PRESSURE SWITCH AND ELECTRICAL SWITCH THEREFOR

Filed June 29, 1965 2 Sheets-Sheet 1

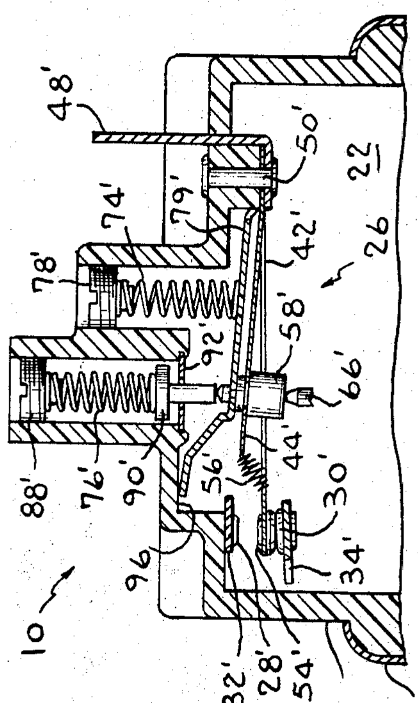

FIG. 3

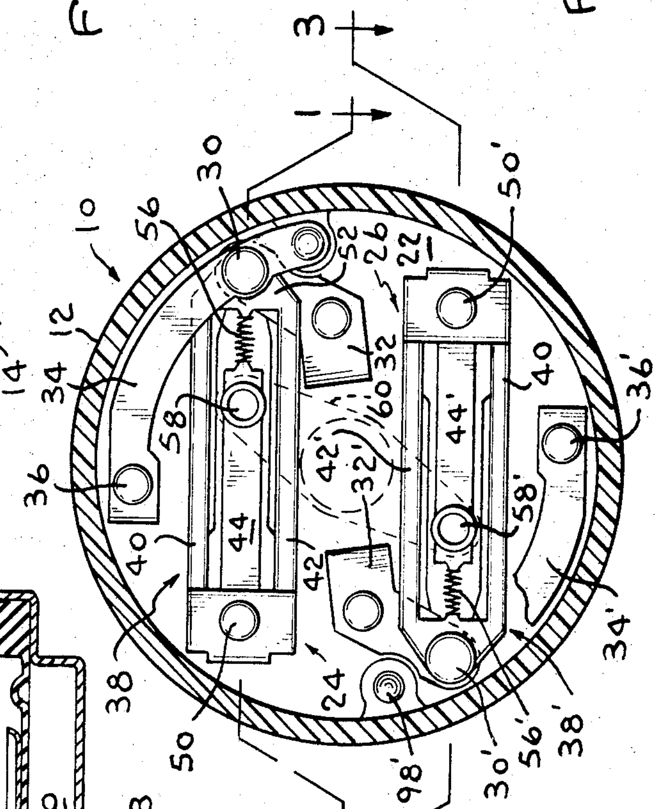

FIG. 2

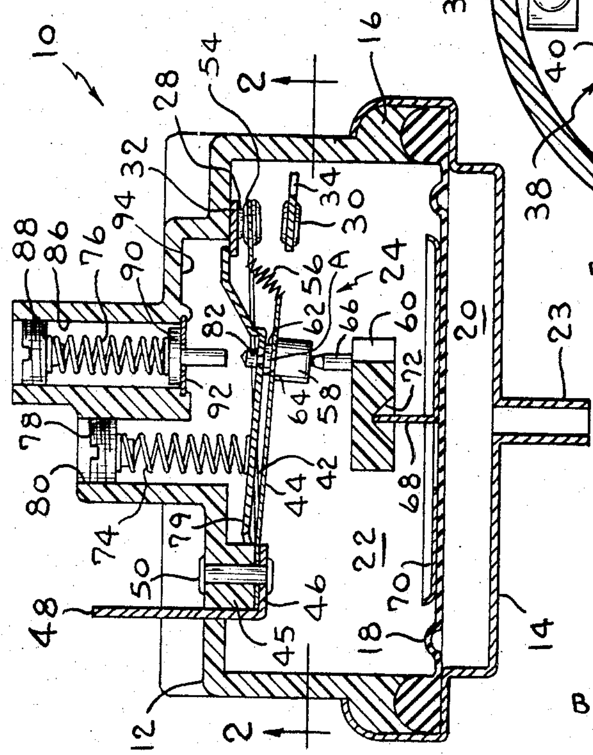

FIG. 1

INVENTOR
JOHANNUS J. COOLS

BY Bayard H. Michael
ATTORNEY

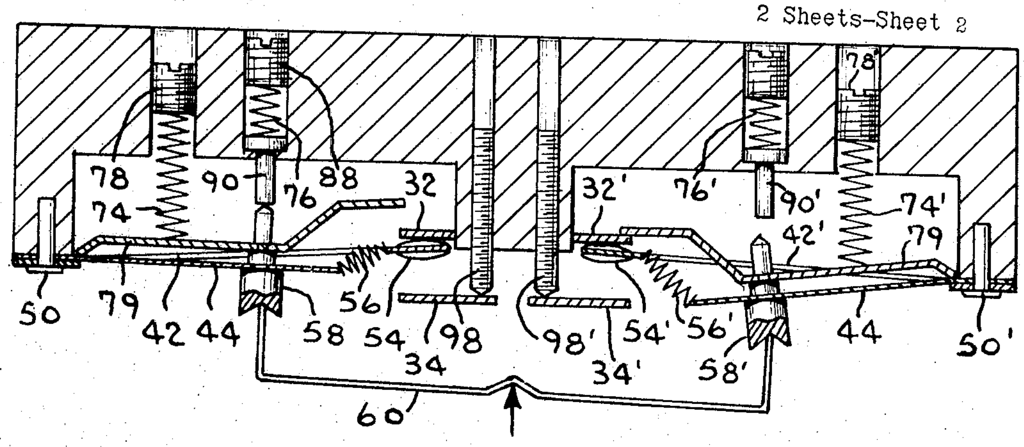

FIG. 4

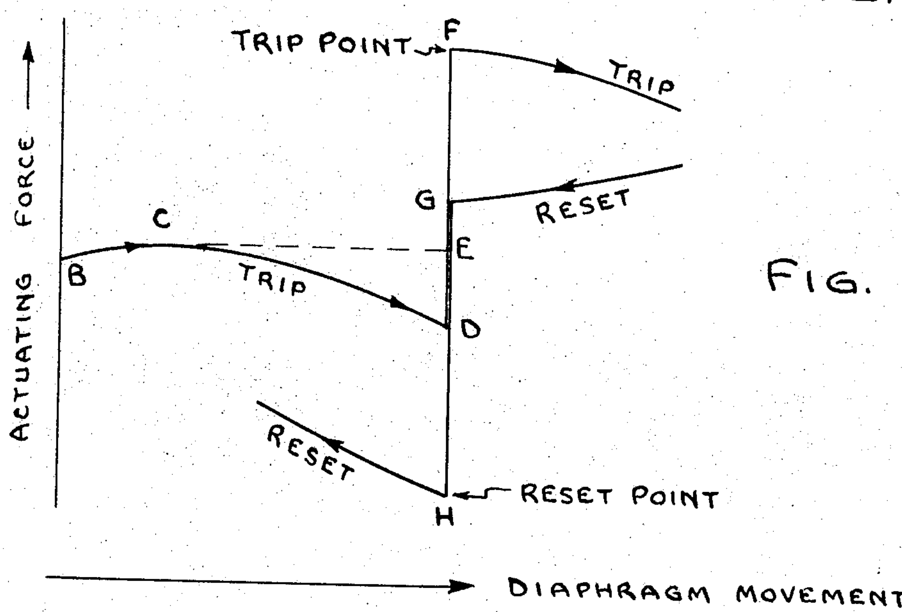

FIG. 5

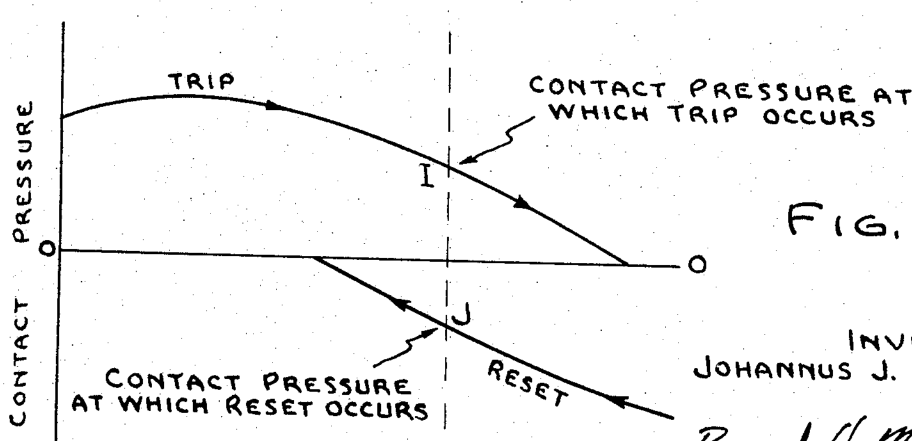

FIG. 6

INVENTOR
JOHANNUS J. COOLS

BY Bayard H. Michael
ATTORNEY

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PRESSURE SWITCH AND ELECTRICAL SWITCH THEREFOR

Johannus J. Cools, Nijmegen, Netherlands, assignor to Controls Company of America, Melrose Park, Ill., a corporation of Delaware

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19 Claims. (Cl. 200—83)

This invention relates to pressure switches and to electric switch constructions of the type used in pressure switches.

A general object of this invention is to provide an improved pressure switch.

Another object of this invention is to provide a pressure switch which exhibits improved electrical characteristics.

Another object of this invention is to provide a pressure switch construction which affords improved maximum and minimum trip and reset differentials at both low and high trip pressures.

A further object of this invention is to improve the electrical characteristics of an electrical snap-action switch.

A more specific object of this invention is to provide a pressure switch and/or an electrical toggle-type switch wherein switching from one position to another starts from a condition where the movable contact is held in engagement with a fixed contact with adequate contact pressure to carry a substantial electrical load.

