is under control of the lockout timer assembly as in connection with Figure 9, and as previously set out is adjustable by the relative position of the balance wheel 86 and pendulum arm 83 on the quadrant scale 91. As the shaft 70 is rotated counterclockwise by the energy stored in the spring 73 by the clockwise rotation of the shaft 70 and after it has rotated approximately 90% of its allowable angular return motion, the arm 95 of collar 94 is brought into mechanical engagement with the prong 97 of the collar 96 and the pointed end 99 of collar 96 is then forced out of the notch 104 of the resilient leaf spring 103 during the subsequent 10% of the allowable rotation of the shaft 70. Thus, when the end 99 of the collar 96 has been forced out of the notch 104, the locking dog lever 102 drops by gravity to its unlocked position with prong 106 resting on the stationary peg 108 in the present embodiment. In the embodiment of the invention disclosed, I have provided a construction of lock-out timer so designed that the time required for the shaft 70 to revolve counterclockwise and allowing the lockout dog lever 102 to drop to unlocked or inoperative position may be adjustable to a maximum of 45 seconds or a minimum of 15 seconds or may be adjusted for any time therebetween. It will therefore be seen that one operation of the switch consisting of one opening and closing operation, will place the locking nose 109 in the position indicated in dotted lines, and the nose 109 will be held in this position by the pointed end 99 of the collar 96 engaging in the notch 104 of resilient leaf spring 103 until the pointed end 99 has been forced out of the notch by counterclockwise rotation of the shaft 70. If the switch should be tripped open while the locking nose is in the position indicated in dotted lines, the switch will be locked in open position. However, if the switch should remain closed, after tripping and subsequent reclosing for the allotted

time for which the lock-out timer LT is adjusted the pointed end 99 will be forced out of the notch 104 of the spring 103, and the locking dog lever 102 and lever arm 100 and their associated parts will drop by gravity into their inoperative or unlocked positions. The lock-out timer LT, therefore, allows the switch to open and reclose but will lock the switch in open position if a second trip-out occurs within the allotted time to which the lock-out timer has been adjusted.

With the switch locked in open position by any one of the prongs 50 through 55 of the pronged wheel 49 being engaged with the locking nose 109, the frictional engagement of the locking nose with the particular prong, due to the force exerted by coil spring 11 tending to close the switch, is sufficient to prevent locking dog 102 from dropping by gravity to unlocked or inoperative positions when the pointed end 99 is forced out of engagement with notch 104 of the spring 103 at the expiration of the lock-out timer operation, and the switch will then remain in locked open position until the trip lever 35 is manually tripped.

It is desirable to latch the switch in open position during shipping and handling thereof and the like, and I therefore provide a latching lever 112 pivoted intermediate its ends about a horizontally extending pivot pin 113. The lever 112 and pivot pin 113 are arranged in the assembly so that the prong 114 at the upper end of the lever is adapted upon clockwise rotation of lever 112 to bring the prong 114 into mechanical engagement with the end portion 107 of the locking dog lever 102 opposite the locking nose 109 to transmit a lifting motion to the locking dog lever 102 thereby bringing the locking nose 109 into the dotted line position. If the switch is then tripped to open position it will be locked out due to engagement of one of the prongs of the pronged wheel 49 with the locking dog lever. The lower end of lever 112 is extended to form an arm 115 which is disposed between a pair of radially spaced prongs 116 and 117 of a suitable collar 118. The collar 118 is fixed to a vertically extending rotatable shaft 119 rotary movement of which will cause pivotal movement of the lever 112 about its pivot and thereby move the prong 114 of the lever 112 into or out of engagement with the portion 107 of the locking dog lever 102. When the lever 112 is engaged with the locking dog lever 102, the latter cannot move to unlocked position until the shaft 119 is rotated in the opposite direction to disengage the prong 114 from the locking dog lever 102. Indicator member 120 is fixed to the shaft 119 and indicates on a dial 121 the position of the lever 112. The outer end of shaft 119 is suitably formed to be engaged by the recessed end of a suitable insulated hook stick so that the shaft 119 may be safely manipulated by an operator with the switch in position in a live line.

When the switch is in service and has become locked in open position by action of the lockout timer LT, it must be assumed that some electrical fault exists on the circuit under the control of the switch, and the operating procedure would, therefore, be to first make the necessary repairs on the circuit to remove the fault and then allow the switch to close and restore service. Closing of the switch as before mentioned is accomplished by manual tripping of the trip lever 35 which disengages the locking action of locking dog lever 102 from the pronged wheel 49, thereby allowing the controlling member 15 with its associated shaft assembly and current carrying arms to rotate to closed position. Referring again to the

trip lever 35, it will be seen that the spring member 122 is fixed on one end thereto and is so located in the assembly with relation to the locking dog lever 102 that when trip lever 35 is in its inoperative position resting against the peg 125 and locking dog lever 102 is in locked position, the rigid extension arm 123 of locking dog lever 102 is immediately adjacent to the spring member 122. Thus, in tripping of lever 35 force will be transmitted by the spring member 122 to the extension 123 of the lockout dog lever to force the latter out of engagement with the pronged wheel 49. The spring member 122 is of sufficient rigidity to overcome the frictional engagement of the locking dog lever 102 with the pronged wheel 49 without flexing. However, if the lever 35 should be tripped while the locking dog lever 102 is being held in locked position by engagement of the prong 114 of the lever arm 112 with locking dog lever 102, the flexible member 122 would flex without distortion, and any further motion of lever 35 would be prevented by the latter coming into engagement against a rigid peg 124 positioned opposite the peg 125 and to the other side of the lever 35.

When the switch is locked in open position and the trip lever 35 tripped to disengage the locking dog lever 102 from the pronged wheel 49, the motion of trip lever 35 also transmits movement to the manual trip lever 39 through the spring 122 by its engagement with the end portion 40 of lever 39, and the locking nose 26 of the toggle release latch 27 will be moved out of its locking position with the prong 25 of lever 24 by engagement of the manual trip lever 39 with the peg 42 fixed in lever 27. However, no movement of levers 21, 23 or 24 takes place as they are held in stationary position by the retrieving spring 44. Also, the projection 25 of lever 24 is not under stress to engage projection 26 of toggle release latch 27 until the switch has rotated under control of the reclosing timer to its closed position.

The action of the lockout timer LT, as so far described, will lock the switch open after the second trip-out, if the second trip-out occurs within the time which the lockout timer is adjusted to release the locking mechanism to unlocked or inoperative position. Terminology of the art would designate this action as "two shot."

In order to provide for a number of successive trip-outs before lock-out to be adjustable, and for a plurality of switch operations greater than two, I have provided a recycling disc 68, the mechanical function of which is to prevent the peg 111 in lever 100 from lifting locking dog lever 102 into locking position until a predetermined number of switch operations have occurred.

It will be seen that the recycling disc 68 is pivotally mounted about a pivot pin 126, and is provided with a substantially radially extending arm 138 terminating in a pointed end 140. A quadrant 147 is arranged in the assembly of the lockout timer LT with its radial center at the pivot 126 for the recycling disc 68. A movable lug 141 is adjustable on the quadrant 147 and acts to hold the arm 138 of the recycling disc 68 with the pointed end 140 thereof in any of the positions indicated at 142 to 146 on the quadrant 147 against a counterclockwise rotation by gravity of the recycling disc 68. The recycling disc 68 is designed so that its center of gravity will normally tend to cause the disc to rotate counterclockwise about its pivot 126 when the pointed end 140 of the arm 138 is in any angular

position between positions 142 through 148 on the quadrant 147. If desired a spring may also be incorporated to assist or replace gravity as the force tending to impart the counterclockwise rotation to the recycling disc 68 without altering the concept of the recycling disc of my present invention. In the particular embodiment of my invention disclosed, approximately one-half portion of the recycling disc 68 has been provided with five prongs shown at 127 through 131, each prong being spaced 30° apart. The other half portion of the disc is provided with a relatively deep notch 132 and with a plurality of smaller notches 133 through 137, these smaller notches also being placed 30° apart. The recycling disc 68 is suitably mounted in the assembly of the lockout timer LT in a position relative to the controlling member 15 such that if the switch was tripped open when the arm 138 was resting against the adjustable lug 141 with the pointed end 140 thereof at position 146 on quadrant 147, the peg 19a in controlling member 15 would come into mechanical engagement with prong 131 of the disc 68 after the controlling member 15 had rotated 45° freely and an additional 5° under control of the reclosing timer RT. In this manner a clockwise rotation is imparted to recycling disc 68, and the continued rotation of controlling member 15 will cause the peg 19a to pass out of engagement with prong 131 of the recycling disc when the latter had rotated 30° in a clockwise direction. The recycling disc 68 would then rotate counterclockwise by gravity to its original position with the pointed end 140 thereof at position 146 on quadrant 147. The continued rotation of controlling member 15 in moving toward closed position would then bring peg 19a into engagement with lever 69 and thereby force the pointed end 99 of the collar 96 into the notch 104 of the resilient leaf spring member 103, and transmit a lifting motion to the lever 100 as previously described.

The lever 100 has a recycling peg 139 fixed in the free end thereof and in such relative position with respect to the recycling disc 68, that clockwise motion of the lever 100 about its pivot 101 will bring the recycling peg 139 into engagement with the notch 137 of the recycling disc 68 and prevent lever 100 from moving a sufficient distance to allow the peg 111 to lift the locking dog lever 102 into locking position. The recycling peg 139 will remain in notch 137 under flexing stress of the resilient spring member 103 until the pointed end 99 of the collar 96 has been forced out of notch 104 of the spring member 103 by counterclockwise rotation of the shaft 70 under control of the lockout timer LT.

