

Feb. 21, 1961

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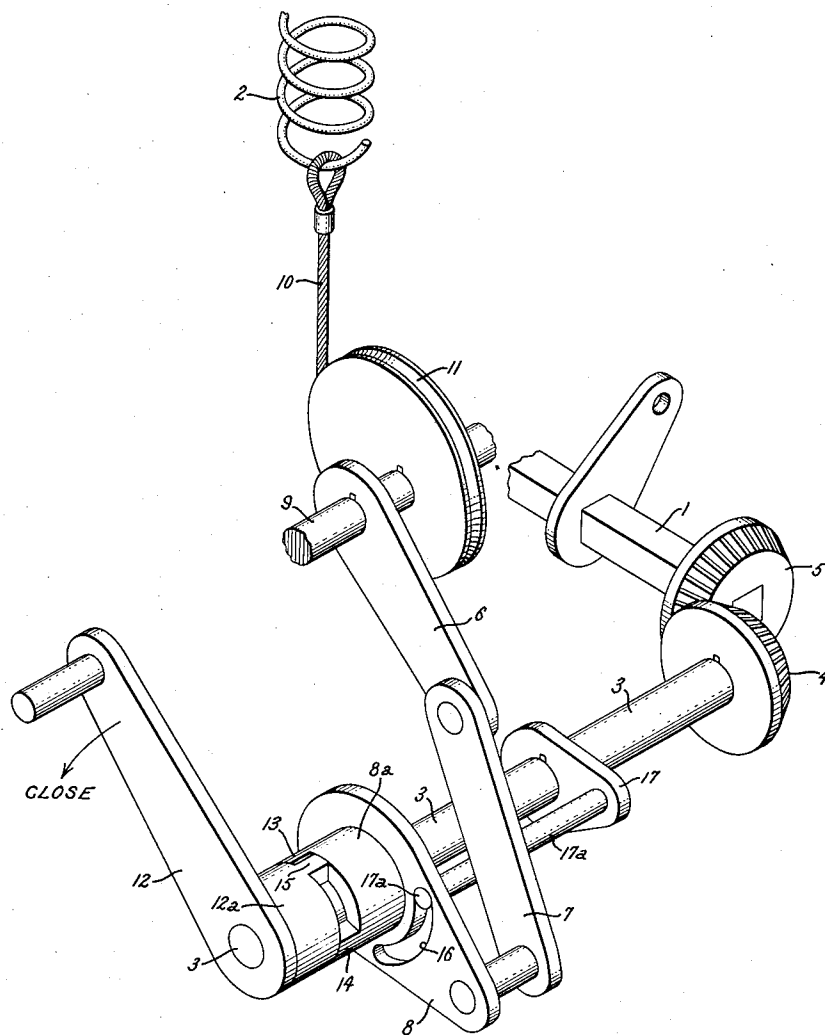
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STORED ENERGY OPERATING MECHANISM FOR SWITCHES

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4 Sheets-Sheet 1

Fig. 1.