Another object of this invention is to provide a multiple level pressure switch which affords improved maximum and minimum differentials between the trip levels and the reset levels of the switch assemblies of the pressure switch.

A still further object of this invention is to provide for independent adjustment of each of the switch assemblies of a multiple level pressure switch.

For the achievement of these and other objects, this invention contemplates a toggle-type switch construction wherein a spring, in addition to the toggle spring, is arranged to oppose an actuating force acting to move the movable contact from one position to another, for example the force exerted through the diaphragm of a pressure switch. This spring and the toggle spring are selected so that switching starts before the force component of the toggle spring holding the movable contact on a stationary contact is reduced to zero. More particularly, the spring rate of the toggle spring is negative in this arrangement and it and the spring rate of the additional spring, commonly referred to as the calibrating spring, are selected such that the spring rate of the calibrating spring is exceeded by the negative spring rate of the toggle spring at a point before the toggle spring is moved to its overcenter position. At this point the combined rate of the springs becomes negative with respect to the actuating force, the switch is in an unbalanced condition, and dynamic switching occurs. With dynamic switching, switching starts before physical movement to the overcenter position and proceeds dynamically by snapping the movable contact instantaneously through the zero contact pressure point. This eliminates dwell at or near the zero contact pressure point which occurs in mechanical switching wherein the toggle spring must be physically moved overcenter by the diaphragm and through the zero contact pressure point before switching starts.

