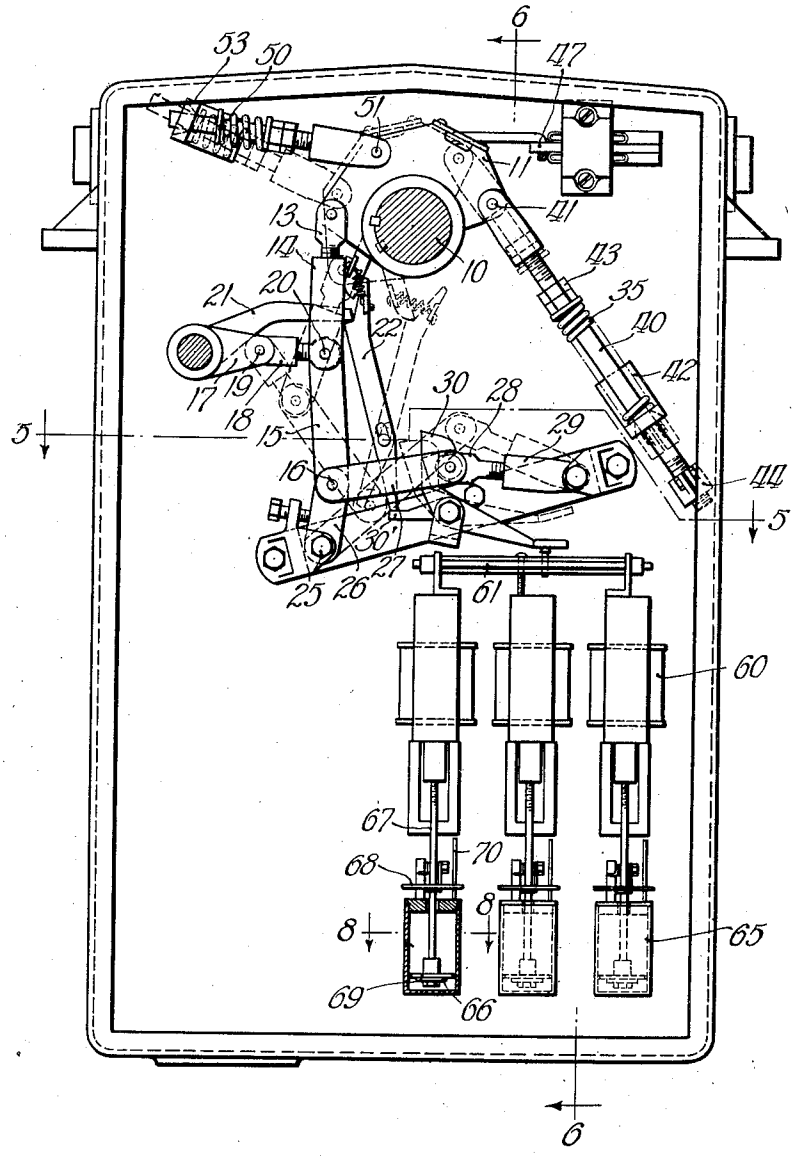
Jan. 24, 1939. J. H. STARR 2,145,140

OIL SWITCH

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Fig. 1.



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Fig. 2.