If the switch is tripped open again before the lockout timer has released the frictional engagement of recycling peg 139 from notch 137, the peg 19b of controlling member 15 will next come into engagement with prong 131 of the recycling disc 68 during the next switch operation and thereby rotate the recycling disc 68 in a clockwise direction 30° before escaping from the prong 131. The recycling disc 68 will then have been advanced in a clockwise direction to a position with the recycling peg 139 engaged in notch 136 and with prong 130 in the position previously occupied by prong 131. The pointed end 140 of arm 138 will then be in the position indicated at 145 on the quadrant scale 147. The force being exerted by spring 11 during operation of the switch is sufficient to overcome the frictional engagement of peg 139 from any of the notches

133 to 137 while recycling disc 68 is being engaged by peg 19a or 19b of controlling member 15, but the frictional engagement of recycling peg 139 with any of the notches 133 to 137 is sufficient to prevent recycling disc 68 from rotating counterclockwise by gravity.

It will therefore be observed that each successive operation of the switch, if occurring within the time allowed for the lockout timer LT to release the frictional engagement of recycling peg 139 from the recycling disc 68, will advance the recycling disc 68 an angular distance of 30° in a clockwise direction, and, that after five successive opening and closing operations of the switch, recycling disc 68 will have been advanced to a position with recycling peg 139 engaged in notch 133 and with the pointed end 144 of the arm 138 registering at the position indicated at 142 on the quadrant 147, and with the prong 127 now in the position originally occupied by the prong 131. If the switch should now be tripped a sixth time without recycling disc 68 having been released by the lockout timer, the prong 127 would be engaged by peg 19a of controlling member 15, and the notch 133 would be forced out of engagement with the recycling peg 139, whereupon peg 139 would immediately move into the deep notch 132 by the spring 103 acting on lever 100, thereby allowing lever 100 to move upward causing the peg 111 carried by lever 100 to lift the locking dog lever 102 into locking position and the switch would then become locked in open position.

Thus, it will be seen that when the adjustable stop lug 141 is positioned on the quadrant 147 to hold the pointed end 140 of the arm 138 in position indicated at 146, the switch would lock open after being tripped open six successive tripouts and this locking adjustment in the terminology of the art would be called "six shot." If it should be desired to have the switch lock open after five successive tripouts in the modification of the invention disclosed, the lug 141 would be adjusted on the quadrant 147 to hold the pointed end 140 of disc 68 in the position indicated at 145, and all features and operations of the recycling disc 68 would then have been advanced one operation closer to the position where the recycling peg 139 can move into notch 132 and allow the locking action to take place.

Adjusting of the stop lug 141 to the position indicated at 144 on the quadrant 147 would advance the recycling disc 68 still another operation toward lockout position, and the switch would lock open after four successive tripouts. Using position 143 on quadrant 147, the switch would be locked open after three successive tripouts, and by positioning the lug 141 at the position indicated at 142 on the quadrant, the switch would lock open after two successive tripouts.

However, if the switch should remain closed after any operation, for the length of time required for the lockout timer to force the pointed end 99 of the loose collar member 96 out of engagement with the notch 104 of the leaf spring member 103, the frictional engagement of recycling peg 139 with the cycling disc 68 would be released and recycling disc 68 would then revolve counterclockwise by gravity into the position at which it was set on quadrant 147 and a new complete lockout cycle would be started when the switch was again tripped.

When the switch has been locked open from successive openings and closings the recycling peg 139 rests in notch 132 of the recycling disc 68 until released by the lockout timer forcing the pointed end 99 of the collar 96 out of notch 104

of the leaf spring member 103. However, the prong 127 of the recycling disc 68 remains engaged with either peg 19a or 19b of controlling member 15 in the position where rotation of the controlling member 15 was caused to be stopped by locking engagement of the lockout dog lever 192 with the pronged wheel 49. In this locked position, the recycling disc 68 has been advanced 15° in a clockwise direction from the position indicated at 142 on the quadrant 147 by the clockwise motion transmitted to the recycling disc 68 by the pegs 18a on 19b moving against the prong 127, before the locking action took place, and the recycling disc 68 is held in this 15° advance position against counterclockwise rotation by gravity by the prong 127 remaining engaged with either the peg 19b or peg 19a of the controlling member 15.

When the locking action of the locking dog lever 102 with the pronged wheel 49 has been released by manual thrust on the trip lever 35, the controlling member 15 is then permitted to continue rotation into closed position, and the pegs 19a or 19b, whichever is engaged with the prong 127, will impart an additional 15° clockwise rotation to the recycling disc 68 before passing out of engagement with prong 127, and recycling disc 68 will then drop counterclockwise to the set position on quadrant 147.

It will therefore be observed that if the switch should be put into closed position by tripping of lever 35, after having been locked open by the lockout timer, and a fault should still exist on the circuit of sufficient magnitude to trip the switch successively until it is again locked open, that the number of tripouts occurring before locking open would be one less than the number at which the recycling disc 68 was set. However, if there was no fault on the line, and the switch was closed by tripping of lever 35, and if the switch remained closed for the time necessary for the lockout timer to release the locking dog lever to its normal or inoperative position, the switch would then again operate through the same number of operations for which it was set before locking out. This feature is of advantage it will be seen that one operation of the switch, which would otherwise be unnecessary, is eliminated if the switch should be closed, directly on a faulty circuit from which it has been locked opened, without the fault first having been repaired.

It will be observed that the design of the recycling disc 68 described above provides for the number of tripouts before lockouts to be adjustable from 2 to 6 inclusive. However, it will be understood that the design may be extended to provide for more than six operations without effecting the scope of my present invention.

The function of the electromagnetic overload trip mechanism E shown in Figure 11 is to provide a means whereby the current passing through the switch is used to produce magnetic action to release the latch member 27, which holds the switch in closed position, when line current reaches a predetermined magnitude, and thereby allow the switch to trip into open position. Means are also incorporated in the electromagnet mechanism E to impose an adjustable time delay action upon the tripping mechanism such that the time required to elapse before tripping is inversely proportional to the magnitude of the line current in excess of that for which the tripping mechanism was set to operate. Also, further means are provided to limit the inverse proportional characteristics of the time delay such that the time delay becomes definite after

a predetermined line current has been reached, regardless of this increased magnitude of line current. Adjustable means are also provided such that an instantaneous tripping action may be superimposed upon the time-delay to trip the switch when line current reaches a predetermined magnitude in excess of the current at which the tripping mechanism was set to operate.

In the embodiment shown in Figure 11, the electromagnetic means E comprises six coils 150 through 155 connected in series such that current passing through the coils will produce an accumulated magnetic effect of ampere turns in the U-shaped magnet 149 in proportion to the current and the number of turns, and the magnet bar 164 is so located in the assembly in relation to the U-shaped magnet 149 that the magnet bar 164 will not respond to the U-shaped magnet until a magnetic urge produced by approximately 750 ampere turns on the U-shaped magnet has been reached.

The incoming lead of the coil 150 is connected electrically to the contact-sleeve 5, thence through shaft 2, and thence through the associated current carrying arm 237 to the contact 7, the other end of coil 150 being connected to a terminal lug 156.

The incoming lead of coil 151 is connected to terminal lug 156 and the outgoing lead thereof is connected to a terminal lug 157. The several coils 152, 153, 154 and 155 are connected in the same progressive manner to the several contact lugs 157 through 161. The contact lugs 156 to 161 inclusive, have threaded tap holes therein, and are mounted rigidly in a suitable insulated support in the assembly so that the several lugs register coaxially with holes in the flexible fingers of the member 162. The plate member 162 is of electrical conducting material and is rigidly mounted in the assembly in such a position that the fingers, when unflexed, are not in contact with any of the contact lugs 156 to 161 inclusive. The member 162 is connected electrically to the metal base plate 249 of the switch structure and thence through contact sleeve 4 to shaft 1 and then through the current carrying arm to the fixed electrical contact 8. A threaded stud 163 is provided for making electrical contact with any one of the terminal lugs 156 to 161, inclusive, with its corresponding finger of the plate member 162 by engaging the stud in the selected threaded hole and its associated terminal lug, thereby flexing the selected finger of plate member 162 into contact with its associated terminal lug. It will therefore be seen that the number of turns which become magnetically effective on the U-shaped magnet 149 by current passing through the switch is determined by the particular terminal lug which is brought into electrical contact with an associated finger therefor of the plate member 162. In the switch described herein the number of turns per coil is such as produce approximately 750 ampere turns on the U-shaped magnet 149, when five amperes passes through terminal lug 161, ten amperes through lug 160, 15 amperes through lug 159, 20 amperes through the lug 158, 30 amperes through the lug 157, and 50 amperes through the terminal lug 156.

A magnet bar 164 is arranged adjacent the end of the U-shaped magnet 149 and is hinged at one end upon a pivot pin 165 to yieldingly support a supporting member 166 of non-magnetic material. The member 166 is rigidly fixed in the assembly at its forked ends 167 and 168 to the base 249 with its opposite end flexed upon the edge of

an eccentric dial member 169. The dial member 169 is pivoted about a fixed pivot pin 170 in such manner that the dial member 169 can be rotated by manually overcoming the friction of the dial member 169 with its pivot pin 170. Various positions to which the member 169 may be positioned are indicated on a scale 171 fixed to base 249 in juxtaposition of the member 169. Movement of the arm 169 into any of the several positions on the scale 171 changes the magnetic gap between the U-shaped magnet 149 and the magnet bar 164 by raising or lowering the ends of the non-magnetic member 166 which carries pivot pin 165 to which bar 164 is pivoted. The dial member 169 is provided with a cam surface engaging the free end of member 166 and the parts are so designed so that upon setting of the arm at the position marked "0.7" on the scale 171, the magnetic gap between the U-magnet 149 and the magnet bar 164 will be such that the bar 164 would be set into motion by a magnetic force occasioned by $\frac{1}{2}$ of 750 ampere turns in the particular embodiment of the invention disclosed. In like manner, setting of the arm 169 of scale 171 at the position shown as 1.1 would increase the magnet gap such that $1\frac{1}{2}$ times 750 ampere turns would be required to actuate magnet bar 164. It will therefore be seen that the various positions at which the arm 169 may be set with respect to the scale 171 indicates the decimal multiplier applicable to any of the terminal lugs 156 to 161 inclusive, which may be caused to contact the member 162, in determining the ampere load at which the switch will trip. In the description of my invention to follow, the action of the magnet bar 164 will be predicated on the assumption that the arm 169 is set in position 1.0 on scale 171, in which position the magnetic bar 164 will be attracted by 750 ampere turns.