Although this switch construction has general application wherever a snap action switch is used it finds particular application in pressure switches and in multiple level as well as single level pressure switches. When used in multiple level switches e.g. a dual level pressure switch having two toggle-type switch assemblies, it is further contemplated that the switch assemblies be operatively isolated to permit independent adjustment. This is preferably achieved by providing stops which limit switch travel toward both trip and reset positions.

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Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the embodiments shown in the drawings, in which:

FIG. 1 is a sectional view through a dual level pressure switch taken generally along line 1—1 of FIG. 2 and illustrating one of the switch assemblies thereof in a reset position;

FIG. 2 is a sectional view taken generally alone line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken generally along line 3—3 of FIG. 2 and illustrating the other switch assembly in a trip position;

FIG. 4 is a schematic illustration of the dual level pressure switch illustrating one switch assembly in a condition just prior to trip and the other switch assembly in a reset condition;

FIG. 5 is a plotting of diaphragm actuating force against diaphragm movement illustrating both trip and reset curves; and

FIG. 6 is a plotting of contact pressure against diaphragm movement again illustrating both trip and reset curves.

With particular reference to the drawings, pressure switch **10** includes housing **12** and metal cap **14** rolled onto flange **16** with diaphragm **18** clamped between the housing and the metal cap. The diaphragm divides the interior of the pressure switch into pressure chamber **20** and switch chamber **22**. An outlet **23** communicates with pressure chamber **20** to provide for connecting the pressure switch to an external source the pressure of which will vary and can be used as a basis for actuating the pressure switch. This invention is preferably embodied in a dual level pressure switch and, accordingly, two switch assemblies **24** and **26** are disposed in switch chamber **22**. The switch assemblies are identical and to facilitate this description only one switch will be described in detail with prime numbers being used to identify components of switch assembly **26** which are identical to those of switch **24**.

Switch assembly **24** is a toggle-type switch having a double throw to selectively establish a circuit through, with respect to the pressure switch, normally closed reset contact **28** and normally open trip contact **30**. Reset contact **28** is carried on terminal plate **32** suitably fixed to housing **12** and trip contact **30** is carried on terminal plate **34** which is anchored to housing **12** by pin **36** and is adjustable, in a manner to be described more completely hereinafter, to vary the contact gap between the trip and reset contacts. Movable switch blade **38** includes rails **40** and **42** and tongue **44** all anchored at one end by being clamped between housing boss **45** and end **46** of terminal **48** by means of rivet **50** extending through housing **12**. The movable end of switch blade **38** includes a web **52** which connects the rails and carries contact **54** for selective engagement with either the reset or trip contact. A toggle spring is compressed between web **52** and tongue **44** to cooperate in providing overcenter switching, in this instance the toggle spring takes the form of barrel spring **56** but other forms of toggle springs can be used without departing from the scope of this invention.

Movement of switch blade **38** between the reset and trip contacts occurs with a snap action due to the toggle action produced by cooperation of the switch rails with the switch tongue and barrel spring. In moving from either the reset or trip positions, the movable contact remains in engagement with either the reset or trip contact as the angle between the rails and the tongue, and correspondingly the angle of the barrel spring with the rails, decreases. Conventionally, a force is applied to the switch assembly in a given direction to move the rails, tongue and spring to a point of coincidence whereupon further movement in that direction switches the movable contact from one contact to the other with a snap action. More particularly, movement from the reset to trip position is effected by an increase in pressure in chamber 20 with the resultant diaphragm movement being toward the switch assembly whereas movement from the trip to the reset position occurs as a result of a reduction in pressure in chamber 20 with the resultant diaphragm movement being away from the switch assembly. The pressure switch also includes a calibrating spring system which exerts a force in opposition to the actuating force exerted through the diaphragm in accordance with the pressure in chamber **20**.

Structurally, switch assembly **24** is connected to diaphragm **18** through block **58** and bridge member **60**. Block **58** includes a flange **62** and tongue **44** of the switch assembly is clamped between flange **62** and shoulder **64** of block **58** to provide a connection between the tongue and diaphragm and establish an actuating point A through which the actuating force on the diaphragm acts on the switch assembly. Bridge **60** engages block **58** through pin **66** and the connection between bridge **60** and diaphragm **18** is completed through pivot arm **68** which is formed from backing plate **70** connected to the diaphragm and with pivot arm **68** extending into a notch **72** in the lower side of bridge **60**. In the illustrated embodiment the above mentioned calibrating spring system includes springs **74** and **76** which are arranged to oppose movement of the diaphragm, and correspondingly switch assembly **24**, in response to an increase in pressure in chamber **20** and also, when switch assembly **24** is in its trip position, to move the switch assembly toward a reset position in response to a decrease in pressure in chamber **20**.

In the prior art the loading or calibrating spring has been placed to act at the actuating point and to afford adequate trip pressures has had a spring rate which necessarily resulted in mechanical switching with attendant reduction of the contact pressure to zero at the trip point. The term mechanical switching is used to refer to the type of switching action requiring physical movement of the toggle spring overcenter to reverse the bias on the moving contact. Since the movement of the actuating point is slow, the reduction of contact pressure to zero renders the switch subject to premature tripping due to vibration and shock and the contacts are subject to "frying" in addition to severely limiting the switching capacity.

