June 10, 1958 E. G. HILLS ET AL 2,838,624

SWITCHING APPARATUS

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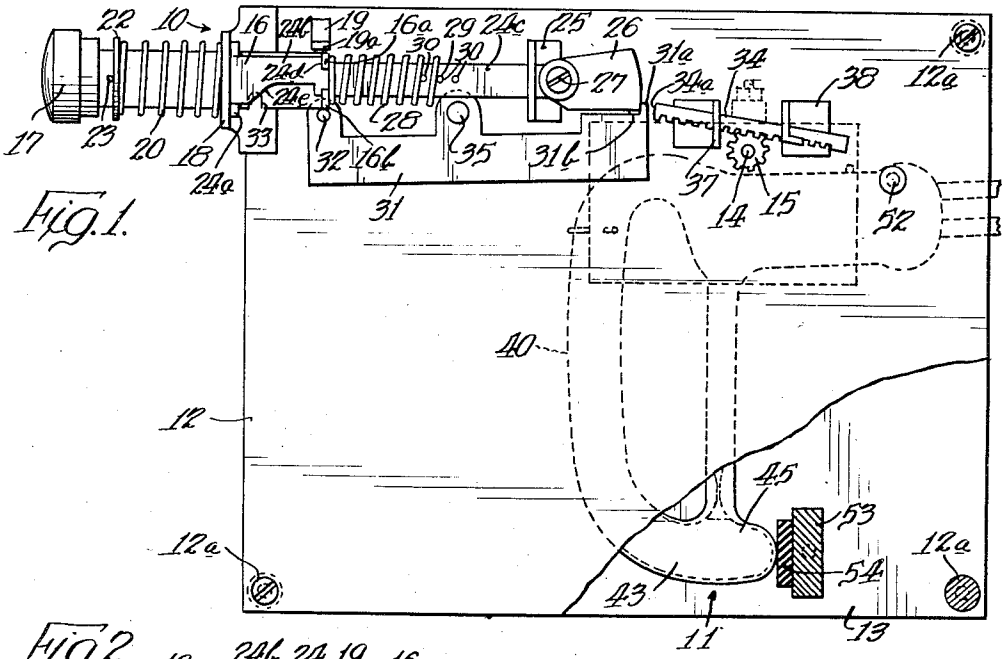


Fig. 1.

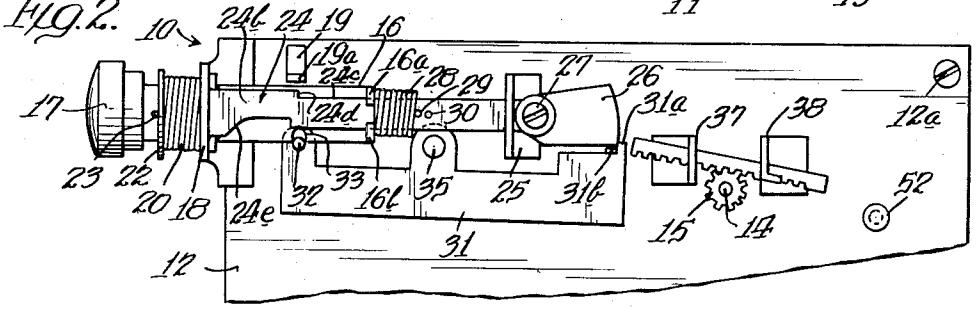


Fig. 2.

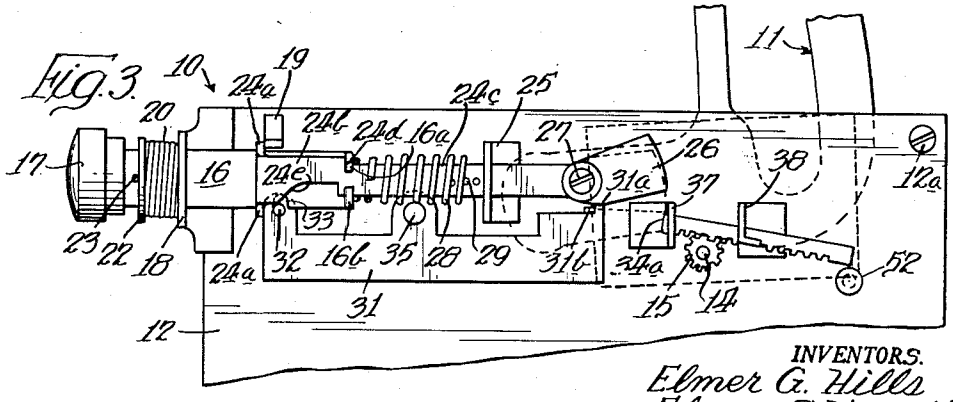


Fig. 3.

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Fig. 4.