A leaf spring 172 is fixed rigidly at one end adjacent the hinged end of magnet bar 164, and the free end of the spring member is flexed over a roller 173 carried on a peg rigidly fixed in one end of an arm member 174. The arm member 174 is free to rotate about the shaft 175, but its clockwise rotation is limited by engagement against a rigidly fixed peg 176. The force of the spring 172 occasioned by its engagement with roller 173, with the arm 174 resting against the peg 176, holds the magnet bar 164 in a position where the arm 178 carried at the end of the magnet bar 164 opposite its pivoted end is in engagement with the trip arm 177 carried by and rigidly fixed in the end of arm 174 opposite the end carrying peg 173. The magnet bar 164 is held in this position by the leaf spring 172 against any magnetic stress occasioned in the magnet bar 149 by less than 750 ampere turns. A coil spring 179 is attached at one end to the trip arm 177, and the other end of the spring is attached to the adjacent end of the magnet bar 164 by an adjustable screw 180. The screw 180 provides for adjustment of the tension of the spring 179, and it will be seen that if spring 179 was not used, that magnet bar 164 would overcome the tension of spring 172 and be moved directly against the ends of the U-magnet 149 when 750 ampere turns are carried in the electric circuit. However, with the spring 179 assembled as shown and described, the motion of magnet bar 164 is transmitted by spring 179 to the arm 174 thereby moving the arm 174 counterclockwise about the shaft 175 and away from the peg 176. The roller 173 carried by arm 174 is thus moved in a counterclockwise direction

thereby producing an additional flexing stress in spring 172. This additional flexing stress on spring 172 occasioned by counterclockwise motion of the peg carrying roller 173 while magnet bar 164 is being moved toward the U-magnet 149, counteracts and balances the accumulative increase which occurs in the magnetic urge on magnet bar 164 due to the progressive shortening of the magnetic gap between the bar 164 and the ends of the magnet 149 as the magnet bar 164 approaches the U-magnet 149. When the magnet bar 164 has been brought against the U-shape magnet 149, the trip bar 177, if unretarded, would have been carried therewith by the urge of spring 179 holding the trip arm 177 against the arm 178 and in this position trip arm 177 would engage the arm 28 of the toggle release latch 27 and allow the switch to trip into open position. It will therefore be seen that if the free motion of lever arm 174 was not controlled by a retarding means, that the switch would trip open immediately when 750 ampere turns were impressed on the U-magnet 149.

In order to provide a means for interposing a time delay action to the motion of the trip arm 177, it will be observed that I provide an arm 181 which is rigidly fixed at one end to the arm 174. A trunnion 182 is carried by the other end of 181 and in parallel alignment with the shaft 175 so that rotating motion of the arm 174 about shaft 175 will cause the axial line of trunnion 182 to describe an arc around the shaft 175. A latch 183 is assembled on the trunnion 182 for rotation relative thereto, and it is assembled in rotational alignment with the rotational plane of a first gear 189 of a gear train. A ratchet prong 184 formed as part of the latch 183 normally rests by gravity in the teeth of the gear 189. The gear 189 is free to rotate counterclockwise around the fixed shaft 175, but it is in mesh with a gear 190 of a train of speed increasing gears 190, 192, 193, 195 and 196, which are assembled in conventional manner on fixed shafts 191, 194 and 197. These shafts are free to rotate in suitable bearings. When the magnet bar 164 responds to magnetic urge of the U-magnet 149, the motion of magnet bar 164 is transmitted through the spring 179 to trip arm 177 and a counterclockwise rotation is transmitted to arm 174 about the shaft 175. This causes trunnion 182 to move counterclockwise in an arc around shaft 175. Since the ratchet member 184 is engaged between the shaft 182 and the gear wheel 189, the gear 189 and the train of gears 190 through 196 are caused to be driven. The speed at which trip arm 177 is allowed to approach the toggle release latch 28 is proportional to the rate at which the magnetic urge of magnet bar 164 can transmit acceleration through the spring 179 to the train of gears. To provide a means of adjusting the extent to which the train of gears is allowed to control the motion of trip arm 177, a pointer arm 186 is assembled on a shaft 175 having a peg 187 rigidly mounted therein. The pointer arm 186 is adjustable to various positions on a scale member 188 adjacent the arm 186 and is so located in the assembly that the lip 185 of the member 183 will engage the peg 187 and thereby lift the ratchet arm 184 out of engagement with the teeth of the gear 189. This will occur when the gear 189 has rotated to the angular position where the lip 185 engages with the peg 187 which is determined by the setting of pointer arm 186 with respect to the scale 188.

When the ratchet prong member 184 has been disengaged from the gear 189 there is no further retardation to the free motion of the trip arm 177 and its associated parts whereupon the trip arm 177 moves freely into trip position against the toggle release latch 28.

When the switch has tripped open, the line current is interrupted, and magnetic urge on the magnet bar 164 ceases whereupon the spring 172 returns the magnet bar 164 into position with the arm 174 disposed against the stationary peg 176 in which position the ratchet prong 184 engages with a tooth of the gear 189. The tripping mechanism and time delay are now in position to perform through another operating cycle when line current again exceeds 750 ampere turns.

It will therefore be observed that the time required for the trip arm 177 to reach tripping position against the toggle release latch 28 is inversely proportional to the excess of line current above that at which the tripping mechanism is set to operate, and that if, after having moved part way toward trip position, the line current should recede to the below tripping magnitude, the magnet bar 164 and all moving parts associated therewith would be returned to normal or inoperative position by the force exerted by the spring 172. However, if heavy fault current should occur of sufficient magnitude to immediately overcome the tension in springs 172 and 179, the magnet bar 164 would be drawn to the U-magnet 149 immediately, but the tripping motion of the rod 177 would still be controlled by the speed at which the power stored in spring 179 could rotate the train of gears 189 through 196. As this train of gears start rotating, under this condition, the tension on the coil spring 179 is progressively lessened as the arm 177 moves toward the bumper arm 178, and any progressive increase in momentum of the train of gears is prevented by this progressive lessening of the urge or force of spring 179 such that the gear train rotates at a constant speed until ratchet 184 becomes disengaged from the gear 189 and tripping action takes place. It will therefore be observed that if the tension on spring 179 was so adjusted by the screw 190 that the bumper arm could not be moved away from trip arm 77 by magnetic stress on magnetic bar 164 occasioned by less than 1500 ampere turns, or 100% in excess of trip setting, that the time required to trip would be inversely proportional to the magnitude of line current between trip setting and 100% above trip setting. However, if fault current should occur in excess of 100% over trip setting the time of tripping would be constant regardless of the magnitude of the current over 100% of the trip setting, and this time element is adjustable by position of the pointer 186 on the scale 188. The coil spring 179 also has another function when fault current occurs of sufficient magnitude to immediately overcome the tension of springs 172 and 179 and draw magnet bar 164 directly to the U-magnet 149. Under this condition, the train of gears 189 through 197 providing the time delay has prevented the arm 174 from moving counterclockwise and therefore no motion of the peg carrying roller 173 on the member 174 has occurred and cannot occur until the gear train starts in motion by force of spring 179. As previously explained, the counterclockwise motion of the peg carrying roller 173 produces an additional flexing stress on spring 172 to counteract the proportional increase in magnetic urge of bar 164 as the magnet bar 164

approaches the U-magnet 149. If this necessary counterstress was not exerted against the increasing magnetic stress on magnet bar 164, and line current should recede below tripping magnitude, the tripping mechanism would not be retrieved and the switch would trip open. However, it will be seen from the construction, that as magnet bar 164 is moved toward the U-magnet 149, and if the fault current is of such magnitude as to overcome the delaying action of the gear train, that the advance movement of magnet bar 164 must flex the spring 179 and this flexing of spring 179 in addition to the incomplete flexing of spring 172 counteracts the increased magnetic stress as magnet bar 164 approaches the U-magnet 149. Thus if the fault current recedes below tripping magnitude before tripping action occurs, the tripping mechanism will be retrieved and the switch will remain closed.

If instantaneous tripping is desired without any time delay when the line current produces 750 ampere turns in the particular switch described, the pointer 186 should be placed in its extreme clockwise position on the scale 188. In this position the peg 187 is engaged under the lip 185 and holds the ratchet 184 out of engagement with the gear 189. The trip arm 177 and its associated assembly is then free to move in response to movement of magnet bar 164 without engaging the train of gears 189 to 196 inclusive.