The force necessary to displace the switch tongue sufficiently to achieve switching is determined by the barrel spring, which has both a vertical and horizontal force component at the actuating point and, in the just-discussed prior art constructions, to a greater extent by the calibraing spring system. To improve the electrical characteristics of these switches, primarily the problem of insufficient contact pressure at and just prior to switching, this invention makes use of an arrangement whereby switching starts while the barrel spring still has a vertical force component. From this point switching proceeds dynamically and the movable contact is moved instantaneously through the zero contact pressure point. Accordingly, there is no dwell at or near zero contact pressure so that the switch can carry greater electrical loads. More specifically, in moving toward trip position the vertical force component of the barrel spring opposes the actuating force of the diaphragm and decreases as the overcenter position is approached or, put another way, as the angle of the tongue or barrel spring with the rails decreases. Viewed in another sense, the barrel spring has an effective vertical spring rate which is a negative spring rate in that the force necessary for movement of the actuating point in opposition to the barrel spring forces decreases as the overcenter position is approached. This negative vertical rate of the barrel spring becomes more negative as the overcenter position is approached. Prior to tripping, the system will be stable at any given point. At the moment of tripping the added increment of movement of the actuating point requires an added spring force dictated by the constant spring rate of the calibrating spring but at the same time there is a decrease in the opposing force imparted by the barrel spring and this decrease is greater than the increase indicated by the calibrating spring with the result that the actuating force is no longer opposed by a balancing force and the net opposing force is falling so that the toggle spring will rapidly approach and pass over the center point to switch the moving contact to the trip position. Therefore, by proper selection of a low spring rate of the calibrating spring dynamic switching is achieved since the switching occurs at the point where the rate of decrease of the vertical force of the toggle spring becomes greater than the spring rate of the calibrating spring. Put another way, tripping will occur dynamically when the effective vertical spring rate of the toggle or barrel spring becomes numerically more negative than the positive spring rate of the calibrating spring. This then means the switch will trip when the combined spring rates of the two springs become negative with respect to the actuating force. The difference between dynamic switching and mechanical switching is that in mechanical switching the rate of decrease of the vertical force of the toggle spring never becomes greater than the rate of the calibrating spring before physically going overcenter. Stating this distinction now from the standpoint of spring rates, the prior art mechanical switching would not have a calibrating spring and toggle spring so related that the effective vertical rate of the toggle spring would become more negative than the rate of the calibrating spring.

The same condition applies on moving toward a reset position. In the trip position illustrated in FIG. 3 the calibrating spring is exerting a downward force on the switch tongue and as the actuating force from the diaphragm is reduced the calibrating spring moves the switch tongue downwardly. In moving toward the reset position the vertical force component of the toggle spring is acting against the force of the calibrating spring but here again the effective vertical spring rate of the barrel spring is a negative spring rate so that the force exerted in opposition to the calibrating spring decreases as the overcenter position is approached and the negative vertical spring rate thereof becomes more negative as the overcenter position is approached. Prior to switching to the reset position the spring system and diaphragm force are stable at any given point but when the reduction in the vertical component of the barrel spring for a given increment of movement becomes more negative than the positive spring rate of the calibrating spring the system becomes unstable with the calibrating spring overcoming the actuating force and dynamic switching occurs from a point before the overcenter position is reached.

From the foregoing it can be seen that dynamic switching will occur when the combined spring rate acting against the actuating force becomes negative. In other words at this point on trip the spring force opposing the actuating force is decreased below what is required by a given increment of movement to balance the force causing that movement, and on reset the spring force becomes greater at the switching point than is required by a given increment of movement. This can be graphed as indicated in a portion of FIGS. 5 and 6. In FIG. 5 the portion between B and C indicates the increasing force as the trip point is approached with C being the peak opposing force. Then as the motion continues, that is trip occurs, the spring force is decreasing toward point D. Portion BD of the trip curve is representative of the characteristics of a switch including a single calibrating spring influencing switch operation, and the reset curve with a single calibrating spring would be the inverse of portion

BD as is indicated by the reset curve in FIG. 5, the significance of the reset curve being segmented will become apparent as this description proceeds. On reset the spring force decreases until the switching or trip point is reached, at which time the barrel spring would go overcenter and contributes its force to switch movement rather than oppose it. Comparing FIGS. 5 and 6, for the same diaphragm movement, or movement of the actuating point, it will be seen that switching starts, on both trip and reset, at a point where contact pressure is still maintained. In other words, the contact pressure curves also rise to a peak and then fall off but the fall-off after switching starts is not gradual since the switch is into dynamic motion and the travel is substantial, rapid and with a snap action.

In the above description the calibrating spring was considered as acting directly above the actuating point. This arrangement places a severe limitation on the maximum available trip force while maintaining dynamic switching and in order to stay within the realm of feasibility a variation of this arrangement is preferred. Maximum available trip pressure is determined by the buckling or collapsing force of the spring which, in turn, is related to the spring rate. With a light spring rate the collapsing force or, put another way, the maximum loading before the spring is collapsed is too low for practical use in connection with, for example, pressure switching as used in appliances. If the calibrating spring is moved toward the anchor point of the switch blade the spring rate of the spring itself can be increased without affecting dynamic switching. For example, if it is moved half way between the anchor point and actuating point the spring movement is reduced by one-half and therefore the spring rate can be increased four times without changing the effective spring rate acting at the actuating point. Increasing the spring rate four times multiplies the buckling force of the spring by four times resulting in doubling the effective buckling force (maximum available trip pressure) or actuating force at the actuating point, so that by moving the calibrating spring half way between the anchor point and actuating point the maximum available trip force is doubled without changing the effective spring rate opposing the actuating force and without losing the benefit of dynamic switching. Obviously, other positions between the actuating and anchor points with corresponding increases in spring rate over that which could be used at the actuating point are possible.