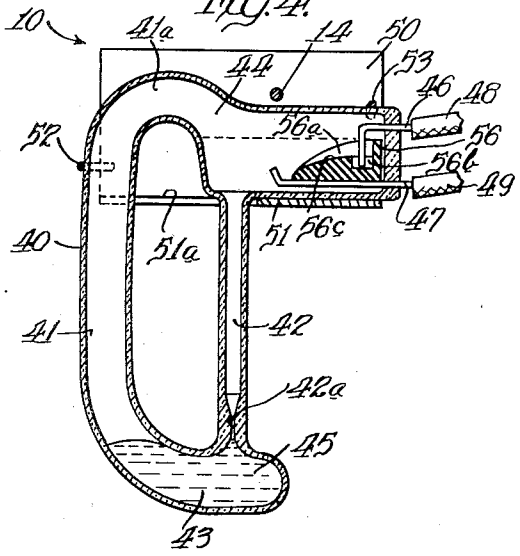


Fig. 5.

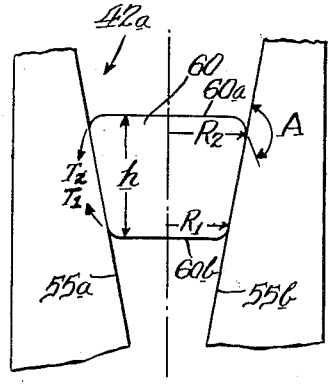


Fig. 6.

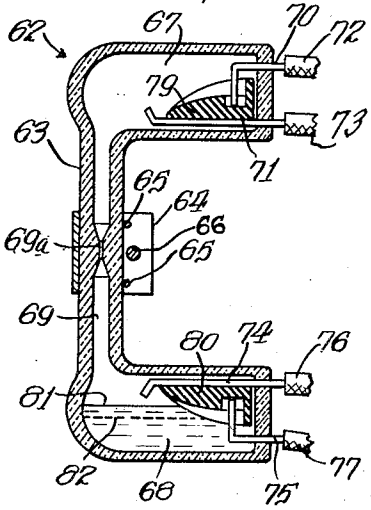


Fig. 7.

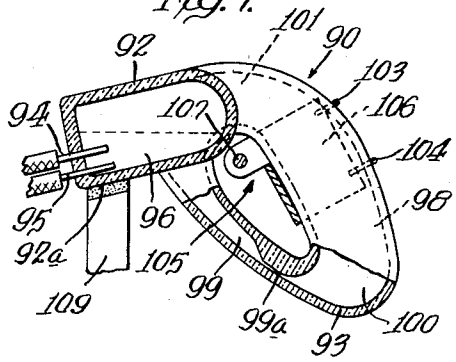
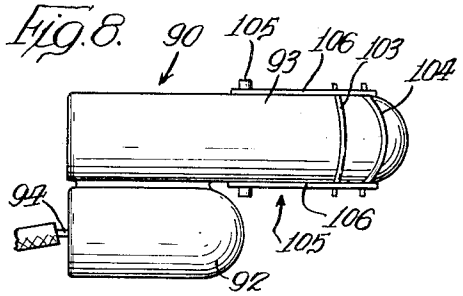


Fig. 8.



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SWITCHING APPARATUS

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Application February 25, 1954, Serial No. 412,489

3 Claims. (Cl. 200—33)

This invention relates generally to switching apparatus and, more particularly, to a new and improved timing switch and associated actuating mechanism for delivering a uniform force to actuate the switch.

The switching apparatus of the present invention is particularly adapted for use in energizing and de-energizing the electrical control circuits for a hand drying mechanism, although it will be understood that the apparatus is not limited to such use. However, since operation of the apparatus in conjunction with electrically operated hand driers affords an excellent illustration of most of its features, the ensuing description will be concerned primarily therewith. One of the principal requirements for switching apparatus for hand driers is that suitable contacts must be closed immediately upon the actuation of the switch by the operator and these contacts must remain closed for a predetermined interval while the drying operation is performed. Prior arrangements for meeting this requirement have generally involved elaborate relay holding circuits of the mechanical or electromagnetic type which have been both space-consuming and expensive.

At present, hand drying mechanisms are principally used in public establishments where they are operated by any number of persons who apply widely divergent degrees of force to the manually actuated switch control element. Since repeated applications of force of excessive magnitude to the switching mechanism controlled by the manually actuated element would cause damage to the switch to appreciably shorten its life, it is desirable to apply a uniform force to this mechanism regardless of the force applied to the manually actuated element.

It is an object of the present invention, therefore, to provide new and improved switching apparatus which obviates all of the aforementioned difficulties.

Another object of the invention is to provide a simply constructed, inexpensive, yet efficiently operating switching apparatus which is sufficiently rugged to withstand a relatively long period of hard use.

A further and more specific object of the invention is to provide a manually operable switching apparatus including means for applying a uniform force to actuate the switch of a magnitude which is independent of the degree of force applied to the manually operated elements of the mechanism.

A still further object of the invention is to provide a manually actuated switch for instantly closing its contacts when actuated, and for maintaining its contacts closed for a predetermined interval measured by the passage of fluid through a restricted passageway.

The invention both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings in which:

Fig. 1 is a front elevational view partly in section showing a switching apparatus characterized by the features of the present invention;

Figs. 2 and 3 are partial views of the switching apparatus shown in Fig. 1 illustrating the position occupied by the various component elements of the mechanism during its manual actuation;

Fig. 4 is a vertical sectional view showing the switch portion of the apparatus of Fig. 1;

Fig. 5 is a greatly magnified view of the constricted opening through which fluid flows to time the interval of contact closure in order to aid in explaining the present invention;

Fig. 6 is a vertical sectional view illustrating a second embodiment of the switch portion shown in Fig. 4;

Fig. 7 is a front elevational view partly broken away of a third embodiment of the switch portion shown in Fig. 4; and

Fig. 8 is a plan view of the switch portion shown in Fig. 7.