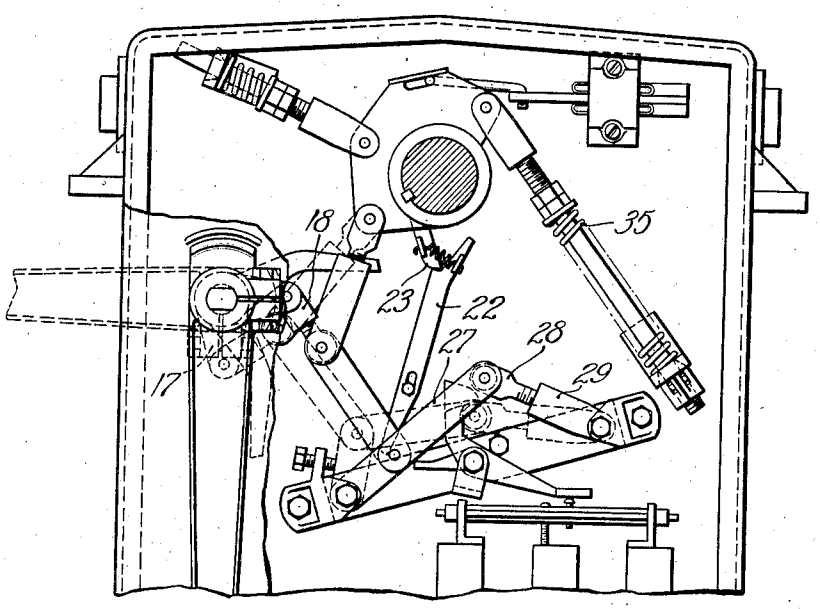
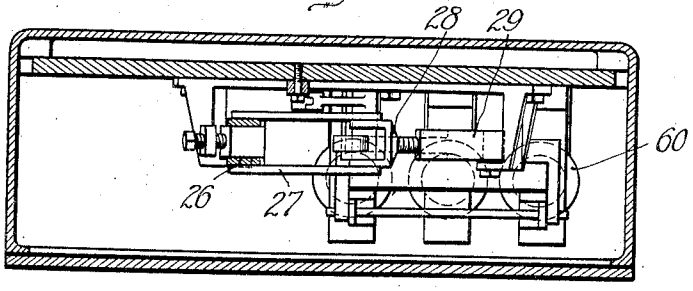


Fig. 3.



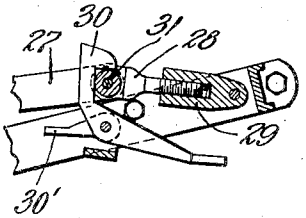


Fig. 5

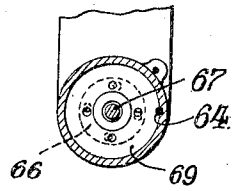


Fig. 6.

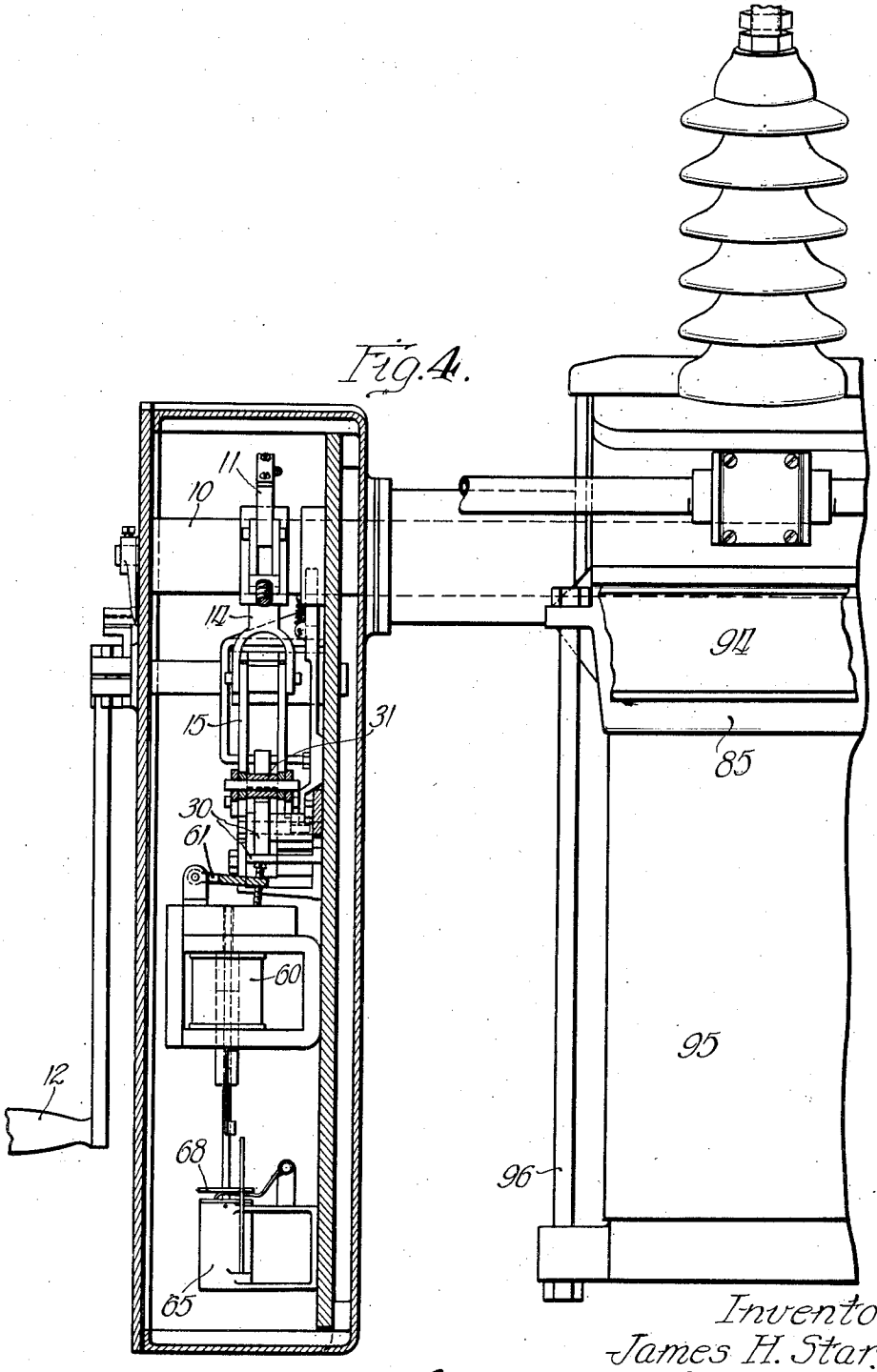
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OIL SWITCH