If the calibrating spring is mounted to act directly on the switch tongue the tongue would be stressed and bend. For this reason pivoted lever **79** is preferably included and is operatively interposed between the calibrating spring and the switch tongue to avoid tongue distortion. Structurally spring **74** is seated against adjusting screw **78** received in threaded opening **80** in body **12** and the opposite end thereof bears on lever **79**. One end of the lever is pivoted on boss **45** and the lever is connected between flanges **82** and **62** of block **58** to establish the connection thereof with the block for movement with the diaphragm.

With the calibrating spring located half way between the actuating point and the anchor point of the switch blade a satisfactory maximum trip pressure can be achieved. Since the adjustment of the spring **74** by itself will determine, in effect, the maximum trip pressure and the reset pressure, the differential, that is the trip pressure minus the reset pressure, is fixed when spring **74** is adjusted. In some cases, however, it is desirable to have a predetermined reset pressure which may not fall within this more or less fixed differential. To provide for separate adjustment of the trip and reset pressures a second spring **76** is introduced. This spring acts against headed pin **90** which is biased against shelf **92** to constitute the downward limit on motion of spring **76**. The pin has a depending shank which is arranged for engagement by block

58 as may be seen in FIG. 3, for example, so that the force of spring **76** will oppose the actuating force. In practice this results in opposing trip by means of both springs **74, 76** while on reset only spring **74** is operative. Referring now to FIG. 4, the point at which the actuating pin has come up and abutted headed pin **90** is illustrated in the left portion of the illustrated pressure switch. At this point both springs are opposing the actuating force and the two springs must be selected so that their combined effective spring rate falls within the parameters previously discussed, that is they must not be so great that at some time prior to the toggle spring going overcenter the numerical negative rate of the toggle spring cannot become greater than the combined positive rate of the two springs. In other words, the spring rates of springs **74** and **76** must be sufficiently light to permit the negative spring rate of the toggle spring to exceed the combined spring rate of springs **74** and **76** before the switch goes physically overcenter. With this arrangement both springs **74** and **76** can be separately adjusted and preloaded to effect both the desired trip and reset pressures. With this arrangement the desirable operation of dynamic switching is preserved, a practical maximum trip pressure is available and the reset pressure is independent of the trip pressure to increase the available trip-reset differential. Thus another shortcoming of prior art pressure switch designs is eliminated, namely that with prior art constructions wide differentials of trip and reset pressures could not be achieved at high pressures since elevating the trip pressure also raised the reset pressure leaving the differential virtually unaffected.

In operation and with reference to FIGS. 1 and 4 and the curves of FIGS. 5 and 6, as the pressure in chamber **20** increases diaphragm **18**, block **58** and switch tongue **44** move upwardly. This upward movement continues as the pressure on the diaphragm increases and FIG. 5 plots actuating force against diaphragm movement and FIG. 6 plots contact pressure against diaphragm movement for both trip and reset operation, with FIG. 6 including an indication of contact pressure at trip and reset. Because of the lost motion connection between block **58** and pin **90**, only spring **74** and the vertical force component of the toggle spring oppose the actuating force during initial movement and the trip curves proceed as illustrated in FIGS. 5 and 6. Without spring **76** in the system, and with spring **74** being within the design parameters discussed above, switching would occur at point C or at the maximum actuating force from the diaphragm. As can be seen by a comparison of the curves of FIGS. 5 and 6, at this point sufficient contact pressure remains to insure adequate contact pressure to switch relatively high electrical loads. However, when spring **76** is used it becomes operative at approximately point C and prevents switching until a higher pressure is reached. After spring **76** comes into the system further operational consideration can proceed from approximately point E on the trip curve in FIG. 5. More particularly, when point C is reached block **58** may be spaced somewhat from pin **90** so that tripping movement of the switch tongue begins with the attendant fall-off of contact pressure to point D where pin **90** is engaged. At point D the actuating force is additionally opposed by spring **76** and returns vertically to point E. In FIG. 4, switch assembly **24** is illustrated in a position just prior to trip or in a condition corresponding to point E on the trip curve. From point E the actuating force increases with virtually no diaphragm movement as illustrated by the straight vertical line portion of the trip curve. A relatively constant contact pressure is maintained until the requisite actuating force is reached at trip point F whereupon dynamic switching occurs and starts at a sufficient contact pressure I (FIG. 6) to permit a relatively high electrical load to be carried. The actuating force falls off after switching starts because the vertical component of the toggle continues to decrease to the overcenter position after which it is reversed in direction and acts in the same direction as the actuating force.

After trip, switch assembly **24** assumes trip position as illustrated in FIG. 3 in connection with switch assembly **26**. The reset operaton of the switch assembly will now be described and in connection with switch assembly **26**. As pressure in chamber **20** decreases the actuating force through the diaphragm decreases and springs **74'** and **76'** force block **58'** and tongue **44'** downwardly. As the actuating force decreases springs **74'** and **76'** expand and the vertical force component of the toggle spring is opposing springs **74'** and **76'** but has a negative spring rate. As the actuating force decreases the diaphragm and switch tongue **44'** move downwardly with the contact pressure falling off and the vertical force component of the toggle spring decreasing at a progressively greater rate. This variation in spring force and change in contact pressure with a variation in actuating force continues to point G on the reset curve of FIG. 5. At approximately point G pin **90'** seats on stop **92'** and is rendered inoperative. When spring **76'** leaves the system a marked drop in actuating force occurs with virtually no diaphragm movement until reset point H on the reset curve is reached. Reset occurs at the point where the decrease in the vertical force component of the toggle spring has exceeded the spring rate of spring **74'** so that for a given increment of movement the resultant force of the vertical component of the toggle spring and spring **74'** is greater than what would be indicated for the increment of movement at that point thereby unbalancing the switch. Switching starts at reset point H and occurs dynamically through switchover. After switchover the operating force increases as all spring forces are then acting in the same direction. Point J on the reset curve indicates that reset starts from a point of substantial contact pressure. The vertical portions of the trip and reset curves in FIG. 5 have been offset for better illustration but it will be appreciated that in practice they are virtually coincident.