Referring now to the drawings, and more particularly to Figs. 1, 2 and 3 thereof, the present invention is there illustrated as embodied in a switching apparatus comprising a manually operable switch actuating mechanism, indicated generally as **10**, and a switch or switch portion, generally indicated at **11**, both of which are mounted upon a frame including a pair of substantially parallel flat plates **12** and **13**, which may be formed of metal, plastic, or any other suitable material. These plates are preferably maintained in spaced apart relationship by the insertion of four cylindrical spacers, all designated by the reference character **12***a*, and each mounted between adjacent corners of the opposed plates. As illustrated in Figs. 1 and 3, the component elements of the actuating mechanism **10** are supported upon one side of the plate **12**, whereas the switch **11** is mounted in the space between the plates **12** and **13** on a shaft **14** extending horizontally through the plates and having one end protruding beyond the plate **12** in order to receive a gear **15**, the purpose of which will be evident as the description proceeds.

For the purpose of actuating the switch **11**, the mechanism **10** includes a manually actuated reciprocable plunger **16** of any suitable cross section carrying a push button **17** on its free end and extending through a cooperating guide opening in a guide bar **18** suitably secured to the plate **12**. In order to provide additional means for guiding the plunger **16** in its reciprocation from left to right and from right to left, as viewed in Figs. 1, 2 and 3, the plate **12** also mounts an L-shaped guide **19** having a leg **19***a* in contact with the upper edge of the plunger **16**.

In order to return the plunger **16** to its normal or deactuated position, as shown in Fig. 1, after it has been manually moved to the right, as viewed in Figs. 2 and 3, by force applied to the push button **17**, a suitable compression spring **20** encompasses the plunger and is held between the guide bar **18** and a spring retaining collar **22** carried by the plunger. The collar **18** is maintained in position on the plunger between one end of the spring **20** and a holding pin **23** inserted within a small aperture in the plunger. Thus, in the absence of pressure on the push button **17**, the spring **20** urges the plunger **16** and the push button to the left, as viewed in the drawings, and holds them in the position shown in Fig. 1.

To relate the plunger **16** to other elements of the switching apparatus of the present invention, the end of plunger **16** remote from knob or push button **17** may be bifurcated with the bifurcations **16***a* and **16***b* extending laterally away from plate **12** so as to define a slot or channel between the bifurcations. The bifurcations are preferably notched to further define a channel for receiving a reciprocable bar **24** which includes an end portion **24***a* extending laterally of the bar and having a suitable opening through which the plunger **16** passes. If a rectangular plunger **16** is employed, this opening will, of course, be rectangular. The bar **24** also includes a

portion 24*b* and a somewhat downwardly displaced portion 24*c*, the junction of these two portions forming an upper abutment 24*d* which functions as a stop for limiting the movement in one direction of the plunger 16 in a manner to be more fully described hereinafter.

The lower edge of the portion 24*b* of the bar 24 is suitably indented to form a camming surface 24*e* for purposes which will become apparent from the ensuing description. The portion 24*c* of the bar 24 extends through a rectangularly-shaped opening in a guide flange 25 secured in any suitable manner to the plate 12. The end of the bar 24 remote from plunger 16 has pivotally mounted thereon a pawl 26. As illustrated, pawl 26 has a bifurcated end portion 26*a* fitting over the end of the bar in order to permit the pawl to pivot about a pivot pin 27 which may be threaded through aligned openings in the bifurcations so as to extend loosely through an opening in the end of the bar 24.

For the purpose of delivering a uniform force to the bar 24 when the plunger 16 is actuated, a spring 28 surrounds the bar and has its respective ends in engagement with the laterally extending bifurcations 16*a* and 16*b* on the plunger and with a spring retaining pin 29 inserted within an appropriate aperture 30 in the bar 24. Actually, a plurality of aligned and spaced apertures, all indicated by the reference character 30, are provided in the bar in order to provide a means for adjusting the amount of compression of the spring 28, thereby to control the magnitude of the uniform force delivered to the bar 24.

From the above description it will be apparent that the plunger 16 and bar 24 together provide a telescoping force transmitting member for delivering a uniform force determined by the energy stored in spring 28 to a mechanism to be actuated regardless of the force applied to plunger 16.

In order to retain the bar in position to permit the spring 28 to be compressed upon actuation of the plunger 16, there is provided a latch 31 mounted for limited pivotal movement about a stub shaft or pivot 35 on the plate 12 and having a retaining lip or latching portion 31*a* in engagement with the pawl 26. To provide for the release of the pawl 26 from latching portion 31*a* of the latch 31 only after the spring 28 has been fully compressed, the latch 31 includes a detent 32 which cooperates with a slot 33 in the lower portion of the plunger to pivot the latch portion 31*a* out of engagement with the bar 24. When the latch 31 is disengaged from the pawl 26, the energy stored in the spring 28 is released to deliver a uniform force to the bar 24 due to the fact that spring is always compressed by the same amount. The latch 31 also includes a support 31*b* for preventing the pawl 26 from pivoting in a clockwise direction as viewed in Fig. 1 of the drawings.