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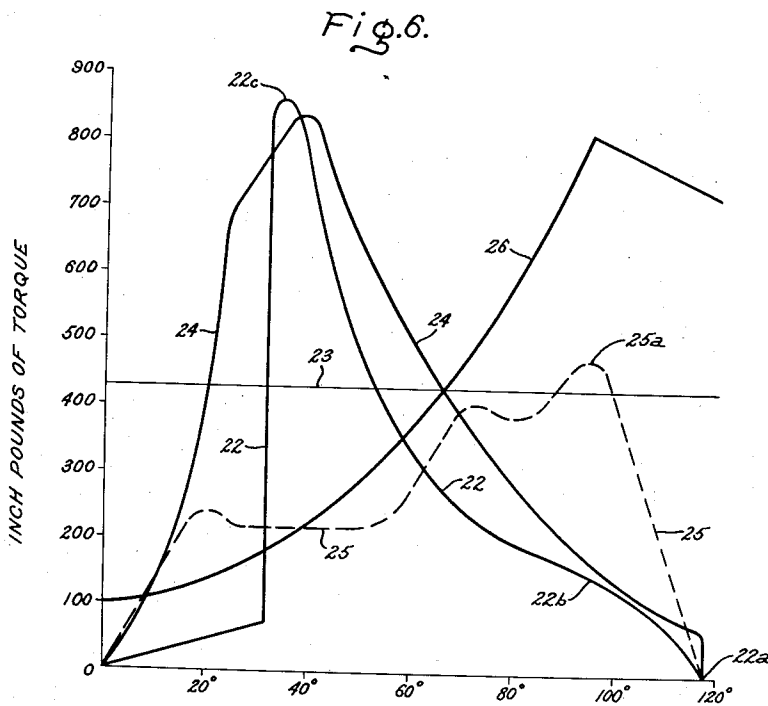
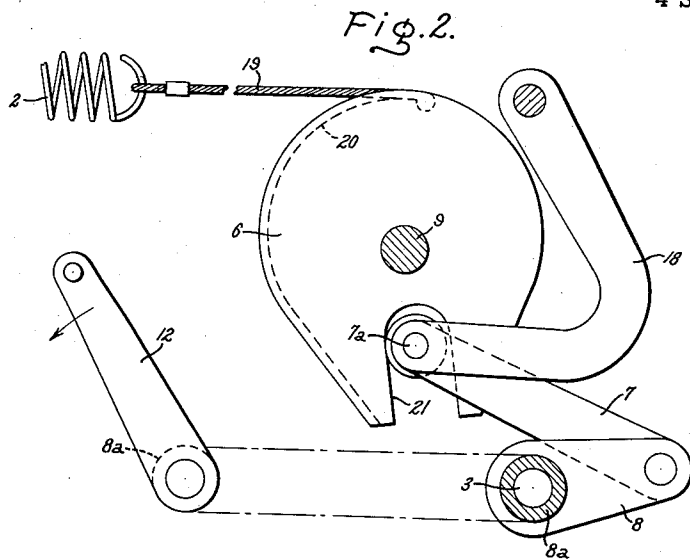
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Fig. 3.

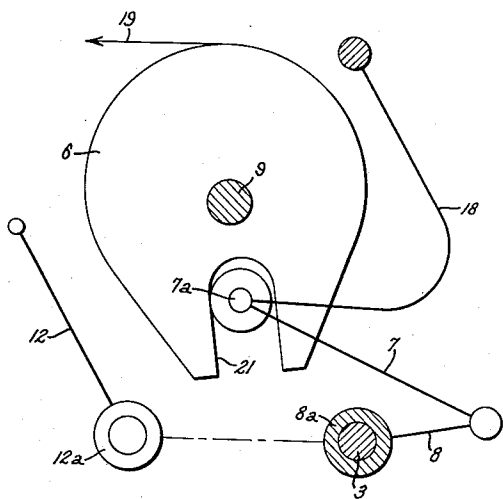


Fig. 4.

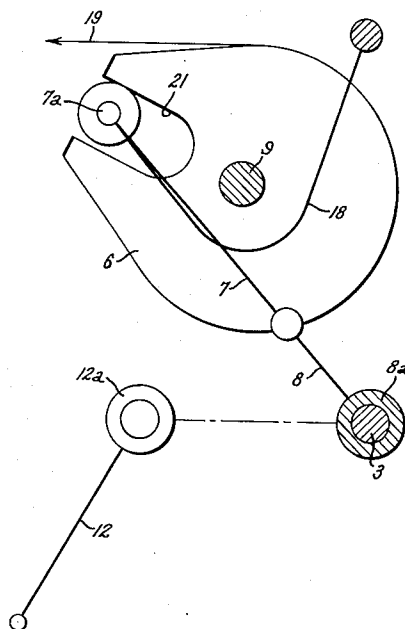
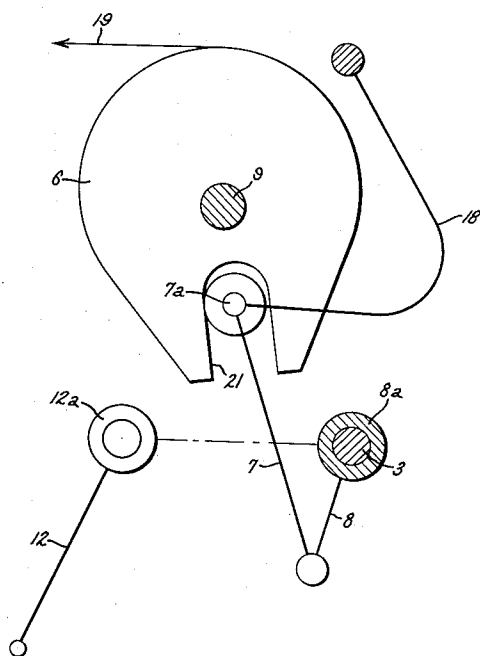


Fig. 5.