Under certain conditions it may be desirable to have the switch trip open immediately on fault current, independent of time delay, but only if the fault current is of sufficient magnitude to overcome the tension of spring 179 and draw magnet bar 164 directly against U-magnet 149, under such conditions, for example, which would exist as described above by fault current producing 1500 ampere turns. To perform this function an arm 198 is frictionally attached as by a rivet to the end of magnet bar 164 adjacent its free end so that the free end 200 of the arm 198 may be adjusted into the position shown in dotted lines so that the arm 198 travels directly with magnet bar 164. If the arm 198 is adjusted to its dotted line position it will come into engagement with the toggle release latch 28 and trip the switch open, independent of time delay by action of fault current of sufficient magnitude to overcome the tension of the spring 179. If the arm 198 is adjusted to the position shown in full lines, it will not engage the toggle release latch 28 and the tripping action can take place only when trip arm 177 has reached toggle release latch 28 under control of the time delaying gear train 189 through 197.

In the design and association of the time delay assembly for the electromagnetic means E it is necessary that the train of gears 189 to 197 be of such relative size and mass that the speed of rotation be in proportion to the power exerted by magnet bar 164 through spring 179 in order to obtain the coordinated action described above. The only momentum which can be allowed to accumulate in the gear train is that quantity sufficient to maintain constant speed in the gear train during the gradual lessening of the force of spring 179 when the latter has been fully flexed by movement of the magnet bar 164 in being drawn directly to the U-magnet 149 by fault current in excess of 1500 ampere turns.

In the particular switch shown in the drawings the total mass of the gear train 189 to 197, inclusive, is approximately $\frac{1}{16}$ oz., and the total mass

of gear 196 and shaft 197 is approximately $\frac{1}{200}$ of an oz., with the diameter of gear 196 being approximately $\frac{1}{8}$ inch.

The coil spring 179 is of a character possessing flexing characteristics which may be adjusted by the screw 180 so that if magnet bar 164 is drawn directly to the U-magnet 149 by excessive fault current, the energy stored in the spring 179 will cause the gear train to rotate into extreme tripping position in one second, and during this action of the gear train the speed of gear 196 is approximately 5000 R. P. M. It will therefore be seen that by the use of comparatively small mass and of proportionately high velocity the rotational speed of the gear train is governed largely by the centrifugal force exerted by magnet bar 164 and spring 179. When the ratchet member 184 has been disengaged from the teeth of gear 189, the motion of the gear train ceases and the small amount of momentum in the gear train is not sufficient to cause the gear train to continue to rotate or coast after energy supplied by movement of the magnet bar 164 and the coil spring 179 has ceased. The elimination of coasting of the gear train is necessary as the switch may be closed in one second after tripping open, and if a fault continued to remain on the line, the gear train would be immediately engaged by the tripping mechanism, and if momentum was still carrying the gear train the time element would not be constant as when accelerated from idle position.

It is a feature of the switch of my present invention to provide one in which the total weight of all parts constituting the removable housing section can be of relatively small size and light weight and therefore all stresses must be limited to an extent such that extremely heavy fault current cannot exert destructive forces on the relatively small and light members of the assembly. In the embodiment shown, there is a total of 150 turns of wire on U-magnet 149 which would be in series if the switch was set to trip on five amperes of line current, thereby producing 750 ampere turns on the magnetic circuit, and if fault current of 1000 amperes should occur on the circuit the magnetic circuit would be subjected to 150,000 ampere turns. Therefore, the relative cross-section of metal in the magnetic circuit, and the length of magnetic circuit is so constructed that magnetic saturation of the magnetic circuit of U-magnet 149 and magnet bar 164 is reached at approximately 2000 ampere turns. In this manner the force that may be exerted by magnet 164 is limited to a magnitude produced by 2000 ampere turns regardless of the number of ampere turns in excess of 2000 which might occur in the winding of U-magnet 149.

Sufficient energy to operate the switch through a plurality of open and closing operations is stored in the coil spring 11 (see Figure 10), one end of which is fixed to the shaft 1 with the other end fixed to the spring barrel 12. The spring 11 is wound to store energy therein by manually rotating the worm gear 13 by means of an insulated hook stick when the switch is in its position in the line, to rotate the spring barrel 12 about the shaft 1. In this manner the spring is wound around shaft 1 and tension is held in spring 11 by means of the ratchet 14.

Only a portion of the energy stored in spring 11 can be used for correct operation of the switch, as the spring 11 must be flexed to some extent from free condition before sufficient torsional inch pounds are stressed on the shaft assembly to cause

the switch to operate properly. Therefore the usable range of the stress of spring 11 is limited by complete flexing and minimum operating flexing. In the embodiment of the invention shown, that is, for a 50 ampere 7500 volt switch this usable stress will cause the switch to open and close 19 times and trip open the 20th time. If the switch performs 19 consecutive closing operations after full winding and trip the 20th time without the spring 11 having been rewound, the switch becomes automatically locked open against any further attempt to operate until rewound. Provision is also made to prevent overwinding and breaking of spring 11 by preventing further rotation of worm gear 13 when spring 11 becomes fully wound. Structure is also provided to give a visible indication of the number of operations which the switch has performed and the number of possible operations remaining before rewinding is necessary.

The indicating mechanism comprises in general a vertically extending rotatable shaft 206 extending through the base member 249 and is assembled in suitable bearings so that its axis extends at right angles to the longitudinal axis of shaft 1. The shaft 206 has fixed at its lower end a pointer member 207. A dial 208 is rigidly fixed in the housing structure adjacent the bottom surface of base 249 and is located in relation to the pointer 207 so that the rotational position of shaft 206 is indicated by the pointer 207 on the dial 208. A bevel gear 204 fixed to the upper end of the shaft 206 and, in the particular embodiment disclosed, is provided with 22 teeth. A pair of pronged wheels 203 and 216 are mounted for rotation about a horizontal axis in juxtaposition of the gear teeth of the bevel gear 204 and are provided with ten prongs each. The pronged wheels 203 and 216 are assembled on suitable trunnions 219 and 220, respectively, on opposite sides of the bevel gear 204 with the axes of the trunnions 219 and 220 in coaxial alignment and parallel with the axis of shaft 1. The prongs of pronged wheels 203 and 216 have meshing engagement with the teeth of the bevel gear 204. A pair of leaf springs 205 and 217 each having one end rigidly fixed upon the base plate 249 are formed so that their free ends engage between the prongs of the pronged wheels 203 and 216, respectively, and are provided to exert flexing force to hold the pronged wheels in fixed rotational position. A double end arm 202 is rigidly fixed or keyed to shaft 1 and rotates therewith. The arm is fixed to the shaft 1 so that it is in rotational alignment with the pronged wheel 203. The outer ends 202a and 202b of the arm 202 are of such radial distance, from the center of shaft 1, that one prong of the pronged wheel 203 is adapted to be engaged by either end of the arm member 202. Each 180 degree rotation of shaft 1 would constitute one operation of the switch. The arm 202 is fixed to shaft 1 in such angular relation to the controlling member 15 that the ends 202a and 202b of the arm 202 are adapted to engage the pronged wheel 203 while shaft 1 is rotating into closed position under control of the reclosing timer RT. It will therefore be observed that one closing operation of the switch will cause the pronged wheel 203 to rotate clockwise $\frac{1}{20}$ of its circumference and it will cause the bevel gear 204 to rotate to $\frac{1}{22}$ of the circumference of the bevel gear 204. This rotation of the bevel gear 204 is transmitted to the pronged wheel 216 causing the latter to rotate $\frac{1}{20}$ of its circumference in a counterclockwise direction. The force exerted

by arm 202 against the prong of the pronged wheel 203 is sufficient to overcome the holding stress of the leaf springs 205 and 217, and the springs 205 and 217 are adapted to again seat themselves between adjacent prongs of the pronged wheels 203 and 216, respectively, in the next succeeding position as the arm 202 escapes from a prong of the pronged wheel 203.

Therefore in the embodiment disclosed 19 closing operations of the switch will cause the bevel gear 204 to move to $19/22$ of its circumference, and the pointer 207 carried on the shaft 206 with the bevel gear 204 will have indicated 20 positions including starting position on the dial 208. These 20 positions on the dial 208 are marked and numbered and, the two unused positions on the dial 208 are preferably designated by colored segments 231 to provide visual calculations of the relative position of the pointer 207 with segment 231 at distances too great to actually read the position numbers on the dial 208.

When the switch has tripped open and reclosed 19 times, without being rewound, it is necessary that the switch be prevented from further operation after the 20th trip-out. In order to accomplish this a vertically extending peg 209 is rigidly fixed adjacent the periphery of the bevel gear 204 for travel therewith. The peg is so located in relation to the other elements of the assembly, that after 18 reclosing operations of the switch (without rewinding of spring 11) the peg 209 has been advanced by counterclockwise rotation of the bevel gear 204 to be in the position shown in dotted lines in Figure 10 and directly adjacent the end 221 of a horizontally movable locking bar 211. The locking bar 211 has fixed therein and extending upwardly of its upper surface a peg 213. The locking bar is slidably assembled in a slotted supporting member 212 fixed to the upper surface of base plate 249. The bar 211 is normally held by means of a spring 214 suitably associated with the slide bar 211 and the slotted member 212 to exert force tending to urge the locking bar 211 to cause peg 213 to engage against a flange of the member 212 at the end thereof extending toward the shaft 206. The opposite end of locking bar 211 is formed with a diagonal edge 222 which is adapted to engage a rigid peg 215 fixed in the base 249 of the switch housing. In this position the long lengthwise edge of locking bar 211 is directly adjacent the depending portion of arm 123 of the locking dog lever 102. If the switch should now operate the 19th time, the reclosing operation would advance the peg 209 in the gear 204 one position and this motion of the peg 209 against the adjacent end 221 of the locking bar 211 would overcome the force of spring 214, and move the diagonal end 222 of the locking bar against peg 215 thereby transmitting a sidewise movement of the locking bar in the slot 218, allowing the long lengthwise edge of the locking bar to move against the arm 123 of the locking dog lever 102 lifting the dog lever 102 into locking position. In this position, the switch will remain locked open if it should be tripped open the 20th time.