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Fig. 4.



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UNITED STATES PATENT OFFICE

2,145,140

OIL SWITCH

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Application October 20, 1928, Serial No. 313,729

13 Claims. (Cl. 200—89)

This invention relates to electric oil switches of the kind that may be tripped either electromagnetically or manually and which are reclosed manually and are maintained in the closed position mechanically. While this invention is particularly applicable to switches of this kind, especially high voltage oil switches, it is not limited to such switches and is applicable to electrical switches in general that are used for interrupting large currents or currents at high voltage.

In opening high volage switches, it is particularly important that the contacts be separated at a minimum speed in order to reduce as far as possible the period of arcing and, to keep the arc, as long as it does exist, in the middle of the tank to prevent the burning of the tank wall by the establishment of an arc between the switch contact and the tank wall.

Consider a single pole oil circuit breaker opening a single phase short circuit and assume the current to be decreasing in accordance with the usual sine law. As the current decreases a point is reached at which the resistance of the arc increases more rapidly than the current decreases and consequently the voltage drop across the arc begins to build up. As this process continues a point is reached where the potential required to maintain the arc at the current then flowing is greater than the instantaneous value of the voltage across the arc. At this instant, arc conduction ceases (that is the arc goes out) but conduction continues through the still partially ionized gas bubbles, the gas acting as if it were a simple resistance. A very short time later, say one or two electrical degrees, the current is zero in accordance with the sine law. At this instant, the rate of change of current is a maximum and the voltage drop across the gas bubble formed in zero. A very short period of time later, the voltage has a finite and increasing value in the reverse direction, the conduction through the gas bubble again being what Steinmetz describes as "residual vapor conduction," no arc having yet been reestablished. The resistance of the gas bubble to this type of conduction is high and, as the current increases, a point is soon reached at which RI drop across the gas bubble is equal to the full instantaneous value of the generated voltage, assuming of course, that the gas bubble has not been broken down at a lower potential. During the brief period just described, while the arc is out, the gases have become, to a great extent, deionized.