For the purpose of utilizing this uniform force to actuate a suitable mechanism such as the switch 11, the energy delivered to the bar 24 moves the bar and the pawl 26 to the right, as viewed in Fig. 1, and may be utilized to actuate any suitable mechanism. To convert reciprocal movement to rotary movement, the pawl 26 is caused to engage one end 34*a* of a rack 34 positioned in the path of movement of the pawl. To guide the reciprocal movement of the rack 34, it extends through suitable openings in guide flanges 37 and 38 formed on the plate 12, and meshes with the gear 15 on the switch shaft 14. Thus, when the pawl 26 engages the end 34*a* of the rack 34 and moves the rack to the right, as viewed in Fig. 1, the shaft 14 is rotated through a predetermined angle, which, in order to illustrate the invention, will be assumed to be approximately 180°. To provide for the disengagement of the pawl from the end 34*a* of the rack 34 after the shaft has been rotated through the desired angle, the rack is downwardly inclined so that as it moves to the right it also has a slight downward movement which eventually causes the end 34*a* to descend below the essentially straight path of movement of the pawl 26. Upon the latter occurrence the pawl disengages itself from the rack gear and the shaft returns to its normal position, as shown in Fig. 1, by any suitable means, such, for example, as by the action of gravity on the switch 11, as will become evident from the ensuing description. It will be understood that the mechanism thus far described, although admirably suited to actuate a switch, may be used to operate other devices requiring the application of a uniform force. Before describing the switch 11 in detail, it may be pointed out that the switch is mounted for pivotal movement with shaft 14, and such pivotal movement actuates the same.

From the foregoing explanation it will be understood that the switch 11 and its actuating mechanism 10 are both shown in Fig. 1 in their normal or deactivated positions prior to the application of manual force to the mechanism. In order to actuate the switch, the operator presses on the push button 17 to move the plunger 16 from the position shown in Fig. 1 to that shown in Fig. 2. The movement of the plunger 16 compresses both of the springs 20 and 28, as shown in Fig. 2, since, during this movement of the plunger 16, the bar 24 remains stationary due to the fact that the pawl 26 remains in firm engagement with the lip or latching portion 31*a* of the latch 31. As soon as the plunger 16 occupies the position shown in Fig. 2, the detent 32 comes into alignment with the slot 33 in the lower edge of the plunger 16. The force of the compressed spring 28 against the lip 31*a* pivots the latch 31 about the shaft or pivot 35 and causes the detent 32 to move into engagement with the slot 33. As the latch 31 is pivoted about the shaft 35, the lip 31*a* moves out of engagement with the pawl 26 which is resting on support 31*b*, and the bar 24 is thus free to move to the right under the force produced by the energy stored in spring 28. The engagement of the detent 32 with the slot 33 prohibits further movement of the plunger 16 to the right, and thus the force delivered to the bar 24 is solely that which results when the stored energy in the spring 28 is released. Therefore, this force is uniform and its magnitude is independent of the pressure applied to the knob or push button 17, provided, of course, that such pressure is sufficient to move the plunger 16 the required distance to the right, as viewed in the drawings.

As the bar 24 moves to the right from the position shown in Fig. 2 due to the expansion of spring 28, the pawl 26 engages the end 34*a* of the rack 34 and induces the latter to rotate the gear 15 and the shaft 14. The rotation of the shaft 14 actuates the switch 10 in a manner which will become evident from the ensuing description. By the time that the shaft 14 has been rotated through an angle sufficient to actuate the switch 10, the inclined rack 34 has been moved both downward and to the right to the position shown in Fig. 3, at which time the end 34*a* of the rack 34 is moved out of engagement with the pawl 26. The movement of the bar 24 to the right also brings the camming surface 24*e* of the portion 24*b* of the bar 24 into engagement with the detent 32 resting within the slot 33. As the bar 24 is further moved to the right by expansion of spring 28, the camming surface 24*e* moves the detent out of the slot and pivots the latch 31 in a counterclockwise direction about the shaft 35 until it assumes the position shown in Fig. 3. The pawl is pivoted slightly about the axis of the screw 27 due to the engagement between the lower edge of the pawl and the upper edge of the lip 31*a* on the latch. With the detent 32 moved out of the slot 33 by the camming surface 24*e*, the plunger 16 is free to return to its normal position, and thus the energy stored in the spring 20 during the actuation of the mechanism 10 is released to begin movement of the plunger 16 to the left

from the position shown in Fig. 3. The plunger **16** moves to the left, as viewed in Fig. 3, under the force of spring **20** until the laterally extending bifurcation **16***a* on the end of the plunger **16** strikes the abutment **24***d* on the bar **24**, thereby limiting the movement of the plunger **16** in this direction. After the lip **16***a* and the abutment **24***d* are in engagement, the plunger **16** and the bar **24** move in unison to their initial positions shown in Fig. 1 under the continued force exerted by spring **20**. When the bar **24** reaches its initial position, shown in Fig. 1 of the drawings, the pawl **26** pivots slightly in a clockwise direction from the position shown in Fig. 3 due to the force of gravity on this member, thus bringing the free end of the pawl again into engagement with the lip **31***a*, as shown in Fig. 1. When this occurs, the switching mechanism is completely restored to its normal position in preparation for a subsequent application of pressure to the push button **17** in order to repeat the operation described above.