With the dual spring arrangement, springs **74** and **74'** establish the reset pressures whereas the trip pressure is established by the combination of springs **74, 74'** and **76, 76'**.

By properly matching the barrel spring load and the spring rates of the calibrating springs (spring **74, 74'** alone or **74, 74'** and **76, 76'** together) improved switching can be achieved both from a mechanical and an electrical standpoint. More particularly, switching occurs with a sufficient contact pressure to permit relatively higher electrical loads, electrical life is increased and the switch is rendered more stable as being less susceptible to shock and vibration. Moreover, by properly matching the calibrating spring rate, or rates, with the highest allowable barrel spring load, that is the highest allowable and still guarantee dynamic switching, a minimal trip and reset differential can be provided.

It is further desirable that not only should the trip and reset levels of a pressure switch be adjustable but in the case of a dual, or multiple level pressure switch, the construction should afford minimum and maximum differentials between the trip pressure and the reset pressure of the two switches. Heretofore, dual switch arrangements for a dual level pressure switch for example, have not been satisfactory because adjustment of the trip or reset level of one switch affected the trip or reset level of the other switch thereby losing control over the trip and reset differentials between the switches. In another aspect of this invention it is intended to provide an arrangement which isolates the switches one from the other for independent adjustment. To achieve this, levers **79** and **79'** are used in conjunction with stops for limiting travel of the switches in both directions or actuation. In the illustrated embodiment the stop in one direction is provided by faces **94** and **96** of housing **12** and in the other direction by carriers **32** and **32'**. Preferably the trip and reset pressures of switch assembly **24** will be greater than those of switch assembly **26** and, with the provision of the limits on travel of the switch lever, adjustment of one switch blade will not affect the other switch blade so long as this relationship between the respective trip and reset pressures is maintained and the differentials between the two do not fall below a prescribed minimum pressure, for example three to seven tenths of an inch of water volume pressure for a typical pressure installation.

Where only calibrating springs **74** and **74'** are used the reset pressure is varied by moving trip contact **30** with respect to reset contact **28**. To effect this movement terminal plates **34** and **34'** are made of resilient material and are anchored at one end to body **12** by rivets **36** and **36'** and have their other end free and engaged by adjusting screws **98** and **98'**. The adjusting screws work against terminal plates **34** and **34'** to increase the contact gap and, to reduce the contact gap, release the terminal plates for movement due to their resiliency. Where the dual calibrating spring is used a fixed contact gap is set by manipulation of screws **98** and **98'** and spring **74, 74'** and **76, 76'** are adjusted by manipulating seats **78, 78'** and **88, 88'** to vary the reset and trip levels respectively.

Although this invention has been illustrated and described in connection with particular embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. A pressure switch comprising, in combination,

a switch assembly including a contact supporting member, an actuated member, and a toggle spring acting between said contact supporting member and said actuated member and mounted for overcenter operation to produce movement of the contact supporting member to either one of two positions, said toggle spring acting to hold said contact supporting member in either of said positions and passing overcenter as the contact supporting member moves from one position to the other,

diaphragm means,

means connecting said diaphragm means to said actuated member and defining an actuating point through which the actuating force of said diaphragm means is applied to said actuated member,

spring means connected to and exerting a force on said actuated member in opposition to the force of said diaphragm means,

said toggle spring exerting a force component on said actuated member at said actuating point parallel to the force direction of said spring means and diaphragm means, and

the characteristics of said spring means and toggle spring being such that in movement from either of said positions to the other the combined spring rates of said spring means and toggle spring become negative before the toggle spring passes overcenter to thereby initiate switching before said toggle spring force component reverses in direction and dynamically switches said contact carrying member from one position to another.

2. The pressure switch according to claim **1** in which said contact supporting member and said actuated member are mounted for pivotal movement and said spring means is physically positioned between said actuating point and the pivot point of said actuated member.

3. A multiple level pressure switch comprising, in combination,

first and second switch assemblies each comprising a contact supporting member, an actuated member and a toggle spring connected between said actuated member and said contact supporting member to produce overcenter action of said contact supporting member to either one of two positions,

diaphragm means,

means connecting said diaphragm means to each of said actuating members and defining an actuating point at each switch assembly through which the actuating force of said diaphragm is applied to said actuated members,

spring means,

lever means interposed between each of said spring means and said actuated members and connected to and movable with said actuated members,

said spring means connected to each of said lever means and exerting a force on said actuated members through said lever means in opposition to the force of said diaphragm means,

means for adjusting the force with which said spring means oppose the force of said diaphragm means, and

means defining limit stops in the path of movement of each of said switch assemblies and arranged for engagement with said lever means and to limit movement of said lever means toward both of the positions of said switch assemblies.

4. The multiple level pressure switch of claim **3** wherein said means connecting said diaphragm means to each of said actuating members comprises a bridge member also connecting said first and second switch assemblies to each other.