It is interesting to note that the rate of deionization increases as the pressure increases although in less than a direct ratio. This explains the fact, long realized, that increased pressure made maintenance of an arc more difficult. During this same period of time, the gas bubble has been expanding more or less rapidly depending on the pressure developed within it during the previous half cycle. The energy liberated at an arc is, of course, the product of the current in the arc and the voltage across it at any instant, integrated over a period of time. The energy so liberated is absorbed in raising the oil in contact with the arc to the temperature or vaporization and in vaporizing it. The application of a given quantity of energy to a given oil at a given rate and temperature will produce a given amount of oil vapor. Thus for a specified oil switch, the gas generated per arc in any given half cycle is approximately proportional to the current in that arc since the rate of energy liberation is proportional to the current. Oil vapor tends to occupy a greater volume than the oil from which it was formed and therefore, the gas formed by the arc will be under pressure. The total quantity of gas generated during an operation (measured in units of weight) is more or less directly related to the total energy liberated at the arc.

In the large electric systems of the present type, the current that a switch must break under a short circuit is enormous and the energy available at the arc is correspondingly great.

Since the energy is liberated in an exceedingly short period of time the pressure within a few inches of the arc reaches a high value and the expansion of the bubble formed takes place with almost explosive rapidity. There is a violent motion of the oil away from the contacts. Since the extinguishment of the arc is assisted by the cooling action and the pressure of the oil, it is important that fresh oil should constantly surround the arc.

According to my present invention, I provide a switch having a high opening speed, obtained by moving both contacts of the switch simultaneously. Each contact draws its own arc in the center of the tank, both arcs being adjacent one another. The direction of flow of current in the two arcs is such that they repel one another, thereby minimizing the possibility of both arcs merging into one. The arcs are adjacent and, at the instant of formation, rather close to one another. By this arrangement the violent motion of the oil at either one of the arcs tends to force fresh oil around the contacts between which

the arc is drawn. Thus each arc increases the rate of cooling by the oil adjacent the other arc. There is also a possibility that the explosion produced at one arc increases the hydrostatic pressure at the other arc during the short period of time that it exists, thereby increasing the rate of deionization of the gases when the arc goes out upon the current passing through the zero value at each half cycle during the arcing period.

The present invention further contemplates the use of a single operating shaft for operating both contact carrying arms, the arms being operated from the shaft by a novel link arrangement so constructed that approximately equal angular movement of the arms is obtained throughout the entire range of travel.

In a polyphase system, it is advantageous to operate all poles of the switch from a common shaft. It is therefore the common practice to place the switches as close together as possible with the operating shaft extending through all of the switch tanks. To protect the portion of the operating shaft that extends between the tanks from the weather there is provided a cover or housing surrounding the shaft. I have found that gases frequently creep along the shaft from one pole unit to another. This is very objectionable, for an explosion in one tank may thereby be communicated along the operating shaft with destructive effect to the other pole units. It is an object of this invention to prevent the creepage of gases along the shaft and thus prevent the communication of explosions from one tank to another. In the structure here illustrated this is accomplished by providing a flame proof seal along the shaft between the pole units. The seal consists of a babbited bearing carried by each protective housing between the pole units. The bearings not only prevent the creepage of gases along the shaft but also support the shaft between the pole units. The supporting of the shaft between the pole units is of considerable importance in itself, since the total length of the shaft in a three phase system of even medium voltage is considerable.

The operating mechanism of switches of the kind here contemplated is generally held in the closed position by a latch which may be tripped either manually or electromagnetically. In switches with which I am familiar the latch or equivalent toggle generally rides with the operating link and is therefore subject to intense jars during closing. Another objectionable feature of such arrangements is that the latch has an appreciable velocity during the closing movement and it frequently causes faulty tripping of the switch at that time. The present structure overcomes this difficulty by mounting the latch independent of the operating linkwork so that the latch swings about a stationary axis. By this arrangement the movement of the latch during the closing of the switch is reduced to simple rotation through a small angle, and the switch may be tripped at any time independent of the position of the operating handle.

It is a further object of this invention to provide a switch closing mechanism so arranged that an overtravel of the closing handle cannot produce an over stressing of the brushes. This is obtained by providing a double toggle arrangement wherein the links of the toggles approach alignment as the brushes reach the normal closed position, hence an over travel of the handle cannot force the brushes to move appreciably closer together. It is however to be understood that the invention is not limited to such an arrangement.