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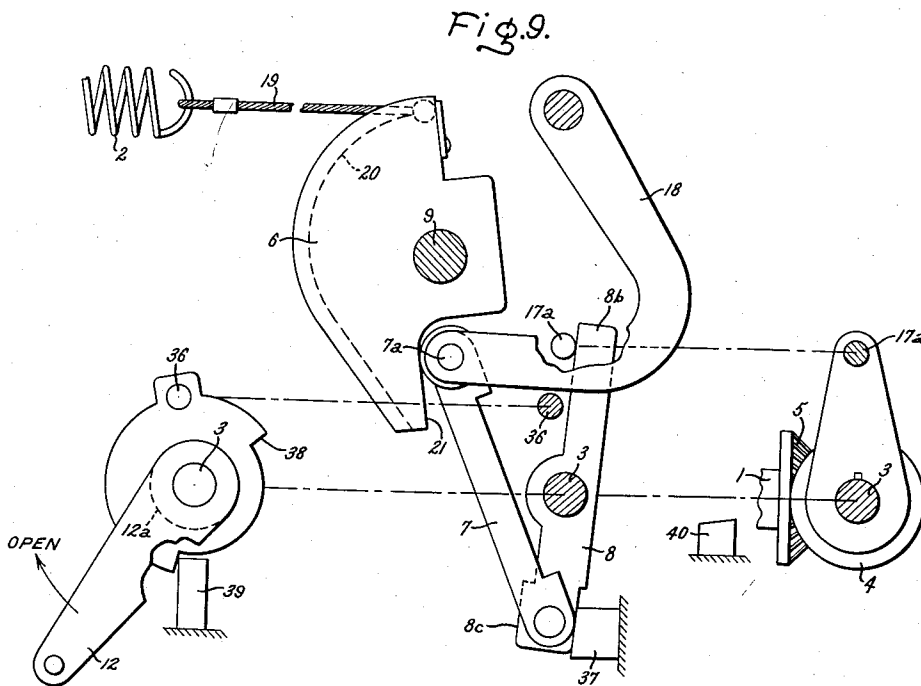
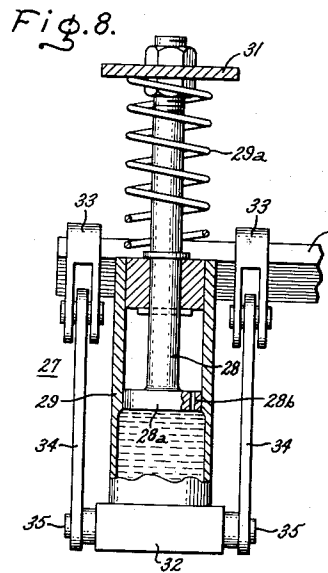
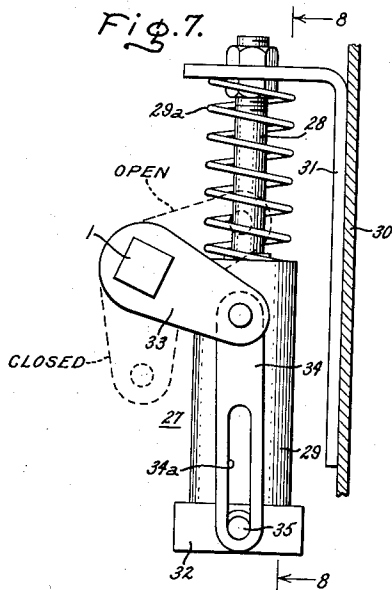
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STORED ENERGY OPERATING MECHANISM FOR SWITCHES

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4 Sheets-Sheet 4



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STORED ENERGY OPERATING MECHANISM FOR SWITCHES

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Filed Dec. 31, 1959, Ser. No. 863,242

5 Claims. (Cl. 74-97)

This invention relates to stored energy operating devices and more particularly to a stored energy operating device that are especially suited for high speed closing of medium and large circuit interrupters and it has for an object the provision of a simple, reliable, compact and inexpensive device of this character.