5. In a pressure switch including a toggle-type switch assembly movable overcenter to trip and reset positions and including a toggle spring having a force component in both of said trip and reset positions actuating to hold said switch assembly in said trip and reset positions respectively,

a diaphragm,

spring means,

means connecting said diaphragm and spring means to said switch assembly with said diaphragm connected to apply an actuating force to said switch assembly and said spring means applying a force in opposition to said actuating force and to bias said switch assembly toward said reset position, and

said spring means having a predetermined spring rate and said force component of said toggle spring diminishing as said switch assembly moves from both said trip and reset positions toward the other at a rate which exceeds the spring rate of said spring means before said toggle spring is moved physically to its overcenter position so that switching from one of said trip and reset positions to the other occurs before the force component acting in said trip and reset directions reverses or reduces to zero.

6. The pressure switch of claim **5** including means mounting said spring means at a point removed from said actuating point so that the spring rate and force of said spring means can be greater than the spring rate and force thereof applied at said actuating point.

7. A switch comprising, in combination,

a movable contact supporting member,

means mounting said contact supporting member for movement between first and second positions,

a toggle spring,

means connecting said toggle spring to said contact supporting member to produce overcenter movement of said contact supporting member between its first and second positions,

means for applying an actuating force to said contact supporting member,

spring means connected to said contact supporting member and opposing said actuating force, and

the spring rate of said spring means being such that in movement from both said first and second positions to the other position the reduction in the force component of said toggle spring acting in the direction of said spring means and said actuating force exceeds the spring rate of said spring means before said toggle spring reaches its overcenter position.

8. The switch of claim **7** including an actuated member,

means supporting said actuated member for pivotal movement,

said toggle spring acting between said contact supporting member and said actuated member to produce said overcenter movement of said contacting supporting member,

said means for applying said actuating force applying said force to the actuated member at an actuating point,

and said spring means opposing said actuating force at a point between said actuating point and the pivot point of said actuated member.

9. A pressure switch comprising, in combination, relatively spaced first and second contacts,

a switch assembly including a contact supporting member, an actuated member, a toggle spring acting between said contact supporting member and said actuated member and mounted for overcenter operation to produce movement of the contact supporting member to either one of two positions for engagement with either one of said first and second contacts, said toggle spring acting to hold said contact supporting member in either of said positions and passing overcenter as said contact supporting member moves from one position to the other,

diaphragm means,

means connecting said diaphragm means to said actuated member and defining an actuating point through which the actuating force of said diaphragm means is applied to said actuating member,

spring means connected to and exerting a force on said actuating member in opposition to the force of said diaphragm means,

said toggle spring exerting a force component on said actuating member and said actuating point parallel to the force direction of said spring means and diaphragm means,

the characteristics of said spring means and toggle spring being such that their combined spring rates become negative before to toggle spring passes overcenter to thereby initiate switching before said toggle spring force component reverses in direction and dynamically switches said contact supporting member from one position to another,

and means for adjusting the relative spacing between said first and second contacts so that the point at which said contact supporting member switches from one position to the other can be adjusted.

10. The pressure switch of claim **9** wherein said first and second contacts comprise a fixed trip contact and a reset contact and including

means supporting said reset contact for movement relative to said trip contact to adjust the reset point of said pressure switch.

11. A multiple level pressure switch comprising, in combination,

first and second switch assemblies each comprising first and second relatively spaced contacts, a contact supporting member, an actuated member and a toggle spring connected between said actuated member and said contact supporting member to produce overcenter action of said contact supporting member to either one of two positions in engagement with either one of said first and second contacts,

means connected to and operative to move the first and second contacts of each of said switch assemblies relative to each other so that the point at which said contact supporting member switches from one position to the other can be adjusted,

diaphragm means,

means connecting said diaphragm means to each of said actuating members and defining an actuating point at each switch assembly through which the actuating force of said diaphragm is applied to said actuated members, spring means connected to each of said first and second switch assemblies and exerting a force on said actuated members in opposition to the force of said diaphragm means,

means for adjusting the force with which said spring means oppose the force of said diaphragm means,

and wherein said toggle springs exert a force on said actuating members at said actuating point parallel to the force direction of said spring means and diaphragm means and the characteristics of said spring means and toggle spring are such that their combined spring rates become negative before the toggle springs pass overcenter to thereby initiate switching before said force component of said toggle springs reverse in direction and dynamically switch said contact supporting members from one position to another.

12. The pressure switch of claim **11** wherein said first and second contacts of each of said switch assemblies comprise a fixed trip contact and a reset contact, and including

means supporting said reset contacts for movement relative to said trip contact to adjust the reset points of said pressure switch.

13. A snap switch including

a contact supporting member and an actuated member having a toggle spring acting therebetween and mounted for overcenter action to produce movement of the contact supporting member from one position to another position, the toggle spring acting to hold the contact supporting member in either position and passing overcenter as the contact supporting member moves from one position to the other,

an actuator for applying an actuating force to the actuated member at an actuating point,

spring means exerting a force in opposition to the actuating force,

said contact supporting member and the actuated member mounted for pivotal movement and said spring means exerting a force on the actuated member and being physically positioned between the actuating point and the pivot point of the actuated member,

said toggle spring exerting a vertical force component on the actuated member,

the characteristics of the spring means and the toggle spring being selected so that their combined spring rates become negative before the toggle spring passes overcenter to thereby initiate switching action,

and a pivoted lever operatively interposed between the spring means and the actuated member and contacting the actuated member substantially at the actuating point.

14. A snap switch including

a contact supporting member and an actuated member having a toggle spring acting therebetween and mounted for overcenter action to produce movement of the contact supporting member from one position to another position, the toggle spring acting to hold the contact supporting member in either position and passing overcenter as the contact supporting member moves from one position to the other,

an actuator for applying an actuating force to the actuated member at an actuating point,

spring means extering a force in opposition to the actuating force,

said toggle spring exerting a vertical force component on the actuated member,

the characteristics of the spring means and the toggle spring being selected so that their combined spring rates become negative before the toggle spring passes overcenter to thereby initiate switching action,

and second spring means and lost motion connection means between the actuated member and the second spring means whereby the second spring means becomes operative to oppose the actuating force before the contact supporting member moves from one position to the other and is rendered inoperative before the contact supporting member moves from said other position to said one position, said spring means, said second spring means and the toggle spring having a combined spring rate which becomes negative before the toggle spring passes overcenter.