The switch is provided with an accelerating spring to accelerate the opening movement and with a decelerating spring which is brought into action near the end of the opening movement to first decelerate the movement of the operating parts and as the parts come very close to their limit of travel the direction of application of the force of the decelerating spring is reversed, thus effectively preventing a rebound of the moving part.

The attainment of the above and further objects will be apparent from the following specification taken in conjunction with the accompanying drawings forming a part thereof.

In the drawings:

Fig. 1 is a side view of the operating mechanism taken with the cover removed, showing the operating parts in the closed position;

Fig. 2 is a fragmentary view similar to Fig. 1 showing the position of the operating parts when the switch is in the open position;

Fig. 3 is a section taken along the line 5—5 of Fig. 1;

Fig. 4 is a section taken along the line 6—6 of Fig. 1;

Fig. 5 is a fragmentary view showing the tripping latch; and

Fig. 6 is a detail view taken along the line 8—8 of Fig. 1;

While ordinarily the operating mechanism is connected to three switches, it is understood that the same could be used to operate one switch or any number of switches as desired. A common shaft extends through all the switches and is adapted to be rotated by the switch operation mechanism for controlling the switches. The tripping mechanism may be operated electromagnetically by means of suitable trip coils located within the casing, or may be operated manually by the lever 12. A pointer 13 on the outside of the casing indicates whether the switches are in closed or open position. Referring now to Fig. 1 wherein the operating mechanism is shown in the closed position, the main shaft 10 enters the housing and carries the crank plate 11 which is keyed thereto. The link consisting of the parts 13 and 14 forms a toggle with the link 15, the opposite end of which is supported on but free to rotate about the pin 16. The link consisting of the parts 17 and 18 pivoted together at 19 is pivoted at 20 to the toggle formed by the links 14 and 15. The member 17 is rigidly attached to a short shaft which is operated by the handle 12 (Fig. 4). Since the member 13 is pivoted to the plate 11, there is thus obtained a double toggle which is capable of exerting a very great force at the main shaft 10 with a small effort at the handle 12. The pin 16 which carries the reaction of the toggle is itself the center pin of a third toggle reacting on the stationary pin 25. The toggle consisting of the links 15 and 26 is maintained in extended position by the link 27 which, in conjunction with the link formed of the parts 28 and 29, forms a fourth toggle which is maintained in the extended position by the latch 30 when the crank plate 11 is rotated in the closed position.

The release of the latch 30 permits the toggle formed by the links 27 and 28—29 to break upward, moving the pin 16 about the pin 25 as a center with the link 26 as the radius. This is equivalent to breaking the toggle formed by the links 15 and 26 and the pin 20 thus swings about

the pin 19 as a center, permitting the links formed by the members 13 and 14 to move downward and allow the crank plate 11 to rotate to the open position under the action of the compressed accelerating spring 35. This movement, it is to be noted, is independent of the operating handle 12 and the member 17 fixed thereto. With the switch in the released position the link mechanism occupies the position shown in Figure 2. To reclose the switch, the operating handle 12 is first moved to the closing position shown in dotted lines in Figure 2 and is then returned to its initial position. Movement of the handle to the dotted line position shown in Figure 2 rotates the lever 17 in a clockwise direction, thus drawing the toggle formed by the links 15 and 13—14 to the position shown in the dotted lines in Figure 2. This draws the pin 16 about the pin 25 as center, thereby drawing the toggle formed by the links 27 and 28—29 downward beneath the latch 30. If the latch 30 is being held open at this time, the movement of the handle 12 is of no effect, and upon the restoration of the handle 12 the link mechanism is restored to the position shown in Figure 2 with no effect upon the shaft 10. If the latch is not held open by the electro-magnetic coils, it is first pushed back by the roller 31 and, as the roller rides over the cam surface of the latch, the latch drops back and locks the roller 31 against upward movement upon the restoration of the handle 12.