Since a mercury type switch is one readily operated to the closed or open position, the switch **11** has been indicated as a mercury switch, and the present invention is also concerned with certain features of the switch **11** apart from the mechanism **10** already described. Turning now to Fig. 4, there is shown the switch **11**, illustrated as a mercury switch disposed in its open position, as also shown in Fig. 1 of the drawings. As illustrated, the switch **11** comprises an enclosed envelope or housing **40**, preferably formed of glass or the like, and including two parallel connected passageways comprising a large passageway **41** and a smaller passageway **42** including a restricted portion **42***a*, both of these passageways being joined at the bottom by a well **43** and at the top by an enlarged chamber **44**. As best shown in Fig. 1, the well **43** contains a pool of conducting fluid **45**, preferably of mercury, when the switch **11** is in its normal position prior to actuation of the mechanism **10**. To complete the switch, a pair of fixed contacts **46** and **47** extend through the wall of the housing **40** and into the enlarged chamber **44**, the outer ends of these contacts being connected through leads **48** and **49** to any electrical device or circuit to be controlled. For the purpose of preventing oxidation of the metal parts of the switch **10** upon the occurrence of switching arcs, the housing **40** may be filled with inert gas or reducing gas in addition to including the mercury **45**.

To provide means for mounting the switch **11** between the parallel supporting plates **12** and **13** for pivotal movement with shaft **14**, the housing **40** is carried by a U-shaped channel piece having opposed sides **50**, only one of which is shown in Fig. 4, joined by a bottom plate **51** which extends only partly along the length of the sides **50** to provide an opening **51***a*. The portion of the housing **40** defining the enlarged chamber **44** rests on the bottom plate **51**, while that portion of the housing **40** defining the passageways **41** and **42** and the well **43** extends through the opening **51***a* and downwardly from the opposed sides **50**. In order to maintain the housing **40** in position on the U-shaped channel piece, a pair of spaced retaining pins **52** and **53** extend between pairs of aligned openings in the opposed sides **50**, each of these pins contacting the exterior wall of the housing **40**. The shaft **14**, which is rotated by the actuating mechanism **10**, extends through each of the opposed sides **50** in positive engagement therewith in order to cause rotation of the switch **11** with the shaft **14**, as mentioned above.

When the shaft **14** is rotated through an angle of 180° in the manner previously described, the switch **11** is rotated in a clockwise direction until it is inverted from the position shown in Figs. 1 and 4, at which time this switch occupies the position shown in Fig. 3. The clockwise rotation of the switch **11** is limited by a suitable stop **52** secured to the plate **13** and adapted to engage an edge of one of the sides **50** at the extremity of desired

movement of the switch. When the switch **11** is inverted, the pool of mercury **45** in the well **43** flows through the large passageway **41** into the enlarged chamber **44**, which chamber at this time is located at the bottom of the switch. At the completion of the actuating stroke delivered to the shaft **14** by movement of the bar **24**, the pawl **26** becomes disengaged from the rack **34** and the weight of the mercury causes the switch **11** to rotate in a counterclockwise direction and return to its normal position due to the effect of gravity. The counterclockwise rotation of the switch **11** is limited by a stop **53** secured between the plates **12** and **13**, and preferably including suitable cushioning material **54** so that when the stop is contacted by the glass housing **40** damage will be avoided. The return of the switch to the position shown in Fig. 4 induces a counterclockwise rotation of the shaft **14** and at the same time restores the rack **34** to its normal position (Fig. 1). The return of the switch **11** to this position has another very important result in that a portion of the pool of mercury is trapped within the enlarged chamber **44**, as best shown in Fig. 4. This is because the connection with passageway **41** is defined by a passageway section **41***a* above the contacts **46** and **47**, whereby the entrapped liquid covers the contacts **46** and **47**, and thus closes the electrical circuit controlled by the contacts through the conductors **48** and **49**. The mercury trapped in the chamber **44** can return to the chamber **45** only through passageway **42**. Due to the fact that this passageway includes a constricted portion **42***a* providing a structure somewhat analogous to the well-known hour glass, the flow of mercury is impeded.

When the switch **11** returns to its normal position after actuation, the sudden deceleration of the mass of mercury induced by the impact of the glass envelope with the stop **53** increases the effective pressure head above the constriction **42***a* and starts the flow of mercury through the small opening. The mercury **45** in the upper chamber **44** is maintained in simultaneous contact with both of the fixed contacts **46** and **47** for the interval of time required for the flow through the constriction **42***a* to reduce the level of mercury in the upper chamber and break the contact. The length of this interval is a function of the rate of flow of the mercury, which in turn depends upon the size of the opening in the constricted portion **42***a* of the passageway **42**.