Proper manual operation of a circuit interrupter requires experience or "feel" on the part of the operator, and accordingly, a further object of this invention is the provision of a stored energy type operating device that automatically effects proper operation that avoids excessive arcing on opening and the danger of strike on closing while requiring from the operator no more than application of a substantially constant force to charge the energy storage device.

Still another object of the invention is the provision of an energy storage operating device for switches in which the level of the force required for charging operation is kept as low as possible in order to provide maximum ease of operation.

A still further object of the invention is the provision in a stored energy switch operating device of means of varying the energy pay out of the storage device so as approximately to match the force curve of the switch that is to be operated thereby.

Other objects of the invention will manifest themselves from a reading of the following specification.

In carrying the invention into effect in one form thereof, an operating mechanism for a switch is provided with an energy storage device that is fully charged before any motion of the switch occurs. This is accomplished by means of a toggle and a lost motion driving connection interposed between a crank and the energy storage device to provide for charging the latter in response to rotation of the crank to extend the toggle. Discharge of the energy storage device to actuate the switch follows the movement of the toggle past dead center. An additional lost motion device included in the driving connection between the toggle and the crank prevents shock to the crank during discharge. A variable position connection between the toggle and a pivoted link in the driving connection from the toggle to the energy storage device provides a variable moment arm around the pivotal axis of the link for any force that is transmitted between the toggle and such link. This results in approximately matching the energy pay out of the storage device with the requirements of the switch.

For a better and more complete understanding of the invention reference should now be had to the following specification and to the accompanying drawings in which:

Fig. 1 is a view in perspective of a stored energy switch operating mechanism embodying certain features of the invention;

Fig. 2 is a view in front elevation of a preferred form of the invention;

Figs. 3, 4 and 5 are diagrammatic sketches illustrating relative positions of the parts of the Fig. 2 modification during a switch closing operation;

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Fig. 6 is a chart of characteristic curves which facilitate an understanding of the invention;

Fig. 7 is a view in elevation of a detail;

Fig. 8 is a side view partly in section of the detail shown in Fig. 7, and

Fig. 9 is an exploded view, partially schematic of an improved form of the modification of Fig. 2.

Referring now to the drawing and particularly to Fig. 1 the contacts of a circuit interrupter switch (not shown) are opened and closed by rotation of a shaft 1 that is rotatably mounted on a suitable support such as the switch housing. Contact opening and closing forces are imparted to the shaft 1 from an energy storage device such as spring 2 acting through a linkage mechanism and an operating shaft 3 which, owing to its angular disposition with respect to switch shaft 1 is connected to the latter through bevel gears 4 and 5. The linkage mechanism comprises a crank link 6 and links 7 and 8 the latter two of which are pivotally connected and mounted to constitute a toggle connection between the operating shaft 3 and the crank link 6. As shown, the crank link 6 is fixedly secured to a shaft 9 which is suitably mounted on the supporting housing for rotation, thereby to provide for rotation of crank link 6 about the axis of the shaft, whereas the end of toggle link 8 remote from the knee of the toggle is provided with a hub portion 8a that is mounted on the operating shaft 3 but is not pinned or keyed to it and consequently is freely rotatable thereon.

One end of the spring 2 is anchored to the support. Between its opposite end and the crank link 6 is provided a driving connection that is illustrated as comprising a cable 10 and a pulley 11 that is fixedly secured to the crank link 6 so as to rotate therewith.

For the purpose of charging the spring 2, a crank member 12 is provided. It has a hub portion 12a that is mounted on the operating shaft 3 but is not pinned nor keyed to it and hence is free to rotate on it. On the hub 8a are a pair of axially extending lugs 13 and 14 that are circumferentially spaced apart approximately 125 degrees. A similar lug 15 on crank hub 12a projects axially into the space between lugs 13 and 14 and cooperates with them. The circumferential span of each of the lugs is only a few degrees of arc and hence there is approximately 120 degrees lost motion between the crank 12 and hub 8a when one is rotated with respect to the other. Between the operating shaft 3 and the toggle link 8 is provided a similar lost motion driving connection that comprises an arcuate shaped slot 16 in the link 8, a crank pin 17a that is secured to a crank member 17 fixedly mounted on shaft 3 in such position that the crank pin extends into the slot.

In order that the spring 2 may be charged by application of constant torque to the handle of crank 12 the circumference of pulley 11 is made eccentric to compensate for the gradient of the spring 2.