The force of springs 205 and 217 engaged in the prongs of the pronged wheels 203 and 216, prevent the spring 214 from imparting clockwise rotation to the bevel gear 204. The frictional engagement of the diagonal end 222 of the locking bar 211 against the stationary peg 215 is sufficient to withstand the flexing stress of the flexible member 122 carried at the end of trip lever 35 if manual thrust is imparted to the trip lever. The locking bar 211 therefore remains in this locked

position until the switch is rewound. When the switch is rewound, the peg 209 is moved away from end 221 of locking bar 211 by clockwise rotation of the bevel gear 204, and the locking bar 211 responds to urge of spring 214 and moves into unlocked position allowing the locking dog lever 102 to drop to its unlocked or inoperative position by gravity.

The winding mechanism of my invention comprises an arm 223 formed by a pair of diametrically opposed rigid arm members 223a and 223b fixed 180° apart to the hub of the spring barrel 12 for rotation therewith. A flexible leaf spring member 224a is fixed at one end to the arm member 223a, and a flexible leaf spring member 224b is fixed at one end to the rigid arm member 223b so that these several members of the winding mechanism all rotate with the spring barrel 12 as the spring 11 is being wound. The outer ends of the spring members 224a and 224b are assembled in rotational alignment with the plane of rotation of the pronged wheel 216 and are of such radial distance from the axis of shaft 1 that either of the free ends of the spring elements 224a or 224b will engage one prong of the pronged wheel 216. As the spring barrel 12 is being rotated during the winding operation, the ends of the member 224a or 224b are brought into contact with a prong of the pronged wheel 216, and the continued rotation of spring barrel 12 producing flexing stress in the spring members 224a or 224b against a prong of the prong wheel 216 thereby overcoming the holding stress of the springs 205 and 217. When the springs 224a or 224b have been flexed sufficiently to overcome the holding action of the lock springs 205 and 217, the pronged wheel 216 moves one position clockwise, which in turn rotates the bevel gear 204 one position clockwise. The new position is indicated by the pointer 207 on the dial 208. The action of the springs 205 and 217 in the prongs of the pronged wheels 203 and 216 is such as to retard rotation of the latter during the first half motion thereof and will assist and cause snap rotation during the last half motion of the same. Therefore, when either of the springs 224a or 224b has flexed sufficiently to overcome the force of springs 205 and 217, the pronged wheels 203 and 216 immediately respond with a rapid snap motion to the combined stress of the several springs, namely, 205 and 217, and 224a or 224b, and the prongs of the pronged wheel 216 with which one of the spring members 224a or 224b is now engaged, is moved to allow escapement of one of said spring members in unflexed condition and out of the rotational sphere of the prongs of the pronged wheel 216 as the pointer 207 snaps into new position on the dial 208.

To prevent over winding of the coil spring 11, lever 227 is assembled intermediate its ends upon a pin 226 carried by the base 249. The lever is held in an inoperative or normal position with an arm portion 225 inwardly of the pivot thereof resting against a rigid peg 229 carried by the force of spring 232, and in this position, the opposite end 228 of the member 227 is free of the prong 231 at the lower end of the worm 13. Now as the spring 11 is being wound, the bevel gear 204 with the peg 209 fixed therein is rotated in a succession of rapid step by step advances occurring at each escapement as provided by the springs 224a and 224b from a prong of pronged wheel 216. This causes rotation of the bevel gear 204 in a direction opposite to its direction of ro-

tation during closing operation of the switch. The lever 227 is located so that the arm portion 225 extends within the rotational sphere of the peg 209 and is so placed in relation to the travel of the peg 209, that when spring 11 has been sufficiently wound to provide energy for the 19th opening and 18th closing operation, the peg 209 has been rotated to be in a position directly against the arm portion 225. As the spring barrel 12 is rotated through the next 180° and either spring arms 224a or 224b disengages from the pronged wheel 216, the combined spring action of the spring members 205, 217 and 224a or 224b overcomes the force of spring 232 causing peg 209 to move the lever 227 in a counterclockwise direction, and thereby bring the end 228 of the arm 227 into position to engage prong 230 of the worm 13 preventing further rotation of the spring barrel 12. The pointer 207 indicates the wound position on dial 208. The prong 230 does not remain in frictional stressed position against the end 228 of the member 227 when manual winding energy has ceased, as the action of the ratchet 14 against the worm 13 is such as to allow slight reaction of the worm 13 by torsional stress from the spring barrel 12 when manual winding energy on the worm 13 has ceased. Therefore the end 228 remains in position to prevent any further winding of spring 11, but is free to move to unlocking position by urge of spring 232 when peg 209 has moved away from arm 225 at the first operation.

From the construction described above it will be observed that during each closing operation of the switch the pronged wheel 203 is rotated clockwise through $\frac{1}{6}$ of its circumference, and a corresponding counterclockwise rotation is thereby transmitted to pronged wheel 216 through the bevel gear 204. Likewise each 180° rotation of the spring barrel 12, during winding operation, produces a clockwise rotation of the pronged wheel 216 through $\frac{1}{6}$ of its circumference and pronged wheel 203 is thereby caused to rotate counterclockwise through $\frac{1}{6}$ of its circumference. Therefore, when the switch is operating from open position to closed position, and pronged wheel 203 is being rotated by the arm 202, the pronged wheel 216 must be out of engagement with the spring 224 and free to respond to counterclockwise motion by action of the pronged wheel 203. Likewise when spring 11 is being wound, and the pronged wheel 216 is being rotated by a spring 224, the pronged wheel 203 must be out of engagement with the arms 202a or 202b to be free to respond to counterclockwise motion by action of the pronged wheel 216. The arm 202 is fixed on shaft 1 in position to engage a prong of the pronged wheel 203 when the shaft 1 is rotated 125° from closed position, and the arm 202 escapes from the pronged wheel 203 after 5° rotation of shaft 1, such that with the switch in closed position, the arm 202 has advanced 50° from engagement with pronged wheel 203. With the switch held in open position (with shaft 1 at 60° from closed position) the arm 202 is 65° from engagement with the pronged wheel 203. Therefore the arm 202 does not interfere with rotation of the pronged wheel 203 when the prong wheel 216 is being rotated by the spring 224 during winding operation of the switch in open or closed position.

When the switch is being wound, the extent of the winding is indicated on dial 208 by successive and rapid advances of the pointer 207 and the action of the springs 224a and 224b, i. e., the

spring elements 224a and 224b are such that when pointer 207 has moved into the next advanced position the springs 224a or 224b have become automatically disengaged from the pronged wheel 216, and will not interfere with counterclockwise motion of the latter when the pronged wheel 203 is rotated by closing operation of the switch.

Referring now to Figures 7, 8 and 10, I have shown a current carrying arm 231 two of which are fixed to the main shaft assembly 1, 2 and 3, one at either end thereof. The current carrying arms rotate with shaft assembly, and each arm member rotates in an insulated housing, one at either end of the removable housing section of the switch, which housings constitute arcing chambers to control the action and extent of the electric arc occasioned by the separation of the arms from the fixed contacts 7 and 8 when the switch is opened. Each arm is of dual construction, extending in a like manner 180° apart from the center of the main shaft assembly, such that two operations of the switch are accomplished by one 360° rotation of the main shaft assembly. The detail construction of the current carrying arms is shown in Figures 10, 7 and 8 to which reference may now be had. The two arcing chambers and the current carrying arms that rotate therein are of like construction and therefore the explanation of one will suffice for purposes of the present disclosure. Likewise, the construction and action of one contact arm is a duplicate of that extending in the opposite direction 180° therefrom so that the explanation and description of one contact arm will also apply to the other. A switch blade supporting member 233 of electrical conducting material is assembled in a slot 234 in the end of shaft 1 and is held rigidly in place by a nut 235 threaded on the end of the shaft. A current carrying arm 237 is hinged in electrical contact with the supporting member 233 by a pin 236. A barrier 242 of insulating material is fixed to the current carrying member 237 and travels therewith. The purpose of the barrier 242 is to form an insulating seal along one side of the current carrying arm 237. A block 240 of insulating material is fixed to the blade supporting member 233 and a vane 243 of resilient insulating material is suitably fixed at one end to the insulating block 240. A spring 239 is assembled around the pin 236 and is flexed over a hook 238 formed integral with the current carrying arm 237 to urge the latter against a bumper arm 244 formed as a part of the member 233. The housing 10 is also of insulating material and constitutes the arcing chamber. It is cylindrical in form with the inner diameter thereof being sufficient to allow rotation of the barrier 242 and vane 243 without frictional engagement against the inner surface of the cylindrical wall thereof. An opening 245 is provided in the upper end of each housing 10, over which is rigidly fixed one of the stationary contacts 7 and 8 each of which is provided with a contact finger 241 extending through the aperture into the arcing chamber. The arcing chamber is formed with lip portions 247 and 248 protruding slightly beyond the cylindrical surface thereof on either side of the opening 245.

When the switch is in open position, as shown in Figure 8, the end of arm 237 is out of engagement with contact finger 241 of the fixed contact 8, and rests against bumper arm 244 formed integrally with the member 233. The vane 243 is

in an intermediate position between the contact end of current carrying arm 237 and the finger 241. With the arm 237 resting against the bumper 244, the radial distance from the end of the current carrying arm 237 to the shaft 1 is slightly less than the distance from the outer end of lip 247 to shaft 1, and as the switch is moved into closed position under urge of spring 11, the end of 237 passes inside the lip 247 but is engaged by the finger 241. The tension of spring 239 is not sufficient to retard the motion of shaft 1, and, therefore, the rotation of the contact end of the current carrying arm 237 is stopped by engagement with finger 241. The spring 239 is then further flexed by continued rotation of shaft 1 into full closed position, at which point further rotation of shaft 1 is prevented by controlling member 15 being engaged by lever 21 as previously described. As the contact end of the current carrying arm 237 is engaged by finger 241, and shaft 1 continues to rotate into closed position, the radial length of the contact arm assembly is increased by straightening action in the contact arm assembly, and the end of the current carrying arms 237 is thereby forced against the curved surface of fingers 241.