Upon restoring the handle 12 to the position shown in full lines in Fig. 2, the member 17 is rotated in a counterclockwise direction forcing the toggle formed by the links 15 and 13—14 to the right, said toggle bearing against the pin 16 which is now held against movement in a clockwise direction by the link 27 that is held stationary by the latch 30 and the links 28—29. As a result, the toggle formed by the link 15 and links 13—14 is reset, thereby causing the crank plate 11 to rotate in a clockwise direction compressing the spring 35. By reason of the action of the link work shown, it is apparent that the shaft 10 cannot be moved beyond the position shown in Fig. 1 even though the handle 12 is moved beyond its normal position. This is so since with the handle 12 in its normal position the links 17 and 18 are almost aligned, and upon the further rotation of the link 17 in a counterclockwise direction, the pin 20 is drawn very slightly to the left rather than to the right, hence the shaft 10 is not rotated in a counterclockwise direction beyond the position shown at Fig. 1. This action effectively prevents overstressing of the brushes due to a possible over-travel of the handle 12.

With the mechanism in the closed position, movement of the handle 12 through approximately five degrees towards the open position, that is, in a clockwise direction, causes the crank arm 21 to move the link 22 downward against the finger 30' integral with the latch 30, releasing the latch to permit the tripping of the circuit breaker in the same manner as though the latch had been tripped electro-magnetically.

In resetting, the cam 23 (Fig. 2) through a spring connection causes the upper end of the link 22 to rotate about a guide pin passing through a slot in the link 22, and the roller 31 may then be forced under the cam surface of the latch 30 to permit the swinging of the switch to the closed position, as previously described.

The rod 40 is pivoted at the pin 41 to the crank plate 11 and passes freely through an opening in the stationary plate 42. With the apparatus in the closed position, as shown in Fig. 1, the spring 35 is under compression and exerts a powerful tangential force tending to rotate the shaft 10 in a counterclockwise direction, that is, to the open position. The latch 30 acting through the linkwork previously described prevents the rotation of the shaft. The compression of the spring 35 may be adjusted at the lock nuts 43, and the length of stroke of the rod 40 may be adjusted at the lock nut 44. When the switch is in the closed position, the decelerating spring 50 is not stressed. As the crank plate 11 rotates to the open position, the spring 50 comes into action near the end of the opening movement, is compressed and exerts a force on the crank plate 11 which has a powerful tangential component. The force exerted by this spring may be adjusted by means of lock nuts similar to the nuts 43 for adjusting the spring 35, and can be set to reduce the velocity of the moving parts to a low value, which is just sufficient to carry the point 51 across a line drawn from the center of the shaft 10 through the center of the decelerating spring rod guide support 53.

The component of the force exerted by the spring 50 tangent to the crank disc is reversed in direction as the pin 51 passes dead center near the end of the stroke, and it then tends to force the mechanism slightly further open. Actually this force carries the mechanism a very short distance further until the stop 44 engages the stationary plate 42. The mechanism is thus brought to rest at the end of the stroke without shock and the rebounding of the parts is thus effectively prevented. The stop 44, being adjustable, the location of the switch parts in the open position may be accurately fixed.

The automatic tripping of the latch 30 is brought about by the plunger of any of the electro-magnets 60, of usual construction, raising the pivoted lever 61 in a manner apparent from Fig. 4 of the drawings. The rate at which any of these magnet plungers may rise is controlled by a novel time-delay device in the form of a dash pot 65. The dash pot consists of a cylinder closed at its lower end and containing a suitable liquid which is of an approximately constant viscosity between the temperature limits anticipated. A piston disc 66 is rigidly attached to the lower end of the vertical rod 67 carrying the trip coil armature, and is restrained against rotation by a spring wire guide 70 engaging one of several notches in the periphery of a disc 68 rigidly attached to the vertical rod immediately above the dash pot. Resting upon the piston 66 is a disc 69, the outside diameter of which is equal, except for mechanical clearance, to the inside diameter of the cylinder.