To provide means for quickly moving the mercury away from the contact **46** to break sharply the electrical conducting path between the contacts **46** and **47**, there is provided a barrier **56** of ceramic or the like having a liquid guiding trough **56***a* formed therein. The barrier **56** preferably rests upon the lower contact **47** and includes a small contact receiving well **56***b* into which the contact **46** extends. When the desired time interval has elapsed and the level of the mercury in the upper chamber has dropped to a point where its surface nearly touches the bottom of the trough **56***a* in the barrier at the point designated **56***c* in Fig. 4, the surface tension of the mercury causes a sudden parting of the surface into two portions, one of which is the main body of mercury in the upper chamber **44** and in the restricted passageway **42**, and the other of which is a small drop of mercury in the well **56***b* surrounding the lower end of the contact **46**. Obviously, when the surface of the mercury is broken into two parts, the electrical conducting path between the contacts **46** and **47** is severed. After electrical contact is broken, the mercury continues to flow through the restricted passageway **42** until the entire mercury pool has again collected in the well **43** at the bottom of the housing, at which time the switch **11** is ready for the next succeeding actuation by the mechanism **10**.

The operation of the constricted portion **55** of the passageway **42** in impeding the flow of mercury therethrough will be best understood by reference to Fig. 5, which is a greatly enlarged view of this constricted portion. In order to insure that mercury trapped in the

upper chamber **44** of the housing **40** upon actuation of the mechanism **10** will begin to flow through passageway **42**, it is necessary that the constricted portion **42***a* be properly tapered as indicated by the sloping side walls **55***a* and **55***b* in the greatly enlarged view of Fig. 5. Considering first a small quantity of mercury **60** having an upper surface **60***a* and a lower surface **60***b*, and adapted to pass through the small opening in the constricted portion **42***a*, it will be recognized that the surface of the mercury will contact the glass walls of the passageway at an angle indicated by the reference character A. The magnitude of this angle is a function of the characteristics of the mercury, and is thus constant for all bounding edges of the mercury in contact with the glass walls. Both the upper and lower surfaces of the mercury exert forces on the glass walls as a result of the surface tension of the mercury, the surface tension due to the upper surface **60***a* being directed downwardly in the direction of the arrow T_2, and that due to the lower surface being exerted upwardly in the direction indicated by the arrow T_1. The total upward force resulting from the surface tension of the lower surface **60***b* is equal to the length of the line of contact between the mercury and the glass multiplied by the surface tension of the mercury, the latter being a constant equal to 470 dynes per centimeter. Thus, the total upward force may be expressed as:

$$T_1=(2\pi R_1)k$$

where k is the surface tension constant of mercury, and R_1 is the radius of the passageway at the lower surface **60***b*.

The upward pressure P_1 resulting from this force is, of course, the total force divided by the area (πR_1^2), and may be expressed as:

$$P_1=\frac{2k}{R_1}$$

Thus, it can be seen that the pressure is inversely proportional to the radius. It, therefore, follows that the upward pressure exerted by the lower surface **60***a* exceeds the downward pressure resulting from the surface tension of the upper surface **60***b* due to the fact that the radius R_2 of the upper surface is larger than the radius R_1. Therefore, in order for mercury to begin to flow through the passageway **42**, the pressure head, due to the weight of mercury in the column above the constricted portion **42***a*, must overcome the excess surface tension exerted by the lower surface. In the limiting case in which the mercury would just barely start to flow downward, the difference between the pressures on the two surfaces would equal the pressure on the lower surface due to the head of the mercury *"h"* of Fig. 5. By so constructing the glass tube such that the change in tube radius for a given change in tube height is always less than a certain amount, the mercury will always flow through the tube under its own weight. Once the stream of mercury has started through the neck of the tube such that the lower surface area is increasing as the mercury moves downward, the back pressure of the lower surface continually decreases and the mercury flows faster and faster. If the tube is shaped such that its divergence is less rapid than given by the formula:

$$R_2=\left(\frac{1}{1/R_1-136h}\right)$$

where all unknowns are in inches, then the mercury will always start through the opening.

From the foregoing explanation of the switch **11**, it will now be apparent that when the switch is in its normal or quiescent condition, the pool of mercury **45** is collected in the well **43** at the bottom of the housing **40**. Upon the actuation of the switch actuating mechanism **10** in the manner previously described, the shaft **14** is rotated through an angle of 180° to invert the switch **11** and cause mercury to flow through passageway **41** into the upper chamber **44**. As previously described, the switch actuating mechanism **10** operates to withdraw the pawl **26** and the bar **24** as soon as its power stroke is delivered, with the result that the weight of the switch **11** causes rotation of the switch and the shaft **14** to return the switch to its normal position almost instantly. The mercury trapped in the chamber **44** closes the contacts **46** and **47** almost instantaneously with the actuation of the mechanism **10** and these contacts remain closed for a predetermined interval while the mercury flows slowly through the passageway **42**. At the end of the predetermined interval, the length of which is determined by the size of the opening in the constricted portion **42***a* of the passageway **42**, the level of the mercury in the upper chamber **44** is reduced so that the mercury no longer engages the contact **46** and the electrical circuit is broken.