When the switch has reached closed position, the pin 236 has moved slightly past the center line of shaft 1, and end of arm 237, and arm 237 continues to exert pressing stress against contact fingers 241. The end of vane 243 is resting against the lip 247, as shown in Figure 7. The closing action of the current carrying arms 237 with contact fingers 241 occurs rapidly, as the member 237 is fixed on shaft 1 at an appropriate angular relation to the controlling member 15, that as controlling member 15 escapes from the control of the reclosing timing mechanism RT, the end of current carrying arm 237 is approximately under lip 247. The succeeding 45° of rotation of the shaft assembly into closed position occurs during unrestricted urge of spring 11 on the shaft assembly.

When the switch is tripped open by release of the latching action on the controlling member 15 as previously described, the shaft assembly is allowed to continue its rotation unrestricted for 45°, and during this rapid 45° rotation the member 233 rotating with the shaft assembly advances the hinge 236 a distance sufficient to cause the contact end of current carrying arm 237 to escape from finger 241. This motion of the member 233 further flexes the spring 239 such that the current carrying arm responds to the urge of the spring 239 to rotate at hinge 236 against the bumper arm 244 and also acquires additional momentum imparted by simultaneous rotation of the shaft assembly to open position. During this rapid opening action the insulating barrier 242 which is fixed to the current carrying arm 237 for rotation therewith, creates a disturbing action of air on the arc between the end of the current carrying arm 237 and contact finger 241. The insulating vane 243 traveling with the shaft assembly produces a simultaneous slapping action across the lips 247 and 248 of the aperture 245 to extinguish the arc. The housings 7 and 8 at their lower end are provided with an aperture 246 to allow a view of the position of the switch arm. When the switch is in closed position the barrier 242 and the arm opposite the current carrying arm 237 to that making contact, is visible through the aperture or opening 246, and the word "Closed" is lettered on each barrier. When the switch is opened, one of the vanes 243 is visible

through the opening and the word "Open" is lettered on each vane.

The entire removable housing section is assembled on the base plate 249, and a prong 250 is rigidly fixed to extend from the bottom surface of the base plate 249 with the end of the prong 250 formed for engagement with the end of an insulated hook to provide for safe manipulation of the removable housing section by an operator.

The inner parallel opposed end walls of the housings 9 and 10 which are adjacent to the base plate 249, and formed with the two key-like projections 251 and 252, respectively, and a cover 253 of insulating material is formed on the inner side edges thereof to engage with the key-like projections 251 and 252 when the cover is assembled on the plate thereby enclosing the working parts of the switch against weather, dirt, etc.

The stationary mounting section of the switch of my invention is more clearly shown in Figures 1, 2 and 3 which are about 1/3 full size of the switch constructed in accordance with this disclosure. It comprises in general a mounting frame, insulated for supporting the removable housing section, electrical terminals for the line wires, electrical contacts for engaging the contacts of the removable housing section and electrical conducting links for bypassing the removable housing section. The mounting frame consists of a channel member 254 to which is rigidly fixed frame member 255 assembled in T formation, as shown. Bolts 256 and 257 are assembled in slotted holes formed in the member 255, and together with a clamping member 258 to provide for mounting of the same on wooden cross bars or other structure. Insulators 259 and 260 are fixed to opposite ends of the member 254 and extend at substantially right angles to the plane of the mounting frame with a center to center spacing coinciding with center to center spacing of the insulating housings 9 and 10 of the removable section or housing portion of the switch. Supporting brackets 262 and 263 are assembled on the other ends of insulators 259 and 260, respectively, and electrical conducting contact members 264 and 265 are assembled to the terminal plates 262 and 263 respectively by the terminal bolts 266 and 267. The terminal bolts 266 and 267 are also utilized for forming terminals for the line wires.

The lower end of the terminal elements 264 and 265 are of substantially V form to engage in the openings 278 and 279 of the switch contacts 7 and 8 respectively, and also act as a supporting means for the removable housing section. In addition they form electrical contacts with the lips 281 and 280 of the contacts 7 and 8 respectively.

The insulator 261 at the lower end of the mounting frame 255 has a bracket member 275 rigidly assembled at its outer end. A stud 276 is threadedly engaged in the member 275. A slotted bracket member 277 is fixed to the base 249 of the removable housing section, and is so located in relation to the bracket member 275 and the stud 276, that when the removable housing section has been assembled with the stationary section with the fixed contacts 7 and 8 engaged over the curved ends of 264 and 265, the stud 276 will engage in the slot of clip 277, and the removable housing section will be held rigidly in place by tightening the stud 276. The end of stud 276 is formed for engagement with the end of an insulated hook and stick or the like for manipulation by an operator.

A conducting link 268 is hinged at 269 in electrical contact with the upper end of the terminal

element 264 and the stud 272 is carried by the opposite end thereof. A conducting link 271 is hinged at 270 in electrical contact with the upper end of the terminal element 265. The relative lengths of links 268 and 271 are such that they may be moved into contacting position with each other with stud 272 of link 268 engaging into the slot 273 formed in the outer end of link 271. Rigid electrical contact is maintained therebetween by tightening of stud 272. The end of stud 272 is formed for engagement by end of an insulated hook stick or the like to provide for safe manipulation by the operator. A stop lug 274 is formed on terminal 264 such that when the link 268 has been moved to engage thereagainst, the free end of the link 268 is then in position for the slot 273 of link 271 to engage the shank of stud 272 carried by link 268. It is therefore possible for an operator to close the line circuit through links 268 and 271 and thereby allow opening, closing, removal, or replacement of the removal housing section without interrupting the line current.

In the preferred form of my invention the several studs 163, 119, 250 and 272 are all of the same shape and size in order that they may be engaged by a recessed end of a common hook stick. Also, the outer end of the worm gear 13 is preferably of this shape so that the spring 11 may also be wound by the same hook stick or insulated pole member.

Reference may now be had to Figures 4, 5, 6, and 9 for a more detail description of the mounting of the reclosing timing mechanism RT, the lockout timing mechanism LT, and the electromagnetic means E. As shown in these figures a pair of vertically extending panels 290 and 291 are provided with opposed bottom flanges 293 which are secured by suitable bolts to the base plate 249. The plate members 290 and 291 are provided with suitable openings through which the shaft 1 extends. The spring barrel 12 and the associated winding mechanism comprising the worm gear shaft 13, bevel gear 204 and its shaft 206, together with the pronged wheels 203 and 216, the arm member 202, and also the arms 223a, 223b and the leaf spring element 224a and 24b for engaging the prongs of the pronged wheels 203 and 216 are assembled between the inner surface of the housing 10 and the vertically extending panel 291. Likewise, the associated mechanism for preventing winding of the spring barrel excessively and for actuating the sliding lock bar 211 are arranged in this portion of the removable housing section as previously described.

The shaft 56 carrying the pronged wheel 49 of the reclosing timer is mounted for rotation in the plate member with its end opposite the pronged wheel 49 carried in plate member 295 extending parallel to the panels 290 and 291 and therebetween. The plate 295 is secured in fixed relation to the panel 290 and spaced therefrom by a pair of spacing collars 296 and 297. These collars together with the panel 290 provide a mounting means for the gear train 58 through 62 and the pendulum arm 64. The shaft 59 carrying the gears 58 and 60 has its opposite ends suitably mounted in the panel 290 and the frame member 295. The shaft 62 carrying the eccentric 63 and gear 61 is likewise mounted for rotation with its ends having bearing mounting in the panel 290 and the frame member 295. The shaft 65 for the pendulum arm 64 is carried by the panel 290. The lockout timer mechanism LT is carried on opposite sides of the vertically extending panel

291. The pivot pin 38 for the trip lever 35 at the front end of the removable housing section extends into and is carried by the panel 291 with the trip lever being disposed between the panel 291 and the switch chamber 9. The quadrant 147 of the recycling mechanism comprises a plate member fixed in spaced relation from the surface of panel 291 toward the cylindrical housing 9, and a pair of spacing collars 300 and 301 through which suitable bolts extend and which are secured in panel 291. The pivot pin 126 of the recycling disc 68 is carried by the quadrant plate 147. The shaft 70 of the lockout timer is fixed at one end in the quadrant plate 147 and extends through the panel 291. The shaft 70 at its other end is carried by a plate member 305 disposed in fixed spaced relation adjacent the panel 290. A second plate member 306 similar to plate member 305 is disposed adjacent the panel 291 between it and the panel 290. The two plate members 305 and 306 are secured in fixed spaced relation with respect to each other and to the panels 290 and 291 by the anchor pin 74 for the spring 73, the anchor pin 74 being fixed at one end in the panel 290 and an anchor pin 307 which is also fixed at one end in the panel 290.