With the foregoing understanding of the elements and their organization the operation of the Fig. 1 modification will readily be understood from the following description.

The crank 12 is assumed to be manually operated and it is illustrated in the switch contact open position. To close the switch, the crank is rotated in a counterclockwise direction. The engagement of lug 15 with lug 13 effects a corresponding counterclockwise rotation of hub 8a and of the link 8 of which it is a part. Owing to the free rotation of hubs 12a and 8a on the operating shaft 3 and further owing to the initial lost motion between the slot 16 and crank pin 17a the shaft 3 remains motionless. As the counterclockwise rotation of the crank 12 and toggle link 8 proceeds the toggle becomes fully extended, i.e., straightened, and this effects counter-

clockwise rotation of the crank link 6 which in turn causes the pulley 11 to rotate in a counterclockwise direction to tension the spring 2. During charging, the spring gradient is compensated by the eccentricity of the pulley 11 and consequently the hand of the operator on the crank 12 experiences a more uniform force.

When the toggle is in its fully extended position, the spring 2 is fully charged; however, at this point the lower end wall of the slot 16 has approached closely to but has not yet engaged the crank pin 17a. Consequently, up to this point in the operation the switch operating shaft 3 has remained entirely motionless and the movable switch contact has not started to close. Continuation of the counterclockwise of the rotation of the crank 12 for the few degrees necessary to cause the end of slot 16 to engage the crank pin 17a carries the knee of the toggle, i.e., toggle pin 7a past the dead center position. This occurs as the end of slot 16 engages the crank pin 17a. In this position, the spring is connected to the switch operating shaft 3 through the crank link 6, toggle links 7 and 8 and slot 16 and crank pin 17a and crank 17. As the toggle passes its dead center position, the spring begins to discharge thereby reversing the direction of rotation of crank link 6 and continuing the counterclockwise rotation of toggle link 7. Since the spring 2 is now connected to the switch operating shaft 3 through the slot 16 and crank pin 17a its discharge rotates the switch operating shaft and causes it to close the switch contacts. The continued counterclockwise rotation during the closing operation moves the lug 13 away from lug 15 and moves lug 14 toward lug 15 to take up the lost motion. However, the contacts of the switch are fully closed and the rotation of the hub 8a is arrested very slightly before the lug 14 engages the lug 15; consequently no shock is delivered to the hand of the operator.

To open the switch, the crank 12 is rotated in the opposite or clockwise direction. Engagement of the lug 15 with lug 14 initiates clockwise rotation of toggle link 8 to extend the toggle and rotate crank link 6 in a counterclockwise direction to charge the spring without effecting any rotation of the switch operating shaft 3. As the clockwise rotation of the toggle link 8 is initiated, the right-hand end of slot 16 leaves crank pin 17a and the opposite end of the slot moves toward it. As in the previously described operation the spring continues to charge until the toggle becomes fully extended. At this point the left-hand end of slot 16 engages the crank pin 17a to connect the spring to the switch operating shaft 3. The ensuing discharge of the spring continues the clockwise rotation of toggle link 8 and operating shaft 3 to open the switch. In the fully opened position of the switch, the toggle links 7 and 8 are in the positions in which they are illustrated in Fig. 1 and the lug 15 is separated from the lug 13 by a very small clearance.

Thus it will be seen, that during the charging of the spring preparatory either to opening or closing the switch, the switch operating shaft 3 remains motionless and the discharge of the spring either to open or close the switch does not impart a blow like impact to the operator's hand.

The modification illustrated in Fig. 2 is somewhat similar to the Fig. 1 modification and accordingly corresponding parts have the same reference characters. Primarily, the Fig. 2 modification differs from the Fig. 1 modification in that the toggle pin 7a is radially movable with respect to the center of rotation of crank link 6 whereas in the Fig. 1 modification it is connected to the crank link 6 at a constant distance from the center. To provide this radial movement, the crank link 6 is bifurcated at one end to provide a slot 21 in which the pin 7a moves. Movement of the pin toward or away from the axis of rotation of the crank link 6 is effected by means of a generally U-shaped link 18 having one ex-

trinity pivotally connected to the pin 7a and having its other extremity pivotally connected to the supporting housing.