It will now be appreciated that the uniform force delivered to the shaft **14** from the switch actuating mechanism **10** causes the switch **11** to rotate at the same rate and by the same amount regardless of the speed or force of operation of the push button **17**. In this manner damage to the glass housing is avoided and the timing cycle of the switch **11** is uniform in duration. Thus, when applied to a hand drying mechanism, the mechanism remains energized for the same predetermined length of time regardless of how the user actuates the push button **17**. Obviously, the device of the present invention may be used for numerous timing operations and switching functions.

Instead of actuating the mercury switch through a complete cycle for every operation, a sort of double-ended device may be employed in which a half cycle is sufficient for one operation. Such an arrangement is disclosed in a second embodiment of the present invention, shown in Fig. 6, wherein there is shown a switch **62** which differs from the switch shown in Fig. 4 principally by the use of a second set of contacts and by the elimination of the enlarged passageway **41**. Specifically, the switch illustrated in Fig. 6 comprises a housing **63** attached to a U-shaped channel **64** in any convenient manner, as by retaining pins **65** extending between opposed sides of the channel. The channel **64** is fixedly mounted in any suitable manner on a shaft **66** which functions to alternately invert the switch for purposes which will be evident hereinafter. The housing **63** includes a pair of enlarged chambers **67** and **68** interconnected by a passageway **69** having a constricted portion **69***a* therein for inhibiting the flow of a pool of mercury or other conducting fluid contained within the housing. Extending through the walls of the housing **63** and into each of the chambers **67** and **68** are two pairs of fixed contacts, the upper pair of contacts being designated as **70** and **71**, and being connected through leads **72** and **73** to a device to be controlled. The lower set of contacts, designated **74** and **75**, are also connected through leads **76** and **77** to a device to be controlled, which device, if desired, may be different from that controlled by contacts **70** and **71**.

Barriers **79** and **80** of ceramic or the like, which may be identical with the barrier **56** described above, are provided between the upper and lower pairs of contacts in order to provide for the rapid withdrawal of mercury from the upper contacts **70** and **71** in the manner heretofore described in conjunction with the description of the barrier **56**. When the switch **62** is in its normal or quiescent position, the mercury within the housing **63** is collected in the lowest of the two chambers, for instance, the chamber **68**, the supply of mercury being such that the level of the pool indicated at **81** is below the fixed contact **74**, and the electrical circuit between contacts **74** and **75** is open. Obviously, at this time there is no mercury in the upper chamber **67**, and the contacts **70** and **71** are also electrically disconnected. When the switch vessel **63** is inverted by a suitable mechanism for driving the shaft **66**, the mercury tends to flow very

slowly through the passageway **69** due to the constriction **69***a* therein. The level of the mercury in the chamber **68**, as indicated at **82**, is at this time sufficient to immerse both of the contacts **74** and **75**, thus closing the electrical circuit controlled thereby as soon as the shaft **66** is actuated. The contacts **74** and **75** will remain closed for a predetermined interval until the flow of mercury through passageway **69** reduces the level of the mercury in the chamber **68** below that required to maintain contact. After contact between contacts **74** and **75** is severed, the mercury continues to flow through passageway **69** until it is all collected in the chamber **67**, which at this time occupies the lowest position. When all of the mercury has been deposited in the chamber **67**, the level of the same is still insufficient to close the contacts **70** and **71**. The next succeeding actuation of the shaft **66** reverts the switch to the position shown in Fig. 6 and closes the contacts **70** and **71** due to the level of the mercury in chamber **67**. These contacts remain closed for a predetermined interval until enough mercury flows through passageway **69** and into the chamber **68** to reduce the level in chamber **67** below the contact **70**. When all of the mercury is collected in chamber **68**, another cycle of operation has been completed and the switch is ready for the next succeeding actuation of shaft **66** to initiate a new cycle.

In the switch arrangements described thus far, suitable barrier devices were required to insure quick circuit opening. In another embodiment of the invention, quick break is insured without employing such barriers. Such an embodiment is illustrated in Fig. 7, wherein there is shown a switch **90** which differs from the switch **10**, shown in Fig. 4, principally by the provision of means for automatically returning the switch to its normal position only after the timed interval has expired, thus insuring a quick break without the barrier requirement. Specifically, the switch **90** comprises a housing divided into two separate and independent sections **92** and **93**, which are sealed from each other. A pair of fixed contacts **94** and **95** extending through the wall of section **92** of the housing are adapted to be controlled by the flow of a pool of mercury **96** contained within this housing section **92**. A barrier like that shown in Fig. 4 may be interposed between the contacts **94** and **95**, if desired, although it is not at all necessary, as will become apparent from the following description.

The housing section **93** also contains a pool of mercury which, as previously indicated, is completely isolated from the pool **96** contained within the chamber **92**. The section **92** includes a relatively large passageway **98** permitting the free flow of mercury therethrough and a restricted passageway **99** permitting only a small flow of mercury. For the purpose of impeding and controlling the flow of mercury through the restricted passageway **99**, this passageway includes a constricted portion **99***a* having a small opening therein. The passageways **98** and **99** are joined at the bottom by a common mercury receiving well **100**, and at the top by a chamber **101**.