The disc 69 is free to move vertically on the rod 67 but is held from rotation about its vertical axis by a vertical guide 64 extending the length of one side of the dash pot adjacent to its inner circumference. The piston 66 and the disc 69 are each provided with a plurality of holes at the same distance from the center, which holes may be made to line up, to close one another, or to assume intermediate positions by rotating the rod 67. The rod 67 may be held in any rotated position by selecting the notch in the disc 68 which engages the stationary wire guide 70. By this adjustment the resistance against upward movement of the piston 66 through the oil may be varied. On the re-set stroke, which is accomplished by gravity, the resistance of the liquid tends to hold the disc 69 while the piston 66 drops more rapidly. Once the piston 66 has separated from the disc 69, the full area of the holes

in the disc 69 is exposed and the disc follows the piston to the re-set position with a minimum delay. The auxiliary switch 47 controls a signalling circuit to indicate whether the main switch is open or closed.

The casting 85 is firmly secured to two supporting channel beams 94 and supports the oil tank 95. The oil tank is supported from the cover 85 by four bolts 96 placed one at each corner of the tank. The shanks of the bolts are turned down to a diameter less than that at the root of the threads and are so proportioned that a small but distinct elastic stretch will result before the material is stressed to the elastic limit. The bolts 95 are made of a material having a low modulus of elasticity combined with a high elastic limit. By this means a resilient support for the tank is obtained.

In compliance with the requirements of the patent statutes, I have herein shown and described a preferred embodiment of my invention. I do not wish to be limited to the precise structure here shown, the same being shown for illustrative purposes only. What is believed to be new and desired to be secured by Letters Patent is:

1. In an electric switch operating mechanism, an operating shaft having a limited angular movement, a spring for decelerating the movement of the shaft as the shaft approaches the limiting switch opening position, said spring being in substantially its unstressed condition when the mechanism is in its normal closed position, the spring being connected at one end thereof to be moved by the shaft to approach a position extending radially of the shaft as the shaft approaches the full open position and to reach the radial position slightly before the shaft reaches its limiting position, whereby the direction of force of the decelerating spring is reversed as the same passes the radial position.

2. In an operating mechanism for electric switches accelerating means for accelerating the movement of the switch from the closed position to the open position, a stop for limiting the movement of the switch, and decelerating means effective as the shaft approaches the limit of motion in its switch opening direction to first decelerate the movement of the shaft and then accelerate the movement.

3. A switch operating mechanism including a switch operating member biased to its open position, an actuator for the mechanism, a link pivoted to the operating member, a second link pivoted to the first link and pivoted to the actuator, a toggle guiding the movement of the pivot between the two links, and means for releasably retaining the knuckle of the toggle against breaking, one of the members of the toggle and the first mentioned link being in position of toggle when the switch is closed whereby the first mentioned toggle takes the thrust of the bias on the operating member.

4. A switch operating mechanism including a switch operating member biased to its open position, an actuator for the mechanism, a link pivoted to the operating member, a second link pivoted to the first link and pivoted to the actuator, a toggle guiding the movement of the pivot between the two links, and means for releasably retaining the knuckle of the toggle against breaking, said means comprising a second toggle extending between the first toggle and a fixed point and a latch holding the second toggle to hold the knuckle of the first toggle, one of the members of the first toggle and the first mentioned link being in position of toggle when the switch is closed whereby the first mentioned toggle takes the thrust of the bias on the operating member.

5. A switch operating mechanism including a switch operating member biased to its open position, a toggle extending between said member and a movable point, actuating means connected to the knuckle of said toggle and holding said knuckle against breaking when the mechanism is in its switch closed position and including a pair of links approximately in toggle position when the mechanism is in its switch closed position, and releasable means for holding said movable point fixed, thereby maintaining the toggle system in equilibrium.

6. A switch operating mechanism including a switch operating member biased to its open position, a toggle extending between said member and a movable point, actuating means connected to the knuckle of said toggle and holding said knuckle against breaking when the mechanism is in its switch closed position and including a pair of links approximately in toggle position when the mechanism is in its switch closed position, and releasable means for holding said movable point fixed, thereby maintaining the toggle system in equilibrium, said releasable means including a toggle holding said movable point and a latch holding said toggle.

7. A switch operating mechanism including a switch operating member biased to its open position, a toggle extending between said member and a movable point, actuating means connected to the knuckle of said toggle and holding said knuckle against breaking when the mechanism is in its switch closed position and including a pair of links approximately in toggle position when the mechanism is in its switch closed position, releasable means for holding said movable point fixed, thereby maintaining the toggle system in equilibrium, said releasable means including a toggle and a latch holding the toggle, and electromagnetic tripping means for tripping said latch to release said last mentioned toggle thereby releasing said movable point to permit movement of the operating member.