With the foregoing understanding of the elements and their organization in the Fig. 2 modification, its operation will readily be understood from the following description. In a general way the operation is the same as that of the Fig. 1 modification but differs therefrom in the important respect in that the U-shaped link 18 moves the pin 7a radially with respect to the axis of rotation of crank link 6 and thus provides with respect to this axis, a variable moment arm for any force transmitted between the crank link 6 and the toggle 7, 8. This is illustrated by the linkage diagrams in Figs. 3, 4 and 5. In Fig. 3 which illustrates the relative positions of the links when the switch contacts are open, the pin 7a has a position near the bottom of the radial slot 21, i.e., closest to the center of rotation of crank link 6. Rotation of the crank 12 to charge the spring causes the pin 7a to apply a force normal to the wall of the slot. Since the pin 7a is closest to the bottom of the slot at the contact open position the moment arm of such force with respect to the axis of rotation of crank link 6 has minimum value.

As the toggle links 7 and 8 move toward the extended position during the spring charging operation, the U-shaped link 18 moves the pin 7a radially outwardly in the slot thereby increasing the moment arm of the force of the pin 7a against the crank link 6 about the axis of rotation of the latter. In the fully extended position of the toggle, the spring is fully charged and as shown in Fig. 4, the pin 7a is at its maximum radially outward displacement from the axis of rotation of link 6. Consequently the moment arm has its maximum value at this point.

Movement of the toggle past dead center and through the angle of repose permits the spring 2 to take over, reverse the rotation of crank link 6 to continue the rotation of the toggle links 7 and 8 thereby to initiate the closing stroke of the switch. Although fully charged at this take over point, the spring, owing to the maximum radially outward position of the pin 7a has minimum mechanical advantage with respect to the force of the pin 7a against the link 6 which is the force of the switch's resistance to closing.

As the spring continues to discharge and collapse the toggle, the U-shaped link 18 moves pin 7a radially inwardly thereby decreasing the moment arm of the resisting force of the switch, i.e., the force of pin 7a against link 6. In the fully closed position of the switch, the pin 7a, as illustrated in Fig. 5 is in its position nearest to the axis of rotation of link 6 and consequently the moment arm of the force of pin 7a against link 3 at this point is minimum and the mechanical advantage of the spring force with respect to its is maximum.

Similarly, during the opening operation, the moment arm is minimum at the beginning of the charging of the spring, maximum at the take over point when the fully charged spring is initiating the opening movement of the switch and minimum again when the switch is fully open.

The effect of the variable moment arm and associated linkage is graphically illustrated by force curves in Fig. 6 in which abscissae represent degrees rotation of the switch operating shaft 3 from its switch open position at zero degrees and ordinates represent inch pounds of torque. The curve 22 is the manual static curve for opening the switch. It represents the relationship between the static torque on the switch operating shaft and the degrees rotation of this shaft from the open position of a switch that is typically representative of switches to which this invention may advantageously be applied. Such a switch may be assumed to have main contacts and arcing contacts combined on a moving contact assembly. On curve 22 the ordinates between points 22a and 22b represents the torque that must be applied to slide the movable main

contact on its cooperating stationary contact during the contact separating movement. The maximum value point 22c is the torque required at the point of separation of the arcing contacts which occurs at approximately 34 degrees from the fully open position of the switch. The horizontal curve 23 represents the nearly constant torque which the spring 2 applies at the periphery of the eccentric portion of the crank link 6 during the opening and closing operations and the curve 24 represents the torque which, by virtue of the varying moment arm and the linkage, the spring applies to the switch operating shaft during the opening operation.

Curve 25 is the static manual force curve for the closing operation on normal rated load current and represents the relationship between the torque on the switch operating shaft and the degrees rotation of the shaft from the open position. The torque which the spring, as a result of the varying moment arm and linkage, applies to the switch operating shaft is represented by the curve 26. Maximum value point 25a of curve 25 represents the torque required to cause the movable main contact to spread the fingers of the cooperating stationary contacts. This occurs at approximately 95 degrees rotation of the switch shaft from the switch open position.

The net effect of varying the moment arm of the force of pin 7a against crank link 6 is that:

(1) The mechanical advantage of the spring 2 is varied inversely with the charge of the spring, i.e., is increased as its stored energy decreases and is decreased as the stored energy increases.

(2) The mechanical advantage of the spring is generally directly proportional to the resisting force of the switch, i.e., maximum or minimum when the resisting force is maximum or minimum respectively.