For the purpose of actuating the switch **90** by bringing the mercury **100** into engagement with the contacts **94** and **95**, this switch is mounted in any suitable manner as by retaining pins **103** and **104** on a pivotable structure **105**, including a frame **106** attached to shaft **107**. When the shaft **107** is rotated in a counterclockwise direction, as viewed in Fig. 7, by suitable actuating mechanism, not shown, the switch **90** is rotated until the bottom edge **92***a* of the section **92** contacts a stationary stop **109** positioned at any desired point in its path of movement. When the switch **90** is rotated in this manner, a portion of the pool of mercury in section **93** of the housing is trapped in the upper chamber **101**, and the pool of mercury **96** in section **92** flows into engagement with the contacts **94** and **95** in order to complete the electrical circuit therebetween. The trapped mercury in the chamber **101** begins to flow through the passageway **99** and into the well **100** at the bottom of section **93** of the housing. When sufficient mercury has passed through the opening in the constricted portion **99***a* of the passageway **99**, the weight of the mercury in the well **100** causes a moment of force to be produced which tends to move the switch **90** away from the stop **109** and to rotate the same in a clockwise direction, as viewed in Fig. 7. As soon as the switch **90** is lifted away from the stop **109**, the bulk of the mercury in the chamber **101** pours through the large passageway **98** and into the well **100**, thus causing the entire switch unit to rotate rapidly and quickly break the electrical circuit between contacts **94** and **95** by moving the mercury **96** in section **92** away from these contacts. The switch **90** then remains in the position assumed after its clockwise rotation until the next succeeding actuation of the shaft **107**. Obviously, after each actuation of the shaft, electrical contact between contacts **92** and **93** is maintained for a selected interval determined by the time required for sufficient mercury to flow through passageway **99** to shift the center of gravity of the switch. The separation of the mercury into separate pools for engaging the electrical contacts and for timing the interval during which the contacts are closed has the desirable effect that amalgamation or contamination of the mercury due to contact with metal parts which might lead to the formation of scum does not clog up the constricted portion **99***a* of the passageway **99**. Thus, the timing interval is maintained uniform even after extended use of the switch.

From the foregoing explanation, it is apparent that the present invention provides a sturdy, inexpensively constructed and yet efficiently operating switch which closes its contacts at a selected instant and maintains the same closed until the expiration of a predetermined interval. Such a switch can readily interrupt a current of 20 amperes at 110 volts after a time delay of a half minute or more. Due to the elimination of most of the moving parts of the switch, mechanical failures are practically eliminated, and, as a consequence, useful life of the switch is very long. Furthermore, the actuation of the switch by a uniform force regardless of the amount of manual force applied to the operating mechanism for the switch provides a cycle of operation having a constant duration and at the same time minimizes the possibility of damage to the switch which might result from the application of excessive operating force.

While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto, since many modifications may be made, and it is contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A timing switch for electrically closing a pair of contacts at any initial instant and for maintaining said contacts closed for a definite interval thereafter, comprising a pivotable housing including structure dividing the same into separate enclosed sections, a first of said sections carrying said contacts in spaced apart relationship, a supply of conducting fluid within said first section and adapted to flow into and out of engagement with said contacts to make and break the same, a supply of fluid contained within the second section of said housing, said second section including structure defining a passageway having a constricted portion therein through which the fluid in the second section is adapted to flow and also including structure forming a well offset from the axis about which said housing is pivoted, means for pivoting said housing from its normal position at said initial instant to bring the conducting fluid in the first section into electrical contact with said contacts to make the same and for elevating the fluid in said second section to cause the latter to begin to flow through said passageway, the flow of fluid through said passageway and into said well continuing until the weight of fluid in said well is sufficient

to pivot said housing about its axis and restore the same to its normal position, at which time electrical contact between said conducting fluid and said contacts is broken.

2. In a switch, a pivotable housing, at least one pair of electrical contacts carried by said housing, a barrier member associated with one of said contacts, said barrier including a well in which the associated contact is disposed, and a trough in said barrier connecting said well with the interior of said housing, a supply of conducting fluid contained within said housing, at least a portion of which is adapted to flow into and out of engagement with said contacts in order to electrically make and break the same, selectively controlled means for pivoting said housing to control the flow of said fluid into or out of engagement with said contacts, and means including a passageway in said housing having a constriction therein for restricting the flow of at least a portion of said fluid for controlling the time interval between the actuation of the means for pivoting said housing and the flow of fluid into or out of engagement with said contacts.

3. Switching apparatus comprising a housing divided into two sections, a plurality of electric contact members extending through the wall of said housing into one of said sections, a conducting fluid disposed in said one of said sections, means for pivotally mounting said housing so that when said housing is in a predetermined condition

of orientation the fluid in said one of said sections connects certain ones of said contacts and when the housing is in another condition of orientation the fluid in said one section is disposed so that said certain ones of said contacts are mutually disconnected, a liquid in the other of said sections, said other of said sections including a relatively large passageway for permitting the free flow of liquid therethrough and a restricted passageway for impeding the flow of liquid threthrough, and first and second reservoirs in said housing, said reservoirs being disposed on opposite sides of said restricted passageway and interconnected by said large passageway, said reservoirs being so located that when said liquid is in one of said reservoirs the housing is oriented under the force of gravity in said predetermined condition and when said liquid is in the other of said reservoirs said housing is oriented under the force of gravity in said other condition of orientation.

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