The plate members 305 and 306 carry the opposite ends of the several shafts for the several gears 77, 78, 79 and 80, and the pivot 82 of the pendulum arm 83 of the lockout timer mechanism. The ratchet 71 for the lockout timer is also mounted on the shaft 70. The arcuate slot 90 for adjusting the position of the balance wheel supporting member 38 is formed in the rearward lower portion of the panel 290. The pivot 92 for the balance wheel arm 38 is also formed in the panel 290. A vertically extending plate member 311 is secured in spaced relation from the surface of the panel 291 disposed toward the arcing chamber 9 by the anchor peg 45 for the retrieving spring 44 and a suitable bolt and spacing collar 312. The plate member 311 lies in substantially the same vertical plane as the quadrant plate 247 and is disposed rearwardly of the housing as viewed from the front of the switch. The pivotal mounting pin 29 for the latch 27 is carried by plate member 311. The latter plate member also carries the stop peg 33 for the latch 27. The opposite ends of the fixed pivot pin 22 for the lever 21 are carried by plate member 311 and the adjacent panel 291. The shaft 113 for the manual locking lever 112 is also fixed in the panel 291. The panel 291 is further provided with a suitable opening at and through which the prong 114 of lever 112 extends for engaging the locking dog lever 102. The pin of stationary peg 108 associated with the notched end of the locking dog lever is also carried by the panel member 291. The pivot pin 101 for the lever arm 100 is carried between the panel 291 and quadrant plate 147.

The electromagnetic means E and the time delay means thereof are disposed between the inner surface of the chamber 9 and the lockout timer mechanism LT and the arrangement thereof in the removable housing section is readily discernable upon a comparison of Figures 4 through 6 with the showing of Figure 11. The U-shaped magnet 149 and its associated coils are enclosed in a suitable casing 315 carried at the bottom of the base plate 249. The base plate member is provided with suitable openings through which the ends of the magnet 149 extend. It will be observed in the showing of Figures 4 to 6 that the support 166 for the magnet

bar is carried by the upper surface of the base plate 249. The shaft 175 about which the arm 174 is adapted to have rotational movement, and about which the gear 189 of the gear train providing for the time delay action in the tripping action of electromagnetic means is mounted in a sub-assembly structure indicated generally at 320. This sub-assembly structure 320 is made up of the panel member providing the scale 188 for the pointer arm 186 which carries the lifting peg 187. Suitable panel members 223 are supported in spaced relation with respect to the member forming the scale plate 186 by the spacing sleeves 324, 325, and 326. The plate members 188 and 223 providing for bearing mounting of the several shafts of the gear train shown at 189 through 197. The scale plate member 188 is suitably secured to the upper surface of the base 249 by a flanged member 327 to which the scale plate member 188 is fixed to extend vertically.

The like reference numerals throughout the several views of Figures 4, 5 and 6 indicate the parts described in conjunction with Figures 10, 11 and 12, and further reference may be had to the former figures for a description of the several parts of the switch of my present invention.

Referring now to Figure 13 I have shown a hypothetical distribution system illustrating the application of several of the circuit breakers of my invention, in which the power supply bus is indicated at 330. In the circuit arrangement it will be seen that a plurality of switches 331 of my invention have been arranged in a series relation. The load on the several individual circuits are indicated at 33. Each switch in a series is adapted to be adjusted for one or more additional operations before lockout than the next adjacent switch further from the source of the power supply bus 330. The number of operations allowable for each switch in the system shown in the drawings is indicated by the numbers inscribed upon each of the several switches 331. By use of the method of adjusting the number of switch operations before lockout on the typical distribution system shown in which there are two or more switches in series, the switch near the source of supply is allowed to close one or more additional times than the next adjacent switch further from the source of supply. The possibility of any two or more switches in series locking out simultaneously is eliminated as only the switch which feeds directly into the faulty section will remain locked out when it has operated its allowed number of times. The switches near the source of supply can reclose and establish service on the portion of the system from which the faulty section has been locked out.

While I have shown what I consider to be a preferred embodiment of my invention it will be understood that various details, rearrangements, and modifications may be made therein without departing from the spirit and scope of the invention.

I claim:

1. A reclosing circuit breaker comprising a shaft, energy storing means associated with said shaft for rotating the latter, a switch arm connected to said shaft for opening and closing the breaker, a controlling member carried by said shaft for rotation therewith, a reclosing timing mechanism having means adapted to be engaged by said controlling member for governing the speed of rotation of said shaft to provide a predetermined time delay between opening and closing of said breaker, a latch mechanism having a re-

leasable latch arm normally urged into engagement with said controlling member to prevent rotation of said shaft by said energy storing means, electromagnetic means having a trip arm adapted upon an abnormal line condition to permit disengagement of said latch arm from said controlling member to free said shaft for rotation under control of said reclosing timing mechanism to open and close said breaker, and a lock-out timer mechanism between said controlling member and said reclosing timing mechanism having means adapted to be actuated by said controlling member to an operative position to engage said means of said reclosing timing mechanism to lock-out the reclosing timing mechanism and prevent rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker upon continuation of a substantially sustained abnormal condition on the line.

2. A reclosing circuit breaker comprising a shaft, energy storing means associated with said shaft for rotating the latter, a switch arm connected to said shaft for opening and closing the breaker, a controlling member carried by said shaft for rotation therewith, a reclosing timing mechanism having means adapted to be engaged by said controlling member for governing the speed of rotation thereof to provide a time delay between opening and closing of said breaker, a latch mechanism having a releasable latch arm normally urged into engagement with said controlling member to prevent rotation of said shaft by said energy storing means, electromagnetic means having a trip arm to permit disengagement of said latch arm from said controlling member to free said shaft for rotation under control of said reclosing timing mechanism to open and close said breaker, time delay means associated with said electromagnetic means for delaying engagement of said trip arm with said latch arm of said latch mechanism until an abnormal line condition has continued for a predetermined length of time, and a lock-out timer mechanism operatively associated with said reclosing timing mechanism having means actuated by rotation of said controlling member to an operative position to engage said means of said reclosing timing mechanism to lock-out said reclosing timing mechanism and prevent rotation of said shaft with said switch arm in open position after a predetermined number of successive opening and closing operations of said breaker upon continuation of a substantially sustained abnormal line condition.

3. A reclosing circuit breaker comprising a shaft, energy storing means associated with said shaft for rotating the latter, a switch arm connected to said shaft for opening and closing said breaker upon rotation of the shaft, a controlling member keyed to said shaft, a reclosing timing mechanism having means adapted to be engaged by said controlling member for governing the speed of rotation of said shaft for a portion of its rotary movement to provide a time delay between opening and closing of said breaker, a latch mechanism having a releasable latch arm normally urged into engagement with stop means on said controlling member to prevent rotation of said shaft by said energy storing means, electromagnetic means having a trip arm adapted upon an abnormal line condition to permit disengagement of said latch arm from said stop means freeing said shaft for rotation under control of said re-

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closing timing mechanism to open and close said breaker, said trip arm upon opening of said breaker being adapted to release said latch mechanism whereby said latch arm returns to its normal position, a lock-out timer mechanism having means actuated by rotation of said controlling member to an operative position to engage said means of said reclosing timing mechanism to lock-out said reclosing timing mechanism and prevent rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker upon continuation of a substantially sustained abnormal line condition, and means for said lock-out timer for adjusting the number of successive opening and closing operations of said breaker required to actuate said lock-out timer to its operative position.

4. A reclosing circuit breaker comprising, a shaft, energy storing means associated with said shaft for rotating the latter, a switch arm connected to said shaft for opening and closing said breaker upon each half revolution of the shaft, a controlling member keyed to said shaft for rotation therewith, a reclosing timing mechanism having means adapted to be engaged by said controlling member for governing the speed of rotation of said shaft for a portion of each half revolution thereof to provide a time delay between opening and closing of said breaker, said controlling member having a pair of oppositely disposed stop abutments, a latch mechanism having a releasable latch arm normally urged into engagement with one of the stop abutments on said controlling member to prevent rotation of said shaft by said energy storing means, electromagnetic means having a trip arm adapted upon an abnormal line condition to permit disengagement of said latch arm from one of said stop abutments freeing said shaft for rotation under control of said reclosing timing mechanism to open and close said breaker, said trip arm upon opening of said breaker being adapted to release said latch arm of said latch mechanism whereby said latch arm returns to its normal position, a lock-out timer mechanism having means actuated by rotation of said controlling member to an operative position to engage said means of said reclosing timing mechanism for a predetermined length of time for locking out said reclosing timing mechanism and preventing rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker, upon continuation of a substantially sustained abnormal line condition, or upon reoccurrence of an abnormal line condition within the predetermined length of time of the operative position of said lock-out timer, and means for said lock-out timer for adjusting the number of successive opening and closing operations of said breaker required to actuate said lock-out timer to its operative position.

5. A reclosing circuit breaker comprising a shaft, energy storing means connected to the shaft for rotating it, a switch arm connected to said shaft for opening and closing said breaker upon each half revolution of said shaft, a controlling member carried by said shaft, a reclosing timing mechanism having means adapted to be engaged by said controlling member governing the speed of rotation for a portion of each half revolution of said shaft to provide a time delay between opening and closing of said breaker, said controlling member having a pair of oppositely dis-

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posed stop abutments, a latch mechanism having a releasable latch arm normally urged into engagement with one of the stop abutments of said controlling member to prevent rotation of said shaft by said energy storing means, electromagnetic means comprising a magnet, a magnet bar therefor, a trip arm associated with said magnet bar for engaging said latch mechanism to permit disengagement of said latch arm from one of the stop abutments of said controlling member to free said shaft for rotation under control of said reclosing timing mechanism to open and close said breaker, and time delay means for said electromagnetic means delaying engagement of said trip arm with said latch mechanism until an abnormal line condition energizing said electromagnetic means has existed for a predetermined length of time, said trip arm upon opening of said breaker being adapted to release said latch mechanism whereby said latch arm returns to its normal position to engage the next succeeding stop abutment on said controlling member to hold said shaft against rotation with said breaker in closed position, a lock-out timer mechanism having means actuated by rotation of said controlling member while said shaft is under the governed control of said reclosing timing mechanism, said lock-out timer having a locking dog lever adapted to be disposed in an operative position for a predetermined length of time to be engaged by said means of said reclosing timing mechanism to lock-out the latter, and prevent rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker upon continuation of a substantially abnormal line condition, causing said trip arm to reengage said latch arm of said latch mechanism after each closing operation of said breaker, or upon reoccurrence of an abnormal line condition within the predetermined length of time of the operative position of said locking dog lever, and means for said lock-out timer for adjusting the number of successive opening and closing operations required to actuate said lock-out timer to its operative position.