Following the separation of the main contacts during the opening stroke of the switch, there remains stored in the spring sufficient energy to accelerate the movable main and arcing contact assembly to such a high velocity as would interfere with the proper cooling and extinguishment of the arc after separation of the arcing contacts. In order to prevent the movable contact assembly from attaining such an undesirably high speed, a suitable motion damping time delay device, such for example, as the dash pot 27 illustrated in Figs. 7 and 8 is provided. It is shown as comprising a stationary plunger 28 and a cooperating relatively movable cylindrical fluid container 29. The diameter of the plunger disk plus a slight clearance is equal to the inside diameter of the cylinder except for that portion of the cylinder which is situated beneath the bottom surface of the plunger disk in its initial or rest position in which it is illustrated in Fig. 7. The diameter of this lower portion is somewhat greater than the diameter of the disk 28a with the result that when the top surface of the disk is below the top of the enlarged diameter portion oil moves freely from the space beneath the disk to the space above as though passing through an open valve. A compression spring 29a between the bracket 31 and the top of the cylinder biases the cylinder in a downward direction. As shown, the plunger 28 is fixedly mounted on the front panel 30 of the switch housing by means of an angle mounting bracket 31. The cylinder 29 is supported on a suitable pivotal mounting accessory 32 that is pivotally connected to the switch shaft 1 by means of arms 33 each having one extremity fixedly mounted on the switch shaft and having opposite ends pivotally connected to links 34. Trunnions 35 on the mounting accessory extend into elongated slots 34a in the links 34. The design is such that during a little more than half of the rotation of the switch shaft 1 during the opening stroke, the links 34 rotate to provide relative movement of the trunnions 35 and the slots 34a without producing any movement of the cylinder. After this amount of rotation, the parts are in the position in which they are illustrated in Fig. 7 with the trunnions 35 in engagement with the bottom end wall of

the slot. During the next following portion of the rotation of the shaft, the cylinder is moved relatively upward with respect to the plunger. An initial portion of this upward movement equal to the thickness of the plunger disk takes place at a rate that is determined by the rate of escape of oil through the hole 28b in the plunger disk. This rate of upward movement is sufficiently low to retard the speed of rotation of the switch shaft during the corresponding part of its rotation (in the switch opening direction) and that of the movable contact assembly which is driven thereby to a value that will promote effective cooling and extinguishment of the arc. As the top of the enlarged diameter portion of the cylinder rises above the top surface of the plunger disk of the cylinder, oil escapes freely around the edge of the disk with the result that the switch shaft and movable contact assembly are again accelerated to high speed.

During the closing stroke of the switch the conical spring 29a resets the cylinder to its initial position in which it is illustrated in Fig. 8.

The modification of Fig. 9 differs from the modification of Fig. 2 mainly in the structure of the lost motion connection between the crank and the toggle and between the toggle and the switch operating shaft 3. As shown, the toggle arm 8 is lengthened to provide a crank arm 8b extending from the hub 8a in the opposite direction and the crank hub 12a is provided with a crank pin 36 that extends axially to intersect the plane of rotation of extension 8b. When the switch is in the closed position the parts occupy the positions in which they are illustrated in Fig. 9 with the knee end of toggle arm 8 abutting against a stop 37.

To open the switch the crank 12 is rotated in a clockwise direction as in the modification of Fig. 2. This causes the crank pin 36 to engage the toggle arm extension 8b and rotate it in a clockwise direction to extend the toggle and charge the spring. During the spring charging operation the toggle arm 8 is out of engagement with crank pin 17a and consequently no rotation is imparted to the switch operating shaft 3 and the switch shaft 1.

After the toggle has passed through dead center and a small additional angle of repose, the lug 33 on crank hub 12a abuts against stop 39 and further clockwise rotation of the crank 12 is prevented. At this point in face 8c of the toggle arm is in engagement with crank pin 17a and the spring takes over to continue the clockwise rotation of the toggle arm. This effects rotation of the switch operating shaft 3 in a direction to open the switch. At the end of the opening stroke, the toggle arm 7 is stopped by the stop 40 with the toggle arm 8 just short of engagement with crank pin 36.

To close the switch the crank 12 is rotated in a counter-clockwise direction. At the end of the closing stroke the parts are in the position illustrated in Fig. 9.