8. A switch operating mechanism including a switch operating member biased to its open position, a first link pivoted thereto, a second link pivoted to the first link, a third link pivotally connecting said second link to a fixed point, said first two links being in position of toggle when the mechanism is in its switch closed position and said second and third links being also in position of toggle when the mechanism is in its switch closed position, actuating means holding one of said toggles against breaking when the operating mechanism is in its closed position, and releasable latch means holding the other toggle against breaking, said other toggle being urged in its breaking direction by the bias on said switch operating member whereby the toggle system is rendered unstable by the release of the latch.

9. A switch operating mechanism including a switch operating member biased to its open position, a first link pivoted thereto, a second link pivoted to the first link, a third link pivotally connecting said second link to a fixed point, said first two links being in position of toggle when the mechanism is in its switch closed position and said second and third links being also in position of toggle when the mechanism is in its switch closed position, actuating means holding

one of said toggles against breaking when the operating mechanism is in its closed position, releasable latch means holding the other toggle against breaking, said other toggle being urged in its breaking direction by the bias on said switch operating member whereby the toggle system is rendered unstable by the release of the latch, and means responsive to the initial movement of the actuating means from the switch closed position towards the switch open position for tripping the latch to render the toggle system unstable.

10. A switch operating mechanism including a switch actuating toggle pivoting at one end about a fixed axis, a second toggle pivoted at one end about another fixed axis, a pivotal connection between the other ends of the two toggles, a switch operating member, a link connecting the operating member with the pivotal connection between the two toggles, said link being in toggle position with the adjacent link of the second toggle, and means for releasably holding the second toggle against breaking, said means including a latch pivoted about a stationary pivot.

11. A switch operating mechanism including a switch actuating toggle pivoting at one end about a fixed axis, a second toggle pivoted at one end about another fixed axis, a pivotal connection between the other ends of the two toggles, a switch operating member, a link connecting the operating member with the pivotal connection between the two toggles, means for releasably holding the second toggle against breaking, said means including a latch pivoted about a stationary pivot, and means responsive to a movement of one of the members of the first toggle towards the switch opening position for tripping the latch to trip the second toggle.

12. A switch operating mechanism including an operating member movable through a limited angle of less than 180° from its switch open position to its switch closed position, a crank arm carried by said member, an actuating spring engaging said crank arm for constantly urging the member towards its open position, a decelerating spring pivotally connected at one end to said crank arm to form with said member a toggle connection offering substantially no impediment to the initial opening movement of the member, whereby the full force of the actuating spring is available to produce a high acceleration of the operating member upon the initiation of the switch opening movement, a pivotal connection for the other end of said decelerating spring said spring being stressed by the continued opening movement of the operating member against said last-named pivotal connection and being moved to toggle position extending radially of the operating member slightly before the operating member reaches its limiting open position, whereby the direction of application of force by the decelerating spring on the operating member is reversed as the operating member approaches its full closed position to prevent rebounding of the operating member.

13. In combination, a switch operating member biased to its open position, a linkage extending between said member and a movable point and sustaining at least a substantial portion of the thrust of the biasing force which urges the operating member from its switch closed to its switch open position, means for holding the linkage stable against the biasing force, said means including an electromagnetically controlled tripping latch pivoted about a stationary pivot and means controlled by the latch for holding the movable point against movement in the direction that it is urged by the biasing force exerted on the linkage by the operating member, and actuating means including an actuating link pivoted about a fixed axis and a second link pivotally connecting the actuating link with the linkage, said actuating link being movable through a limited angle in one direction to effect a switch closure movement of the linkage only when the movable point is held fixed by the latch, and in the reverse direction to reset the latch controlled holding means for the movable point after a tripping of the linkage by a release of the latch, the linkage being incapable of moving the actuating link from its normal closed position towards its open position, whereby the actuating link tends to remain in its switch closed position while the linkage is in the switch closed position.

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