15. A pressure switch comprising, in combination,

a switch assembly including a contact supporting member, an actuated member, and a toggle spring acting between said contact supporting member and said actuated member and mounted for overcenter operation to produce movement of the contact supporting member to either one of two positions, said toggle spring acting to hold said contact supporting member in either of said positions and passing overcenter as the contact supporting member moves from one position to the other,

diaphragm means,

means connecting said diaphragm means to said actuated member and defining an actuating point through which the actuating force of said diaphragm means is applied to said actuated member,

spring means connected to and exerting a force on said actuated member in opposition to the force of said diaphragm means,

said contact supporting member and said actuated member mounted for pivotal movement and said spring means being physically positioned between said actuating point and the pivot point of said actuated member,

said toggle spring exerting a force component on said actuated member at said actuating point parallel to the force direction of said spring means and diaphragm means,

the characteristics of said spring means and toggle spring being such that their combined spring rates become negative before the toggle spring passes overcenter to thereby initiate switching before said toggle spring force component reverses in direction and dynamically switches said contact carrying member from one position to another,

and a pivoted level operatively interposed between said spring means and said actuated member and connected to said actuated member substantially at said actuating point.

16. A pressure switch comprising, in combination,

a switch assembly including a contact supporting member, an actuated member, and a toggle spring acting between said contact supporting member and said actuated member and mounted for overcenter operation to produce movement of the contact supporting member to either one of two positions, said toggle spring acting to hold said contact supporting member in either of said positions and passing overcenter as the contact supporting member moves from one position to the other,

diaphragm means,

means connecting said diaphragm means to said actuated member and defining an actuating point through which the actuating force of said diaphragm means is applied to said actuated member,

spring means connected to and exerting a force on said actuated member in opposition to the force of said diaphragm means,

said toggle spring extering a force component on said actuated member at said actuating point parallel to the force direction of said spring means and diaphragm means,

the characteristics of said spring means and toggle spring being such that their combined spring rates become negative before the toggle spring passes overcenter to thereby initiate switching before said toggle spring force component reverses in direction and dynamically switches said contact carrying member from one position to another,

and second spring means and means connecting said second spring means to said actuated member with a lost motion connection so that said second spring means becomes operative to oppose said actuating force before said contact carrying member moves from one position to the other and is rendered inoperative before said contact carrying member moves from said other position to said one position, the characteristics of said spring means and said second spring means and said toggle spring having a combined spring rate which becomes negative before said toggle spring passes overcenter.

17. A multiple level pressure switch comprising, in combination,

first and second switch assemblies each comprising a contact supporting member, an actuated member and a toggle spring connected between said actuated member and said contact supporting member to produce overcenter action of said contact supporting member to either one of two positions,

diaphragm means,

a bridge member connecting said diaphragm means to each of said actuated members and defining an actuating point at each switch assembly through which the actuating force of said diaphragm is applied to said actuated members, said bridge member also connecting said first and second switch assemblies to each other,

spring means,

lever means interposed between each of said spring means and said actuated members and connected to and movable with said actuated members,

said spring means connected to each of said lever means and extering a force on said actuated members through said lever means in opposition to the force of said diaphragm means,

means for adjusting the force with which said spring means oppose the force of said diaphragm means,

means defining limit stops in the path of movement of each of said switch assemblies and arranged for engagement with and to limit movement of said lever means toward both of the positions of said switch assemblies,

and said toggle springs exerting a force component on said actuated members at said actuating point parallel to the force direction of said spring means and diaphragm means and the characteristics of said spring means and toggle springs being such that their combined spring rates become negative before the toggle springs pass overcenter to thereby initiate switching before said force component of said toggle springs reverse in direction and dynamically switch said contact members from one position to another.

18. The multiple level pressure switch of claim **17** wherein said lever means engage each of said actuated

members at said actuating points and each of said spring means engage said lever means at a point intermediate said actuating point and the pivot point of said lever means.

19. A multiple level pressure switch comprising, in combination,

first and second switch assemblies each comprising a contact supporting member, an actuated member and a toggle spring connected between said actuated member and said contact supporting member to produce overcenter action of said contact supporting member to either one of two positions,

diaphragm means,

means connecting said diaphragm means to each of said actuated members and defining an actuating point at each switch assembly through which the actuating force of said diaphragm is applied to said actuated members,

spring means,

lever means interposed between each of said spring means and said actuated members and connected to and movable with said actuated members,

said spring means connected to each of said lever means and exerting a force on said actuated members through said lever means in opposition to the force of said diaphragm means,

means for adjusting the force with which said spring means oppose the force of said diaphragm means,

means defining limit stops in the path of movement of each of said switch assemblies and arranged for engagement with and to limit movement of said lever means toward both of the positions of said switch assemblies,

and second spring means associated with each of said switch assemblies and means connecting said second spring means to said lever means with a lost motion connection so that said second spring means are operative to oppose said actuating forces before said contact supporting members move from one position to the other and are rendered inoperative before said contact supporting members move from said other position to said one position, said spring means, said second spring means and said toggle springs having a combined spring rate which becomes negative before the toggle springs pass overcenter.

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BERNARD A. GILHEANY, *Primary Examiner.*

G. MAIER, H. B. GILSON, *Assistant Examiners.*