Although in accordance with the provisions of the patent statutes this invention is described as embodied in concrete form and the principle of the invention has been explained together with the best mode in which it is now contemplated applying that principle will be understood that alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit or from the scope of the annexed claims.

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

1. In combination, a support, an operating shaft for actuating the movable contact member of a switch, a crank member rotatably mounted on said support, an energy storing spring mounted on said support, a crank link pivotally mounted on said support and provided with an eccentric force transmitting member connected to said spring, a toggle having a first arm pivotally mounted for rotation with respect to said support and having a driving connection to said crank member, a second

toggle arm pivotally connected to said first arm and to said crank link to provide extending said toggle and charging said spring in response to rotation of said crank member, a lost motion driving connection between said first toggle arm and said operating shaft to permit said shaft to remain motionless during charging of said spring and to effect rotation of said shaft in response to discharge of said spring, and a second lost motion driving connection between said first toggle arm and said crank member to prevent imparting a blow to said crank member by the discharge of said spring.

2. In combination, a support, an operating shaft for actuating the movable contact member of a switch, a crank member freely mounted on said operating shaft for rotation with respect thereto, an energy storing spring mounted on said support and provided with an eccentric force transmitting member connected to said spring, a toggle device having a first arm freely mounted on said operating shaft for rotation with respect thereto and mechanically coupled to said crank member and having a second arm pivotally connected to said first arm and to said crank link to provide extending said toggle and charging said spring in response to rotation of said crank member, a lost motion driving connection between said first toggle arm and said operating shaft to remain motionless during charging said spring and to effect rotation of said shaft in response to discharge of said spring, and a second lost motion driving connection between said first toggle arm and said crank member to prevent imparting a blow to said crank member by the discharge of said spring.

3. In combination, a support, an operating shaft for actuating the movable contact member of a switch, a crank member freely rotatably mounted with respect to said shaft, an energy storage spring mounted on said support, a crank link pivotally mounted on said support and connected to said spring at a point displaced from its pivotal mounting, a toggle comprising a first arm pivotally mounted on said shaft and having a driving connection to said crank member and a second arm pivotally connected to said first arm and having a displaceable pivotal connection to said crank link to effect extending said toggle and charging said spring in response to rotation of said crank member, and means for effecting radial displacement of said displaceable connection with respect to the axis of rotation of said crank link to vary the moment arm with respect to said axis of the force acting at the point of engagement of said second toggle arm and said crank link.

4. In combination, a support, an operating shaft for actuating the movable contact member of a switch, a crank member freely mounted on said shaft for rotation with respect thereto, an energy storing spring mounted on

said support, a crank link pivotally mounted on said support and provided with a force transmitting connection to said spring, a toggle having a first arm pivotally mounted for rotation with respect to said operating shaft and having a driving connection to said crank member, a second toggle arm pivotally connected to said first toggle arm and having a pivotal connection to said crank link to effect extension of said toggle and charging of said spring in response to rotation of said crank member, a lost motion driving connection between said first toggle arm and said operating shaft to permit said shaft to remain inactive during charging of said spring and to effect rotation of said shaft in response to discharge of said spring, and means for effecting radial displacement of said pivotal connection with respect to the axis of rotation of said crank link to vary the moment arm with respect to said axis of the force acting at said pivotal connection thereby to effect a generally inverse relationship between the amount of charge of the spring and its mechanical advantage with respect to said force.

5. In combination, a support, an operating shaft for actuating the movable contact member of a switch, a crank member freely mounted on said shaft for rotation with respect thereto, an energy storing spring mounted on said support, a crank link pivotally mounted on said support and provided with a force transmitting connection to said spring, a toggle having a first arm pivotally mounted for rotation with respect to said operating shaft and having a driving connection to said crank member, a second toggle arm pivotally connected to said first toggle arm and having a slide pivotal connection to said crank link to effect extension of said toggle and charging of said spring in response to rotation of said crank member, a lost motion driving connection between said first toggle arm and said operating shaft to permit said shaft to remain inactive during charging of said spring and to effect rotation of said shaft in response to discharge of said spring and means for effecting a generally inverse variation between the charge of said spring and its mechanical advantage with respect to the force acting on said crank link at the point of said slidable connection comprising a link pivotally connected to said support and to said pivotal connection for displacing said pivotal connection radially away from the axis of rotation of said crank link as said spring is charged and radially toward said axis as said spring is discharged.

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