6. In an automatic reclosing circuit breaker having a rotatable shaft for effecting opening and closing of the breaker, the combination of a controlling member keyed to said shaft, a reclosing timing mechanism having means adapted to be engaged by said controlling member for controlling the speed of rotation of said shaft to effect a time delay between opening and closing of said breaker, and a lock-out timer mechanism having means adapted to be actuated by said controlling member in the rotation thereof, said lock-out timer mechanism having a locking dog lever adapted to be disposed in an operative position for a predetermined length of time to be engaged by a member of said reclosing timing mechanism to lock-out the latter, and prevent rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker.

7. In an automatic reclosing circuit breaker having a rotatable shaft for effecting opening and closing of the breaker, the combination of a controlling member keyed to said shaft, a reclosing timing mechanism having means adapted to be engaged by said controlling member for controlling the speed of rotation of said shaft to effect a time delay between opening and closing of said breaker, and a lock-out timer mechanism having means adapted to be actuated by said controlling

member in the rotation thereof, said lock-out timer mechanism having a locking dog lever adapted to be disposed in an operative position for a predetermined length of time to be engaged by a member of said reclosing timing mechanism to lock-out the latter, and prevent rotation of said shaft with said breaker in open position after a predetermined number of successive opening and closing operations of said breaker, and means for said lock-out timer for adjusting the number of successive opening and closing operations of said breaker required to actuate said locking dog lever to its operative position.

8. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing the breaker, the combination of a controlling member keyed to said shaft, a reclosing timing mechanism associated with said controlling member comprising, a train of gears, means between the first gear of said train of gears and said controlling member for bringing a portion of the rotary movement of said shaft under the control of said train of gears, a pendulum, and an eccentric driving connection between the last gear of said train of gears and said pendulum.

9. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing the breaker, the combination of a controlling member keyed to said shaft, a reclosing timing mechanism associated with said controlling member comprising, a train of gears, a star wheel rotatably connected to said first gear of said train of gears, a pendulum, and an eccentric driving connection between said pendulum and the last gear of said train of gears, and pin means on said controlling member for engaging said star wheel to bring rotation of said shaft under control of said train of gears and said pendulum.

10. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing the breaker, the combination of a controlling member keyed to said shaft, a reclosing timing mechanism associated with said controlling member comprising, a train of gears, a star wheel rotatably connected to said first gear of said train of gears, a pendulum, a weight adjustably mounted on said pendulum, and an eccentric driving connection between said pendulum and the last gear of said train of gears, and pins means on said controlling member for engaging said star wheel to bring rotation of said shaft under control of said train of gears and said pendulum, said weight being positionable upon said pendulum for adjusting the length of time said shaft is under the control of said reclosing timing mechanism.

11. In an automatic reclosing circuit breaker having a rotatable shaft for effecting opening and closing of the breaker, and a reclosing timing mechanism including a rotatable member for effecting a time delay between opening and closing of the breaker, the combination of a controlling member keyed to said shaft for rotation therewith, a lock-out timer mechanism having means adapted to be actuated by said controlling member in the rotation thereof and having a locking dog lever adapted to be disposed upon actuation of said means in an operative position for a predetermined length of time to be engaged by the rotatable member of said reclosing timing mechanism to lock-out the latter, and prevent rotation of said shaft with said breaker in open position after a predetermined number of suc-

cessive opening and closing operations of said breaker, and means for said lock-out timer between said first named means thereof and said locking dog lever for adjusting the number of successive opening and closing operations required to actuate said locking dog lever to its operative position.

12. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing the breaker, and a reclosing timing mechanism for effecting a time delay between opening and closing of the breaker, the combination of a controlling member keyed to said shaft, a lock-out timer mechanism comprising a pivotally mounted locking dog lever arranged to be disposed in an operative position for engagement with a member of said reclosing timing mechanism, a recycling disk having a plurality of projections arranged to be engaged by said controlling member to advance said recycling disk step by step, means for engaging said recycling disk to retain it in its advanced positions, said means having a member for engaging said locking dog lever to advance the same to its operative position after a predetermined number of step by step advancements of said recycling disk, and a timing device for retaining said lock-out arm in its operative position for a predetermined length of time.

13. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing the breaker, and a reclosing timing mechanism for effecting a time delay between opening and closing of the breaker, the combination of a controlling member fixed to said shaft, a lock-out timer mechanism comprising a pivotally mounted locking dog lever having an operative position for engagement with a member of said reclosing timing mechanism, a recycling disk having a plurality of projections arranged to be engaged by said controlling member to advance said recycling disk step by step, means for positioning said recycling disk with respect to said controlling member providing for adjustment of the number of step by step advancements adapted to be imparted to said recycling disk by said controlling member, means for engaging said recycling disk to retain it in its advanced positions, said means having a member for engaging said locking dog lever to advance the same to its operative position after a selected number of step by step advancements of said recycling disk, and a timing device for retaining said locking dog lever in its operative position for a predetermined length of time.

14. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing of the breaker, and a reclosing timing mechanism for effecting a time delay between opening and closing of the breaker, the combination of a controlling member fixed to said shaft for rotation therewith, a lock-out timer comprising a recycling disk formed with a plurality of fingers adapted to be engaged by said controlling member to advance said disk step by step, a pivotally mounted recycling lever arm, a spring member connected at one end to said recycling lever arm, a spring wound time delay device, a lock-out timer lever arm connected to a shaft fixed to said time delay device, said lock-out timer lever having a normal position adapted to be engaged by said controlling member to load the spring of said time delay device, said lock-out timer lever upon disengagement with said controlling member returning to its

normal position under control of said time delay device, said lock-out timer lever in its loaded position engaging said spring member to bias said recycling lever arm into engagement with said recycling disk to retain the latter in its advanced step-by-step positions, a locking dog lever, and means carried by said recycling lever arm for engaging said locking dog lever to position it to an operative position to be engaged by a member of said reclosing timing mechanism after a predetermined number of successive step-by-step advancements of said recycling disk, said locking dog lever returning to its inoperative position upon return of said lock-out time lever to its normal position.

15. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing of the breaker, and a reclosing timing mechanism for effecting a time delay between opening and closing of the breaker, the combination of a controlling member keyed to said shaft for rotation therewith, a lock-out timer comprising a recycling disk formed with a plurality of fingers adapted to be engaged by said controlling member to advance said disk step-by-step, means for positioning said recycling disk with respect to said controlling member providing for adjustment of the number of step-by-step advancements adapted to be imparted to said recycling disk by said controlling member, a pivotally mounted recycling lever arm, a spring member connected at one end to said recycling arm, a spring wound time delay device, a lock-out timer lever connected to a shaft fixed to said time delay device, said lock-out timer lever having a normal position adapted to be engaged by said controlling member to load the spring of said time delay device, said lock-out timer lever upon disengagement with said controlling member returning to its normal position under control of said time delay device, said lock-out timer lever in its loaded condition engaging said spring member to bias said recycling lever arm into engagement with said recycling disk to retain the latter in its advanced step-by-step positions, a locking dog lever, and means carried by said recycling lever arm for engaging said locking dog lever to position it to an operative position to be engaged by a number of said reclosing timing mechanism after a predetermined number of successive step-by-step advancements of said recycling disk, said locking dog lever returning to its inoperative position upon return of said lock-out time lever to its normal position.

16. In an automatic reclosing circuit breaker having a rotatable shaft carrying a switch arm for opening and closing of the breaker, and a reclosing timing mechanism for effecting a time

delay between opening and closing of the member, the combination of a controlling member keyed to said shaft for rotation therewith, a lock-out timer comprising a recycling disk formed with a plurality of fingers adapted to be engaged by said controlling member to advance said disk step-by-step, means for positioning said recycling disk with respect to said controlling member providing for adjustment of the number of step-by-step advancements adapted to be imparted to said recycling disk by said controlling member, a pivotally mounted recycling lever arm, a spring member connected at one end of said recycling arm, a spring wound time delay device, a lock-out timer lever connected to a shaft fixed to said time delay device, said lock-out timer lever having a normal position adapted to be engaged by said controlling member to load the spring of said time delay device, said lock-out timer lever upon disengagement with said controlling member returning to its normal position under control of said time delay device, said lock-out timer lever in its loaded condition engaging said spring member to bias said recycling lever arm into engagement with said recycling disk to retain the latter in its advanced step-by-step positions, a locking dog lever, and means carried by said recycling lever arm for engaging said locking dog lever to position it to an operative position to be engaged by a number of said reclosing timing mechanism after a predetermined number of successive step-by-step advancements of said recycling disk, said locking dog lever returning to its inoperative position upon return of said lock-out timer lever to its normal position, and manually operable means for engaging said locking dog lever to position and retain it in its operative position.

17. The combination of claim 11 characterized by said lock-out timer mechanism having means associated with said first named means thereof for adjusting the predetermined length of time the locking dog lever is adapted to be retained in its operative position.

FRED FARRELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,744,200	Bakken	Jan. 21, 1930
2,024,216	Grady	Dec. 17, 1935
2,205,083	Cazes	June 18, 1940
2,247,861	Thumim et al.	July 1, 1941
2,288,324	Prince	June 30, 1942
2,311,714	Thompson et al.	Feb. 23, 1943